Original Article

Clinical Characteristics, Treatment Experiences, and Healthcare Accessibility in Patients with Multiple Sclerosis: A Cross-Regional Survey Analysis

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ABSTRACT

Background

Multiple sclerosis (MS) is a chronic, progressive neurological disease characterized by demyelination and neurodegeneration, leading to physical disability, cognitive decline, and reduced quality of life. Despite advances in pharmacological therapy, rehabilitation remains a key component in patient management, yet individualized optimization strategies are still underdeveloped.

Objective

This study aimed to develop and validate an evidence-based algorithm for optimizing rehabilitation programs in MS patients based on clinical, neurological, and functional characteristics to improve quality of life.

Methods

A retrospective and prospective observational study was conducted on 110 anonymized MS patients with varying disease courses and disability levels. Clinical parameters included disease type, neurological deficits, Expanded Disability Status Scale (EDSS), and treatment regimens. Patients were stratified into rehabilitation profiles, and a structured algorithm was developed integrating motor, cognitive, and functional domains.

Results

The cohort demonstrated heterogeneity in disease presentation, with EDSS scores ranging from 1.0 to 8.5. The most common clinical manifestations included spastic tetraparesis, cerebellar ataxia, pelvic dysfunction, and cognitive impairment. Implementation of the algorithm resulted in improved functional outcomes, particularly in mobility, cognitive engagement, and independence in daily activities.

Conclusion

The proposed algorithm provides a structured, individualized approach to MS rehabilitation, aligning clinical characteristics with targeted interventions. This model supports improved quality of life and may serve as a framework for modern rehabilitation strategies.

Keywords

Multiple sclerosis; rehabilitation; EDSS; algorithm; quality of life; neurorehabilitation

INTRODUCTION

Multiple Sclerosis (MS) is a multifaceted autoimmune disease of the central nervous system, marked by inflammatory demyelination and progressive axonal injury. It primarily affects young and middle-aged individuals and remains one of the most common causes of non-traumatic neurological disability globally. The clinical course of MS is highly heterogeneous, encompassing relapsing-remitting, secondary progressive, and primary progressive forms, each characterized by distinct patterns of progression and symptom manifestation.

In addition to physical impairment, MS exerts a profound impact on cognitive abilities, emotional health, and social functioning. Patients often present with a wide spectrum of symptoms, including motor dysfunction (e.g., spasticity and muscle weakness), cerebellar impairment, sensory abnormalities, visual disturbances, and neuropsychological deficits. Collectively, these manifestations significantly diminish quality of life and increase levels of functional dependence [1].

Although the introduction of disease-modifying therapies—such as monoclonal antibodies and immunomodulatory agents (including ocrelizumab, natalizumab, and interferons)—

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has substantially improved disease management, these treatments do not fully resolve functional impairments. Consequently, rehabilitation remains an essential component of comprehensive MS care.

Despite its importance, current rehabilitation approaches are often insufficiently standardized and lack individualization. Many programs adopt generalized protocols rather than being tailored to specific disease profiles, leading to less effective outcomes. This limitation underscores the necessity for a structured, evidence-based framework that incorporates clinical data into personalized rehabilitation strategies.

Therefore, the present study aimed to develop such an algorithm based on real-world clinical evidence, with the goal of optimizing rehabilitation interventions according to disease severity, neurological status, and individual functional needs[2].

MATERIALS AND METHODS

Study Design and Population

This study was designed as a mixed retrospective–prospective observational analysis aimed at developing a practical, evidence-based algorithm for optimizing rehabilitation programs in patients with multiple sclerosis (MS) and related demyelinating spectrum disorders. The retrospective component involved the analysis of existing clinical records, while the prospective component focused on structuring the available clinical information into rehabilitation profiles that could guide individualized intervention planning. This design was selected because MS is a heterogeneous disease, and rehabilitation decisions require not only diagnostic confirmation but also careful consideration of disability level, dominant neurological syndrome, disease activity, and current treatment background[3].

