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# PRINCIPLES OF OPTIMIZING TREATMENT FOR PATIENTS WITH VERTEBROGENIC NEUROLOGICAL DISORDERS

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**Abstract:** Thoraco-lumbar spinal cord injuries (SCI) at the Th10-L2 level are characterized by severe motor, sensory, and pelvic dysfunctions. Traditional rehabilitation often yields suboptimal results in functional independence.

**Objective:** To develop and validate a personalized rehabilitation program integrating transcutaneous spinal cord stimulation (tSCS), robotic exoskeleton therapy, and structured medico-social support.

**Methods:** A prospective study included 250 patients (aged 18–68) with thoraco-lumbar SCI. The intervention group (n=113) received a personalized protocol (tSCS + exoskeleton), while the control group (n=137) followed standard rehabilitation. Assessment tools included SCIM III, FIM, Barthel Index, and neurophysiological monitoring (EMG, SSEP, TMS).

**Results:** After 6 months, the intervention group showed significantly higher functional independence (SCIM III: $68.4 \pm 5.2$ vs $52.1 \pm 6.4$, $p < 0.001$). Correlation analysis revealed a strong link between tSCS intensity and locomotor recovery ($r = 0.72$).

**Conclusion:** The multimodal personalized approach significantly enhances the rehabilitation potential and quality of life for SCI patients.

**Keywords:** Spinal cord injury, neurorehabilitation, transcutaneous spinal cord stimulation, exoskeleton, neuroplasticity.

## 1. Introduction

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Thoraco-lumbar spinal cord injuries (SCI) remain a major cause of permanent disability. According to the WHO (2021), the global incidence of SCI exceeds 250,000 cases annually. The Th11-L2 level is particularly complex due to the transition between the spinal cord and the cauda equina. Recent advances in neuromodulation, specifically transcutaneous spinal cord stimulation (tSCS), have shown promise in activating central pattern generators (Sayenko et al., 2019). However, the practical integration of these technologies into a staged medico-social model remains unresolved.

## 2. Materials and Methods

**Ethical Considerations:** The study was approved by the Institutional Ethics Committee. All participants provided written informed consent.

**Participants:** 250 patients with SCI at the Th10-L2 level.

- **Intervention Group (n=113):** High-tech rehabilitation (tSCS + exoskeleton).
- **Control Group (n=137):** Conventional medical and physical therapy.

**Assessments:** 1. **Clinical:** SCIM III, Barthel Index, FIM.

2. **Neurophysiological:** Electromyography (EMG), Somatosensory Evoked Potentials (SSEP), and Transcranial Magnetic Stimulation (TMS).

3. **Psychosocial:** HADS (Anxiety/Depression) and SF-36 (Quality of Life).

## 3. Results

The intervention group demonstrated a statistically significant acceleration in motor recovery.

**Table 1: Functional and Neurophysiological Dynamics (6 Months Follow-up)**

| Parameter | Intervention Group (n=113) | Control Group (n=137) | p-value |
|---|---|---|---|
| **SCIM III Total Score** | $68.4 \pm 5.2$ | $52.1 \pm 6.4$ | $< 0.001$ |
| **Barthel Index** | $75.2 \pm 4.8$ | $60.5 \pm 5.9$ | $< 0.01$ |
| **FIM (Motor)** | $58.9 \pm 3.7$ | $44.2 \pm 4.1$ | $< 0.001$ |

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| Parameter | Intervention Group (n=113) | Control Group (n=137) | p-value |
|---|---|---|---|
| **SSEP P30 Latency (ms)** | $31.2 \pm 1.4$ | $36.8 \pm 2.1$ | $< 0.05$ |
| **SF-36 Physical Component** | $62.1 \pm 6.1$ | $48.3 \pm 5.5$ | $< 0.01$ |

Analysis of neurophysiological data showed that tSCS combined with verticalization in an exoskeleton improved spinal conductivity and reduced muscle spasticity more effectively than isolated physical therapy.

Figure 1: Comparison of Functional Outcomes at 6 Months Post-Injury

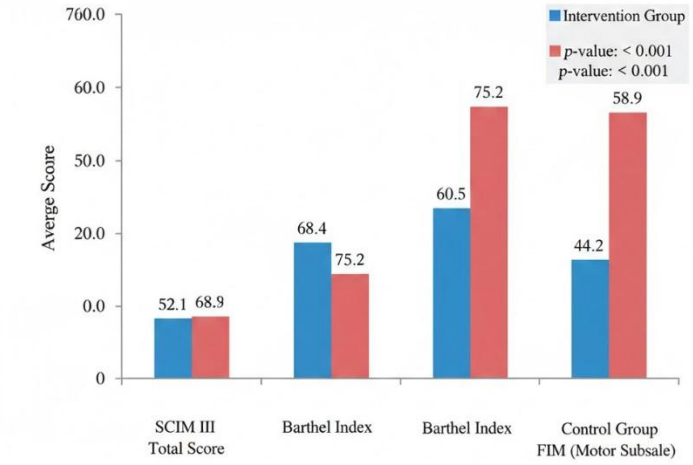



Figure 1: Comparison of Functional Outcome at 6 Months Post-Injury

## 4. Discussion

Our study confirms that tSCS acts as a powerful neuro-orthosis, facilitating activity-dependent plasticity. The synergistic effect of robotic mobilization and electrical stimulation allows for earlier verticalization and improved cardiovascular tolerance. Moreover, the structured social support model ensured higher patient compliance and better psychological adaptation, as evidenced by a 30% reduction in HADS depression scores in the intervention group.

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## 5. Conclusion

Optimization of rehabilitation for thoraco-lumbar SCI through personalized neurostimulation and exoskeleton technology provides a clinically proven advantage. This model allows for higher functional autonomy and successful social reintegration of patients.

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