Identifying Key Impairments and Targeted Rehabilitation using Clinical Gait Analysis in Patients with Partial Spinal Cord Injury

Gupta M[1], Garg B[1], Malhotra R[1,2], Pal M[3,4], Chawla A[5], Mukherjee S[5], Mukherjee K[5]
[1]Department of Orthopedics, All India Institute of Medical Sciences, New Delhi, India.
[2]Department of Orthopedics, Indraprastha Apollo Hospital, New Delhi, India
[3]Defense Institute of Physiology & Allied Science, Defence Research & Development Organisation
[4]Center of Excellence, Footwear Design & Development Institute, Noida, India
[5]Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, India.
Email: manishgupta1307@gmail.com

Summary This study aims to analyze gait impairments in patients with partial spinal cord injury (SCI) using clinical gait analysis, focusing on spatiotemporal, kinematic, and electromyographic (EMG) parameters. Ten partial SCI patients were assessed six weeks post-surgery and ten healthy controls using full-body marker protocols and EMG for key muscle groups. The results showed significant reductions in gait speed (73%) and cadence (44%) in SCI patients, with decreased step and stride lengths. Kinematic analysis revealed increased trunk and pelvis tilt, indicating compensatory movements for balance. Ankle plantarflexion and knee flexion ranges were also restricted, highlighting impaired propulsion and foot clearance. EMG data indicated reduced muscle activation in key muscles like the erector spinae and tibialis anterior, affecting stability and gait efficiency. The findings suggest that partial SCI patients experience significant gait deviations, emphasizing the need for targeted rehabilitation focusing on muscle strength, joint mobility, and postural stability to improve functional outcomes.

Introduction Spinal cord injury (SCI) is a life-changing event that profoundly affects an individual's motor, sensory, and autonomic functions, often leading to severe impairments in gait and mobility [1]. While complete SCI has been extensively studied, there is a significant gap in research focusing on partial SCI, where some neurological function remains. Partial SCI patients often experience deficits in balance, coordination, speed, and efficiency during walking, which impacts their independence, psychological well-being, and overall quality of life [2]. To better understand these gait impairments and develop effective rehabilitation strategies, 3D gait analysis provides valuable insights into spatiotemporal, kinematic, and electromyographic (EMG) variables.

Methods This prospective study involved ten patients with partial SCI and ten age- and gender-matched healthy controls, recruited from the outpatient department of the All India Institute of Medical Sciences (AIIMS), New Delhi, India. The study was approved by the AIIMS ethics committee (Ref. No IEC-855/03.12.2021). The SCI patients had undergone surgical instrumentation for SCI management, and gait analysis with full body marker protocol (Fig: 1) was conducted six weeks postoperatively (SMART DX-7000, BTS Bioengineering, Milan, Italy). EMG data was captured for key muscle groups, including the erector spinae, quadriceps, hamstrings, and tibialis anterior.

Figure 1: SCI Patient image of reflective marker and EMG placement according to Full Body marker protocol.

Results and Discussion Our study found significant differences between SCI patients and healthy controls across various gait parameters. SCI patients demonstrated a marked reduction in gait speed (73%) and cadence (44%) ($p < 0.001$), with step length and stride length significantly decreased. Specifically, the right step length decreased by 54% and the left by 38% ($p < 0.01$). Kinematic analysis revealed increased trunk and pelvis tilt ranges, indicating compensatory movements to maintain balance. Ankle plantarflexion range was reduced to 7^0 (compared to 14^0 in controls, $p < 0.01$), and knee flexion range was restricted (48^0 vs. 62^0, $p < 0.05$), suggesting impaired propulsion and reduced clearance during the gait cycle. EMG results revealed reduced muscle activation, particularly in the erector spinae and tibialis anterior, impairing stability and foot clearance during gait.

Conclusions Our study emphasizes the value of clinical gait analysis in understanding gait dysfunction in partial SCI patients. Rehabilitation strategies that address muscle strength, joint flexibility, and postural stability could significantly improve gait efficiency and overall functional outcomes for these individuals.

Acknowledgments The authors are thankful to DIA-COE, IIT Delhi and DRDO (Grant no. DFTM/03/3203/P/37/JATC-BRAIN-CIAMI-05/011/D[R&D]) for financial support.

References

[1] Wyndaele, M et al, *Spinal Cord*, 2006, **44**(9), 529.
[2] Maggio MG et al, *Brain Sci*. 2024 Jan 28;**14**(2)