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Multimodal Physiotherapy for Functional Recovery and Pain Reduction in L1 Spinal Cord Injury: A Case Report

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Abstract

Background: Spinal cord injury (SCI) leads to motor, sensory, and autonomic dysfunction, resulting in long-term disability. Multimodal physiotherapy is a key component of rehabilitation; however, evidence on long-term outcomes in complete SCI at the L1 level remains limited**.**

Objective: To describe the longitudinal clinical outcomes of multimodal physiotherapy in a patient with traumatic L1 SCI classified as ASIA Impairment Scale (AIS) grade A.

Methods: This study was a case report (n=1) involving a 24-year-old male with traumatic L1 SCI. The patient received multimodal physiotherapy 3–4 sessions per week for 18 months**.** The program included range of motion exercises, muscle strengthening, balance training, functional mobility training, transcutaneous electrical nerve stimulation, and infrared therapy. Outcomes were assessed using Manual Muscle Testing (MMT), Numeric Rating Scale (NRS), and Barthel Index at baseline and at 1, 3, 6, 12, and 18 months. Absolute changes were calculated descriptively.

Results: After 18 months, proximal muscle strength improved from MMT grade 1 to 4, while distal muscles improved from 0–1 to 3. Pain decreased from NRS 4 to 0–1 (−3 to −4 points), and the Barthel Index increased from 30 to 90 (+60 points). Improvements were most evident within the first 3–6 months, followed by gradual stabilization. The patient progressed from total dependence to assisted ambulation.

Conclusion: Multimodal physiotherapy over 18 months was associated with meaningful improvements in strength, pain, and functional independence. Residual limitations in balance and distal function persisted, indicating partial recovery and the need for continued rehabilitation.

Keywords
Spinal Cord Injury; Rehabilitation; Physiotherapy; Paraplegia; Activities of Daily Living

Introduction

Spinal cord injury (SCI) is a neurological condition characterized by disruption of motor, sensory, and autonomic function below the level of the lesion, resulting in substantial functional impairment and long-term disability.[1] Traumatic SCI, particularly due to vertebral fractures, remains the leading cause globally, with the thoracolumbar junction (L1) being especially vulnerable due to its biomechanical transition between the rigid thoracic and more mobile lumbar spine.[2] Such injuries frequently result in severe neurological deficits, including paraplegia, which significantly compromise independence and quality of life.[3]

Globally, SCI represents a major public health burden, with incidence rates ranging from 17 to 26 cases per million population annually.[4] Epidemiological trends indicate a higher prevalence in males and an increasing incidence with age, while younger individuals are more commonly affected by high-energy trauma such as occupational accidents and falls from height.[4] In addition to motor paralysis, SCI is often accompanied by sensory deficits and autonomic dysfunction, including neurogenic bladder and bowel, which further complicate long-term management and rehabilitation outcomes.[5]

The American Spinal Injury Association (ASIA) Impairment Scale (AIS) is widely used to classify injury severity based on motor and sensory function.[6] Patients classified as AIS grade A (complete injury) generally have a poorer prognosis, with limited potential for spontaneous neurological recovery compared with incomplete injuries. Consequently, rehabilitation plays a critical role in maximizing residual function and promoting independence in this population.[7]

Physiotherapy constitutes a cornerstone of multidisciplinary SCI rehabilitation, aiming to enhance motor recovery, prevent secondary complications, and improve functional independence.[2] Common interventions include range of motion exercises, progressive strengthening, balance training, and functional mobility training, often combined with neuromodulatory modalities such as transcutaneous electrical nerve stimulation.[8] These interventions are designed to facilitate neuroplasticity, optimize motor unit recruitment, and improve functional performance through repetitive task-specific training.[9]

Despite the growing body of literature, most evidence on SCI rehabilitation is derived from cohort studies and systematic reviews, which primarily report aggregated outcomes and may not capture individual variability in long-term recovery trajectories.[10] In particular, there is limited detailed documentation of prolonged, multimodal physiotherapy outcomes in patients with complete SCI at the L1 level, especially in real-world clinical settings**.** Furthermore, existing studies often emphasize short- to medium-term outcomes, leaving a gap in understanding the effects of sustained rehabilitation beyond the subacute phase.[11]

This gap underscores the need for detailed case-based evidence that can provide insight into longitudinal clinical progression, individualized response to therapy, and practical rehabilitation challenges in severe SCI. Case reports, although representing a lower level of evidence, offer valuable clinical context that complements findings from larger studies by illustrating real-world application and long-term adaptation processes.

