

D2: 3D pediatric robotic gait training improves locomotor function in children with CP

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Background

- CP is the most prevalent physical disability originating in childhood with an incidence of 2-3 per 1,000 live births.
- 90% of children with CP have difficulty walking.
- Two major walking functional problems: reduced walking speed and endurance.
- An important goal for CP children: attaining functional walking ability.

(Rosen & Dickinson, 1992; Pharoah et al. 1998; Duffy et al. 1996)

BWSTT in children with CP

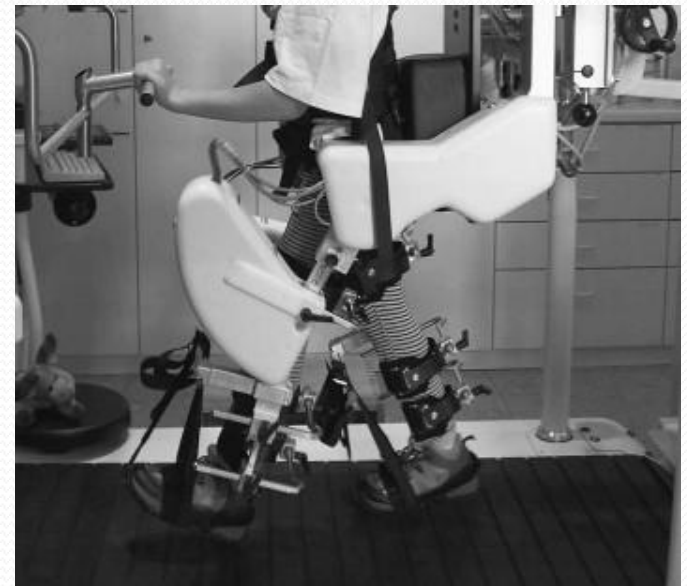
- BWSTT has been used to improve locomotor function in children with CP.
- While significant improvements in walking capacity with BWSTT have been shown, the functional gains are relatively small (0.07 m/s gains in walking speed).
- Requires greater involvement of the physical therapist.



(Willoughby et al. 2009; Dodd and Foley 2007; Schindl et al. 2000)

Robot-assisted BWSTT

- Effective in reducing therapist labor during locomotor training and increasing the total duration of training
- Relatively limited functional gains for some children with CP (0.12 ± 0.17 m/s gait speed improvement).



(Meyer-Heim et al. 2009)

Limitations of the robotic BWSTT

- Limited DOF of the Lokomat only allows movement in the sagittal plane, which may severely affect gait dynamics.
- A fixed trajectory control strategy and low backdrivable actuators may encourage a passive instead of active training.
- Current biofeedback systems seem less effective for motivating children with CP during robotic BWSTT.
- Expensive
- **Need to develop cost-effective robotic systems to improve locomotor function in children with CP.**

(Veneman et al. 2008; Borggraefe et al. 2010)

Project goals

Develop and test a novel 3D robotic gait training system

- Applies controlled forces in both the sagittal and frontal planes
- Allows a natural 3D stepping during treadmill training

Specific Aims:

Development of 3D robotic gait training system that applies controlled forces to both the sagittal and frontal planes during treadmill training

- a. Develop 3D cable driven robotic gait training system that applies synchronized forces to both the pelvis and legs during treadmill training
- b. Develop child-friendly biofeedback system to improve active involvement of children with CP during training sessions

Improve locomotor function in children with CP through 3D robotic BWSTT

- a. Test improvements of locomotor function in children with CP through 3D robotic gait training that applies controlled forces to both pelvis and legs
- b. Compare training effect of the 3D robotic BWSTT vs. BWSTT alone

3D robotic gait training system

- works in conjunction with a body-weight support system and motorized treadmill
- Applies controlled loads to the pelvis (in the frontal plane) and legs (in the sagittal plane)

