

Original Research

Physical Therapy for Motor and Functional Recovery After Encephalitis: A Narrative Review and Conceptual Rehabilitation Framework

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Abstract

Encephalitis can cause persistent motor, cognitive, behavioral, and participation restrictions. This narrative review synthesizes the available rehabilitation literature and develops a clinically oriented, phase-specific conceptual framework for post-encephalitis physical therapy. The framework supports individualized decision-making and future prospective validation; it is not presented as a validated clinical protocol. PubMed, Scopus, and Web of Science were searched for English-language publications from January 2010 to October 2025. Encephalitis concepts were combined with rehabilitation, physical therapy, motor recovery, functional outcome, gait, balance, and task-oriented training using AND and OR. Eligible clinical evidence comprised randomized and non-randomized studies, observational cohorts, case series, and case reports reporting motor or functional outcomes. Reviews and other publications were retained separately as contextual sources. We synthesized the evidence descriptively and used it to inform framework development. Eighteen clinical reports meeting the physical therapy-specific eligibility criteria and reporting measurable motor or functional outcomes were included in the descriptive clinical evidence set: 4 cohort studies, 4 case series, and 10 case reports. Five reports identified during full-text screening as primarily cognitive rehabilitation, dysphagia/swallowing rehabilitation, or general clinical-outcome reports without a sufficiently characterized physical therapy intervention were not included in the



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physical therapy evidence set. Reports without rehabilitation exposure, reports concerning encephalopathy rather than encephalitis, and conference abstracts were also excluded from the intervention evidence set. No randomized controlled trial specifically evaluating physical therapy after encephalitis was identified. We retained additional reviews and broader neurorehabilitation sources only for contextualization and framework development. Four studies provided sufficiently explicit admission-to-discharge data for a limited semi-quantitative summary; heterogeneity precluded pooling. The available evidence suggests that early, individualized, task-oriented physical therapy may contribute to motor and functional recovery after encephalitis when integrated within multidisciplinary rehabilitation. Because the evidence is heterogeneous and largely observational, the proposed framework should be regarded as hypothesis-generating and clinically informative rather than as evidence of established efficacy. Prospective studies are needed to evaluate its feasibility, safety, and effectiveness.

Keywords

Encephalitis; physical therapy; rehabilitation; motor recovery; narrative review; conceptual rehabilitation framework

1. Introduction

Encephalitis, an inflammatory condition of the brain parenchyma, can be infectious (viral or bacterial) or autoimmune in origin. Its clinical spectrum ranges from mild cognitive or behavioral changes to severe, persistent neurological deficits, including paresis, ataxia, aphasia, and long-term functional disability [1]. Epidemiological data indicate that infectious encephalitis occurs in approximately 1.4 to 13.8 cases per 100,000 people annually, with post-infectious sequelae leading to long-term disability in up to 40% of survivors [2].

Pathologically, encephalitis affects both grey and white matter and may spread from focal to diffuse brain regions, including subcortical structures and the brainstem. The resulting combination of inflammation, neuronal loss, demyelination, and secondary changes (such as edema, gliosis, and synaptic reorganization) disrupts motor and sensory pathways, corticospinal tracts, basal ganglia circuits, and cerebellar networks. Clinical manifestations may include hemiparesis or tetraparesis, altered muscle tone, impaired coordination and balance, ataxia, tremor, and limited gait capacity. Patients may also present with cognitive and behavioral disturbances that limit their therapeutic participation. These manifestations necessitate an individualized, phase-specific therapeutic approach [3].

Rehabilitation after encephalitis is a multifaceted process addressing neurological, cognitive, communicative, behavioral, and movement-related limitations [4, 5]. Physical therapy specifically targets movement, motor control, strength, balance, gait, endurance, and postural control, while rehabilitation denotes the broader multidisciplinary process. Physical therapy may also help reduce secondary complications such as contractures, pressure injuries, and deconditioning. Cohort and case-based evidence, together with mechanistic literature on exercise-related neuroplasticity, provides the clinical rationale for these interventions [6-9].

Yet, despite increasing attention, there is still no widely accepted international guideline for rehabilitation specifically designed for encephalitis. Thus, many rehabilitation programs borrow principles from stroke and traumatic brain injury rehabilitation models [3], which may not fully reflect the unique pathophysiology, variability in recovery, and multisystem sequelae of encephalitis.

Contemporary literature, including systematic reviews, cohort studies, case series, and case reports, suggests a role for early, multidisciplinary, and individualized rehabilitation adapted to disease phase and patient-specific limitations [4, 5]. Recovery can be prolonged, and long-term cognitive and functional sequelae have been documented after anti-NMDAR and other forms of encephalitis [1, 4]. Neuroinvasive viral diseases such as West Nile neuroinvasive disease may involve substantial motor, functional, swallowing, and respiratory limitations, highlighting the need for multidisciplinary rehabilitation [10, 11].

Rehabilitation after encephalitis remains less extensively studied than rehabilitation after other acquired brain injuries. The principal gap is not simply the scarcity of randomized evidence, but the absence of a transparent clinical structure that links heterogeneous published interventions to recovery phase, functional targets, individual phenotype, safety considerations, and multidisciplinary planning.

The aim of this narrative review is therefore to synthesize the available literature on physical therapy after encephalitis and translate recurring rehabilitation principles into a flexible conceptual framework for motor and functional recovery.

The framework represents the principal translational contribution of this article. It supports the Individual Rehabilitation Project (IRP), a person-centered rehabilitation management plan developed with the patient or proxy by an interdisciplinary team under the leadership of a Physical and Rehabilitation Medicine physician, as described in the UEMS-PRM European framework [12]. It is not a uniform treatment algorithm, a clinical trial, or a clinically validated protocol.

