Research Report

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TITLE: Soft Wearable Robots Can Increase Walking Speed and Distance after Stroke: Proof-of-Concept

Purpose/Hypothesis : Rigid exoskeletons are the state of the art in wearable robotics[1]. These remarkable machines have enabled individuals who are unable to walk, to walk again. However, for those that retain the ability to walk following neurological injury, such as the majority poststroke, rigid systems may not be necessary to restore more normal walking behavior[2]. Our group thus developed soft wearable robots (exosuits) made from garment-like, functional textiles. As previously described[3], forces generated by actuators are transmitted to the wearer's paretic ankle during walking via the interaction of cable-based transmissions and the exosuit's functional textiles. In preliminary, treadmill-based studies, we demonstrated that exosuits actively assist the paretic limb during walking in a manner able to improve ground clearance, increase propulsion symmetry, and, ultimately, reduce the high energy cost of walking after stroke[4]. Nonetheless, the utility of exosuits in overground contexts has yet to be demonstrated. The present study evaluates the effects of a portable exosuit prototype on the overground walking function of persons poststroke.

Number of Subjects : Four subjects >6 mo poststroke.

Materials/Methods : Participants completed 2 days of testing. On day 1, participants' baseline walking was evaluated. The 10-meter walk test (10mWT) measured short-distance maximum walking speed and the 6-minute walk test (6MWT) measured long-distance walking function. Following baseline testing, participants donned the exosuit and its actuator and were provided up to 12 minutes of exposure to walking with the exosuit delivering assistive forces (i.e., active). To enable evaluation overground, an untethered, waist-mounted actuator pack was used. Importantly, formal training on how to walk with the exosuit was not provided. On day 2, which took place between 1 and 2 weeks later, participants completed the 10mWT and 6MWT with the exosuit active. Changes in walking performance between the baseline and active testing conditions were measured as median±SIQR and compared to the known clinically meaningful differences of 0.14 m/s and 34.4 m for the 10mWT and 6MWT, respectively[5]. Changes in walking speed per minute of the 6MWT were also evaluated.

Results : When walking with the exosuit active, participants walked 0.16±0.05 m/s faster during the 10mWT and 41±17 m farther during the 6MWT (Ps < 0.05)—changes larger than the established clinically important differences. The 41 m average gain in walking distance observed over the duration of the 6MWT was driven by an average gain of 0.12±0.01 m/s per minute of the test.

Conclusions : Exosuits offer a new opportunity for overground gait assistance for individuals who may not benefit from existing assistive devices.

Clinical Relevance : The exosuit technology has the potential to enable physical therapists to target the specific biomechanical deficits contributing to walking-related disability after stroke both in the clinic and directly in free-living settings.

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