Case Study of Vestibular Training and Cognitive abilities in an Aging Person

Scott Thelen, PWS,
Vice President Vestibular Training Services

Abstract
Vestibular Training Services (VTS) provides non-invasive equipment and methods for improving balance and cognitive function in aging adults. This case study uses controlled rotation along a person's vertical axis using VTS patent-pending equipment to increase the balance and cognitive function of a generally healthy 79-year-old female. The results strongly suggest that using VTS equipment and methods can improve an aging adult's balance and cognitive function.

Introduction
One-third to one-half of older adults fall each year in the United States, equating to millions of individuals being affected[1]. Financially, the older adult falls "crisis" represents an estimated $31million cost to the United States healthcare system[2]. Aging influences the loss of balance and can inhibit everyday activities[3]. Custom vestibular therapy is shown to work on the elderly. Vestibular function declines with age, and emerging evidence suggests that vestibular loss is associated with cognitive impairment[4]. Physical activity, notably multimodal and mind-body exercise, offers benefits to cognition in older individuals[5]. VTS individualized management methods can help improve balance in the elderly[6].

VTS Rail-system equipment consists of a non-invasive, dual directional, variable speed motorized rotational platform with handrails. The motorized rotational platform will rotate at a speed customized by VTS trained personnel.

Figure 1. VTS Rail System.

Methods
The VTS methods utilized a pre-rotation and post-rotation comparison of postural sway and cognitive function. VTS utilizes the BTrackS Balance Plate and BTrackS Assess Balance software (BTrackS). The BTrackS is a portable force plate used to determine center of pressure (COP) of postural sway[7]. VTS utilizes a BTrackS Balance and Fall Risk Test (BBT) program which is programmed into the BBT tests for pre- and post-rotational testing. The BBT is used to assess how people use vision, proprioception (body sense), and vestibular (inner ear) systems for balance. Lower postural sway path lengths equate to better balance[8]. An initial pre-rotation test (using BTrackS and BBT) creates a baseline for postural sway.

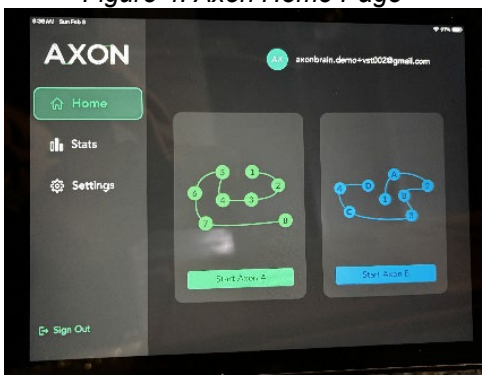
Figure 2. BTracks Plate

Each pre- and post-rotation test consisted of four 20 second (20s) trials beginning and ending with an auditory tone. The test required the participant to stand as still as possible on the BTrackS with eyes opened, hands on hips, and feet shoulder width apart. The initial test is considered a trial test and then the test is repeated three additional times. The BBT result (i.e. postural sway) for each test was calculated by the BTrackS, equivalent to the average total COP path length in centimeters (cm). There were minimal inter-trial delays (<10s). BTrackS guided the test administrator through measurement of COP path length.

Figure 3. BTrackS Patient-on-Plate

Cognitive function was measured via the Axon Cognitive Monitoring System (see Figure 4), which is based on and cross-validated against the classic Trail-Making Test (TMT)[9]. Axon was selected as it is self-administrable, can be completed in under two minutes, and measures dimensions of cognitive executive function which are sensitive to vestibular stimulation, including visuospatial processing ability, working memory, and executive control[10].

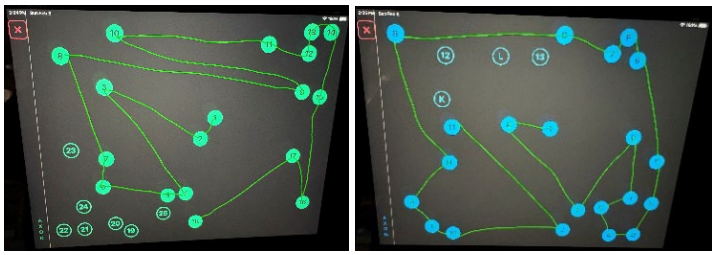
Figure 4. Axon Home Page



Briefly, Axon consists of Tests A and B which generate a screen of random numbers. The user uses a finger or stylus to connect the numbers in consecutive numerical order (Test A) or alternating numerical and alphabetical order (Test B). Axon displays the path taken by the user. The user may not cross the created path or skip the sequential order. The application records the time, in seconds to complete the sequence. The pre- and post- Test times were recorded and used in this case study.