Beyond clinical intervention studies, broader methodological, clinical, and contextual literature provides important background rationale for brain injury and encephalitis outcomes. Systematic review protocols [13] and epidemiological or outcome studies [14] highlight long-term neurological sequelae, while medical management frameworks address specific acute complications such as anti-seizure protocols [15]. Additionally, exercise mechanisms studied in other acquired brain injury models [16] and individual pediatric case reports in related neuroinflammatory conditions such as acute disseminated encephalomyelitis [17] offer complementary insights into neuroplasticity and recovery mechanisms, supporting the need for structured rehabilitation frameworks. We did not include these publications in the clinical physical therapy evidence synthesis but retained them as contextual sources to inform the background and rationale for the proposed rehabilitation framework.

2. Materials and Methods

This work was conducted as a narrative literature review informing the development of a conceptual rehabilitation framework. We selected a narrative design to map a clinically and methodologically heterogeneous evidence base and to support transparent translation of reported interventions into a phase-specific clinical structure. No clinical intervention, pilot implementation, or prospective effectiveness evaluation was conducted as part of this study.

2.1 Literature Search and Eligibility Criteria

PubMed, Scopus, and Web of Science were searched for publications from January 2010 to October 2025. Search strings combined (encephalitis OR autoimmune encephalitis OR infectious encephalitis OR postinfectious encephalitis) AND (physical therapy OR physiotherapy OR rehabilitation) AND (motor recovery OR functional outcome OR gait OR balance OR task-oriented training OR neuroplasticity). We also screened reference lists of relevant publications. The search was intended for narrative synthesis and was not registered as a systematic-review protocol.

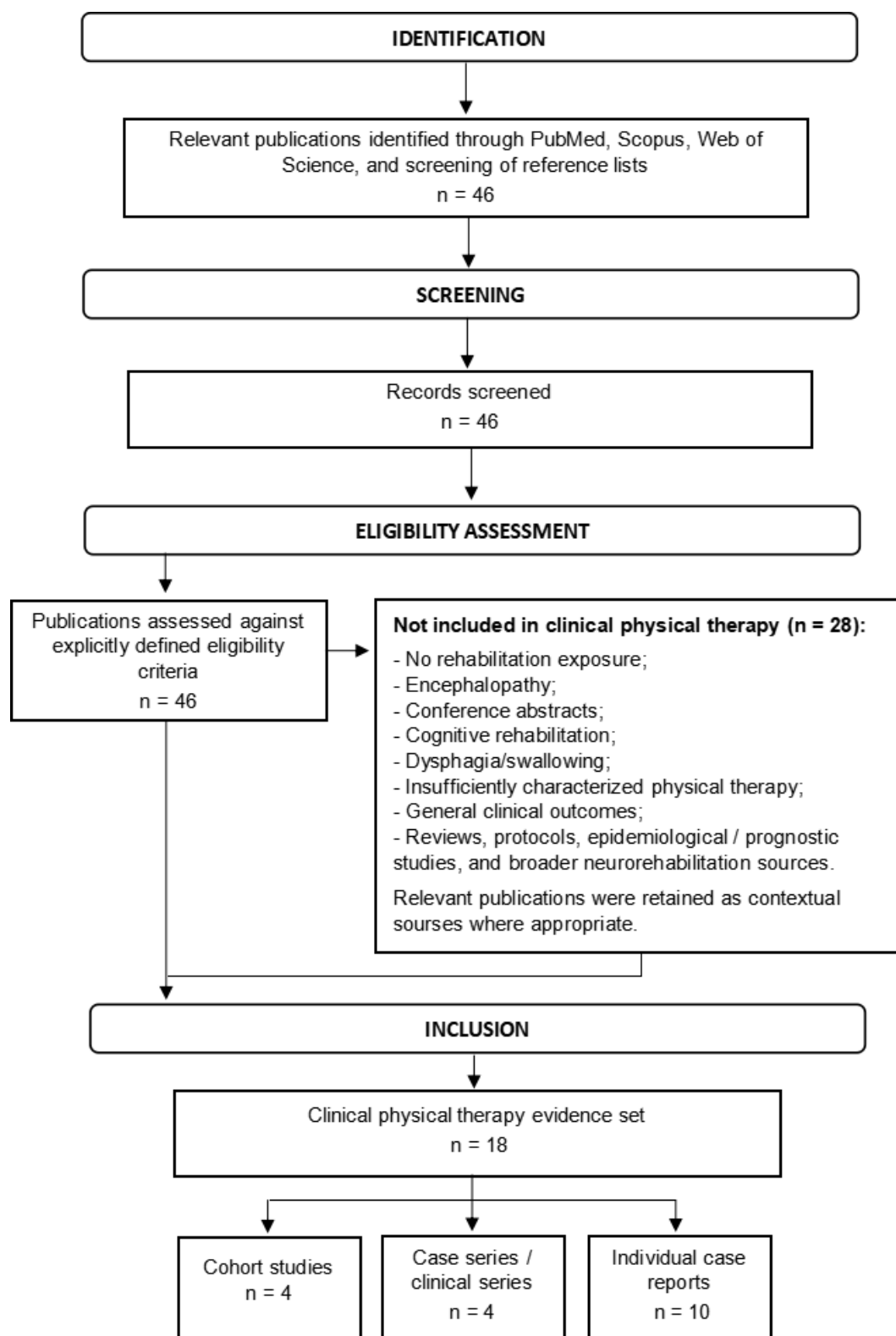
Inclusion criteria:

1. Randomized controlled trials and non-randomized clinical studies evaluating physical therapy or multidisciplinary rehabilitation in patients with infectious, autoimmune, or postinfectious encephalitis.
2. Observational cohort studies, case series, and case reports describing relevant rehabilitation interventions.
3. English-language peer-reviewed publications reporting measurable motor, mobility, activities-of-daily-living, or other relevant functional outcomes.