Therefore, this case report aims to describe the longitudinal clinical outcomes of a patient with traumatic L1 spinal cord injury classified as AIS grade A who underwent 18 months of multimodal physiotherapy. The study specifically focuses on changes in muscle strength, pain intensity, and functional independence, thereby addressing the current gap in long-term, individualized rehabilitation evidence for severe SCI.

Methods

This study was designed as a single-patient case report and prepared in accordance with the CARE (CAse REport) guidelines to ensure comprehensive and transparent clinical reporting. The study followed a longitudinal observational approach over an 18-month rehabilitation period to capture functional progression in detail.

The subject was a 24-year-old male diagnosed with traumatic SCI at the L1 level, initially classified as American Spinal Injury Association (ASIA) Impairment Scale (AIS) grade A (complete injury). The injury occurred following a fall from approximately 10 meters. Radiological evaluation using computed tomography revealed an L1 vertebral fracture with posterior retropulsion of bone fragments causing spinal canal stenosis. The patient subsequently underwent surgical stabilization and was referred for physiotherapy rehabilitation.

This case was selected due to its clinical uniqueness, namely a complete SCI (AIS A) with extended follow-up duration and documented progressive functional recovery, which remains underreported in the literature. The patient was hemodynamically stable, cognitively intact, and able to participate actively in the rehabilitation program. No major comorbidities were reported. Anthropometric data such as body mass index were not available and are acknowledged as a limitation.

Outcome measures were selected based on their clinical relevance and established measurement properties. Muscle strength was assessed using Manual Muscle Testing (MMT) with a grading scale from 0 to 5, where 0 indicates no contraction and 5 indicates normal muscle strength against full resistance**.** Pain intensity was measured using the Numeric Rating Scale (NRS), ranging from 0 (no pain) to 10 (worst imaginable pain)**.** Functional independence was evaluated using the Barthel Index, with scores ranging from 0 to 100, where higher scores indicate greater independence in activities of daily living**.** These instruments have demonstrated acceptable validity and reliability in neurological rehabilitation settings.

Assessments were conducted at baseline (pre-intervention) and at follow-up intervals of 1, 3, 6, 12, and 18 months. To ensure consistency, all evaluations were performed by trained physiotherapy personnel using standardized procedures. Although minimal clinically important differences (MCID) were not formally calculated, outcome changes were interpreted descriptively in relation to clinically meaningful improvements reported in previous studies.

The physiotherapy intervention was delivered 3–4 sessions per week over 18 months and was individualized according to the patient's functional status and recovery stage. The intervention program included range of motion exercises to prevent contractures, progressive muscle strengthening (from isometric to resistive exercises), balance training (sitting and standing), and functional mobility training including bed mobility, transfers, and gait training using assistive devices.

Exercise dosage was structured with 8–12 repetitions per set and 2–3 sets for strengthening exercises, while functional training sessions lasted approximately 15–30 minutes. Progression was guided by objective clinical indicators, including the ability to perform movements against gravity, increased resistance tolerance, and improved postural control. However**,** precise quantification of exercise intensity (e.g., percentage of one-repetition maximum) was not available and represents a limitation in reproducibility.

Adjunct modalities included transcutaneous electrical nerve stimulation (TENS) for pain management and infrared therapy to enhance circulation and muscle relaxation. All interventions were administered by licensed physiotherapists with experience in neurological rehabilitation. Treatment progression was reviewed periodically and adjusted based on reassessment findings to ensure safety and individualized progression. As presented in Figure 2, the clinical and rehabilitation timeline describes the progression of patient management following traumatic spinal injury, including emergency care, surgical intervention, and long-term physiotherapy rehabilitation leading to functional improvement.

