Real-time feedback modalities for training neuromuscular coordination during walking and standing following stroke

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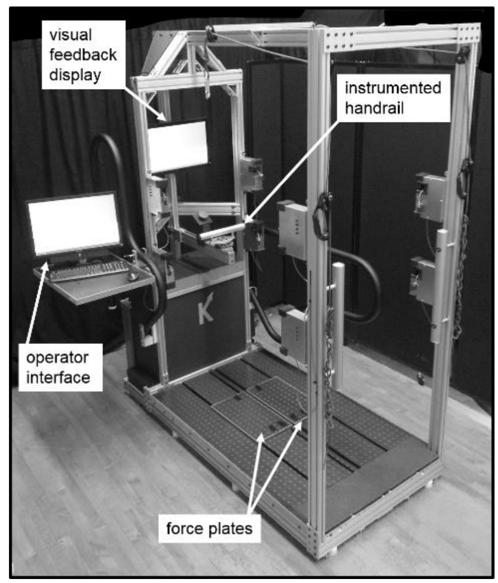
Summary

Rehabilitation of standing and walking should be approached from understanding of the underlying mechanisms of impairment. The complexity of walking and disease, however, has resulted in therapy designed without sufficient theoretical platform. Many walking interventions exhibit limited effectiveness, particularly following stroke (Pennycott, et al. 2012). In order to develop and deliver more effective strategies, we have designed and constructed a robotic walking environment that is able to assess patient-specific underlying muscular coordination deficits and guide therapy accordingly with a variety of possible feedback modalities.

It is widely accepted that feedback can enhance motor learning, but determining the appropriate feedback for relearning walking and standing balance is a challenging task. This aim of this work is bridging knowledge of motor control and behavior, learning, and the mechanics of walking to establish effective use of feedback in rehabilitation on our device.

Device Design

The patient walks or stands with a robotically-controlled 6-axis force plate beneath each foot. (see figure) The force of the ground on the feet (*F*) reflects the coordination of leg muscles, so it can be used to assess patient deficit and generate various forms of feedback to guide correct behavior. The environment also provides a safety harness, an instrumented hand rail, and an instrumented lateral stabilization harness such that patient dependence on these support structures can be quantified and used to guide therapy. Visual feedback on a screen in front of the patient, as well as tactile feedback in the form of anterior-posterior foot plate motion can provide real-time feedback on a number of kinematic or kinetic variables. For example, the foot plates can be controlled to move in a walking pattern only when the user exerts appropriate force direction on them (motion incentivized).



Application to Stroke

Initial studies on the device have focused on chronic stroke patients. This population has shown a systematic lower-limb muscle coordination deficit characterized as anteriorly-biased *F* direction (Rogers, et al. 2004), which is mechanically consistent with their impaired behaviors observed during walking (Boehm & Gruben, 2014).

Nine stroke participants able stand at least 5 minutes and walk 10 meters with or without aid were included in a pilot standing and walking study on the device. While standing, participants were given real-time visual representations of *F* magnitude, center of pressure, and/or direction along and were able to alter their coordination to achieve various targets. Participants were also able to shift weight between limbs with visual cuing in order to walk in a motion-incentivized mode. Some users were able to achieve a *F* direction target in the motion-incentivized mode.

While this work demonstrates initial feasibility of our approach and the ability of stroke patients to alter their disrupted coordination, further study is needed to determine appropriate targeting, challenge level, and whether such training will translate to improved over-ground walking ability.

References

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