Exclusion criteria:

1. Animal or preclinical studies.
2. Reviews, protocols, epidemiological or prognostic publications, and publications focused exclusively on pharmacological or medical management were excluded from the clinical physical therapy evidence set; when relevant, they were retained separately as contextual sources for background or framework rationale.
3. Publications without a relevant measurable motor or functional outcome.
4. Reports lacking sufficient information to characterize the rehabilitation intervention or its functional context; reports concerning encephalopathy rather than encephalitis; conference abstracts; and reports whose primary focus was cognitive rehabilitation, dysphagia/swallowing rehabilitation, or general clinical outcomes without a sufficiently characterized physical therapy intervention.

The literature selection process is presented in an adapted PRISMA-style flow diagram for transparency (Figure 1). Because this study is a narrative literature review rather than a registered systematic review, the diagram summarizes the identification and eligibility assessment of relevant publications without implying a formal systematic-review protocol. A total of 46 relevant publications were considered during the literature synthesis based on database searching and reference list screening. We then assessed publications against the explicitly defined eligibility criteria. Following this screening, 18 reports constituted the final clinical physical therapy evidence set (4 cohort studies, 4 case series, and 10 case reports). Publications not meeting the clinical physical therapy eligibility criteria were excluded from the intervention evidence set; relevant reviews, protocols, epidemiological/prognostic studies, outcome-only reports, and broader neurorehabilitation publications were retained separately as contextual sources where appropriate. The flow diagram accounts for all 46 publications by distinguishing the 18 reports included in the clinical physical therapy evidence set from the 28 publications not included in that evidence set.



* Adapted PRISMA-style presentation for a narrative review; not a registered systematic review.

Figure 1 Adapted PRISMA-style flow diagram of literature identification, eligibility assessment, and clinical physical therapy evidence selection.

Because this was a narrative review, formal risk-of-bias and GRADE assessments were not undertaken. Clinical reports were distinguished from contextual sources and characterized qualitatively by design, sample, population, intervention, outcomes, and limitations. Although

formal risk-of-bias tools were not applied, the qualitative limitations and uncontrolled nature of the included observational evidence are explicitly noted.

2.2 Data Extraction and Descriptive Synthesis

For each eligible publication, the authors extracted and descriptively organized the following information:

1. study design, sample size, and pediatric or adult population;
2. encephalitis etiology and clinical phenotype;
3. rehabilitation phase, intervention type, dosage, and multidisciplinary context;
4. motor, mobility, activities-of-daily-living, cognitive-motor, participation, and other reported outcomes;
5. follow-up duration, reported safety issues, and methodological limitations.

Findings were synthesized descriptively. Quantitative pooling was not performed because patient characteristics, etiologies, intervention content and dosage, outcome measures, and follow-up periods were substantially heterogeneous. Where individual studies reported numerical changes in validated measures, these were retained at study level rather than combined across clinically dissimilar reports.

2.3 Development of the Conceptual Rehabilitation Framework

The conceptual development pathway was: literature identification → descriptive evidence synthesis → identification of recurring rehabilitation principles → phase-specific organization of interventions → integration of patient-specific and multidisciplinary considerations → formulation of the conceptual rehabilitation framework.

The framework links each reported intervention to a functional target, recovery phase, evidence source, and clinical rationale. Neuroplasticity, task-specific practice, graded progression, safety monitoring, and participation were used as organizing principles. These principles informed clinical recommendations but were not treated as proof of intervention efficacy.

1. The resulting framework was designed to inform the IRP and to be adapted to etiology, age, neurological presentation, cognitive and behavioral impairment, seizure history, fatigue, autonomic or cardiorespiratory limitations, premorbid function, complications, rehabilitation potential, and rate of recovery.
2. Primary framework outcomes were functional independence, mobility, gait, balance, and motor control. Secondary outcomes included endurance, participation, fatigue, cognitive-motor performance, communication-related functional limitations, and psychosocial functioning. When established for the relevant population and measure, consider minimal clinically important differences; no single threshold was applied because encephalitis studies used heterogeneous instruments and rarely reported encephalitis-specific MCIDs.
3. This review did not clinically validate the framework. Its proposed dosage and monitoring elements are clinical guidance requiring patient-specific adjustment and prospective evaluation.

3. Results and Conceptual Framework

The literature synthesis identified recurring rehabilitation approaches and outcome domains, while also showing substantial methodological heterogeneity. The following findings describe reported associations and clinical observations; they do not establish treatment efficacy.

3.1 Literature Evidence Synthesis

The descriptive clinical evidence set comprised 18 reports meeting the physical therapy-specific eligibility criteria and reporting measurable motor or functional outcomes: 4 cohort studies, 4 case series/clinical series, and 10 individual case reports. Specifically, Brenner et al. [1], Michaeli et al. [18], Fillâtre et al. [19], and Sonnevile et al. [20] were excluded from intervention counts because they reported outcomes without rehabilitation exposure; Wu et al. [21] and Nerkar et al. [7] concerned encephalopathy rather than encephalitis; and Anastasiadis et al. [22] and Beis & Renard [23] were conference abstracts. Kotteti et al. [24] was excluded because it was a general retrospective clinical-outcomes series without a sufficiently characterized physical therapy intervention. Urakami [25] focused primarily on neurocognitive rehabilitation; Sugahara et al. [26] on dysphagia/swallowing rehabilitation; Son et al. [27] on cognitive impairment; and Corallo et al. [28] on cognitive rehabilitation. These five reports were retained in the reference list as contextual rehabilitation literature but were not counted as physical therapy evidence or used to support physical therapy-specific efficacy claims. No randomized controlled trial specifically evaluating physical therapy after encephalitis was identified in the searched databases. The clinical evidence was therefore observational and case-based.

3.1.1 Study Selection and Evidence Base

Cohort Studies.