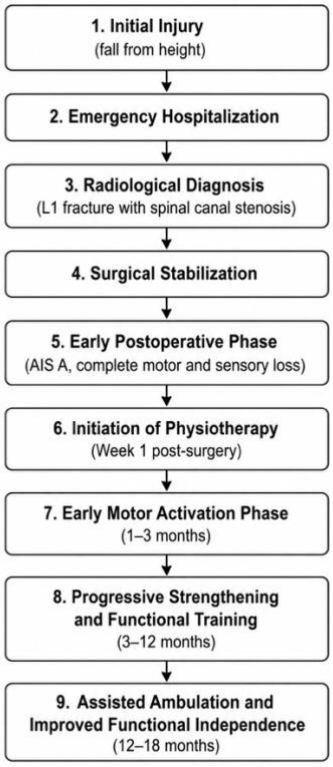

Figure 1. Clinical and Rehabilitation Timeline Following L1 Spinal Fracture with Spinal Canal Stenosis

Data were analyzed descriptively to illustrate longitudinal changes in clinical outcomes. Absolute changes between baseline and final follow-up were calculated for all outcome measures, and trends across time points were examined qualitatively. No inferential statistical analysis was performed due to the single-subject design. Written informed consent was obtained from the patient for participation and publication of anonymized clinical data. Ethical committee approval was not required for this case report according to institutional policy.

Results

This section presents the longitudinal clinical outcomes of a patient with traumatic L1 spinal cord injury (AIS A) following 18 months of multimodal physiotherapy. The findings are reported descriptively in accordance with CARE guidelines, focusing on objective changes in muscle strength, pain intensity, and functional independence without interpretative statements.

At baseline, the patient was a 24-year-old male presenting with complete motor and sensory loss below the level of injury (AIS A). The patient was fully dependent in activities of daily living and required assistance for all mobility tasks. Initial muscle strength assessment using Manual Muscle Testing (MMT) showed minimal voluntary contraction in the lower extremities, with grades ranging from 0–1 at the ankle and 1 at the hip and knee. Pain intensity was reported as 4/10 on the Numeric Rating Scale (NRS), indicating moderate pain. Functional assessment using the Barthel Index yielded a score of 30, reflecting severe dependency.

To provide an overview of the patient's general physiological status at baseline, vital signs and cardiopulmonary parameters were assessed and are presented in Table 1. All parameters were within normal limits, indicating that the patient was clinically stable to undergo rehabilitation.

Table 1. Baseline Vital Signs and Cardiopulmonary Status

Parameter	Result	Interpretation
Blood Pressure	120/80 mmHg	Within normal limits
Heart Rate	80 beats/min	Within normal limits
Respiratory Rate	20 breaths/min	Within normal limits
Body Temperature	Afebrile	Normal
Breathing Pattern	Normal	No abnormalities

Longitudinal changes in clinical outcomes were evaluated at baseline and at 1, 3, 6, 12, and 18 months. The results are summarized in Table 2 to illustrate trends in muscle strength, pain intensity, and functional independence. MMT scores are reported using a 0–5 ordinal scale, NRS using a 0–10 scale, and Barthel Index using a 0–100 scale.

Table 2. Longitudinal Changes in Clinical Outcomes Over 18 Months

Parameter	Baseline	1 Month	3 Months	6 Months	12 Months	18 Months
MMT Hip (0–5)	1	2	3	3	4	4
MMT Knee (0–5)	1	2	3	3	4	4
MMT Ankle (0–5)	0–1	1	2	2	3	3
Pain (NRS 0–10)	4	3	3	2	1	0–1
Barthel Index (0–100)	30	40	55	65	80	90

The data in Table 2 demonstrate progressive changes across all outcome measures over time. No variability measures (e.g., standard deviation) are presented due to the single-subject design. To further quantify the magnitude of clinical improvement over the rehabilitation period, absolute changes between baseline and the final follow-up at 18 months are summarized in Table 3. This table presents the net differences in muscle strength, pain intensity, and functional independence, providing a concise overview of overall changes.

Table 3. Absolute Changes in Clinical Outcomes (Baseline vs 18 Months)

Parameter	Baseline	18 Months	Absolute Change
MMT Hip (0–5)	1	4	+3
MMT Knee (0–5)	1	4	+3
MMT Ankle (0–5)	0–1	3	+2 to +3
Pain (NRS 0–10)	4	0–1	−3 to −4
Barthel Index (0–100)	30	90	+60

In addition to quantitative outcomes, functional progression was documented throughout the rehabilitation period. At baseline, the patient was unable to sit or stand independently and required full assistance. Subsequent assessments showed gradual changes in postural control, sitting ability, standing with assistance, and eventual ambulation using a walking aid.

