P-64

Effectiveness of Gait Rehabilitation Using a Wearable Robot in Patients with Incomplete Spinal Cord Injury: A Case Study

Onyoo Kim[1], Yoone Kang[1], Sunghwan Hwang[2], Byeongjoo Shin[2], Suji Choi[3]

Dept. of Spinal Cord Injury Rehabilitation, National Rehabilitation Center[1], Dept. of Neurological Rehabilitation, National Rehabilitation Center[2], Dept. of Physical and Occupational Therapy, National Rehabilitation Center[3],

Backgrounds

Paralysis and sensory abnormalities resulting from incomplete spinal cord injury (SCI) often lead to gait impairments, with patients experiencing mobility limitations due to partial or complete paraplegia. Recently, wearable exoskeleton robots have gained attention as a promising rehabilitation tool for patients with incomplete SCI. Robotic gait therapy enhances walking ability, and advances in technology have expanded the methods available for robotic rehabilitation training.

This study evaluates the effectiveness of X-ble MEX, a wearable exoskeleton robot, in gait rehabilitation for patients with incomplete SCI. The study examines changes in gait function, balance, physiological parameters, and psychological well-being. X-ble MEX utilizes a position-control mechanism to ensure high-precision movement execution based on pre-set positions.

Methods

The intervention consisted of **20 sessions** conducted five times per week over 4 weeks, with each session lasting 60 min. Assessments were performed at three time points: **pre-test (before training), mid-test (after 10 sessions), and post-test (after 20 sessions)**.

Evaluation tools included: (1) Gait function – 6-Minute Walk Test (6MWT), 10-Meter Walk Test (10mWT), Timed Up and Go Test (TUG), and Walking Index for Spinal Cord Injury (WISCI); (2) Balance ability – Trunk Impairment Scale (TIS) and Berg Balance Scale (BBS); (3) Muscle strength and mobility – range of motion (ROM), Modified Ashworth Scale (MAS), and Manual Muscle Test (MMT), (4) Energy consumption – heart rate (HR) and maximum oxygen uptake (VO_2max); and (5) Psychological assessment – Beck Depression Inventory (BDI).

Results

The effectiveness of X-ble MEX was demonstrated through the following table.

1) **Gait Function**

- **6MWT**: Increased walking distance from 152.2 m (pre-test) to 247.8 m (post-test).
- **10mWT**: Walking speed improved, reducing the time from 21.79 s (pre) to 13.88 s (post).
- **TUG**: Reduced completion time from 32.86 s (pre) to 18.13 s (post).

2) **Balance**

- **TIS**: Improved from 21 points (pre/mid) to 22 points (post).
- **BBS**: Improved from 36 points (pre) to 43 points (mid), and 44 points (post).

3) **Energy Consumption**

- **6MWT VO_2max**: Decreased from 15.42 (pre) to 14.64 (mid), then increased to 19.07 (post).
- **10mWT VO_2max**: Decreased from 10.58 (pre) to 10.15 (mid), then increased to 12.35 (post).
- **6MWT HRavg**: 89.69 (pre) → 88.5 (mid) → 98.37 (post).
- **10mWT HRavg**: 90.83 (pre) → 86.88 (mid) → 93.4 (post).

4) **Psychological Impact**

- **BDI**: Significantly improved from 21 points (pre) to 3 points (mid), maintaining this level post-intervention.

No significant changes were observed in WISCI, ROM, MMT, or MAS before and after the intervention.

Table 1. Intervention Results

	Pre-test	Mid-test	Post-test
6MWT (m)	152.2	162	247.8
10mWT (s)	21.79	18.03	13.88
TUG (s)	32.86	27.6	18.13
TIS	21	21	22
BBS	36	43	44
6MWT_VO2max	15.42	14.64	19.07
10mWT_VO2max	10.58	10.15	12.35
6MWT_HRavg	89.69	88.5	98.37
10mWT_HRavg	90.83	86.88	93.4
BDI	21	3	3

6MWT, 6-Minute Walk Test; 10mWT, 10-Meter Walk Test; TUG, Timed Up and Go Test; TIS, Trunk Impairment Scale; BBS, Berg Balance Scale; HRavg, average heart rate; VO_2max, maximum oxygen uptake; BDI, Beck Depression Inventory

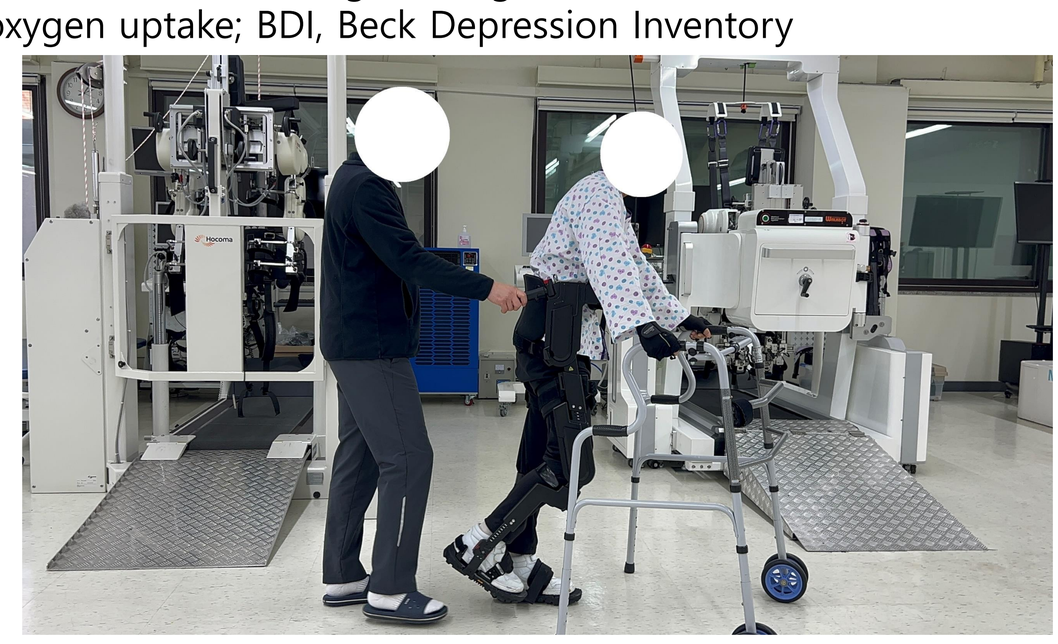

Figure 1. Participants with X-ble Mex

Conclusion

Despite the increasing use of overground gait rehabilitation robots, research on their effects on walking ability and psychological well-being remains limited. This study examines the impact of X-ble MEX, a newly developed wearable robot, on patients with incomplete SCI by assessing changes in their gait function, balance, energy metabolism, and psychological state following a structured rehabilitation program.

The 20-session rehabilitation program using X-ble MEX improved gait function, balance, and energy metabolism while significantly reducing depressive symptoms in the patient. These findings suggest that overground exoskeleton robots can have a positive impact on both gait function and psychological well-being in patients with incomplete SCI. Based on these results, wearable robots can be considered an effective rehabilitation intervention for gait rehabilitation in patients with incomplete SCI.