Four cohort studies met the inclusion criteria for physical therapy or multidisciplinary rehabilitation exposure, encompassing adult and pediatric populations [6, 11, 29, 30]. Kim & Cheong (2021) observed significant improvements in activities of daily living (K-MBI score change from 36.8 ± 24.1 to 58.4 ± 26.5 ; $p < 0.001$) and ambulatory capacity (FAC change from 1.6 ± 1.4 to 2.8 ± 1.5 ; $p < 0.001$) among 18 encephalitis survivors during inpatient rehabilitation, whereas manual muscle test scores did not show statistically significant change [6]. Howarth et al. (2019) reported early functional gains in 27 pediatric patients with anti-NMDAR encephalitis, showing mean total WeeFIM DFQ improvements from 28.6 to 54.3 ($p < 0.01$) [29]. Maccarone et al. (2025) described functional rehabilitation outcomes in patients with neuroinvasive West Nile virus infection [11], while Hoffman & Paschal (2013) documented mobility and self-care gains in adult West Nile virus patients in a rehabilitation hospital setting [30]. Outcome-only cohorts lacking rehabilitation exposure [1, 18-20] were retained for prognostic context but excluded from intervention counts. Because cohort studies lacked randomized control groups and involved concurrent medical care, reported changes cannot be attributed solely to physical therapy.

Case Series.

Four case series met the physical therapy-specific evidence criterion: Houtrow et al. [31], Tailor et al. [32], Patel et al. [33], and Bach [34]. Kotteti et al. [24] and Urakami [25] were retained only as contextual rehabilitation sources because they did not meet this criterion.

Tailor et al. (2013) reported a mean total WeeFIM Developmental Functional Quotient (DFQ) increase from 37 at admission to 64 at discharge, with a mean gain of 26.7 points (range 0-55; $p < 0.001$); 11 of 13 children remained below a DFQ of 85 at discharge [32]. Patel et al. (2021) reported a mean FIM increase from 45.2 (range 14-63) at admission to 82.2 (range 61-100) at discharge, with a mean total gain of 37 points (range 24-60); mean gains were 17.4 for mobility, 12.6 for ADL, and 7 for cognition [33].

Houtrow et al. [31], Tailor et al. [32], Patel et al. [33], and Bach [34] provided observational descriptions of multidisciplinary inpatient rehabilitation in autoimmune and viral encephalitis. Kotteti et al. [24] and Urakami [25] were not included in the physical therapy evidence set because the former did not sufficiently characterize a physical therapy intervention and the latter primarily addressed neurocognitive rehabilitation; both were retained only as contextual sources. The absence of control groups, small samples, concurrent multidisciplinary treatment, and non-standardized interventions limit causal interpretation.

Individual Case Reports.

Ten single-patient case reports met the physical therapy-specific evidence criterion. The report concerning encephalopathy [7] and reports primarily focused on swallowing/dysphagia [26] or cognitive/neurocognitive rehabilitation [27, 28] were excluded from the physical therapy evidence set. The retained case reports described viral, autoimmune, post-infectious, and related encephalitic presentations [5, 8, 9, 35-41]. Rehabilitation was most commonly initiated during the subacute phase, once acute neurological symptoms had stabilized. Frequently applied techniques included PNF, neurodevelopmental (Bobath) approaches, task-specific gait and balance training, and progressive resistive and coordination exercises [5, 8, 35, 37]. Kunjarkar et al. (2022) and Głowacki et al. (2022) reported progress in trunk stability and foot-mediated control in severe motor deficits [9, 36].

Overall, the individual case literature provides clinically informative examples of personalized physical therapy in complex presentations, while remaining hypothesis-generating because of its uncontrolled design.

To provide a transparent overview of the clinical evidence base, Table 1 summarizes the study design, sample characteristics, interventions, and key outcomes of the included reports.

Table 1 Characteristics of Included Clinical Reports (n = 18).

Study/Design	Population & Etiology	Rehabilitation Exposure	Principal Outcome Measures & Main Findings
Kim & Cheong, 2021 [6] (Retrospective cohort)	n = 18 adults; viral or autoimmune encephalitis	Multidisciplinary inpatient PT/OT	Significant gains in K-MBI (36.8 to 58.4) and FAC (1.6 to 2.8); MMT changes not significant
Maccarone et al., 2025 [11] (Retrospective cohort)	n = 29 adults; neuroinvasive West Nile virus	Early Physical Medicine and Rehabilitation assessment; tailored rehabilitation according to functional deficits	Rehabilitation needs included motor weakness, swallowing and respiratory impairment; Barthel Index showed no significant change
Howarth et al., 2019 [29] (Retrospective cohort)	n = 27 children; anti-NMDAR encephalitis	Intensive inpatient neurorehabilitation	Significant total WeeFIM DFQ gain (28.6 to 54.3; $p < 0.01$)
Hoffman & Paschal, 2013 [30] (Cohort study)	n = 12 adults; West Nile virus	Acute rehabilitation facility PT/OT	Improvement in total FIM scores, self-care, and mobility subscales
Houtrow et al., 2012 [31] (Case series)	n = 6 children; anti-NMDAR encephalitis	Multidisciplinary inpatient rehabilitation	Functional gains during inpatient rehabilitation, with persistent deficits at discharge and follow-up
Taylor et al., 2013 [32] (Case series)	n = 13 children; mixed encephalitis	Individualized inpatient multidisciplinary rehabilitation	WeeFIM DFQ increased from 37 to 64 (mean gain 26.7; $p < 0.001$)
Patel et al., 2021 [33] (Case series)	n = 5 adults; West Nile neuroinvasive disease	Acute inpatient multidisciplinary rehabilitation	Mean total FIM gain of 37 points (mobility: 17.4, ADL: 12.6, cognition: 7.0)
Bach, 2014 [34] (Case series)	n = 3 adults; anti-NMDAR encephalitis	Long-term multidisciplinary PT/OT/SLT	Functional motor recovery and ADL independence over extended period
Wang et al., 2022 [5] (Case report)	1 child; viral encephalitis sequelae	Structured exercise prescription & motor retraining	Enhanced functional mobility, balance, and physical performance
Biyani et al., 2024 [8] (Case report)	1 child; viral encephalitis	Pediatric physical therapy (PNF, Bobath)	Improvement in trunk control, postural alignment, and ambulation
Głowacki et al., 2022 [9] (Case report)	1 adult; post-encephalitic plegia	Positioning & foot-movement communication PT	Restoration of functional foot control and communication

