Virtual Reality: A New Frontier in Motion Sensitivity and Balance Assessment

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INTRODUCTION

Visual Motion Sensitivity (VMS) plays an integral role in our ability to integrate sensory information in terms of motor coordination, balance, and overall quality of life. However, objectively quantifying VMS across the balance system continues to remain a challenge. The purpose of this study was to explore the implementation of Virtual Reality (VR) technology to provide an immersive and controlled method for evaluating VMS.

METHODS

- 49 subjects between the ages of 18-30yo (24 male; 25 female) with no recent major injury to the trunk or lower extremities or current use of an assistive device for balance
- Complete the Visual Vertigo Analog Scale (VVAS) along with two VR-based assessments,
  - The Subjective Visual Vertical (SVV), which functions under conditions with and without a 30° bilateral body tilt
  - 43 subjects (21 male; 22 female) also completed a Visual Motion Sensitivity Test (VMST) in standing, incorporating both optokinetic and optic flow stimuli in multiple directions
  - The Visual Analog Scale (VAS) used to record subjective reported symptoms, while objective postural data were obtained via a VR-integrated posturography system and force plates

RESULTS

- Optokinetic testing (Figure 1 - top)
  - A main effect of condition (p<0.001) found. Sway velocities were higher in the up condition, compared to the motionless (p<0.001), left (p<0.001), and right (p<0.001) conditions.
- Optical flow (Figure 1 - bottom)
  - A main effect of condition (p=0.008) found. Sway velocities were higher in the backward condition, compared to the motionless condition (p=0.02).
- Subjective Visual Vertical (Figure 2)
  - A main effect of position (p<0.001) found. SVV errors were lower for the 0° position, compared to -30° (p<0.001) and +30° (p<0.001) positions, while there was no difference in SVV errors between the -30° and +30° positions (p=0.99). No statistical significance between groups at -30.
- Subjective VAS during VMST - sitting vs. standing
  - There was no significant difference in symptoms (p=0.77) between subjects sitting vs. standing during VMST.

Statistically significantly higher sway velocities produced under specific conditions in virtual reality VMS testing