Figure 1 illustrates the sequential rehabilitation progression of the patient from the baseline condition to the final rehabilitation phase. The flowchart demonstrates the gradual improvement in motor function and functional independence achieved through structured physiotherapy intervention. Initially, the patient presented with complete dependence and absence of voluntary movement. During the early rehabilitation phase, minimal muscle contraction and assisted sitting ability began to emerge. Continued physiotherapy intervention contributed to improvements in proximal muscle strength and initiation of assisted standing during the intermediate phase. In the advanced rehabilitation phase, the patient progressed to assisted gait training with improved balance control. At the final stage, the patient achieved independent sitting ability, assisted ambulation, and greater independence in daily activities. This figure highlights the progressive clinical recovery pattern observed throughout the rehabilitation program.

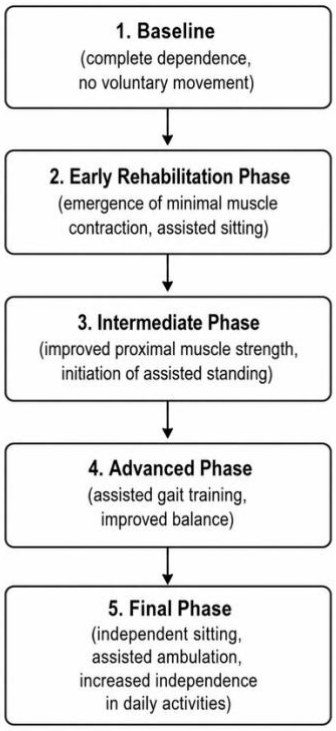

Figure 2. Rehabilitation Progression Timeline Following Severe Neurological Impairment

No adverse events related to physiotherapy interventions were reported during the 18-month follow-up period. Patient adherence to the rehabilitation program was consistent throughout the study.

Discussion

This case report describes the longitudinal clinical course of a patient with traumatic L1 spinal cord injury (SCI) initially classified as AIS grade A who underwent 18 months of multimodal physiotherapy. The findings demonstrate progressive improvements in muscle strength, pain reduction, and functional independence. These outcomes should be interpreted cautiously within the context of a single-case design, where causal inference cannot be established but clinically relevant patterns can be observed.

One of the principal findings of this case is the gradual recovery of motor function, particularly in proximal muscle groups. Improvements in hip and knee strength were more pronounced compared to distal muscles, which is consistent with known neurophysiological recovery patterns following SCI. Motor recovery often follows a proximal-to-distal gradient due to differences in corticospinal tract organization and motor unit recruitment complexity.[12] Similar findings have been reported in cohort studies and neurorehabilitation trials, where proximal muscle groups tend to recover earlier due to relatively preserved neural pathways and lower coordination demands.[13]

When compared with findings from systematic reviews, functional improvements following structured rehabilitation programs are commonly observed, although the magnitude of recovery in complete SCI remains variable.[14] In this case, the observed motor recovery may reflect a combination of therapeutic effects and underlying biological processes, including neural adaptation and compensatory motor strategies.[15]

The observed motor improvement in a patient initially classified as AIS A requires careful interpretation. While AIS A is defined as a complete injury, some patients may demonstrate partial recovery over time due to resolution of spinal shock, neural plasticity, or initial underestimation of preserved function in the acute phase.[15] Neuroplastic mechanisms, including synaptic reorganization and recruitment of spared neural pathways, have been identified as contributors to recovery following SCI. However, the absence of serial ASIA reassessment in this case limits the ability to determine whether neurological recovery corresponded to a formal change in AIS classification (AIS conversion).[16]

Pain reduction represents another important clinical outcome. The decrease in Numeric Rating Scale (NRS) scores over time may be associated with multiple mechanisms, including improved circulation, reduced muscle stiffness, and neuromodulation effects from interventions such as transcutaneous electrical nerve stimulation (TENS).[17] Systematic reviews have demonstrated that neuromodulatory and rehabilitation approaches can contribute to pain reduction in SCI populations, although effect sizes vary depending on intervention intensity and patient characteristics.[18]

Functional independence, as measured by the Barthel Index, showed substantial improvement over the rehabilitation period. This aligns with evidence from rehabilitation studies indicating that task-specific training and progressive strengthening can enhance activities of daily living, even in individuals with severe neurological impairment.[19] Functional gains are often achieved through a combination of motor recovery, compensatory mechanisms, and adaptive strategies, particularly in long-term rehabilitation contexts. An important consideration in interpreting these findings is the potential contribution of natural recovery. Spontaneous neurological improvement may occur during the subacute phase of SCI, particularly within the first 3–6 months post-injury.[20] Therefore, part of the observed improvement cannot be exclusively attributed to physiotherapy interventions. However, the continued progression observed beyond this period suggests that sustained rehabilitation may play a role in maintaining and extending functional gains.