Thakre et al., 2023 [35] (Case report)	1 adult; viral encephalitis	PNF-focused physiotherapeutic protocol	Improvements in muscle tone, bed mobility, and standing balance
Kunjarkar et al., 2022 [36] (Case report)	1 adult; Japanese encephalitis	Therapy-ball-based trunk stabilization PT	Enhanced sitting balance, core stability, and upper limb control
Shukla & Dwivedi, 2024 [37] (Case report)	1 adult; viral encephalitis with hemiparesis	Task-oriented motor retraining & facilitation	Gains in gait speed, balance confidence, and ADL performance
Mahayati & Aryudha, 2022 [38] (Case report)	1 adult; post-encephalitis tetraparesis	Progressive strengthening & mobilization PT	Transition from bedridden status to assisted ambulation
Uno, 2025 [39] (Case report)	1 adult; Bickerstaff brainstem encephalitis	Ataxia rehabilitation & coordination training	Resolution of severe ataxia and achievement of independent gait
Miles et al., 2023 [40] (Case report)	1 child; anti-NMDAR encephalitis	Multidisciplinary allied health rehabilitation	Restoration of age- appropriate motor skills and daily activities
Bradley, 2015 [41] (Case report)	1 adult; anti-NMDAR encephalitis	Subacute multidisciplinary PT/OT	Gains in transfer independence, standing balance, and gait

3.1.2 Key Reproducible Patterns Emerging from the Literature

The narrative synthesis identified recurring themes regarding timing, intervention content, multidisciplinary coordination, and outcome monitoring. These patterns informed the conceptual framework and should be interpreted in light of the low certainty and heterogeneity of the evidence:

- *Early initiation and continuity of rehabilitation*: Observational cohort and case-based reports describe functional improvement during rehabilitation initiated after medical stabilization; however, these studies cannot determine whether rehabilitation itself caused the observed changes [6, 29, 30, 32, 33].
- *Neurofacilitation and task-oriented approaches*: PNF, neurodevelopmental approaches, and task-specific training have been reported in encephalitis rehabilitation studies and case reports [32, 34, 35, 37]. Interpret reported improvements as descriptive observations rather than evidence of independent treatment efficacy.
- *Adjunctive modalities*: Interferential current stimulation has been reported in a case of persistent dysphagia after anti-NMDA receptor encephalitis [26]; this swallowing-focused report was retained as contextual multidisciplinary evidence and was not included in the physical therapy evidence set. PNF, strengthening, balance and mobility exercises have been described in other encephalitis case reports [5, 35, 37]. Evidence for mirror therapy, virtual reality, and aerobic exercise remains insufficiently encephalitis-specific and should therefore be considered extrapolated or hypothesis-generating.
- *Pediatric evidence*: Case series and case reports in pediatric encephalitis describe

improvements in functional independence, balance, coordination, and participation during individualized rehabilitation [5, 29, 31, 32, 40]. These observations do not establish that a specific exercise intensity or duration produces superior recovery.

- *Integrated multidisciplinary interventions:* In cases with complex motor and cognitive limitations, multidisciplinary interventions combining physical therapy with speech therapy, occupational therapy, and cognitive interventions were reported [40].
- *Cognitive and behavioral considerations:* Cognitive impairment and behavioral changes that may persist after encephalitis can limit participation and engagement in physical therapy and therefore require consideration during rehabilitation planning [1, 19, 30].

3.1.3 Semi-Quantitative Summary and Evidence-to-Framework Traceability

To summarize the available quantitatively reported clinical evidence in the physical therapy evidence set, Table 2 organizes the findings according to the phase of recovery, physical therapy techniques applied, functional outcomes, and supporting evidence from the literature. Of the 18 included clinical reports, only the four studies presented in Table 2 provided sufficiently explicit admission-to-discharge quantitative data to allow for semi-quantitative extraction. This synthesis highlights how intervention strategies differ across the acute, subacute, and chronic phases of recovery, as well as the corresponding clinical improvements observed in both pediatric and adult populations.

Table 2 Semi-Quantitative Summary and Evidence-to-Framework Traceability.

Study/design	Population	Phase	Rehabilitation exposure	Functional target	Reported quantitative outcome	Clinical rationale and limits
Kim & Cheong, 2021 [6] Retrospective cohort	n = 18; adults; viral or autoimmune encephalitis	Inpatient; mixed subacute recovery	Multidisciplinary inpatient rehabilitation; ADL, mobility and upper-limb function	ADL independence; ambulation; dexterity	K-MBI score increased from 36.8 ± 24.1 at admission to 58.4 ± 26.5 at discharge ($p < 0.001$); FAC improved from 1.6 ± 1.4 to 2.8 ± 1.5 ($p < 0.001$). MMT showed no statistically significant change.	Supports monitoring functional activity separately from impairment. Uncontrolled pre/post data; concurrent treatment and spontaneous recovery prevent causal attribution.
Howarth et al., 2019 [29] Retrospective cohort	n = 27; children; anti-NMDAR encephalitis; mean age 10.6 y	Inpatient subacute rehabilitation	Intensive multidisciplinary neurorehabilitation	Age-adjusted functional independence	Mean total WeeFIM DFQ: 28.6 at admission to 54.3 at discharge; mean change 25.7 points; $p < 0.01$.	Supports repeated age-adjusted functional measurement and prolonged follow-up. No control group; large discharge range and persistent deficits.
Taylor et al., 2013 [32] Case series	n = 13; children; mixed encephalitis; mean age 9 y	Inpatient subacute rehabilitation	Individualized multidisciplinary rehabilitation	Self-care; mobility; cognition	Mean total WeeFIM DFQ: 37 to 64; mean gain 26.7 (range 0-55), $p < 0.001$. Eleven of 13 remained below DFQ 85 at discharge.	Supports integrated motor-cognitive goals and documenting residual disability. Small heterogeneous series; 2/13 had no measurable total DFQ improvement.

