



Fall Risk Reduction in the Elderly

Disequilibrium of Aging

A 70 year-old woman is referred to physical therapy by her primary care physician. She reports a seven month history of dizziness during movement and disequilibrium. She has fallen once in the yard while walking at dusk. She is unable to work in her garden without great care. The office examination findings were as follows:

- **Past medical history:** Non-contributory
- **Previous work-up:** Non-contributory
- **Clinical examination:** Observations of wall walking, staggering with quick turns, inability to perform tandem gait
- **Test results:** No tests to date

Impression: Because the patient's history and physical examination are not indicative of specific pathology, there is insufficient information to determine the cause of her balance abnormality. The medical findings do not provide a differential diagnosis of aging versus possible specific system pathology.

To answer the questions raised by the medical evaluation and to develop a treatment plan likely to improve her daily life function, additional information is needed:

- What factor or combination of factors are contributing to her functional problems?
 - o Aging process
 - o Vestibular system
 - o Central nervous and/or motor systems
 - o Cardiovascular system
 - o Medication effects



- What is the state of vestibular function? If a vestibular problem is confirmed, then what is the state of compensation?
- What is the relative degree of sensory, motor, or central adaptive system involvement?
- Do the impairments identified point to the presence of a localized, medically treatable pathology?
- Is further diagnostic testing indicated, e.g. ENG?

OUTCOMES

CDP provides information to explain the patient's functional complaints, to provide focused rehabilitation targets, and to establish baseline measurements to evaluate patient progress through therapy.

Inside You'll Find ...

- CDP results that identified impairments and provided focused patient management.
- A solid foundation for treatment based on objective, quantitative information.



Measuring Impairments

A common diagnostic dilemma is whether to refer for a full vestibular evaluation including ENG/VNG given that the primary care exam did not suggest an active or changing vestibular disorder. This patient's failure to compensate and her complaints of functional limitations present questions which are best answered by tests aimed at documenting pathology and gaze and balance control impairments. Hence, the patient was simultaneously referred for balance assessment/rehabilitation and ENG/VNG.

Balance Control: The patient was referred for Computerized Dynamic Posturography (CDP) testing which isolates and quantifies sensory and motor impairments contributing to balance control. CDP also provides information helpful in ruling out central pathway involvement.

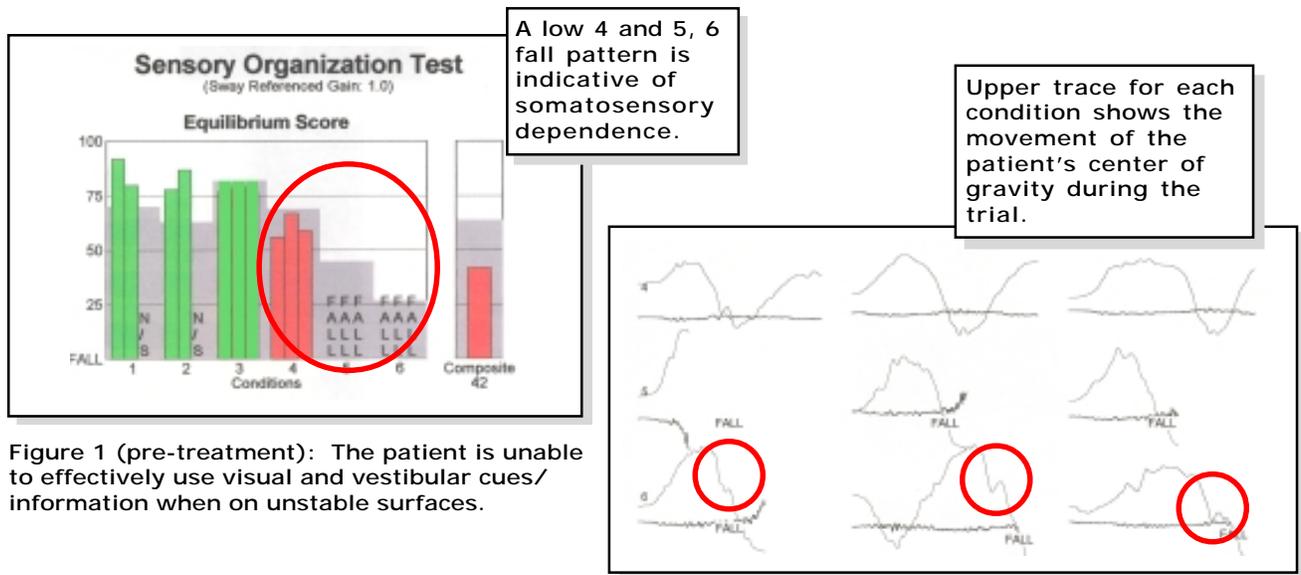


Figure 1 (pre-treatment): The patient is unable to effectively use visual and vestibular cues/information when on unstable surfaces.