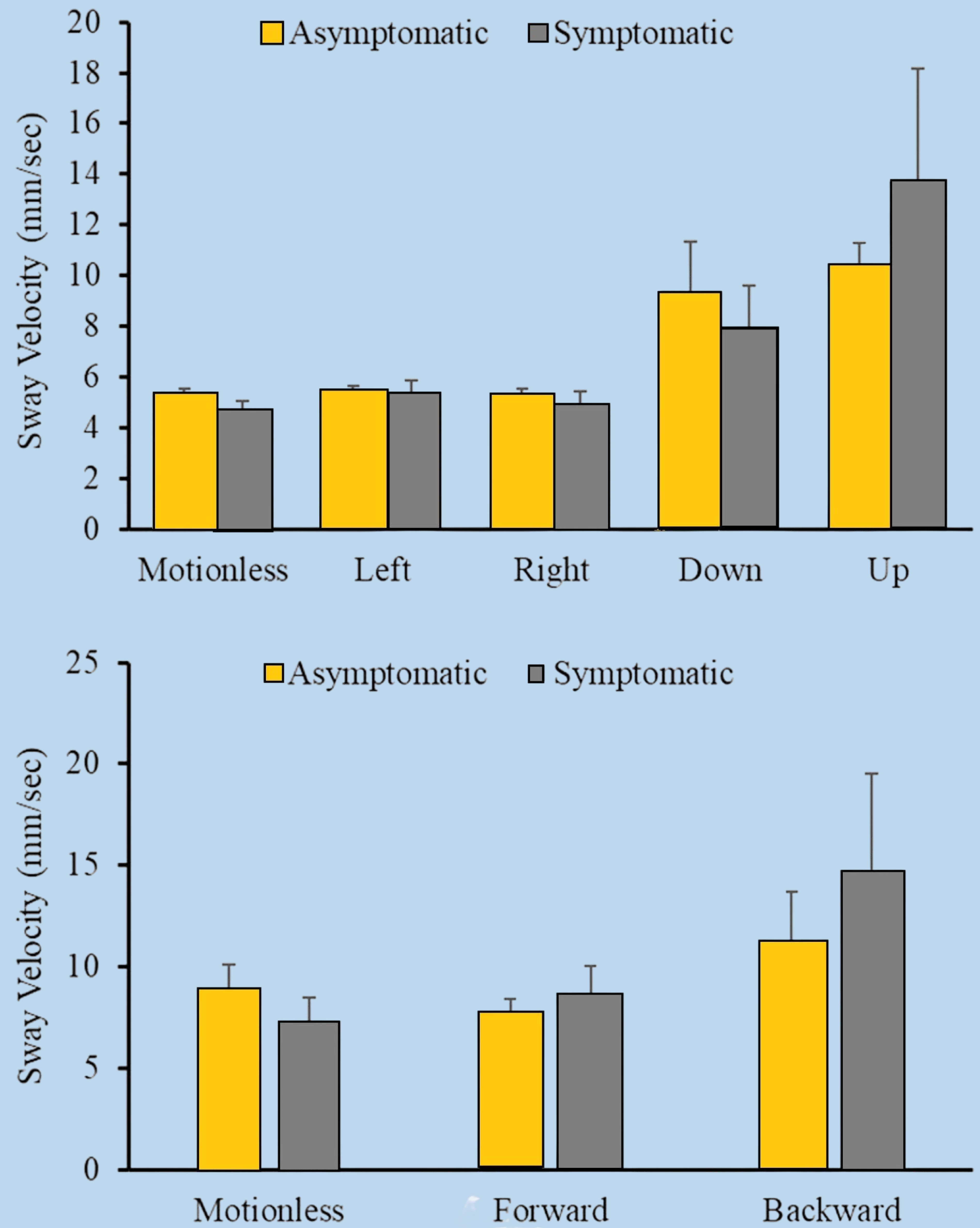

Figure 1. Mean (+ standard error) sway velocities for each condition of the optokinetic (top row) and optical flow (bottom row) testing.

Subjective Visual Vertical Absolute Error

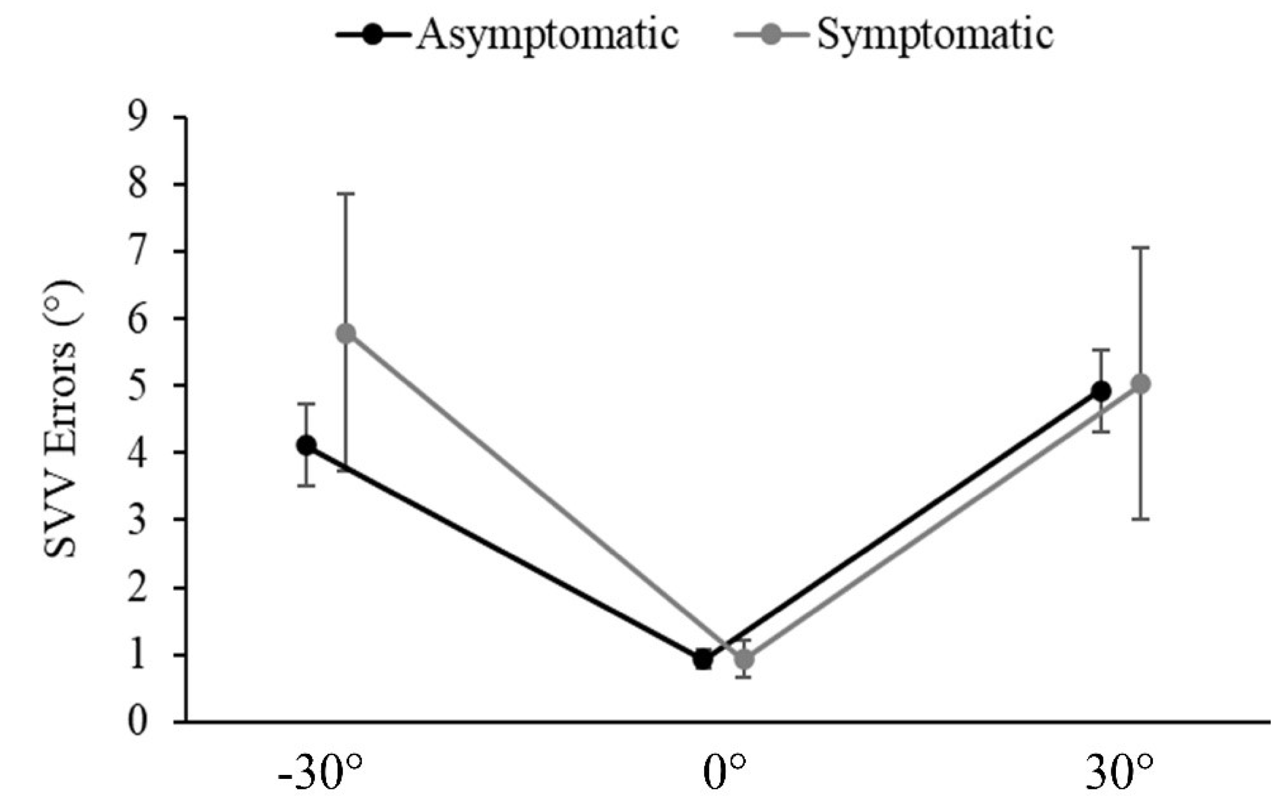

Figure 2. Mean (± standard error) SVV test absolute errors for the asymptomatic and symptomatic subjects in the -30°, 0°, and +30° testing conditions.

Figure 3. Subject seated during SVV testing (left) and screen visualized by subject and tester subject during 30° tilt position (right)

DISCUSSION

Future studies should be conducted to increase the sample size to draw more robust conclusions when comparing symptomatic and asymptomatic individuals in SVV and VMST. Comparing diverse populations, including those with variable demographics such as migraine history, concussions, and previous VR experience, is hypothesized as influential. Reducing test time by focusing on the two significant differences in flow may also enhance the efficiency of assessments. Additionally, potential learned effects in SVV may account for the observed differences at -30°, suggesting the need to modify methods by varying body tilt sequences among participants. Lastly, any variance in the SVV test due to test technique should be ruled out through further investigation.