The study population consisted of 110 patients diagnosed with MS or related inflammatory demyelinating disorders, including neuromyelitis optica spectrum disorder. All data were anonymized before analysis; therefore, no patient names or personally identifiable information were used in the study. Only clinically relevant variables were retained for evaluation, including age-related clinical status, disease course, neurological manifestations, EDSS score, and pharmacological therapy. This approach ensured confidentiality and allowed the analysis to focus on functional rehabilitation needs rather than individual identity[4].

Inclusion Criteria

Patients were included in the analysis if they had a confirmed diagnosis of MS or a related demyelinating spectrum disorder, including neuromyelitis optica. A further requirement was the availability of sufficiently complete clinical documentation, particularly information on neurological deficits, disease course, and current or previous pharmacological treatment. Patients were also required to have a documented Expanded Disability Status Scale (EDSS) score, as this scale was used as the main criterion for disability stratification and rehabilitation planning. Individuals receiving ongoing disease-modifying therapy, symptomatic treatment, or previously completed pharmacological treatment were eligible, since rehabilitation planning in MS is closely connected to both disease activity and therapeutic stability.

Clinical Variables

The clinical analysis focused on variables that are directly relevant to rehabilitation decision-making. First, the disease course was recorded, including relapsing-remitting, slowly progressive, primary progressive, secondary progressive, active, and inactive forms. This classification was important because patients in an active phase may require a more cautious rehabilitation load, while those in a stable or inactive phase can often tolerate more intensive functional training.

Second, the dominant neurological deficits were identified. These included spastic tetraparesis or paraparesis, cerebellar and vestibulo-ataxic syndromes, hemiparesis, visual impairment, pelvic organ dysfunction, cognitive decline, and depressive or emotional symptoms when documented. Particular attention was given to the combination of motor, cognitive, and autonomic disturbances, because these symptoms often interact and jointly determine the patient's quality of life. For example, a patient with moderate EDSS but severe ataxia and pelvic dysfunction may need a different rehabilitation program than a patient with the same EDSS score but mainly cognitive fatigue and mild paresis [5].

Disability severity was assessed using the EDSS. Although EDSS does not fully capture all dimensions of MS-related disability, it remains one of the most widely used clinical tools for estimating functional impairment, especially walking ability and neurological disability progression. Pharmacological

treatment was also recorded, including ocrelizumab, natalizumab, interferon preparations, glatiramer acetate, teriflunomide, rituximab, cladribine, and other therapies. Treatment type was not used as a direct outcome measure but was considered important for understanding disease control and rehabilitation timing.

Data Analysis and Patient Stratification

Patients were stratified into three functional disability groups according to EDSS score. The first group included patients with mild disability, defined as EDSS 1.0–3.0. These patients generally retained independent mobility but often required rehabilitation for fatigue control, balance, mild coordination problems, cognitive complaints, and prevention of further functional decline. The second group included patients with moderate disability, defined as EDSS 3.5–6.0. This group represented patients with more visible motor impairment, gait instability, spasticity, ataxia, or partial dependence in daily activities. The third group included patients with severe disability, defined as EDSS 6.5–8.5. These patients had substantial mobility limitations and required more intensive multidisciplinary support, assistive devices, caregiver education, and prevention of complications such as contractures, falls, pressure injuries, and urinary complications.

Rehabilitation needs were evaluated across three major domains: motor function, cognitive function, and autonomic/pelvic function. The motor domain included gait, balance, coordination, muscle strength, spasticity, and ability to perform activities of daily living. The cognitive domain included memory, attention, mental fatigue, and executive functioning. The autonomic and pelvic domain included urinary urgency, incontinence, retention, bowel dysfunction, and their effect on social participation and psychological well-being [6].

Algorithm Development

Based on these variables, a decision-tree rehabilitation algorithm was developed. The first step of the algorithm was to determine disease phase and activity, since active disease or relapse required lower-intensity and medically supervised rehabilitation. The second step was EDSS-based stratification, which allowed the general intensity and safety level of rehabilitation to be selected. The third step was identification of the dominant clinical syndrome, such as spasticity, ataxia, paresis, cognitive decline, or pelvic dysfunction. The fourth step was assignment of a targeted rehabilitation module.

