Tech4POD
TECHNOLOGIES FOR PEDIATRIC ORTHOPAEDIC DISABILITIES
Marquette University Rehabilitation Engineering Research Center

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 waking 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)

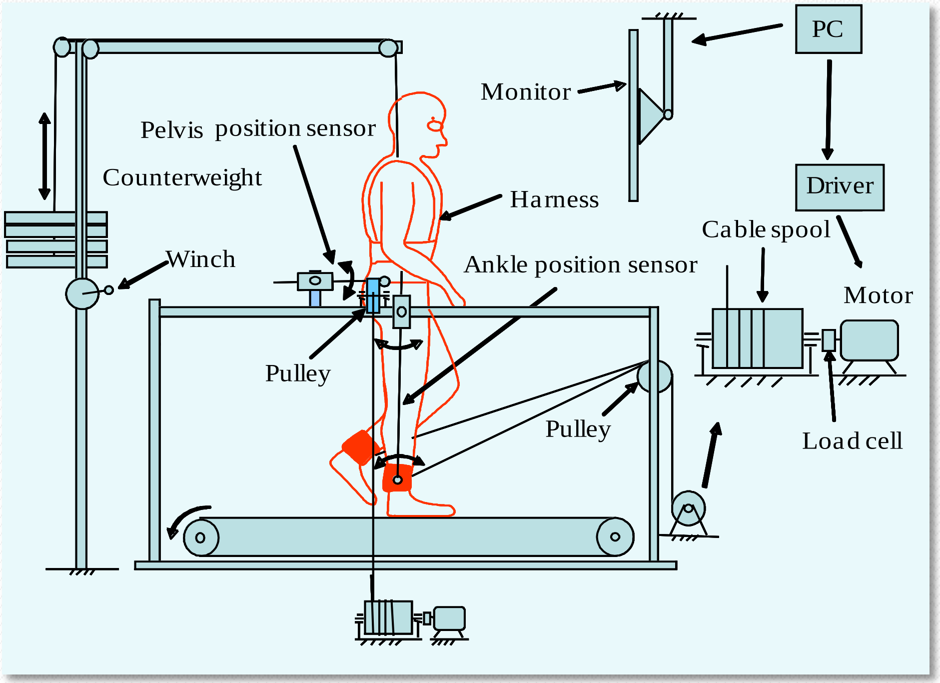


Illustration of the 3D cable driven apparatus with body weight support system

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

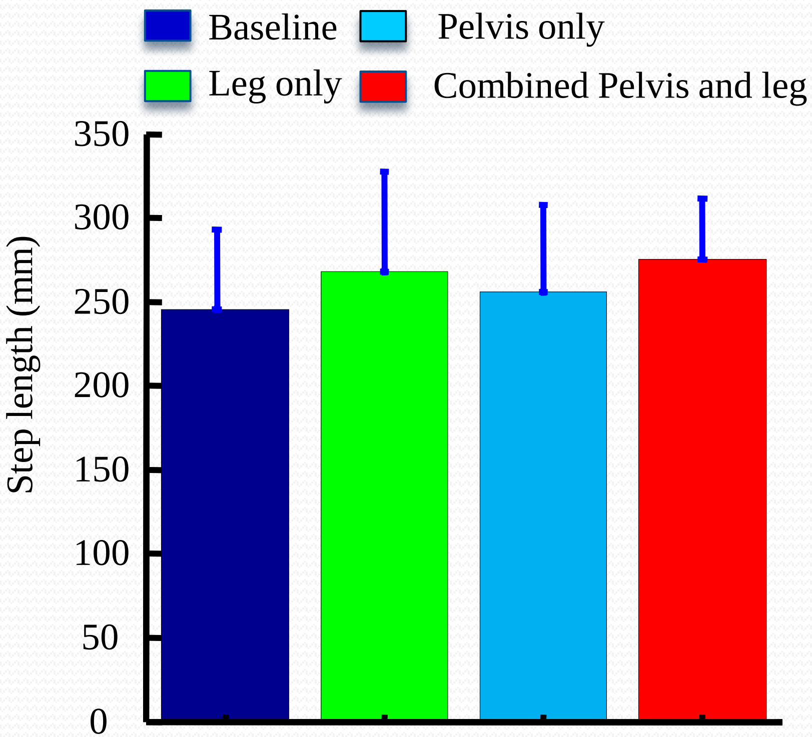
- IRB has been approved.
- Added two motors and cable-spools at the side of the treadmill to provide controlled forces to the pelvis.
- Conducted a feasibility test in three children with CP.

