Patient-Adaptive Robotic Balance Training for Lower-Extremity Stroke Rehabilitation

Ellory Oleen, Biomedical Engineering
Mentor: Dr. Hyunglae Lee, Associate Professor
School for Engineering of Matter, Transport and Energy

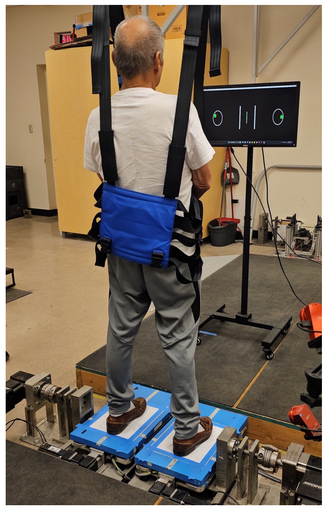
INTRODUCTION

Stroke
- Motor impairments cause balance difficulty
- Hinders independence & quality of life

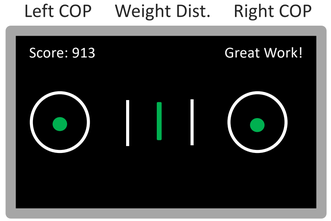
Robot-Aided Rehabilitation
- Automates some of physical therapists' work
- Greater control of training environment
- More easily measured/quantified

Hypothesis: Perturbation-based robotic training on compliant surfaces will lead to improvements in functional & dynamic postural balance for chronic stroke patients.

EXPERIMENTAL SETUP



Left COP Weight Dist. Right COP



2 stroke patients (age: 63, 61 yrs) balanced on a twin dual-axis robotic platform using visual feedback of center of pressure (COP) & weight distribution.

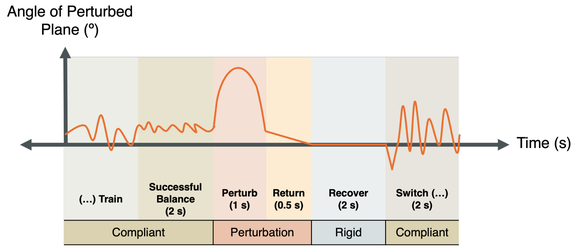
6-week study:
- 12 sessions total + 3-Mo Follow Up
- Clinical assessments (functional balance)
- Training sessions (dynamic balance)

Week 1	Pre - Assess	Practice
Week 2	Training 1	Training 2
Week 3	Training 3	Training 4
Week 4	Training 5	Training 6
Week 5	Training 7	Training 8
Week 6	Training 9	Post - Assess

TRAINING SESSIONS

Perturbations

- Platforms perturbed after balance was obtained
- Dynamic balance assessed by Time to Perturb (TTP) & Time to Stabilize (TTS)



Angle of the perturbed plane during a single cycle in a training block. The non-perturbed plane remained compliant throughout the entire cycle.

Performance-Adaptive Stiffness

Platform stiffness (PS) depended on percent success (%S) in previous block

⇧ %S
⇩ PS
⇧ Difficulty

Linear relationship:

(1) $$PS_{new} = -12 \cdot \%S_{current} + PS_{max}$$

$\boldsymbol{PS_{max}}$: maximum PS (1500 Nm/rad)
$\%\boldsymbol{S_{current}}$: %S of most recent block
$\boldsymbol{PS_{new}}$: temporary PS value

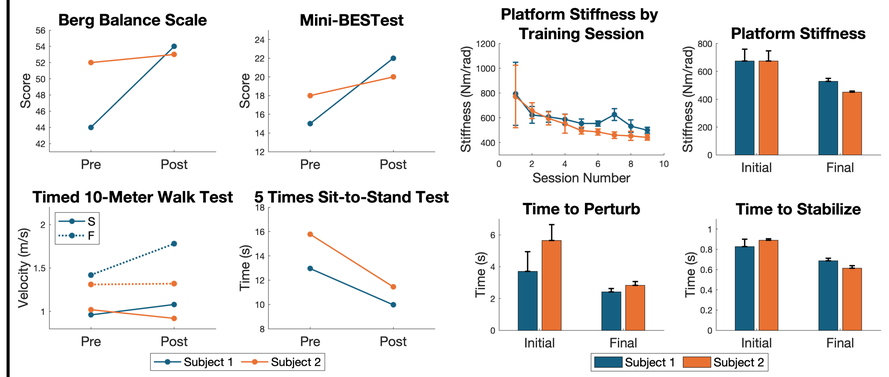
Adaptive bisection method:

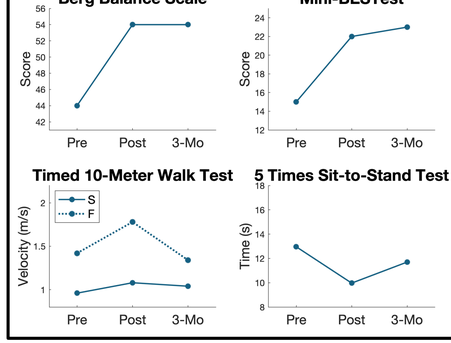
(2) $$PS_{next} = (1 - 0.5^{w}) \cdot PS_{new} + 0.5^{w} \cdot PS_{current}$$

$\boldsymbol{PS_{current}}$: PS of most recent block
$\boldsymbol{w}$: # consecutive prior blocks with ↑ or ↓ %S
$\boldsymbol{PS_{next}}$: PS for next block

RESULTS

⇧ Performance: ⇧ BBS, MBT, 10MWT ⇩ 5XSTS, PS, TTP, TTS





Clinical Assessments:
- Both improved BBS, MBT, 5XSTS, & 10MWT-F
- Subj. 1 improved 10MWT-S

Training Sessions:
- Both improved TTP, TTS, & PS

3-Month Follow Up:
- Subj. 1 retained improvements in BBS, MBT, 10MWT-S, & 5XSTS

CONCLUSIONS

Perturbation-based robotic training on compliant surfaces yielded improvements in **functional & dynamic balance** for chronic stroke patients.
- Increased ability to stabilize in challenging environments (TTP)
- Increased ability to recovery quickly from external perturbations (TTS)

Future Directions:
- ↑ sample size
- Non-uniform perturbations

FURI

Ira A. Fulton Schools of Engineering
Arizona State University