Improvements in Gait after Utilization of a Robotic Exoskeleton with Dynamic Ankle Function Post Stroke

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INTRODUCTION

- Improving functional ambulation is critical in chronic stroke where improved mobility could significantly impact participation and quality of life. Individuals with hemiplegia due to stroke commonly present with gait deficits including weakness or lack of motor control of ankle dorsiflexors and increased spasticity or tone of the plantarflexors.
- In the chronic phase of rehabilitation, ankle dysfunction and persistent lower limb deficits are frequently addressed with an ankle foot orthosis (AFO) to compensate for inefficient or weak gait mechanics, to reduce falls and improve walking speed.
- Robotic exoskeleton advancements allow more targeted rehabilitation at the distal limb with a powered dynamic ankle.

CASE DESCRIPTION

The participant is a community-dwelling 64-year-old right-handed female (height 1.67M and weight 78 kgs) presenting with left sided hemiplegia seven years post ischemic stroke. The participant ambulates with a single-point cane and a conventional AFO with significant gait deviations secondary to severe plantarflexor spasticity.

METHODS

Objective

- The purpose of this study is to implement a robotic-assisted walking program using a novel robotic exoskeleton (RE) device with a powered dynamic ankle and examine the effects on 1) functional ambulation (gait speed and cadence), 2) loading (linearity and center of pressure excursion); and 3) temporal spatial outcomes.

Outcome Measures

- Gait speed (10 meter walk test).
- Plantar loading (PedarX System, Novel Electronics, Inc).
- Temporal spatial variables (Zeno™ Walkway System (Protokinetics).
- Outcomes were collected at baseline and 4 wks post intervention (after 12 sessions) overground without any assistive device.

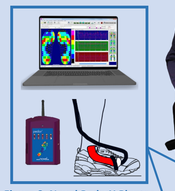
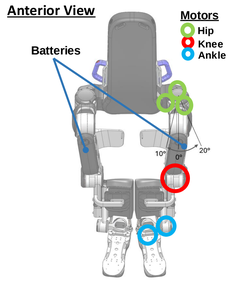
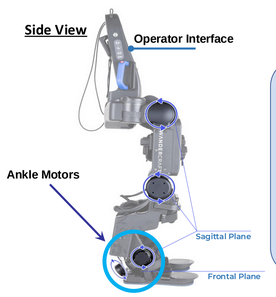


Figure 2. Novel PedarX Plantar Pressure Measurement System

Figure 1. Plantar Pressure Data Collection

- The **ankle** includes **two motors** that provide **dorsiflexion** and **plantarflexion** as well as **eversion** and **inversion** assistance **during walking** and balancing tasks.





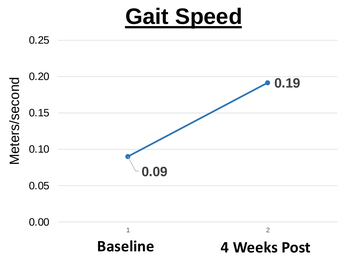
Design Features:
- 12 degrees of freedom
- Trunk has shoulder straps
- Sensor on the back for movement initiation.
- Smart technology software tracks kinematics, step usage, and treatment progression.
- Self Balancing
- Hands Free (no assistive device)
- Requires an overhead harness

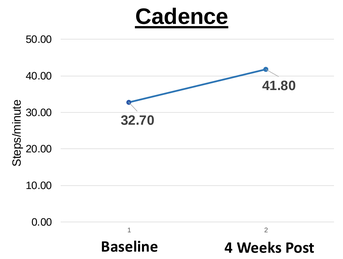
Figure 2. AtalanteX, Wandercraft SAS, Paris, France