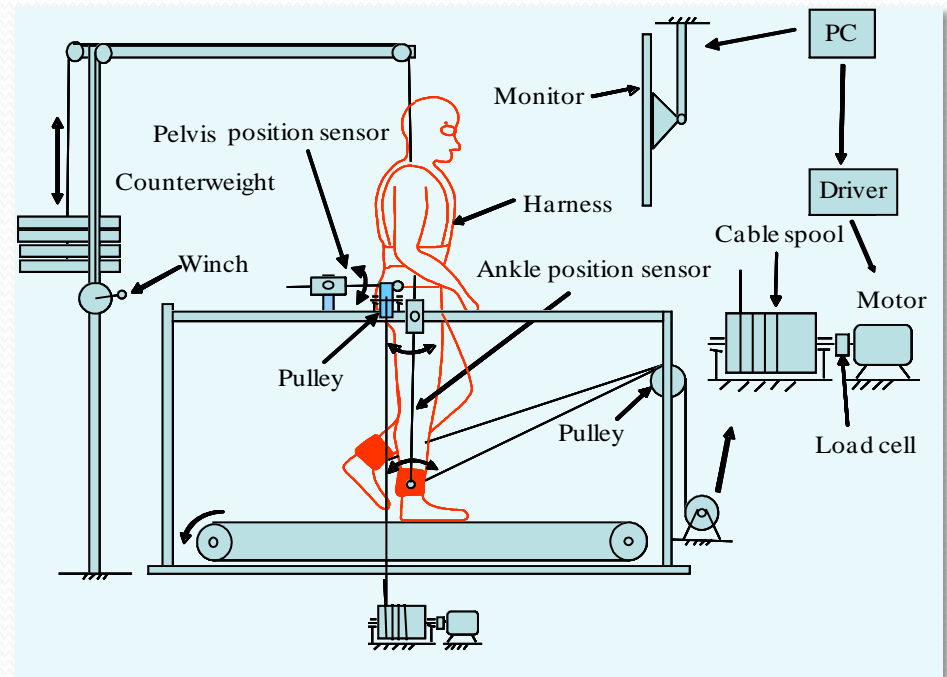


Illustration of the 3D cable driven apparatus with body weight support system

3D cable-driven robot



Task and Time Line:

Activity	YR1	YR2	YR3	YR4	YR5
Specific Aim 1					
a. Manufacture of the 3D robotic system	■				
b. Development of control software		■			
c. Development of biofeedback program		■			
d. Data analysis and publication		■			
Specific Aim 2					
a. Subject recruitment			■	■	■
b. 3D robotic treadmill training			■	■	■
c. Data analysis and publication				■	■

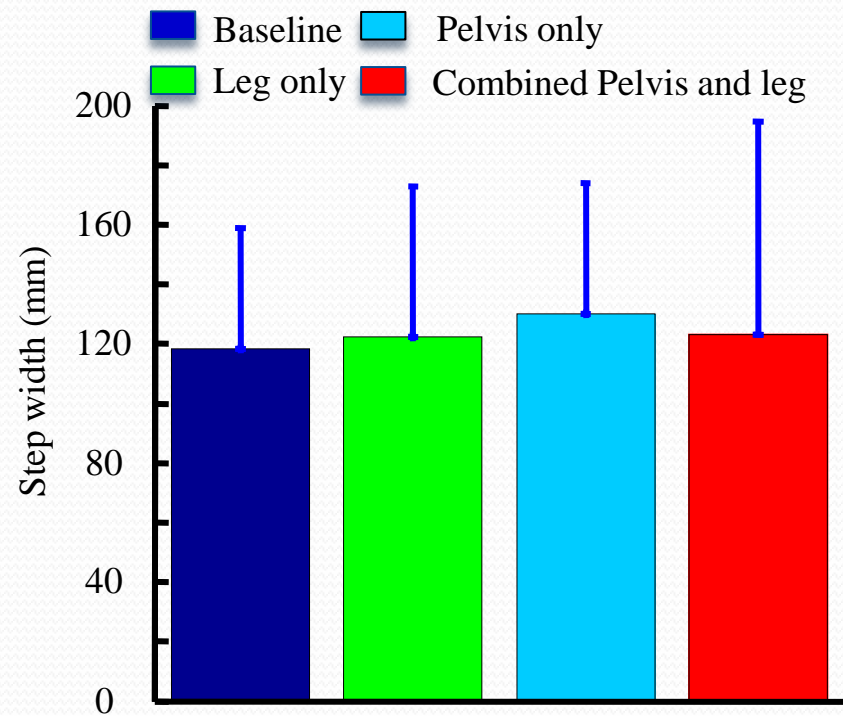
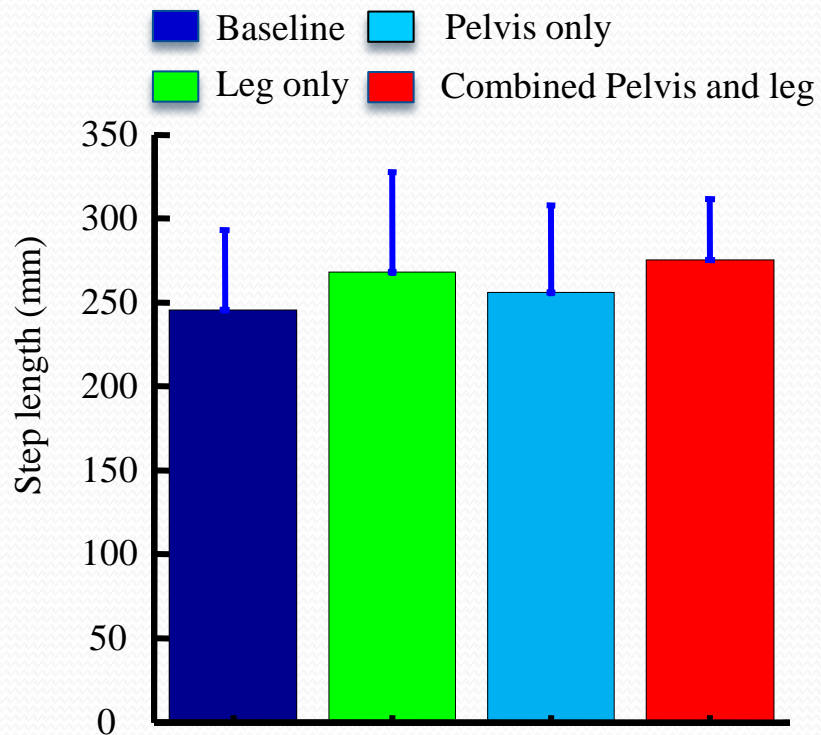
Progress