For mild disability, the algorithm prioritized aerobic exercise, balance training, fatigue management, cognitive stimulation, and patient education. For moderate disability, it recommended individualized physiotherapy, gait correction, spasticity management, occupational therapy, balance rehabilitation, and bladder training where necessary. For severe disability, the focus shifted toward assisted mobility, prevention of secondary complications, caregiver involvement, functional independence training, and quality-of-life support.

Thus, the algorithm was developed not as a rigid protocol, but as a flexible clinical decision-making tool. Its purpose was to help clinicians match rehabilitation intensity and content to the real functional needs of each patient, while respecting disease activity, neurological complexity, and the patient's personal capacity for participation [7,8].

Ethical clearence

This study was conducted in accordance with ethical standards. Ethical approval was obtained from the appropriate institutional review board, and informed consent was secured from all participants prior to data collection.

RESULTS

Clinical Characteristics of the Study Population

The analyzed cohort of 110 patients with Multiple Sclerosis and related demyelinating spectrum disorders demonstrated marked clinical heterogeneity, reflecting the well-known variability of the disease. Patients differed not only in terms of disease duration and course, but also in the severity and combination of neurological deficits, which directly influenced their rehabilitation needs.

The distribution of disability, assessed using the Expanded Disability Status Scale (EDSS), revealed that approximately 20% of patients fell into the mild disability category (EDSS 1.0–3.0), around 50% into the moderate disability group (EDSS 3.5–6.0), and nearly 30% into the severe disability group (EDSS 6.5–8.5). This distribution highlights that the majority of patients required structured rehabilitation interventions, as moderate and severe disability levels are typically associated with significant functional limitations [9].

In terms of clinical manifestations, several neurological syndromes were particularly prevalent across the cohort. Spastic tetraparesis or paraparesis was observed in approximately 60% of patients, making it the most frequent motor impairment. Cerebellar ataxia, characterized by coordination and balance disturbances, was present in about 55% of cases and often significantly limited independent mobility. Pelvic organ dysfunction, including urinary urgency, incontinence, or retention, was documented in roughly 45% of patients and represented a major contributor to reduced quality of life. Cognitive impairment, ranging from mild attention deficits to more pronounced memory and executive dysfunction, was identified in nearly 50% of the cohort, emphasizing the importance of including cognitive rehabilitation in treatment strategies [10,11].

Table 1. Distribution of Clinical Characteristics in the Study Cohort (n = 110)

Variable	Category / Symptom	Percentage (%)
EDSS Distribution	Mild (1.0–3.0)	~20%
	Moderate (3.5–6.0)	~50%
	Severe (6.5–8.5)	~30%
Motor Impairment	Spastic tetraparesis/ paraparesis	≈60%
Coordination Disorder	Cerebellar ataxia	≈55%
Autonomic Dysfunction	Pelvic organ dysfunction	≈45%
Cognitive Impairment	Cognitive decline	≈50%

These findings underscore the multifactorial nature of disability in MS and the necessity of a multidimensional rehabilitation approach that goes beyond purely motor recovery.

Identification of Rehabilitation Profiles

Using clustering principles based on EDSS levels, dominant neurological syndromes, and functional limitations, four main rehabilitation profiles were identified. These profiles allowed for a more structured understanding of patient needs and facilitated the development of targeted intervention strategies.

Profile 1: Mild Functional Impairment

This group included patients with EDSS scores between 1.0 and 3.0. These individuals generally maintained independent mobility and basic daily functioning but frequently reported fatigue, reduced endurance, and subtle cognitive difficulties. Motor deficits were minimal or compensated. The primary rehabilitation focus in this group was preventive and supportive, aiming to maintain function and delay progression. Interventions included aerobic exercise programs, cognitive training exercises, and lifestyle modifications such as sleep hygiene and stress management.

Profile 2: Moderate Motor Dysfunction

Patients in this category (EDSS 3.5–5.5) exhibited clear motor impairments, including spasticity, gait instability, and cerebellar ataxia. Although many remained ambulatory, their mobility was compromised, and they required structured physiotherapy. Rehabilitation in this group emphasized muscle strengthening, balance training, gait correction, and spasticity management. These patients benefited most from individualized physiotherapy programs combined with task-oriented training.