Figure 1A (pre-treatment): Center of gravity raw data tracings show a positive sign for rehabilitation.

The Sensory Organization Test (SOT) identifies impairments in the patient's use of the three sensory systems: somatosensory, visual, and vestibular. Results reveal a pattern of somatosensory dependence when the support surface moves in response to the patient's postural sway (conditions 4,5,6) (Figure 1). This functionally represents an inability to utilize visual or vestibular information for balance decisions when on unstable surfaces. The raw data tracings (Figure 1A) document that the patient attempts but fails to recover balance control when relying on vestibular inputs.

Motor control testing, the MCT, ADT, and LOS tests, were conducted to document the role of central neuromuscular processes.

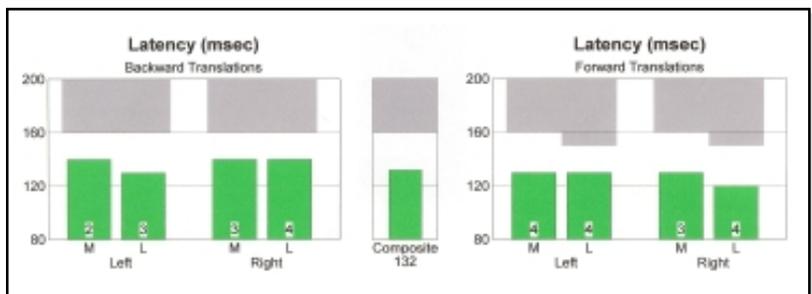


Figure 2 (pre-treatment): Normal automatic motor responses (timing) to external perturbations or stimuli.



The Motor Control Test

The Motor Control Test assesses the ability of the automatic motor system to quickly recover following an unexpected external disturbance. Sequences of small, medium or large platform translations (scaled to the patient's height) in forward and backward directions elicit automatic postural responses. Results of the MCT (Figure 2) of automatic motor response were within normal limits indicating that the sensorimotor pathways linking the lower leg musculature and the brain were functioning normally.

The Adaptation Test

This test assesses the patient's ability to minimize sway when exposed to surface irregularities and unexpected changes in support surface inclination. Sequences of platform rotations in the toes-up or toes-down direction elicit automatic motor responses.

Patient demonstrates limited adaptive ability to recover from surface perturbations in either direction.

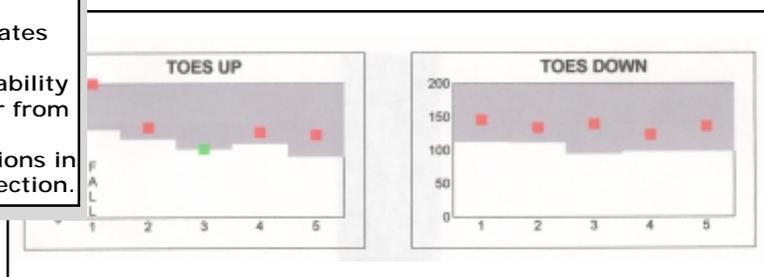


Figure 3 (pre-treatment): Interpretation includes differential etiology of musculoskeletal versus fear versus cerebellar impairments.

In contrast to the results of the MCT, the Adaptation Test (ADT) (Figure 3)

revealed impaired ability to adapt to automatic responses to changes in surface conditions. This latter finding suggests one of two possible functional problems: 1) the inability to adaptively suppress automatic reactions when inappropriate for balance and/or 2) insufficient ankle muscle strength to recover from support surface perturbation. Based on physical findings of normal strength, the first is most likely the cause. Functionally, this relates to the patient's fall risk during sudden or unpredictable changes in the support surface during ADLs.

Limits of Stability (LOS)

Examination of the patient's voluntary movement control of the center of gravity (COG) over the base of support using the LOS test reveals significant impairments. Movement timing and control are within normal performance ranges indicating normal cognitive function and control over balance, however, movement limits are impaired. Theoretically, normal performance is 100% of available limits of stability based upon the patient's height.

The patient demonstrates restricted excursions in the anterior and posterior directions to approximately 40% and 25%, respectively. This is most likely related to patient guarding or inappropriate generation of the motor plan, given the patient's normal strength findings. Functionally, this relates to the patient's fall risk during activities and impaired gait control.

