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The Effects of Rotational Platform Training on Balance and ADLs

Diane M. Wrisley and Marilee J. Stephens

Abstract— **Patients with vestibular dysfunction complain of postural instability and disorientation long after the central compensation is thought to be complete. Previously it has been demonstrated that patients with unilateral vestibular loss who orient more to vertical have better perceived functional status. We proposed that performing balance training with surface perturbations at velocities that target the vestibular system would lead to increased reliance on vestibular information, and therefore improve function. The purpose of this study was to determine whether patients who train using repetitive platform perturbations at these vestibular dependent velocities demonstrate improved postural stability and greater functional abilities than patients who perform traditional balance therapy.**

Twelve subjects with chronic vestibular and balance dysfunction (age 58 ± 15 years; 3 males, 8 females) and 4 healthy control subjects (age 62 ± 23 years; 4 females) participated. Patients were randomized into 3 groups: clinical balance training (CBT n=3) and training with ramp platform perturbations (4 deg amplitude) either at vestibular (1, 2, 4 deg/sec; VESTIB n=6) or at non-vestibular velocities (0.5, 8, 16 deg/sec; Non-VESTIB n=3). The healthy control subjects completed training at vestibular velocities. Subjects' kinematic and kinetic responses to ramp rotational platform perturbations (0.5, 1, 2, 4, 8, 16 deg/sec at 6 deg amplitude), and scores on the Activities-specific Balance Confidence Scale (ABC), Dizziness Handicap Inventory (DHI), Vestibular Activities of Daily Living Scale (VADL) and Functional Gait Assessment (FGA) were compared before and after the 2 week, 3x/week training sessions.

Control subjects demonstrated minimal change in orientation to vertical during platform rotations following training. The VESTIB group demonstrated greater improvements in orientation to vertical during ramp perturbations following training than the Non-VESTIB or CBT groups. Both the CBT and VESTIB groups demonstrated improvements on a composite clinical score incorporating the ABC, DHI, VADL, and FGA following training whereas the Non-VESTIB group did not demonstrate improvement.

These preliminary results indicate that training using platform rotations may be an effective intervention for improving postural control following vestibular loss. Further research is needed to explore the efficacy of incorporating rotational platform training with clinical balance training.

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D. M. Wrisley was with the Department of Rehabilitation Sciences, University at Buffalo, Buffalo, NY. She is with the Department of Physical Therapy, Lynchburg College, Lynchburg, VA 24501 USA (phone: 434-544-8884; fax: 434-544-8887; e-mail: Wrisley.d@lynchburg.edu).

M. J. Stephens was with the Department of Rehabilitation Science, University at Buffalo, Buffalo, NY. She is now with the Department of Neuroscience, University of Alberta. Edmonton, Alberta, CA (e-mail: mjstephe@ualberta.ca).

I. INTRODUCTION

Acute vestibular loss results in dramatic effects on postural stability including vertigo, disorientation, postural imbalance and gait ataxia.[1] Dizziness greatly affects activities of daily living and is second only to lower back pain as the reason patients see their primary care physicians. Balance and spatial-orientation disorders caused by vestibular deficits are one of the most under-diagnosed and misunderstood medical problems.[2] This is likely due to the complex, multi-faceted nature of postural control and because of the remarkable ability of the CNS to adapt postural control to changing environments and pathological conditions. Many patients with vestibular loss continue to report poor balance during functional activities, especially in situations that challenge balance,[3] long after the expected time frame in which compensation should have occurred. The nature of the resultant postural disorders is not well understood, and current interventions do not completely ameliorate all of the patient's symptoms.[4-5]

The relationship between dynamic postural asymmetries and asymmetric tonic activity in central vestibular pathways in patients with vestibular pathology is not well understood. Earlier studies have established that static postural asymmetries following acute vestibular loss are due to an imbalance (asymmetry) in tonic activity in the left and right vestibular nuclei.[3, 6] We propose that these latent postural asymmetries reflect the asymmetrical neural activity in the vestibular nuclei. Static postural asymmetries, such as head and trunk tilt toward the side of the lesion, return to normal within weeks after the vestibular lesion.[7] In recent studies, it has been demonstrated that patients with chronic, well-compensated unilateral vestibular lesions demonstrate asymmetrical trunk tilt when standing on a laterally-tilting surface. It is unknown how this asymmetry changes over time or how it is influenced by vestibular rehabilitation.

