Virtual-reality based Cognitive-motor-balance (VR-CogMoBal) training: Examining behavioral and neuromarkers for fall-risk reduction in older adults with mild cognitive impairment (MCI)

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Methods

Participants

Older adults (> 55 years) will be recruited from the University of Illinois Hospital Geriatric Clinic and flyers in nearby independent living senior centers and grocery stores. We expect ten older adults participated in the study after obtaining a written informed consent.

Participants' eligibility

To be included, participants must score 18-24 out of 30 on the Montreal Assessment on Cognitive Assessment (MoCA). Participants with uncontrolled cardiovascular disease, presence of any neurological condition (e.g., Alzheimer's disease), and/or severe musculoskeletal diseases that may interfere with the ability to receive the intervention were excluded. Additionally, people with the inability to stand independently without an assistive device for the length of a Wii-Fit game, with a fracture risk heel bone density (measured using Lunar Achilles Insight) T-score < -2.0, and inability to communicate and understand English were excluded.

Research Design

This study will be a single arm pre-post research design consisting of 4 weeks of DT exergaming sessions. Baseline (at week 0) and post-testing (at 5th week) outcome measures will be collected.

Intervention

In total, 12 sessions of individual one-on-one DT exergaming will be administered and supervised by a research personnel (physical therapist) in a research facility. Participants will wear a gait belt and were supervised during the session. DT exergaming will be delivered via Wii-Fit standing balance games which was performed at light intensity (rate of perceived exertion via Borg's scale with individuals reporting score of 7-11) (17) and will be concurrently performed with explicit cognitive games (therapist cued) for 90 minutes/session, 3 times/ week. While Wii fit games will implicitly address cognitive domains like working memory, episodic memory, and visuospatial awareness, explicit cognitive games targeted subdomains of executive function – working memory and attention, and semantic memory, abstract memory. Warm up (step-in-place, trunk twists) and cool down (stretching of lower limb) will be performed before and after session, respectively. Refer to supplementary material section for details of protocol.

Assessments

Volitional balance control task: The limits of stability (LOS) test via Balance Master (Equitest® Neurocom) (18) will be administered. Participants will be secured in a safety harness and asked to stand on the force platform of the Balance Master (Figure 1). Participants will be instructed to lean their body either in the forward, backward, left, or right direction to move their center of gravity (COG) projection shown on a screen to the desired direction without losing balance, stepping, or reaching for assistance.