Profile 3: Severe Disability with Mobility Limitation

This profile included patients with EDSS scores between 6.0 and 7.0. These individuals often required assistance for ambulation or relied on assistive devices such as canes, walkers, or wheelchairs. Functional independence was reduced, particularly in activities of daily living. Rehabilitation strategies focused on maintaining residual function, improving transfer skills, and preventing secondary complications such as muscle contractures or pressure ulcers. Occupational therapy and functional training were essential components.

Profile 4: Complex Multisystem Impairment

Patients with EDSS scores above 7.0 represented the most severe group, characterized by combined motor, cognitive, and autonomic dysfunction. These patients often had significant dependency and required continuous support. Rehabilitation in this group adopted a multidisciplinary and supportive approach, involving physiotherapists, neurologists, psychologists, and caregivers. The emphasis shifted toward quality of life, symptom management, and prevention of complications rather than functional restoration alone.

Table 2. Rehabilitation Profiles and Corresponding Interventions

Profile	EDSS Range	Key Characteristics	Main Interventions
Profile 1	1.0–3.0	Mild impairment, fatigue, cognitive issues	Aerobic exercise, cognitive training, lifestyle modification
Profile 2	3.5–5.5	Spasticity, ataxia, gait disturbance	Physiotherapy, balance training, gait correction
Profile 3	6.0–7.0	Mobility limitation, partial dependence	Assistive devices, occupational therapy, functional training
Profile 4	>7.0	Multisystem impairment, severe disability	Multidisciplinary care, caregiver support, palliative rehabilitation

Outcomes of the Rehabilitation Algorithm

The application of the developed rehabilitation algorithm demonstrated meaningful improvements across several functional domains. Patients who underwent structured, profile-based rehabilitation showed better mobility outcomes compared to those receiving non-standardized rehabilitation. Improvements were particularly evident in gait stability, coordination, and endurance among patients in Profiles 1 and 2.

In addition to motor outcomes, cognitive engagement improved in patients who received targeted cognitive training, especially in the mild and moderate groups. Patients reported better concentration, reduced mental fatigue, and improved participation in daily activities. These changes, although sometimes subtle, had a significant cumulative impact on overall quality of life.

Another important outcome was the reduction in secondary complications. Patients in the severe and complex profiles experienced fewer issues related to immobility, such as contractures and pressure-related complications. Furthermore, structured pelvic rehabilitation strategies contributed to better management of urinary symptoms, reducing episodes of incontinence and improving patient confidence in social settings.

Overall, patient-reported outcomes indicated improved quality of life across all groups. Individuals receiving personalized, algorithm-guided rehabilitation demonstrated greater functional stability and slower perceived progression of disability compared to those undergoing non-structured or generalized rehabilitation approaches.

These findings support the clinical value of an individualized, algorithm-based rehabilitation model in MS, emphasizing that tailored interventions aligned with disease severity and functional status can significantly enhance patient outcomes [12].

DISCUSSION

The present study underscores a clear and practical need to move away from generalized rehabilitation approaches toward structured, individualized strategies in the management of Multiple Sclerosis. MS is inherently heterogeneous—patients differ not only in disease course and severity, but also in the specific combination of motor, cognitive, and autonomic impairments they experience. In this context, a "one-size-fits-all" rehabilitation model is unlikely to produce optimal outcomes. Our findings support the idea that rehabilitation must be both flexible and systematic, guided by clinically meaningful indicators that reflect real functional needs [13].

One of the most important insights from this study is the strong and consistent relationship between EDSS levels and rehabilitation requirements. Although EDSS has known limitations—particularly in capturing cognitive and upper-limb function—it remains a useful and widely accepted measure of global disability. In our cohort, patients with similar EDSS scores often demonstrated comparable functional challenges, especially in terms of mobility and independence. This allowed for practical stratification into rehabilitation profiles, simplifying clinical decision-making without oversimplifying patient complexity. In everyday clinical settings, such stratification can help clinicians quickly identify the appropriate intensity and focus of rehabilitation interventions.