Patel et al., 2021 [33] Case series	n = 5; adults; West Nile neuroinvasive disease; mean age 64.8 y	Acute inpatient rehabilitation	Multidisciplinary inpatient rehabilitation	Global independence; mobility; ADL; cognition	Mean FIM: 45.2 (range 14-63) to 82.2 (range 61-100); mean total gain 37 points (range 24-60). Mean mobility gain 17.4; ADL gain 12.6; cognitive gain 7.	Supports multidomain FIM monitoring in severe WNND. Very small uncontrolled sample; findings are descriptive and not subtype-generalizable.
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* Values are reported only where they were explicitly available in the source. Results describe change during multidisciplinary inpatient rehabilitation and should not be interpreted as the isolated effect of physical therapy. DFQ, Developmental Functional Quotient; FIM, Functional Independence Measure; K-MBI, Korean Modified Barthel Index; FAC, Functional Ambulation Category.

Based on this narrative synthesis, the recurring principles were translated into the conceptual rehabilitation framework described below.

3.2 Proposed Conceptual Rehabilitation Framework

The proposed framework is a literature-informed conceptual model that organizes physical therapy within multidisciplinary rehabilitation. It is intended to support clinical reasoning and the formulation of an individualized IRP; it was not implemented or clinically tested in the present review.

The framework requires adaptation to the patient's etiology, clinical phenotype, rehabilitation potential, goals, tolerance, and care setting. Prospective research is required before its feasibility, safety, or effectiveness can be established.

3.2.1 Framework Structure and Traceability

The framework integrates interventions reported in the literature with established neurological rehabilitation principles and clinical reasoning. It is organized across acute, subacute, and chronic recovery phases, with phase-specific goals, tasks, candidate physical therapy interventions, outcome measures, and safety considerations. The intervention choices are recommendations for individualized planning, not claims that any modality has been validated specifically for encephalitis.

Candidate interventions include task-oriented practice, PNF, the Bobath concept, strengthening, aerobic exercise, balance and gait training, mirror therapy, virtual-reality-based exercise, and FES where clinically appropriate. Functional monitoring may include the FIM or Barthel Index, BBS, gait tests, and complementary cognitive or participation measures. Assessment timing should follow the IRP and clinical course rather than a fixed universal schedule.

Three organizing principles recur across the framework:

1. Early mobilization to prevent complications and stimulate neuromuscular activation during the acute stage;
2. Progressive task-specific activation to promote cortical reorganization, postural recovery, and independence in ADL during the subacute phase;
3. Long-term reintegration to improve endurance, community participation, and psychosocial adjustment in the chronic phase.

The accompanying tables link the recovery phase, functional target, candidate intervention, supporting study type and population, outcome measure, and clinical rationale. No formal consensus panel or prospective validation formed part of this narrative review.

Table 3 presents the author-developed conceptual framework, including goals, candidate interventions, dosage considerations, outcome domains, and safety notes. Dosage values are illustrative and must be individualized within the individual recovery plan.

Table 3 Conceptual Physical Therapy Framework for Motor and Functional Recovery after Encephalitis.

Phase	Therapeutic goals	Therapeutic tasks	Candidate physical therapy interventions	Illustrative dosage	Evidence/Source of Intervention and Dosage	Outcome measures	Safety and individualization
Acute	<i>Short-term:</i> Prevent complications and maintain vital functions.	- Optimize positioning and respiratory function. - Maintain joint mobility and prevent contractures.	- Positioning and postural management. - Passive and active-assisted range of motion (ROM) exercises.	20-30 min, 1-2 times daily, 5-6 days/week.	Positioning, ROM, and basic mobility have been described across encephalitis case reports [5, 8, 9, 35-39]. Respiratory and postural management are supported by rehabilitation reports in West Nile disease [11]. Listed dosage is an illustrative clinical starting point (expert/clinical guidance).	- Level of consciousness - Glasgow Coma Scale (GCS), Coma Recovery Scale-Revised (CRS-R). - Muscle tone - Modified Ashworth Scale (MAS). - Respiratory capacity and vital signs.	Monitor vital signs and fatigue; avoid overstimulation and increased intracranial pressure; ensure gradual progression. Individualize dosage and progression within the IRP; values are illustrative.
	<i>Long-term:</i> Preserve musculoskeletal integrity and readiness for active rehabilitation.	- Stimulate arousal and sensory-motor responsiveness.	- Respiratory positioning, breathing exercises, and airway-clearance techniques when clinically indicated. - Gentle proprioceptive and tactile stimulation.				

Subacute	Short-term: Reactivate motor control and posture.	- Enhance coordination and balance. - Retrain motor patterns and transfers. - Initiate gait re-education. - Integrate upper-limb function.	- Proprioceptive neuromuscular facilitation (PNF), neurodevelopmental therapy (Bobath concept), and task-oriented training. - Balance and postural stability exercises (ball, board). - Gait training with assistive devices. - Functional electrical stimulation (FES) for weak muscles.	45-60 min/session, 5x/week, for 4-6 weeks; progressive load.	PNF, task-oriented training, balance and gait training: encephalitis-specific case-series and case-report evidence [31-39]. Bobath and NDT approaches have been described in selected encephalitis rehabilitation reports [8]; the specific approach and dosage remain insufficiently standardized.	- Functional Independence Measure (FIM)/Barthel Index. - Berg Balance Scale (BBS). - 10-Meter Walk Test (10MWT), Timed Up and Go (TUG).	Tailor exercise complexity to fatigue and tolerance; avoid autonomic instability; continuous feedback for motivation and safety. Individualize dosage and progression within the IRP; values are illustrative.
	Long-term: Improve gait and self-care independence.						