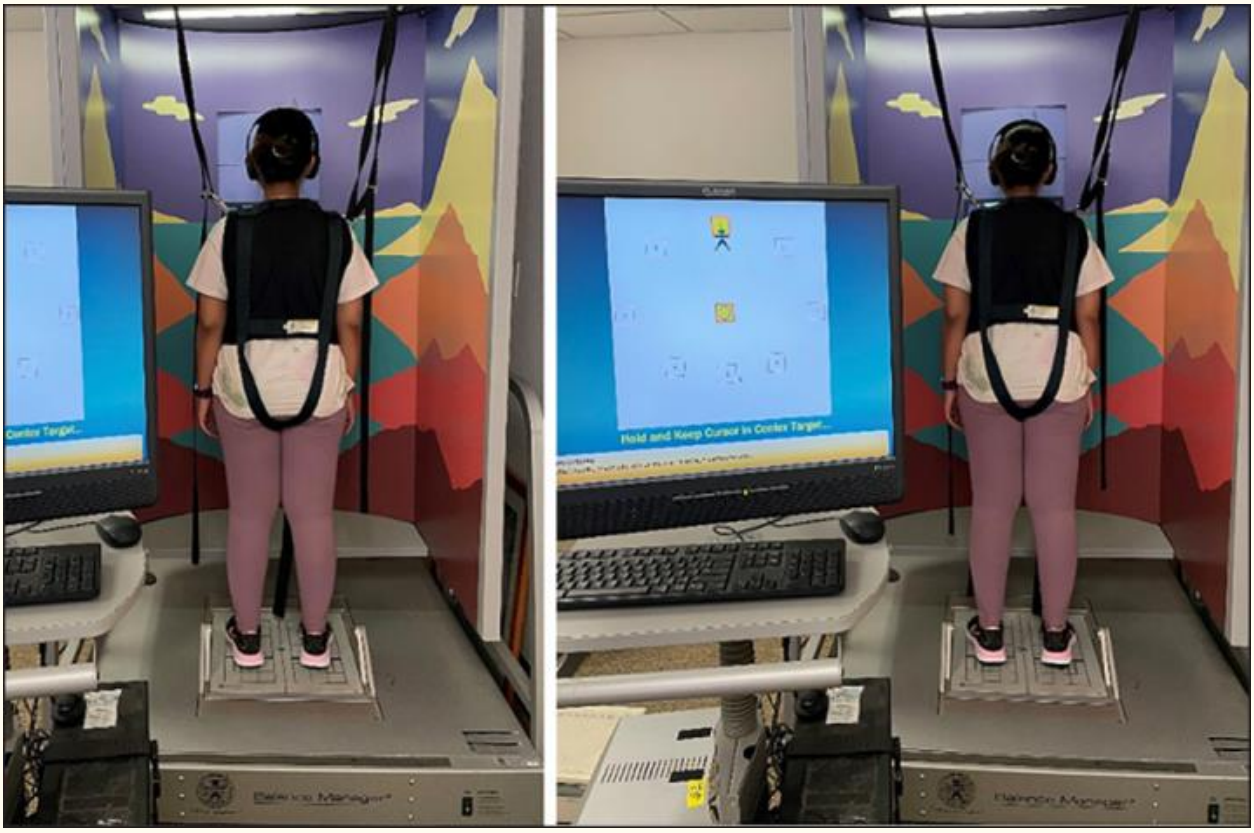

Figure 1
Represents a picture of an individual performing the limits of stability test on Balance Master (Equitest® Neurocom) in the forward direction

Cognitive task

Auditory clock test (ACT) (19) and letter number sequencing task (LNS) (20) will be administered using the DirectRT EmpirisoftTM (21) software to assess subdomains of executive function (visuo-spatial memory, working memory, attention, and cognitive flexibility). The audio

cues will be delivered through headphones and responses will be recorded through a microphone. The ACT involves responding to different times of the day, “yes” if the hour and the minute hand was on the same side of the clock face and “no” otherwise. The LNS will involve sequentially listing alternate letter and number combinations, for example, response to “C5,” was D6, E7, etc.

Interference test

The LOS test (all directions) will be performed along with both cognitive tasks mentioned above. Participants will began responding to the cognitive cues followed by the LOS task.

NIH Toolbox

An iPad will be used to test the motor and cognitive domains. The motor tests will include 4-meter gait speed test and 2-minute walk test. The cognitive tests include list sort memory test (working memory), picture sequence memory test (episodic memory), dimensional change card sort test (executive function), flanker inhibitory control and attention test (attention and executive function), and pattern comparison processing speed test (processing speed) (refer supplementary material section).

Outcome measures

Volitional balance control and interference task: Single task (task when performed alone) and performance during interference task was quantified by the movement stability measurement of maximum excursion (MXE, expressed in percentage), which is the maximum ability to shift one’s COG toward the theoretical limit in the desired direction. Higher values indicate better performance.

Cognitive and interference task: Accuracy [(Correct responses)(Total responses)*100] was calculated during single and interference task.

NIH toolbox: Speed (m/sec) for 4-meter gait test and distance covered in 2-minute walk test for endurance will be computed. Number of correct responses for list sort memory test and accuracy for the remainder tests was included for analysis.

Statistical analyses

Statistical analyses will be performed using SPSS version 24, Chicago, IL, USA. For MXE in each volitional balance control task direction (i.e., forward, backward, left, and right), 2 x 2 repeated measures analysis of variance (ANOVA) will be performed to examine the time (pre- to post-training) and task (single vs. interference task) differences on with follow-up post-hoc tests. Similarly, four repeated measures ANOVA for accuracy (cognitive) in ACT and LNS will be performed. Paired t-test will be conducted for NIH toolbox measures. Refer supplementary material section for detail