Characterization of Gait Over Irregular Terrain to Inform a Virtual Reality Rehabilitation Environment

MaryEllen Hunt[1] Lorinda Smith[2], Bo Foreman[2], Mark Minor[1] and Andrew Merryweather[1]

[1]Department of Mechanical Engineering, [2]Department of Physical Therapy

University of Utah

Background: Falls are one of the leading causes of injury among those with movement disorders such as Parkinson's Disease (PD). Patients with PD have a high fall risk due to the combination of motor and cognitive deficiencies associated with the disease. Research has shown positive improvements in gait and response to perturbations using virtual reality (VR) training environments (1).

Objective: To characterize gait on irregular terrain in a fall prone population to confirm ecological validity of a VR training environment and subsequent changes in gait performance.

Methods: Cobblestone pathways were identified as a challenging terrain with significant fall risk from a questionnaire administered to 11 patients with Parkinson's disease. A removable cobblestone pathway was constructed on an elevated walkway surrounded by 24 V100:R2 cameras (NaturalPoint, Corvallis, OR). Healthy young (18-30) and healthy elderly were recruited to evaluate gait on a smooth hard surface (control) and the cobblestone walkway. Imbedded force plates in the pathway were used in addition to the video data to characterize gait performance.

Results: Pilot data has shown a difference in gait on a smooth surface compared to the irregular surface in both the healthy young and healthy age-matched individuals that have been tested (n=5). Differences are also expected in future testing with a fall prone population. In terms of spatiotemporal observations, the irregular terrain appears to increase cadence, decrease stride length, and increase stride width (Table 1). In terms of kinematic observations, of which the ankle has been a primary focus, dorsal and plantar flexion also appear to be affected differently by the different surfaces, though the extent of such difference has yet to be determined. Overall, the identification of these alterations in gait will provide a dataset for comparison to demonstrate the ecological validity of a virtual training environment with virtual cobblestone walkways, and instrumented haptic shoes for fall prevention training.

	Surface condition	*Cadence (steps/s)*	*Stride length (m)*	*Stride width (m)*
Subject 1	*irregular*	1.53	1.43	0.10
	flat	1.37	1.36	0.09
Subject 2	*irregular*	1.63	1.08	0.11
	flat	1.63	1.17	0.12
Subject 3	*irregular*	1.57	1.34	0.13
	flat	1.63	1.44	0.11
Subject 4	*irregular*	1.26	1.39	0.07
	flat	1.21	1.52	0.05
Subject 5	*irregular*	1.72	1.26	0.11
	flat	1.71	1.30	0.11
mean comparison irregular : flat		1.04	0.96	1.06

Table 1. Gait metrics comparison between surface conditions

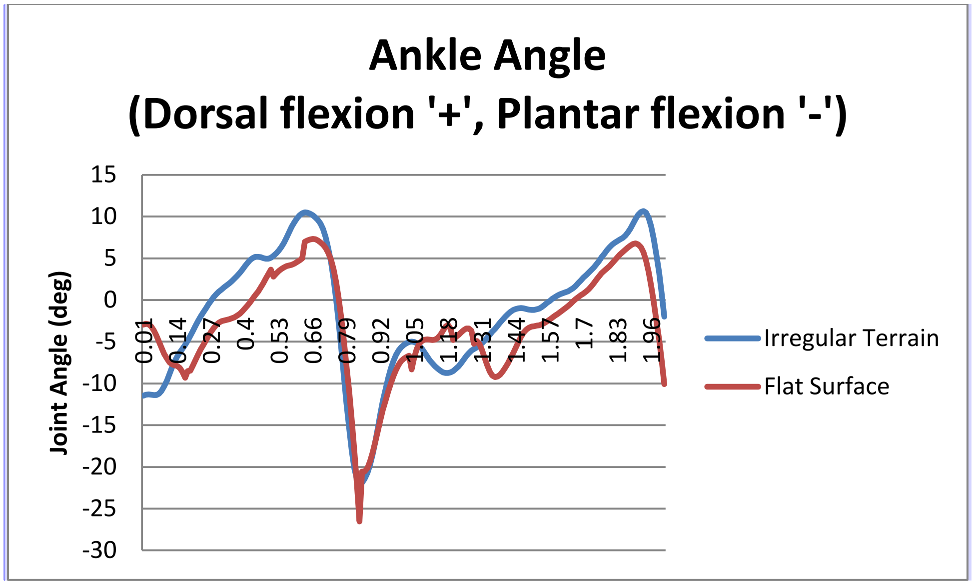

Figure 1. Ankle Angle from Initial Contact to Toe Off of Second Gait Cycle (as observed in one subject)

[O1]**Reference:**

1) Mirelman, A., et al. (2011). "Virtual reality for gait training: can it induce motor learning to enhance complex walking and reduce fall risk in patients with Parkinson's disease?" J Gerontol A Biol Sci Med Sci **66**(2): 234-240.

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