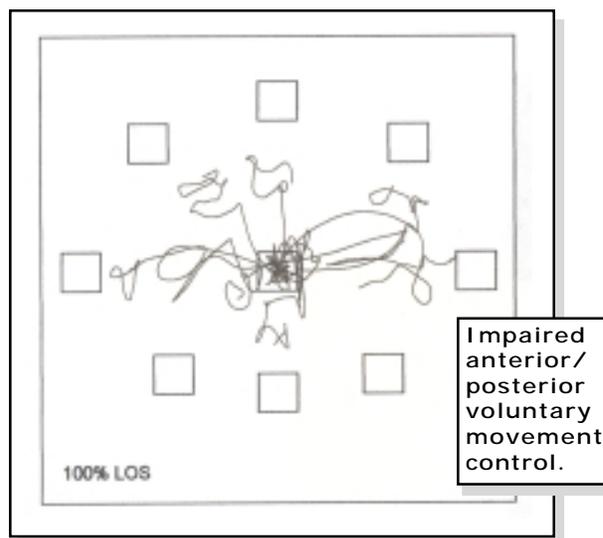


Figure 4 (pre-treatment): The trace shows the movement of the patient's center of gravity from a central starting position to each of a series of targets set at the theoretical limit of stability (100%).



Impression & Recommendation

The ENG/VNG results were within normal limits. The CDP results, however, documented balance problems characterized by 1) poor use of visual/vestibular cues for balance (an over-reliance on somatosensory inputs), 2) poor adaptive motor control on unpredictable surfaces, and 3) restricted movement control in the anterior and posterior directions. In the absence of cognitive, automatic motor control, and strength problems, these results are consistent with non-specific self-restriction of motion and a maladaptation to changes in sensory system changes typically associated with the aging process.

How did the impairment information provided by CDP influence treatment plan?

- **Past medical history:** Non-contributory
 - **Previous work-up:** Non-contributory
 - **Clinical examination:** Observations of wall walking, staggering with quick turns, inability to perform tandem gait
 - **Test results:** ENG/VNG results normal
- CDP identified:**
- Sensory and motor (automatic, voluntary) impairments related to maladaptation to the aging process

The dilemma is whether the ENG/VNG testing is necessary when the office examination does not suggest vestibular involvement. In this case, the ENG did not contribute to the treatment plan. However, the SOT findings (Figure 1A) indicate poor use of vestibular and visual information. Improved responses with each subsequent trial or attempt are good prognostic signs for rehabilitation and outcomes. In the absence of clinical findings of peripheral vestibular or visual involvement, the problem is most likely attributed to impairments in central integration of vestibular and visual inputs. As such, the prognosis would be good for improvements in both sensory and motor impairments with a corresponding improvement in balance for safe function through focused balance rehabilitation.

Treatment Plan

Based upon the above impression, the decision was made to proceed with balance rehabilitation for 30 days with the expectation of measurable improvements in the ability to utilize sensory cues appropriately for balance and effective movement strategies.

The balance rehabilitation program would focus on remediation of the movement control impairment within the appropriate sensory environment/context. Since the patient has normal strength and range of motion, the program will be limited to increasing anterior and posterior movement limits under conditions to facilitate the use of visual and vestibular cues (unstable surface with vision available and unavailable), prescribed to an appropriate level of difficulty. This program will be designed with a combination of clinic and home program and progressed based upon patient response.

Impairment: Disequilibrium

**Tests: Sensory Organization Test (SOT)
Motor Control Test (MCT)
Adaptive Test (ADT)
Limits of Stability (LOS)**

Findings: Poor use of vestibular and visual information; poor movement control due to non-specific self-restrictions; good prognosis with rehabilitation and outcomes.

Overview

Physical Exam/History →

Non-contributory; Falls; Function Decline
• Dizziness • Disequilibrium • Frustration

Diagnostic Hypotheses →

1. *Aging*; 2. Vestibular System; 3. Central Event or Change; 4. Cardiovascular System; 5. Medication Affects

Medical Work-Up →

Diagnostic Testing	Blood Pressure,
<i>ENG</i>	Medications
<i>NL</i>	<i>OK</i>

Diagnosis →

Pathology: None. ENG was within normal limits.
Function: Compensated or uncompensated?
Adequate for lifestyle demands?

1. Watch & Wait?
2. Full Vestibular Work-Up?
3. Full Central Work-Up?
4. Rehabilitation?

Impairment Work-Up →

Tests of Postural Control

Computerized Dynamic Posturography
Sensory: Sensory Organization Test (SOT):
Figure 1 and 1A

Motor: MCT (Automatic), ADT (Adaptive), LOS (Voluntary) Figures 2-4

Impairment Diagnosis →

- Somatosensory dependence; poor use of visual-vestibular cues on unstable surfaces
- Poor adaptive motor control to unstable surfaces
- Poor voluntary movement control

Functional Outcome →

- Thirty day re-evaluation confirmed improved test results for voluntary motor control.
- Data provided documented need for additional rehabilitation time for use of vestibular cues.