Chronic	Short-term: Improve endurance, strength, and dual-task performance.	- Strength and endurance training. - Dual-task motor-cognitive exercises.	- Aerobic and resistance exercise. - Mirror therapy, Virtual Reality (VR) training.	60-90 min/session, 3-5×/week for ≥12 weeks.	Aerobic/resistance exercise: limited encephalitis-specific case evidence [5]; dosage and progression are extrapolated from broader neurological rehabilitation principles [3]. Mirror therapy and VR are extrapolated from broader neurological rehabilitation literature. Dosage is an illustrative clinical starting point/expert guidance.	- 6-Minute Walk Test (6MWT). - Modified Rankin Scale (mRS). - MoCA/MMSE for cognitive progress. - Quality of Life scales - Medical Outcomes Study 36-Item (SF-36) or EuroQol-5 Dimension (EQ-5D).	Gradual increase in intensity; monitor for fatigue, overuse, and behavioral challenges; adapt to individual psychosocial needs. Individualize dosage and progression within the IRP; values are illustrative.
	Long-term: Support social and occupational reintegration and long-term independence.	- Functional and community activities. - Home program and education.	- Cognitive-motor dual tasks. - Home-based and community participation tasks.				

* Evidence labels in this table distinguish encephalitis-specific clinical reports from extrapolation from broader neurological rehabilitation literature and from author-derived clinical guidance. Where a dosage was not explicitly reported in an encephalitis study, the dosage is presented as an illustrative clinical starting point rather than as an evidence-based prescription.

Because encephalitis includes infectious, autoimmune, and postinfectious etiologies with diverse motor, cognitive, behavioral, seizure-related, fatigue, autonomic, and cardiorespiratory profiles, Table 4 provides phenotype-responsive considerations for common clinical problems. These suggestions complement, but do not replace, medical assessment and individualized multidisciplinary planning.

Table 4 Adaptable Physical Therapy Considerations for Common Problems following Encephalitis.

Clinical problem	Goals	Candidate interventions	Illustrative dosage	Outcome measures	Safety considerations
<i>Spasticity</i>	<i>Short-term:</i> Reduce muscle tone. <i>Long-term:</i> Improve voluntary movement and function.	Regular stretching; positioning; functional task practice; PNF and slow rhythmic rotation; gentle weight-bearing activities	Daily, 2-3 sessions/day, 15-20 min each	Modified Ashworth Scale (MAS); Functional Independence Measure (FIM); Mobility subscore	Avoid overstretching; monitor for autonomic instability; combine with relaxation/ breathing techniques
<i>Ataxia</i>	<i>Short-term:</i> Enhance coordination. <i>Long-term:</i> improve dynamic balance and gait.	Frenkel's exercises; visual feedback training; balance board/therapy ball practice; task-specific reach and step training	30-40 min, 4-5 times/week	Berg Balance Scale (BBS); Timed Up & Go (TUG); 10- Meter Walk Test (10 MWT)	Provide stable base; use gait belts; ensure environmental safety; fatigue breaks as needed
<i>Fatigue</i>	<i>Short-term:</i> Optimize activity tolerance. <i>Long-term:</i> Maintain participation in ADL.	Graded activity pacing; submaximal aerobic training; interval rest strategy; energy conservation education	Moderate intensity (40-60% HRmax), 3-4 times/week	Fatigue Severity Scale (FSS); 6-Minute Walk Test (6MWT); FIM Efficiency	Avoid overexertion; monitor vitals; educate patient/family on rest-activity balance
<i>Respiratory Dysfunction</i>	<i>Short-term:</i> Improve ventilation and airway clearance. <i>Long-term:</i> Enhance respiratory endurance.	Diaphragmatic breathing; incentive spirometry; chest percussion and vibration; inspiratory muscle training	10-15 min, 2-3 sessions/day	SpO ₂ ; Respiratory Rate; Max Inspiratory Pressure (MIP)	Defer airway-clearance techniques when medically contraindicated during acute instability; maintain upright posture; stop and seek medical review with clinically significant desaturation or instability

<i>Cognitive/ Behavioral Issues</i>	<i>Short-term:</i> Maintain engagement. <i>Long-term:</i> Improve executive and dual-task performance.	Cognitive-motor dual tasks; structured routine exercise; positive reinforcement; therapist-guided cueing	Integrated within each session	Montreal Cognitive Assessment (MoCA)/ Mini-Mental State Examination (MMSE); Dual-Task Gait Test; FIM; Cognition subscore	Use short, clear instructions; reduce environmental distractions; ensure emotional safety
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* Dosage values in Table 4 are illustrative clinical starting points derived from general rehabilitation principles rather than validated encephalitis-specific prescriptions. Where encephalitis-specific evidence was unavailable, interventions and dosage were extrapolated from broader neurological or rehabilitation practice and should be individualized within the IRP.

3.2.2 Individualization, Multidisciplinary Integration, and Outcome Monitoring

The framework should be operationalized through an IRP developed with the patient or proxy and coordinated by the multidisciplinary team under the leadership and medical responsibility of a Physical and Rehabilitation Medicine physician/physiatrist, consistent with the UEMS-PRM European framework [12]. The team may include physical therapists, occupational therapists, speech and language therapists, psychologists or neuropsychologists, neurologists, nurses, and other professionals according to patient needs.