This study has several limitations inherent to the case report design. First, the absence of a control condition limits causal inference regarding the effectiveness of the intervention. Second, potential biases, including selection bias and reporting bias, cannot be excluded. Third, the lack of objective quantification of exercise intensity reduces reproducibility. Fourth, minimal clinically important differences (MCID) were not calculated, limiting the precision of clinical interpretation. Fifth, detailed baseline characteristics such as

body mass index were not available, which may affect generalizability. Finally, the absence of serial ASIA assessments prevents evaluation of neurological classification changes over time.

Despite these limitations, this case provides practical insights for clinical physiotherapy practice. Long-term, structured, and multimodal rehabilitation delivered at a frequency of 3–4 sessions per week may support gradual improvements in strength, pain, and functional independence in patients with severe SCI. Clinicians should emphasize progressive strengthening, task-specific functional training, and early initiation of rehabilitation, while recognizing that recovery may remain partial and require long-term adaptation strategies.

Future research should employ higher-level study designs, such as prospective cohort studies or randomized controlled trials, to evaluate the effectiveness of specific physiotherapy components in SCI rehabilitation. Standardization of outcome measures, including MCID and longitudinal neurological classification, is also needed to improve comparability and clinical applicability of findings.

In summary, while the findings of this case report should be interpreted within methodological limitations**,** they contribute to the understanding of long-term rehabilitation trajectories and highlight the potential role of sustained physiotherapy in supporting functional recovery in severe SCI.

Conclusion

This case report demonstrates that long-term multimodal physiotherapy over 18 months was associated with clinically meaningful improvements in muscle strength, pain reduction, and functional independence in a patient with traumatic L1 spinal cord injury initially classified as AIS grade A. The patient showed progression from complete dependence to assisted ambulation, although recovery remained partial, particularly in distal motor function and balance.

Given the single-case design, these findings represent a low level of evidence and should be interpreted with caution. However, they highlight the potential role of sustained, individualized physiotherapy in supporting functional recovery in severe SCI. Clinically, a structured program delivered 3–4 sessions per week, incorporating strengthening, balance training, and functional mobility exercises, may be considered to optimize long-term outcomes.

Future research using higher-level designs is required to confirm these findings and to establish standardized rehabilitation protocols for patients with complete SCI.

Author Contribution

Luh Dwi Erna Krismawati: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Writing original draft
Luh Kadek Asri Junita Dewi Negara: Conceptualization, Methodology, Investigation, Writing review and editing, Supervision

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

Written informed consent was obtained from the patient for participation and publication of anonymized clinical data.