Another notable finding is the high prevalence of cognitive impairment across all levels of disability. Nearly half of the patients demonstrated some degree of cognitive dysfunction, ranging from reduced attention and processing speed to memory and executive deficits. Traditionally, rehabilitation programs in MS have focused predominantly on motor recovery, with less emphasis on cognitive domains. However, our results suggest that neglecting cognitive rehabilitation may limit overall effectiveness. When cognitive training was integrated into the rehabilitation algorithm, patients showed improved engagement, better adherence to therapy, and enhanced independence in daily activities.

This highlights the importance of viewing MS not only as a motor disorder but as a multidimensional neurological condition [14].

The interaction between pharmacological treatment and rehabilitation outcomes also deserves attention. Patients receiving high-efficacy disease-modifying therapies, such as ocrelizumab or natalizumab, often experienced greater stability in disease activity. This stability created a more favorable window for rehabilitation interventions, allowing patients to tolerate higher training intensity and achieve better functional gains. These findings emphasize that rehabilitation should not be considered separately from medical treatment but rather as an integrated component of comprehensive care. Aligning rehabilitation programs with the patient's disease phase and treatment response appears to enhance overall effectiveness.

Pelvic organ dysfunction emerged as another critical, yet often under-recognized, factor affecting quality of life. Symptoms such as urinary urgency, incontinence, or retention were common and had a substantial impact on social participation and psychological well-being. In many cases, these issues were more distressing to patients than motor limitations. The inclusion of targeted interventions—such as bladder training and pelvic floor therapy—within the rehabilitation algorithm led to noticeable improvements in symptom control and patient confidence. This finding reinforces the need for a holistic approach that addresses not only visible disabilities but also less apparent, yet highly impactful, functional impairments.

Overall, the proposed algorithm offers a practical framework that integrates clinical data with functional outcomes. By systematically linking disease severity, neurological presentation, and rehabilitation strategies, it helps clinicians tailor interventions more effectively. Rather than replacing clinical judgment, the algorithm supports it, providing a structured guide that can be adapted to individual patient contexts. In doing so, it addresses the multidimensional challenges of MS rehabilitation and contributes to improving long-term quality of life [15].

CONCLUSION

In this study, we developed and applied an evidence-based algorithm designed to optimize rehabilitation programs for patients living with Multiple Sclerosis. The central idea behind this work was simple but important: rehabilitation should not be generic—it should reflect the real clinical picture of each patient. By combining key elements such as disease severity, neurological deficits, and everyday functional limitations, the proposed algorithm allows rehabilitation planning to become more personalized, structured, and clinically meaningful.

One of the main strengths of this approach is the use of EDSS-based stratification as a practical starting point. Although MS presents with diverse symptoms, grouping patients according to disability levels provided a clear framework for decision-making. This made it easier to align rehabilitation intensity and goals with patient capacity, ensuring both safety and effectiveness. At the same time, the algorithm goes beyond a single scale by incorporating multidimensional aspects of the disease—motor, cognitive, and autonomic functions—which are all critical in shaping quality of life.

Another key contribution of this study is the emphasis on targeted, multidomain rehabilitation. Rather than focusing only on physical recovery, the algorithm integrates cognitive training, pelvic function management, and functional independence strategies. This holistic perspective reflects the real-life challenges faced by MS patients and acknowledges that quality of life depends on more than mobility alone. The observed improvements in patient engagement, functional stability, and daily independence further support the value of such an integrated approach.

Importantly, the algorithm is not intended to replace clinical judgment but to support it. It provides clinicians with a structured yet flexible tool that can be adapted to individual patient needs, disease phases, and treatment contexts. In settings where time and resources are limited, having a clear decision-making framework can significantly improve the consistency and quality of rehabilitation care.

Overall, this work represents a meaningful step toward modern, patient-centered neurorehabilitation. By translating complex clinical data into practical rehabilitation strategies, the proposed algorithm has the potential to improve outcomes and enhance the everyday lives of people with MS. It may also serve as a useful foundation for future clinical guidelines, as well as for further research aimed at refining and validating personalized rehabilitation models in neurological practice.

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