Simple Tools to Measure Locomotor Stability and Maneuverability

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1. Motivation

A primary goal of gait rehabilitation following neurologic injury is to regain walking function that enables reintegration into society. Essential to becoming a community ambulator is the development of gait patterns that satisfy both stability and maneuverability demands. However, current rehabilitation programs are likely suboptimal because clinical tools that easily and precisely assess these two abilities do not exist. Quantifying stability and maneuverability is essential for appropriately tailoring interventions to challenge individuals' abilities, monitoring patient progress, and assessing the efficacy of various modalities. In addition, because there are interactions between gait stability and maneuverability, metabolic cost, speed and fall risk, developing measures that provide immediate feedback about these relationships will allow clinicians to make better informed decisions regarding treatment. Therefore, our aim is to develop simple clinical tools that can accurately and rapidly assess locomotor stability and maneuverability.

2. State of the Art

Current measures of gait stability fall into two categories. At one extreme are measures that are subjective but easy to use in clinical settings such as the Berg Balance Scale and Dynamic Gait Index. At the other extreme are measures which are quantitative but difficult to implement in clinical settings including techniques utilizing Lyapunov exponents and Floquet multipliers[1]. Quantitative and clinically implementable measures of stability and maneuverability need to be developed. Adding to the challenge of developing useful clinical measures is the lack of consensus defining gait stability and maneuverability. New tools for measuring gait stability and maneuverability should be quantitative, accessible in clinical settings and able to provide real-time feedback during walking.

3. Own Approach

We define stability as the ability to maintain a target trajectory during walking and maneuverability as the ability to make intended transitions from one trajectory to another. As individuals walk along a target path, we quantitatively assess stability based on positional error. Maneuverability is assessed based on the time required to transition from one target path to another. To measure these variables we are developing a tool to meet the following requirements:

- Provide a safe environment in which to test the limits of gait stability and maneuverability.
- Create challenging environments to probe gait stability and maneuverability.
- Create modifiable target walking paths to assess performance on goal directed stability and maneuverability tasks.

4. Current Results

We have developed the following tool to meet our requirements:

- An oversize treadmill with a walking surface of 1.4x2.6 m and overhead support system that allows fore-aft and lateral movements creating a safe environment to test stability and maneuverability.
- A real-time robotic interface that can transmit laterally directed forces to subjects during walking. This high bandwidth, back drivable system[2] can challenge and probe gait stability by creating spring-like, impulsive, or error augmenting forces.
- A motion capture system linked to a visual display allows for precise tracking of body dynamics during goal directed walking.

5. Best Possible Outcome

Ultimately, it is our hope that a simple version of this device becomes standard in clinical settings, allowing for quick and accurate assessment of gait stability and maneuverability. We anticipate that this device will improve rehabilitation outcomes by creating challenging walking environments that safely match the unique capabilities of every subject.

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References

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