Preliminary results

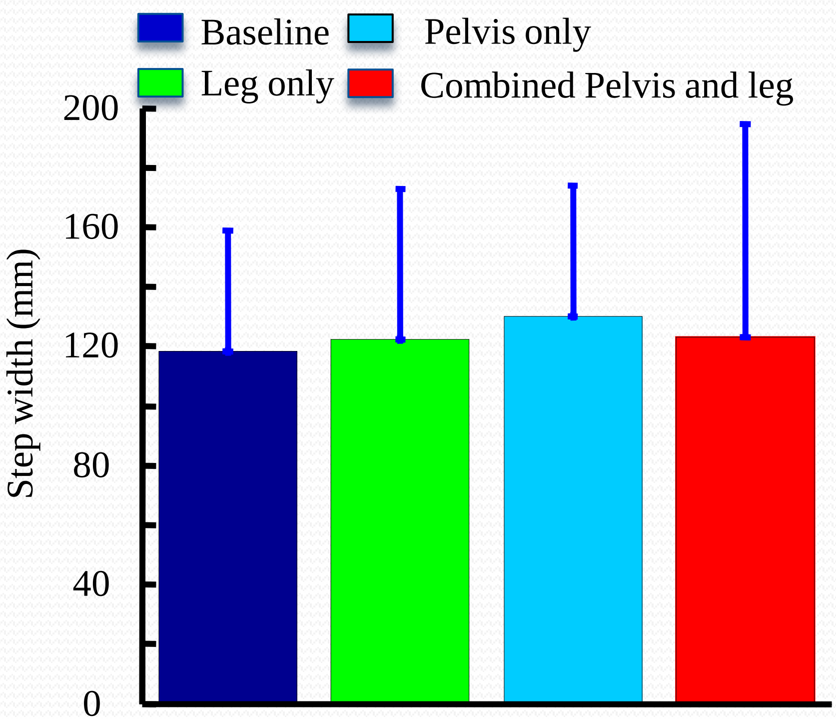
- Three children with CP (two boys and one girl), average age: 11±3 years old
- GMFCS levels are I to II

- 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

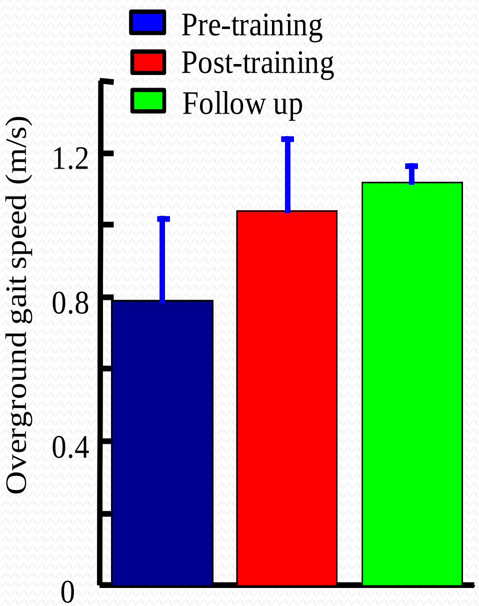


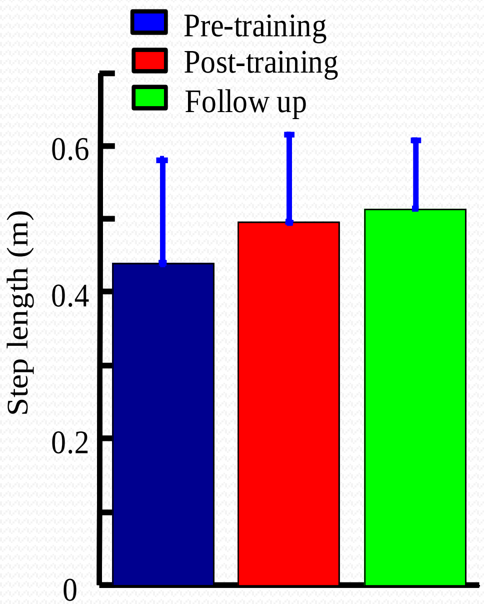
Baseline
Pelvis only
Leg only
Combined Pelvis and leg
Step length (mm)
350
300
250
200
150
100
50
0



Baseline
Pelvis only
Leg only
Combined Pelvis and leg
Step width (mm)
200
160
120
80
40
0

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

Team members:

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Questions?