- IRB has been approved.
- Added two motors and cable-spools at the side of the treadmill to provide controlled forces to the pelvis.
- Conducted a feasibility test in three children with CP.

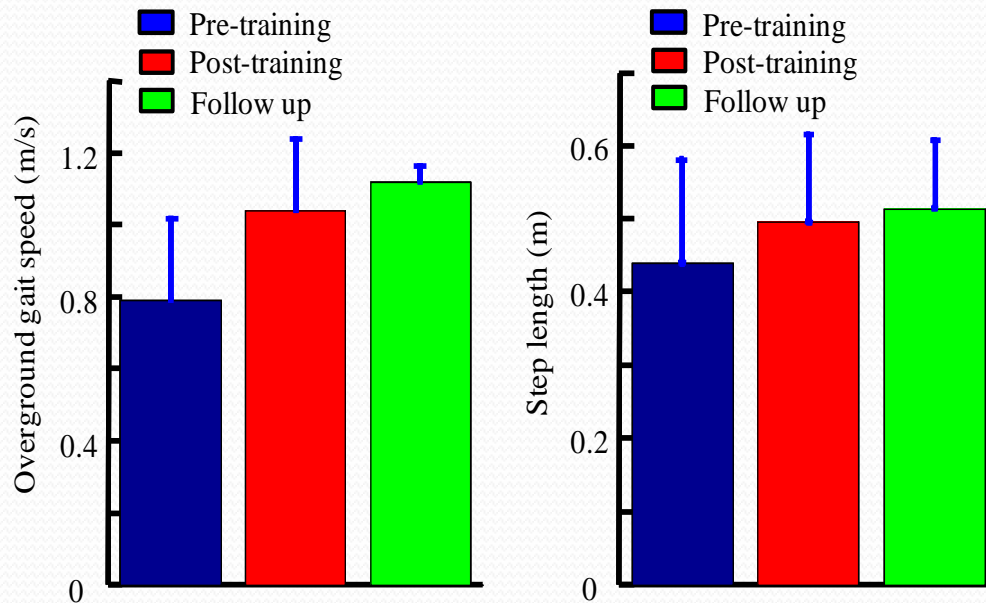
Preliminary results

- Three children with CP (two boys and one girl), average age: 11 ± 3 years old
- GMFCS levels are I to II
- Protocol:
- Hypothesis: Combined pelvis and leg assistance improves stepping in children with CP
- Four test conditions: (1) Baseline, (2) leg assistance only, (3) pelvis assistance only, and (4) combined pelvis and leg assistance
- Outcome measures: (1) leg kinematics, (2) muscle activity

Results



Preliminary training results



2 children with CP, GMFCS level II
2 weeks resistance load treadmill training
2 and 6 months follow up



Plans for year 2

- Development of control algorithm for pelvis force control.

$$F_r = k_p x_c + k_d \dot{x}_c$$

- Development of biofeedback system. One of the options is to integrate the wii game to the system
- Feasibility test in children with CP

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Questions?