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

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**INTRODUCTION**

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

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

**EXPERIMENTAL SETUP**

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)

Left COP  Weight Dist.  Right COP

**TRAINING SESSIONS**

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

**Performance-Adaptive Stiffness**

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

Linear relationship:

\[ PS_{\text{new}} = -12 \cdot \%S_{\text{current}} + PS_{\text{max}} \]

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

Adaptive bisection method:

\[ PS_{\text{next}} = \left( 1 - 0.5^w \right) \cdot PS_{\text{current}} + 0.5^w \cdot PS_{\text{next}} \]

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

**RESULTS**

- Performance: BBS, MBT, 10MWT
- 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