Vestibular rehabilitation (the use of customized postural and gaze exercise to treat vestibular dysfunction[5, 8-9]) was developed in the 1940's by Cawthorne and Cooksey[10-11] and has become the standard of care in treating people with vestibular disorders. People with vestibular dysfunction demonstrate improvements in postural stability, gait function, and perceived disability due to dizziness following vestibular rehabilitation.[5, 9, 12-17] The success of vestibular rehabilitation has been attributed to several mechanisms: rebalancing the tonic central vestibular activity, substituting an intact sensory system for vestibular information for orientation and balance, and motor relearning of balance strategies. It has been thought that patients with vestibular loss who rely more on somatosensory information (information from muscles and joints) through central sensory substitution would demonstrate less functional impairment.[4] In fact, previous studies have investigated the role of sensory substitution in decreasing postural sway in people with vestibular loss. Decreased postural sway is seen in people with bilateral vestibular dysfunction with the use of light touch, visual biofeedback posturography, or vibrotactile trunk stimulation. Previous research has demonstrated that patients with chronic complete unilateral vestibular loss rely less on vestibular information than healthy controls. However, patients with unilateral vestibular loss who rely more on vestibular information and oriented more to vertical perceive fewer functional impairments.[18-19]

Corna et al[20] found that patients who performed balance training on a sinusoidally-translating platform in the anterior-posterior and lateral directions had significantly decreased postural sway and decreased perceived dizziness than patients who performed Cawthorne-Cooksey exercises. However, the vestibular system provides greater control over rotational perturbations than translational perturbations[21-23] and vestibular information appears to be needed more at medium velocities (2 and 4°/sec) than at fast or slow velocities.[24] Therefore the purpose of this study was to determine whether patients who train using repetitive platform perturbations at these vestibular dependent velocities demonstrate improved postural stability and greater functional abilities than patients who perform traditional balance therapy.

II. Methodology

A. Subjects

Twelve subjects with vestibular dysfunction were recruited to participate (58 ± 15 years, 3 males, 8 females). 6 subjects with unilateral vestibular loss (UVL), 2 subjects with bilateral vestibular loss (BVL), and 4 subjects with central vestibular dysfunction (Central). All subjects were able to stand independently with their eyes open and had no other orthopedic, muscular, or neurological dysfunction that would affect standing. Subjects were not concurrently receiving vestibular rehabilitation. Four healthy control subjects (61.5 ± 22.8 years) also participated.

B. Procedures

Before and after intervention subjects completed self-efficacy scales, clinical measures of balance and postural stability testing.

Clinical Measures: Subjects completed the Dizziness Handicap Inventory[25] (DHI), the Vestibular Disorders Activities of Daily Living Scale [26-27] (VADL), and the Activities-Specific Balance Confidence Scale[28] (ABC) to determine their self perceived level of disability due to dizziness and their confidence in the ability to maintain upright. They completed the Functional Gait Assessment[29] (FGA) as a clinical measure of their balance abilities during ambulation. A Clinical Composite Score was calculated as 100*[ABC+(1-DHI)+(100-(10*VADL))+(FGA*3)]/390.[30]

Postural Stability Measures: Kinematic responses to 6° rotational platform ramps at 0.5, 1, 2, 4, 8, and 16°/sec were

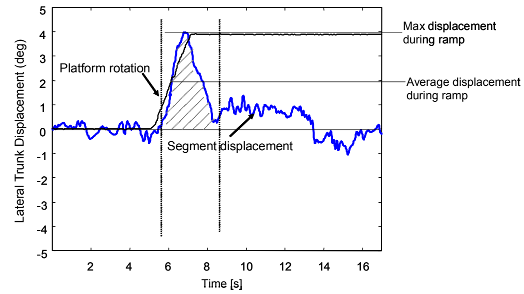

Figure 1 Representative trace of lateral trunk displacement for one subject with unilateral vestibular loss at 2°/sec, 4 degree amplitude lateral ramp rotation. The shaded area represents the integral of the trunk displacement from ramp onset to 1 second after

measured before and after intervention. The orientation to vertical of the trunk segment was measured as the ratio of the trunk tilt to the surface tilt and was calculated as one minus the proportion of the integral of the trunk displacement (Figure 1) from vertical to the integral of the platform movement during the ramp surface perturbation from the start of the ramp to 1 second following completion of the ramp. If the subject's movement followed the platform the value will be high and if the subject maintains orientation to vertical the value will be low.