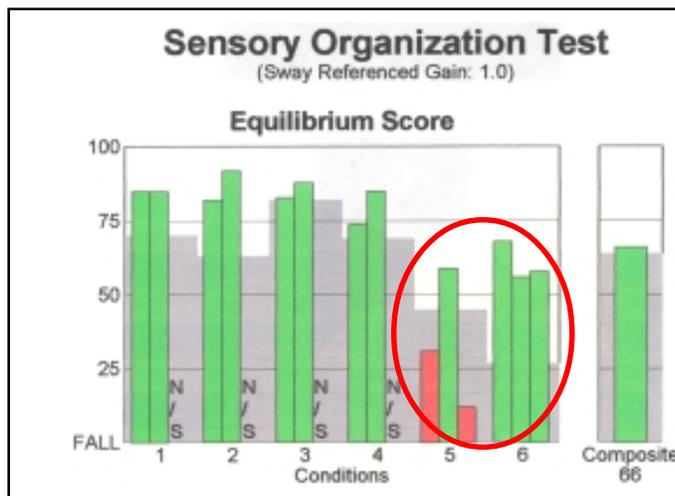
Summary: How did CDP augment the medical decision-making?

1. CDP showed that the patient lacked adequate visual-vestibular compensation to maintain her lifestyle.
2. CDP directed the management approach in general and the vestibular rehabilitation approach specifically.
3. CDP provided an objective benchmark for the need for additional rehabilitation.

Functional Outcome

The patient was measurably improved in both test performance and function within four weeks. Limits of stability (voluntary motor control) was improved to within age-matched normative limits (Figure 5B). SOT (sensory balance) performance was improved in all areas with a residual impairment limited to use of vestibular cues (condition 5). Partial restoration of vestibular function highlights the need for more rehabilitation time but narrows the program to use of vestibular cues with vision absent on unstable surfaces.

Sensory Performance (SOT)



Post-treatment: Sensory balance performance is approaching normative range. Mild condition 5 impairment requires further rehabilitation.

Objective measures of motor performance now within normal limits.

Motor Performance (LOS)

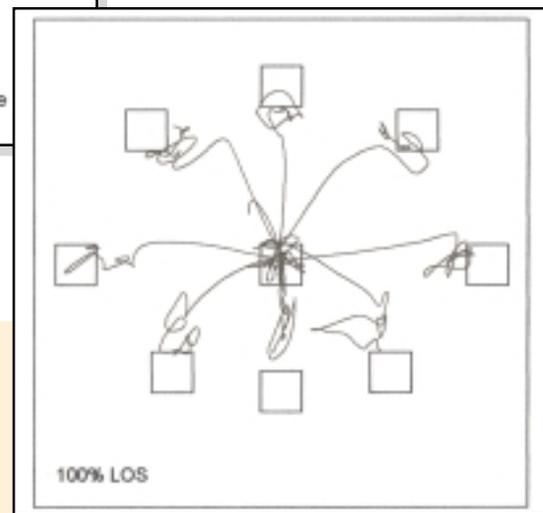


Figure 5A (post treatment): SOT results

Rehabilitation was continued through home program focused to the use of vestibular cues for balance. Full functional recovery was achieved in 30 days.

Figure 5B (post treatment): LOS results

Influence from CDP/ computerized tests on patient management:

The patient presented with a new onset of dizziness and functional impairment without acute pathology. In the absence of CDP results, there was no way to focus the treatment beyond a generalized approach that is frequently less effective. The information from computerized testing identified the impairments resulting in the functional problem and provided a focused key to management. The impairment reduction approach was the key to successful functional outcome.

The information from computerized testing identified the impairments resulting in the functional problem and provided a focused key to management. The impairment reduction approach was the key to successful functional outcome.

The CDP information also provided a sound treatment hypothesis without the need for extensive, site-of-lesion testing. Simultaneous referral for an ENG to confirm the presence or absence of a vestibular lesion was completed and, based upon measured reduction of impairment during the rehabilitation process, subsequently deemed of limited value to the outcome in this case.

The addition of CDP and additional computerized testing of the balance control system provided:

- Objective evidence supporting the patient's complaints and symptoms
- Objective evidence differentiating the effects of aging from pathology
- Pathway for treatment approach
- Post-treatment objective evidence that the management strategy was effective