Body Coordination during Walking and Turning on an Omnidirectional Treadmill with Virtual Reality: Research Protocol

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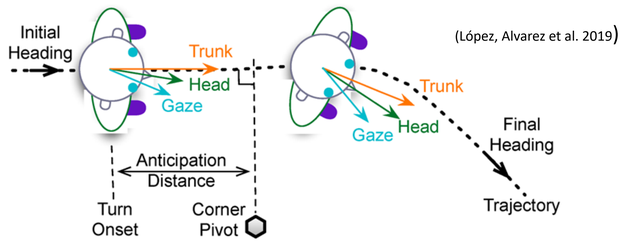
Introduction:

- The ability to navigate and change direction while walking (steering) plays a crucial role in independent community ambulation.[1]
- Locomotor steering involves a typical sequence of body segment reorientation.[2,3,4,5]
- Neurological conditions can compromise independent steering and lead to falls.[6,7]



- Omnidirectional treadmills (OMTs) with virtual reality (VR) can enhance conventional rehabilitation by allowing the training of steering tasks in a safe and controlled environment.

Objective:

- To estimate the differences in timing and amplitude of reorientation of head, thorax, pelvis and heading when executing a steering task on an OMT with VR (OTVR+) compared to when the same task is executed without VR on an omnidirectional treadmill (OTVR-) and overground (OGVR-).

Methods:

- Repeated measures design
- 20 healthy young adults (18-29 years)
- Two Vicon TM systems:
  - 12 Advantage cameras – OVG
  - Six Vero Cameras – OMT
- HTC Vive Pro Eye
- Unity
- Infinadeck OMT
- Conditions: OVGVR- (control), OMTVR- and OMTVR+
- Directions: 90°left, straight, 90°right
- 8 trials per direction/condition

Fig 1. Virtual environment representing the research laboratory (OMTVR+ condition).

- OMT conditions: habituation first without VR and then with VR:
  Until reaching comfortable overground walking speed (10MWT) for a duration of 1 min.
- Mandatory rest periods between conditions (minimum 5 min).
- Order of conditions and directions randomized.

Fig 2. OMT treadmill set up with reflective markers positioned according to the Plug-in Gait model.

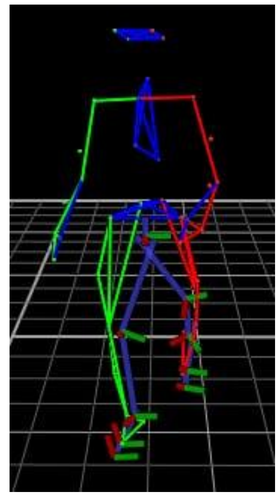


Fig 3. Motion capture data of a turning trial after running the Plug-in gait pipeline.

Outcome measures:

- **Primary**: Amplitude and onset time of segment reorientation and heading.
- **Secondary**: Walking speed, stride and step length, step width, cadence, swing and stance time.
- **Explanatory:** Simulator Sickness Questionnaire (SSQ)[8], Slater-Usoh-Steed Questionnaire (SUS)[9].

Expected Results:

- More 'synchronous' pattern but similar amplitudes of body segment reorientation in the OMT conditions vs. OVGVR-.
- For a similar walking speed, shorter step length, higher cadence, shorter swing phase and larger step width will be observed in the OMT conditions.
- Similar but more subtle differences will be observed between the OMTVR+ vs. OMTVR- condition, due to the effect of VR.

Significance:

- Results will help appraise the suitability of the OTVR+ set-up for the evaluation and training of complex locomotor tasks in rehabilitation.

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