Postural Control Behavior in a Virtual Moving Room Paradigm

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INTRODUCTION

- The human postural control system responsible for maintaining upright balance, recovering from postural perturbations, and preventing falls, relies on both sensory and motor coordination along with a cognitive effort.
- Sensory conflicts between visual, vestibular & proprioceptive/ somatosensory systems can have detrimental effects on the postural control system and induce postural perturbations. Such perturbations when provided under controlled conditions can induce motor learning to aid in faster recovery & prevent falls [1].
- The impact of visual perturbation using virtual reality (VR) is still largely unknown. Hence, the purpose of the study was to was to investigate the impact of a virtual moving room paradigm, that provided both unexpected and expected visual, virtual postural perturbations on postural stability and subjective VR experience.

METHODS

Thirty healthy adults (age: 21 ± 1 years; height: 166.5 ± 7.3 cm; mass: 71.7 ± 16.2 kg) were tested for postural stability in a virtual moving room paradigm that consisted of randomized virtual, visual perturbations of the virtual room moving towards and away from the individual, during both unexpected and expected trials along with subjective experiences to VR and postural stability confidence were also assessed and analyzed using repeated measures analysis of variance at an alpha level of 0.05.

Figure 1. Virtual moving room paradigm tested with HTC VR system and BTrackS balance system

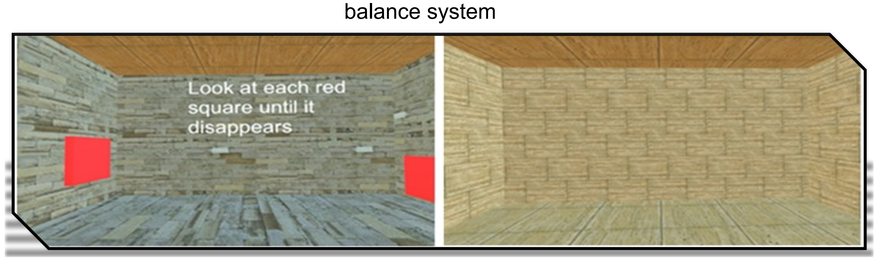
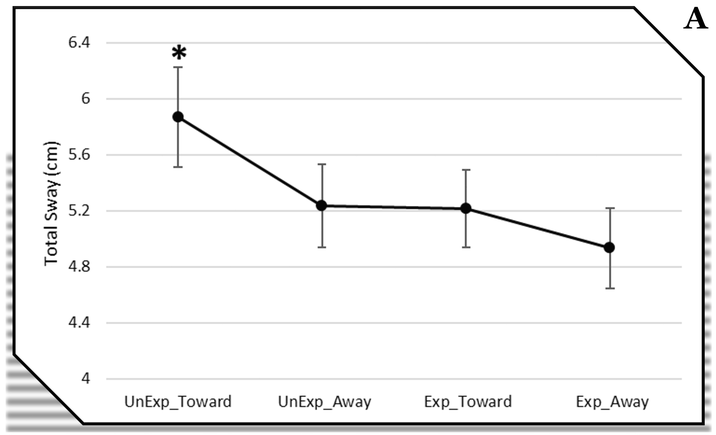


Figure 2. Virtual Environments. Left: lobby and transition environment, right: closed room testing environment

RESULTS

- Significantly higher postural sway was demonstrated when the virtual room unexpectedly moved towards the participants, compared to other virtual moving room conditions at $p < 0.05$.
- Expected virtual room movement, especially away from the participant demonstrated better postural stability.
- Significantly improved balance confidence at $p < 0.05$ were identified with no simulator sickness.



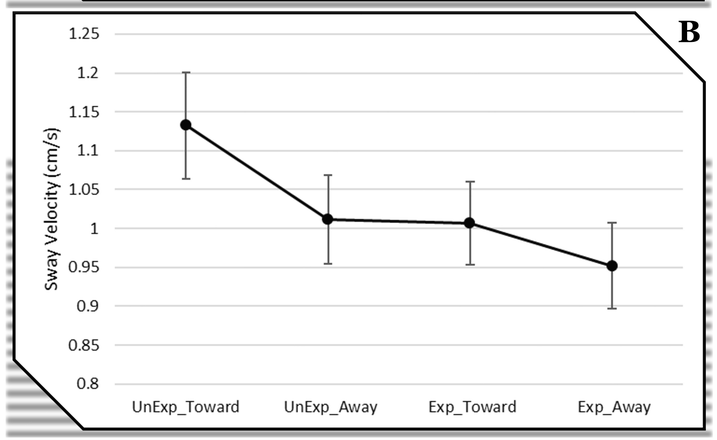


Figure 3: Moving room testing conditions - Center of pressure total postural sway (cm) (A) and Center of pressure postural sway velocity (B) during the four virtual moving room conditions. UnExp_Toward: unexpected movement of the virtual room toward the participant; UnExp_Away: unexpected movement of the virtual room away from the participant; Exp_Toward: expected movement of the virtual room toward the participant; Exp_Away: expected movement of the virtual room away from the participant). * represents significant difference and bars represent standard error.

DISCUSSION

- In the current study, the postural sway variables were significantly higher in the unexpected toward-moving room compared to the unexpected away-moving room, expected toward-moving room, and expected away-moving room.
- Additionally, although not statistically significant, the postural sway variables during unexpected moving room were always higher compared to expected moving room for toward and away respectively.
- These findings suggest decreased postural stability when the perturbations were unanticipated, and when the virtual moving room was moving toward the participants, suggesting the roles of compensatory postural responses (CPRs) and anticipatory postural responses (APRs) when exposed to visual and virtual unexpected and expected postural perturbations [2,3].
- Finding also demonstrated increased subjective balance confidence, realistic immersion in VR, and no simulator sickness during the virtual moving room paradigm [3].
- Future studies incorporating comprehensive biomechanical and cognitive measures and repeated exposure of the virtual moving room paradigm for motor learning are warranted.

CONCLUSION

- Evidence of the virtual moving room inducing postural perturbations that challenge the postural control system, especially when the moving room is unexpected and towards the individual, and increased balance confidence with realistic immersion in the VE with no adverse effects of simulator sickness was observed suggesting the beneficial effects of the virtual moving room paradigm in postural stability and potential balance training.

REFERENCES

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