Movement Amplification to Improve Gait Stability in Spinal Cord Injury: A Case Study

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Background and Purpose

- Individuals with chronic incomplete spinal cord injury (iSCI) have a high rate of injury due to a variety of causes, including falls.¹,²
- The current case study challenged gait stability using a robotic device that amplified lateral velocity of the center of mass during treadmill walking to increase the difficulty of maintaining straight walking.
- The rationale is that movement amplification may improve gait stability by increasing feedback from errors and encouraging exploration of new motor strategies to correct those errors.

Case Description and Methods

- One 61-year-old male with a cervical incomplete American Spinal Injury Association Impairment Scale (AIS) D SCI.

Clinical Outcome Measures

1. Walking Index for SCI II
2. Lower Extremity Motor Scores
3. Functional Gait Assessment (FGA)
4. 10-Meter Walk Test (10-MWT)
5. Reactive Balance – Mini-BESTest
6. Activities-Specific Balance Scale (ABC)

Lab Outcome Measures

1. Step Length Average
2. Step Length Variability
3. Step Width Average
4. Step Width Variability
5. Lateral Margin of Stability Average
6. Lateral Margin of Stability Variability
7. Lane Width

- Eighteen 45-minute training sessions occurred over 3 months.
- The Agility Trainer was used in all sessions to amplify lateral movement.

Training tasks to increase difficulty:

- Increased movement amplification
- Increased speed
- Lateral stepping
- Image identification to promote forward gaze
- Obstacle negotiation

Parameters recorded each session:

- Peak heart rate
- Rate of perceived exertion (RPE)
- Minutes walked
- Peak treadmill speed

Outcomes

Table 1. Pre- and post-training clinical outcome measures.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre Training</th>
<th>Post Training</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC Scale</td>
<td>54.38%</td>
<td>70.00%</td>
<td>15.62%</td>
</tr>
<tr>
<td>FGA Scale</td>
<td>16/30</td>
<td>18/30</td>
<td>2</td>
</tr>
<tr>
<td>Mini-BEST - Reactive</td>
<td>1/6</td>
<td>2/6</td>
<td>1**</td>
</tr>
<tr>
<td>10-MWT</td>
<td>0.857</td>
<td>0.890</td>
<td>0.033</td>
</tr>
<tr>
<td>Fast Speed (m/s)</td>
<td>0.970</td>
<td>1.150</td>
<td>0.180</td>
</tr>
</tbody>
</table>

Table 2. Pre- and post-training laboratory outcome measures.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre Training - Preferred Speed¹</th>
<th>Post Training - Matched Speed¹</th>
<th>Post Training - New Preferred Speed¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step Length - Average</td>
<td>0.252</td>
<td>0.215</td>
<td>0.328</td>
</tr>
<tr>
<td>Step Length - Variability</td>
<td>0.045</td>
<td>0.036</td>
<td>0.026</td>
</tr>
<tr>
<td>Step Width - Average</td>
<td>0.032</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>Step Width - Variability</td>
<td>0.014</td>
<td>0.009</td>
<td>0.008</td>
</tr>
<tr>
<td>Margin of Stability - Average</td>
<td>0.060</td>
<td>0.067</td>
<td>0.073</td>
</tr>
<tr>
<td>Margin of Stability - Variability</td>
<td>0.040</td>
<td>0.012</td>
<td>0.021</td>
</tr>
<tr>
<td>Lane Width</td>
<td>0.176</td>
<td>0.178</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Discussion

Movement amplification challenged ambulation and has potential as an intervention to improve gait stability. Improvements include:

1. Balance
   - ABC and FGA scores improved
   - Maximum gait speed improved
   - Initiated reactive step post training on Mini-BESTest

2. Walking Endurance
   - Improved total minutes walked

3. Center of Mass Control
   - Increased lateral MOS
   - Decreased MOS variability
   - Narrower lane (smaller excursion of COM)

4. Quality of Life (Self-Report)
   - Urogenital function
   - Coordination and control of UE function

Conclusion: Changes in clinical outcomes and laboratory measures suggest that improved gait stability and control of COM was achieved through both active and passive strategies.

References


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