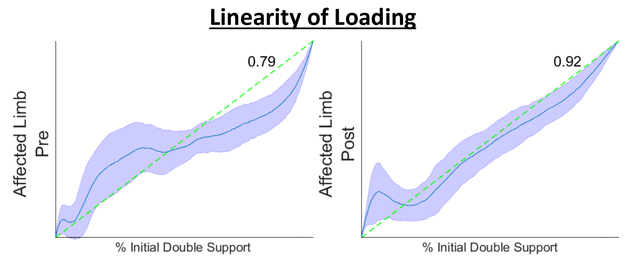
Intervention

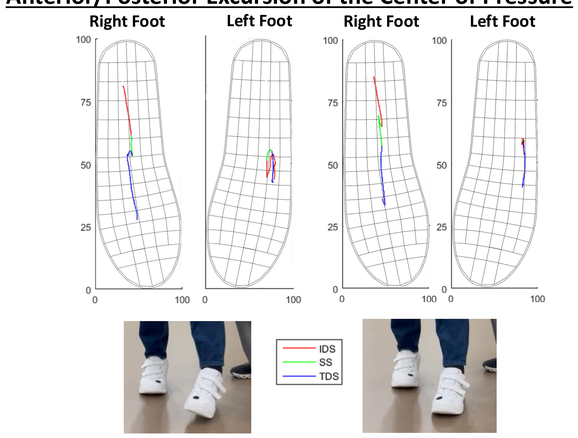
- A 4-week robotic exoskeleton gait training program (12 sessions) was implemented by a licensed physical therapist using a commercially available robotic exoskeleton **(Figure 2)** with a powered dynamic ankle (Atalante X, Wandercraft SAS).
- Training sessions included:
  - 20 minutes of forward walking with progressive adjustment of assistance to increase volitional effort (Borg)
  - Four minutes of lateral sidestepping (two minutes in each direction)
  - Two minutes of backwards stepping
  - Lateral reaching x10 in each direction
  - Squats x10

RESULTS



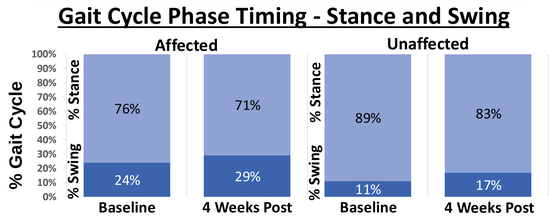


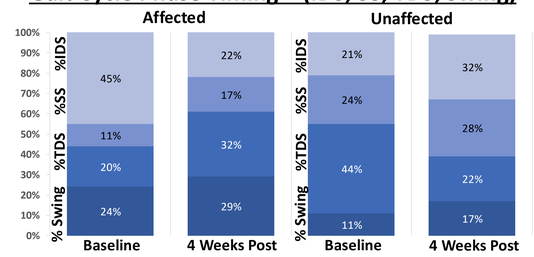




10 Meter Walk:
- Gait speed increased from 0.09 m/s to 0.19 m/s.
- Cadence increased 27.8% from 32.7 to 41.8 steps/minute.

Plantar Loading and Center of Pressure Outcomes
- Increased linearity of loading 4wks post training
  - 0.79 to 0.92
- Improved weight transfer point
- Increased A/P displacement on the affected side.
  - 43% increase in A/P excursion
  - Improved forward progression during TDS





DISCUSSION

- After 4 weeks of robotic-walking training the participant demonstrated improved functional ambulation (gait speed and cadence) and improved weight transfer mechanics on the affected side. Affected limb loading was more linear indicating improved or preserved propulsion mechanics which could have contributed to the improved walking speed after gait 4 weeks of robotic assisted walking with a powered ankle.
- Gait cycle phase timing improved from baseline to 4 weeks post intervention on the affected limb during stance (from 76% to 71%). The largest improvement was demonstrated during stance on the affected side where single support increased and initial double support decreased demonstrating a more efficient weight transfer post intervention. After 4 weeks of robotic training gait cycle timing was more symmetrical but the participant still spent more % time in stance on the unaffected limb.
- Quantifying the CoP in individuals post stroke is a key factor for understanding forward progression and changes in stability. After robotic-walking training with a powered ankle there was increased loading of the plantar surface during stance (A/P CoP excursion) and a transition to a more posterior (towards the heel) initial contact pattern.

CONCLUSIONS & FUTURE WORK

- This case study demonstrated the potential for a robotic exoskeleton with a powered ankle to impact chronic stroke impairment and ankle dysfunction, more research is needed to evaluate the long-term effects of the intervention on a larger scale.

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