Figure 5. Test A and B Screens

Test A Test B



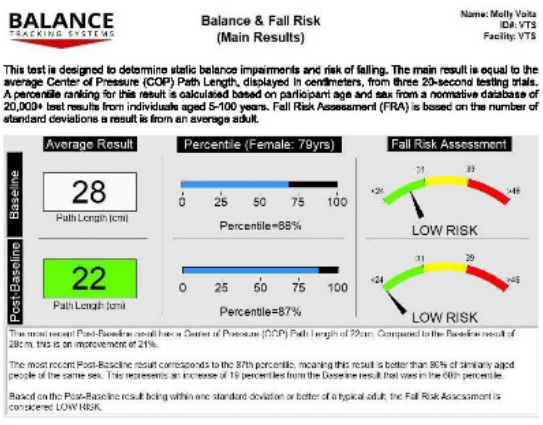
As for VTS, the subject stepped onto the VTS equipment and was secured within a belt. The subject was rotated counterclockwise for 10 rotations and a rotational speed between 10-12 rotations per minute, then spun clockwise for 10 rotations, and then counterclockwise again for 10 rotations. After 6 minutes, the subject was tested again on the BTrackS and with Axon. Post-rotation testing followed the same standardized script as the pre-rotation test. Changes in postural sway pre- and post-test were analyzed by comparing raw path length scores. Changes in cognitive function pre and post Axon Test A and Test B completion times.

Results

The case study focused on an adult 79-year-old relatively healthy female. The subject gave written informed consent prior to participation. VTS equipment methods were adjusted to meet the subject's desire for better balance and cognitive function.

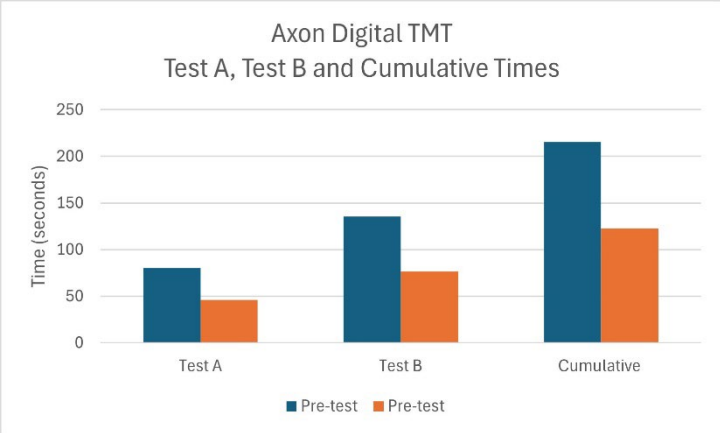
The subject's BBT baseline score included a path length of 28 cm and an age and sex adjusted fall risk assessment percentile in 68th percentile, meaning her results were better than 67% of similarly aged women. The subject's results after the VTS rotation reduced the path length to 22 cm and moved her into the 86th percentile, meaning her results were better than 87% of similarly aged women. This represents a 21% enhancement in balance and reduced her fall risk assessment by 19%, meaning she reduced her chance of falling.

Figure 6. BTracks BBT Scores



The subject's Axon baseline times included a baseline of 80.24 s for Test A, 135.47 fs for Test B, and a cumulative time of 215.71 s. The subject's results after the VTS rotation reduced the time of Test A to 45.90 s, Test B to 76.60 s, with a cumulative time of 122.50 s. This represents a time reduction of 57% for Test A, Test B, and the cumulative time.

Figure 6. VTS Training Results.



Discussion

Rotating along a person's longitudinal vertical axis has been shown to decrease the postural path which is an indicator of better balance and a reduction in fall risk assessment. The results also indicate an acute increase in cognitive executive functional ability as evidenced by lower times to complete the Axon digital TMTs. Thus, the results strongly indicate a robust effect of VTS-based stimulation on balance and cognition, suggesting that VTS equipment along with aging management techniques provide an affordable and non-invasive approach to aging management in all people.

Conclusion

The data supports a decrease in postural paths with the use of VTS which indicates improved balance and decrease in fall risk. The data also supports an increase in the subject's cognitive executive functions.

References

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