Balance training: Subjects were randomly assigned to 1 of 3 groups: a clinical balance training group (CBT n=3; 1 UVL and 2 Central), training with ramp rotations at vestibular dependent velocities (1, 2, and 4 °/sec at 4°amplitude; VESTIB n=6; 3 UVL, 1 BVL) or training with ramp rotations at non-vestibular velocities (0.5, 8, 16 °/sec at

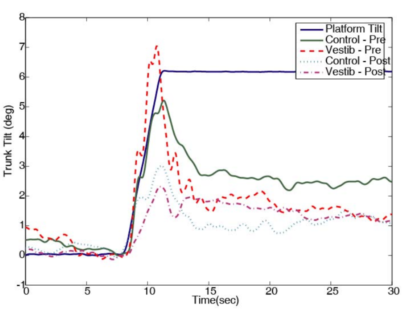

Figure 2 A representative trace of trunk lean during a 6° amplitude 2°/sec lateral ramp rotation for a subject with unilateral vestibular loss and a control subject before and after training at vestibular dependent velocities.

4°amplitude, Non-VESTIB n=3). The control subjects trained at the vestibular dependent velocities. All subjects completed training 3 times per week for 2 weeks.

III. Results

The postural sway for a representative patient with vestibular loss and a control subject before and after training at vestibular dependent velocities is displayed in Figure 2. The group that trained at vestibular dependent velocities demonstrated greater orientation to vertical following intervention than the groups who trained at non-vestibular velocities or with clinical balance training (Figure 3). Both the VESTIB group and the CBT group demonstrated improvements in the clinical balance measures (Table 1) and in the Clinical Composite Score (Figure 4).

Table 1: Number of subjects in each group who improved on each clinical balance measure.

Intervention Group	DHI	ABC	VADL	FGA
Vestib	3/6 (50%)	3/6 (50%)	4/6 (67%)	6/6 (100%)
Non-Vestib	0/3 (0%)	1/3 (33%)	0/3 (0%)	2/3 (67%)
Clinical	2/3 (67%)	2/3 (67%)	2/3 (67%)	3/3 (100%)

IV. Discussion

Balance training using ramp rotational platform perturbations at vestibular dependent improves orientation to vertical better than either clinical balance training or training at non-vestibular dependent velocities. This orientation to vertical is believed to represent an increase in the use of vestibular information for balance. Previously it was hypothesized that balance training focused on the use of somatosensory information as a compensation for the loss of vestibular function resulted in improved function. Our results suggest that intervention focused on the ability to upweight any remaining vestibular information improves functional ability.

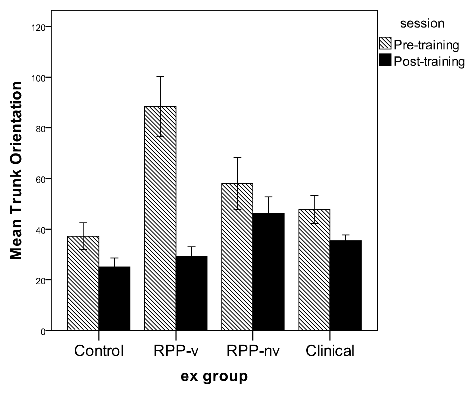

Figure 3Mean (± SEM) lateral trunk orientation for lateral ramp rotational perturbation by exercise group. RPP-v = training at vestibular dependent velocities, RPP-nv = training at non-vestibular velocities, Clinical = clinical balance training. Control subjects trained at vestibular dependent velocities.

Although both the clinical training group and the group training at vestibular dependent velocities improved in their perception of functional abilities, dizziness, and balance abilities, the Vestib group improved more in their ability to orient to vertical. This is in agreement with Corna et al[20] who demonstrated both improvements in perception of dizziness and postural sway with balance training with sinusoidally-translating platforms. Both the current research and the research by Corna et al[20] performed the platform perturbation training in isolation. With the improvements demonstrated in functional activities by the clinical balance training group in the current study it may be that a combination approach of training with ramp rotational

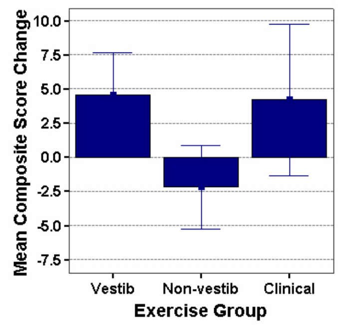

Figure 4: The mean change in the Clinical Composite Score after training for each intervention group. Positive scores indicate improvement. Bars indicate 1 SEM.

platform perturbations at vestibular dependent velocities and clinical balance training may demonstrate even greater improvements in functional abilities and in the use of vestibular information for balance. Further research is needed to determine the optimal combination of platform perturbation training and clinical balance training.

V. Conclusion

These preliminary results indicate that training using platform rotations may be an effective intervention for improving postural control following vestibular loss. A combination of rotational surface training with clinical balance training may improve outcomes for patients with vestibular dysfunction.

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