References

1. Perrouin-Verbe B, Lefevre C, Kieny P, Gross R, Reiss B, Le Fort M. Spinal cord injury: A multisystem physiological impairment/dysfunction. Rev Neurol (Paris). 2021;177:594–605. doi:10.1016/j.neurol.2021.02.385
2. Baroudi M, Rezk A, Daher M, Balmaceno-Criss M, Gregoryczyk JG, Sharma Y. Management of traumatic spinal cord injury: a current concepts review of contemporary and future treatment. Injury. 2024;55:111472.
3. Jain KK. Neuroprotection in Spinal Cord Injury. In: The Handbook of Neuroprotection. Totowa, NJ: Humana Press; 2011. p. 255–80. doi:10.1007/978-1-61779-049-2_5
4. Lu Y, Shang Z, Zhang W, Pang M, Hu X, Dai Y. Global incidence and characteristics of spinal cord injury since 2000–2021: a systematic review and meta-analysis. BMC Med. 2024;22:285.
5. Kim JH, Seo JH. Rehabilitation of neurogenic bladder and bowel after spinal cord injury. Journal of the Korean Medical Association. 2020;63:603–11. doi:10.5124/jkma.2020.63.10.603
6. Burns K, Solinsky R. Autonomic impairment is not explained by neurological level of injury or motor-sensory completeness. Spinal Cord. 2024;62:367–70.
7. Dionne A, Richard-Denis A, Mac-Thiong JM. Predicting Complete versus Incomplete Long-Term Functional Independence after Acute AIS Grade D Spinal Cord Injury: A Prospective Cohort Study. Top Spinal Cord Inj Rehabil. 2024;30:50–8. doi:10.46292/sci23-00090
8. Benlidayi IC, Karaagac H. PHYSICAL MODALITIES IN GERIATRIC PHYSICAL MEDICINE AND REHABILITATION. Anti-Aging Eastern Europe. 2025;4:93–9. doi:10.56543/aaeeu.2025.4.2.03
9. Furqan Ahmed Siddiqi, Saira Jahan, Muhammad Furqan Hassan, Farooq Azam Rathore. Task-Specific Training and Neuroplasticity for Stroke Recovery: Mechanisms, Interventions, and Future Directions. J Pak Med Assoc. 2026;76:470–4. doi:10.47391/JPMA.26-24
10. McIntyre A, Sadowsky C, Behrman A, Martin R, Augutis M, Cassidy C, et al. A Systematic Review of the Scientific Literature for Rehabilitation/Habilitation Among Individuals With Pediatric-Onset Spinal Cord Injury. Top Spinal Cord Inj Rehabil. 2022;28:13–90. doi:10.46292/sci21-00046
11. Reid KF, Storer TW, Pencina KM, Valderrabano R, Latham NK, Wilson L, et al. A multimodality intervention to improve musculoskeletal health, function, metabolism, and well-being in spinal cord injury: study protocol for the FIT-SCI randomized controlled trial. BMC Musculoskelet Disord. 2022;23:493. doi:10.1186/s12891-022-05441-3
12. Eilfort AM, Rasenack M, Zörner B, Curt A, Filli L. Evidence for reticulospinal plasticity underlying motor recovery in Brown-Séquard-plus Syndrome: a case report. Front Neurol. 2024;15. doi:10.3389/fneur.2024.1335795
13. Gallacher DM, Suarez M, Jevotovsky DS, Oehlermarx W, Azad TD, Dovlatyan R. Spinal cord stimulation for pain management following spinal cord injury: a systematic review. J Pain Res. 2026;19:1–15.
14. Burns AS, Marino RJ, Kalsi-Ryan S, Middleton JW, Tetreault LA, Dettori JR, et al. Type and Timing of Rehabilitation Following Acute and Subacute Spinal Cord Injury: A Systematic Review. Global Spine J. 2017;7:175S-194S. doi:10.1177/2192568217703084

15. Mustafa MA. Neuroplasticity in Recovery after Stroke: Mechanisms and Therapeutic Targets. Journal of Physiology and Biology Sciences. 2025;1:1–11. doi:10.69792/jpbs.2025.vol.1.01
16. Wu YY, Gao YM, Feng T, Rao JS, Zhao C. Enhancing Functional Recovery After Spinal Cord Injury Through Neuroplasticity: A Comprehensive Review. Int J Mol Sci. 2025;26:6596. doi:10.3390/ijms26146596
17. Sahebari M, Tahmasbi F, Rahimi-Mamaghani A. Targeting symptoms of fibromyalgia through transcutaneous electrical nerve stimulation (TENS): a systematic review of current systematic reviews. Pain Medicine. 2026;27:350–60. doi:10.1093/pm/pnaf133
18. Noamani A, Lemay JF, Musselman KE, Rouhani H. Postural control strategy after incomplete spinal cord injury: effect of sensory inputs on trunk–leg movement coordination. J Neuroeng Rehabil. 2020;17.
19. Huerta-Mareca R, De-Rosende-Celeiro I, Ares-Senra L, Gálvez-Bermejo C, Pérez-Hernández E. Evaluation of improvement of functional independence in a multicentre cohort of rehabilitation outpatients with neurological conditions. Disabil Rehabil. 2022;44:8332–8. doi:10.1080/09638288.2021.2012840
20. Hylin MJ, Kerr AL, Holden R. Understanding the Mechanisms of Recovery and/or Compensation following Injury. Neural Plast. 2017;2017:1–12. doi:10.1155/2017/7125057