Physical therapy addresses movement-related goals, whereas occupational, communication, swallowing, cognitive, behavioral, and psychosocial needs require coordinated discipline-specific assessment and intervention. Goals and progression should be reviewed jointly as neurological status, fatigue, seizure risk, participation, and functional priorities evolve.

Table 5 provides an illustrative subacute-phase session structure. It is an example for clinical reasoning, not a fixed prescription or evidence of feasibility.

Table 5 Illustrative Therapeutic Session Structure for the Subacute Phase.

Session Component	Therapeutic Focus	Duration (min)	Methods/Techniques	Methodological Notes/Safety Measures
Warm-up and breathing exercises	Preparation; respiratory control; arousal	5-10	Diaphragmatic breathing; gentle upper limb mobilization	Avoid overfatigue; monitor respiratory effort
Passive/active-assisted limb exercises	Joint mobility; tone modulation	10-15	Proprioceptive neuromuscular facilitation (PNF) patterns; task-specific exercises; guided movements	Observe for spastic reactions; adjust range
Balance and postural control	Sitting and standing balance; trunk stability	15-20	Neurodevelopmental therapy (NDT) - Bobath concept facilitation; dynamic weight shifting; ball or cushion work	Ensure safety; therapist support required
Gait training	Initiation of ambulation and weight transfer	10-15	Assisted gait (parallel bars; walker; manual support)	Monitor cardiovascular response; progressive increase
Stretching and relaxation	Cool-down; tone reduction; relaxation	5	Static stretching; guided breathing	End with relaxation to reduce sympathetic load

* The illustrative session structure must be individualized according to the patient's tolerance, fatigue level, neurological status, and individual recovery plan. Goal: Improvement of sitting stability; transfers; verticalisation; initial gait training in a patient with hemiparesis. Illustrative session duration: approximately 60 minutes when tolerated. Frequency and progression should be individualized according to neurological status, fatigue, medical stability, rehabilitation goals, and the IRP; no encephalitis-specific universal frequency or duration has been established.

Outcome monitoring should prioritize functional independence, mobility, gait, balance, and motor control. Secondary domains may include endurance, fatigue, participation, cognitive-motor performance, communication-related limitations, and psychosocial functioning. Measure selection and assessment frequency should reflect patient age, phenotype, baseline ability, goals, and established MCIDs where applicable. The current literature does not support a universal core threshold; development of an encephalitis rehabilitation core outcome set is a priority for future research.

3.2.3 Implications for Future Research

Prospective studies should evaluate the framework's feasibility, safety, acceptability, and effectiveness; stratify results by infectious, autoimmune, and postinfectious etiology and by pediatric or adult population; and report intervention content and dosage transparently. Future work should also define a core set of outcomes spanning motor, functional, cognitive, behavioral, participation, fatigue, and quality-of-life domains.

4. Discussion

This discussion interprets the narrative literature synthesis, explains the clinical rationale for the conceptual framework, and identifies limitations that constrain causal inference and generalizability.

4.1 Overview and Key Findings

This narrative review organizes heterogeneous rehabilitation evidence into a phase-specific conceptual framework for motor and functional recovery after encephalitis. Its contribution is translational: it links reported interventions with functional targets, patient characteristics, outcome monitoring, and multidisciplinary IRP planning. It does not provide clinical validation or evidence of protocol efficacy.

Previous research on post-encephalitic rehabilitation has largely relied on observational cohorts, small case series, and case reports with heterogeneous populations and interventions [5, 42]. This limits comparison, generalizability, and causal attribution. The framework offers a structured way to organize that evidence across recovery phases while preserving the need for patient-specific adaptation.

Standardized measures such as the FIM, Barthel Index, BBS, MAS, gait tests, and age-appropriate cognitive or participation measures may support longitudinal monitoring, but instrument choice and interpretation should be individualized. The authors present evidence-derived observations and clinical recommendations separately.

4.2 Critical Appraisal and Comparison with Existing Literature

The conceptual framework builds on a fragmented evidence base. Most included clinical reports describe change during multidisciplinary rehabilitation rather than the isolated effect of physical therapy [4, 6]. The framework's novelty lies in transparent clinical organization, not in claiming new therapeutic efficacy.

Compared with reports focused on individual techniques, the framework places candidate modalities within a continuum of goals, safety considerations, and outcome monitoring. The

proposed dosage values are clinical starting points requiring individualized adjustment and empirical study; they should not be interpreted as validated encephalitis-specific prescriptions.

Early mobilization after medical stabilization and repetitive, goal-directed practice are biologically plausible principles used in broader neurorehabilitation and have also been described in encephalitis rehabilitation reports [3-6, 10, 11]. Extrapolation from stroke or traumatic brain injury should nevertheless be cautious because encephalitis-specific inflammatory, cognitive, behavioral, seizure-related, autonomic, and fatigue profiles may alter tolerance and recovery.

No prospective implementation, patient-level testing, or formal safety evaluation was performed in this study. Accordingly, the framework's feasibility, acceptability, safety, and effectiveness remain to be established in appropriately designed clinical research.

4.3 Limitations and Future Directions

The principal limitation is the narrative and conceptual design. The search was structured but was not conducted as a systematic review, and no formal risk-of-bias or certainty-of-evidence assessment was undertaken. The evidence base was dominated by observational studies, case series, and case reports, with substantial clinical and methodological heterogeneity and no randomized trials specifically evaluating physical therapy after encephalitis. These limitations preclude causal conclusions.

The framework may overgeneralize across infectious, autoimmune, and postinfectious encephalitis. Etiology, age, lesion pattern, cognitive and behavioral involvement, seizure history, fatigue, autonomic and cardiorespiratory status, premorbid function, complications, resources, and rate of recovery may all require subtype- and setting-specific adaptation.

Outcome reporting was inconsistent and rarely incorporated established MCIDs, which prevented a defensible semi-quantitative synthesis across studies. Concurrent medical and multidisciplinary interventions also make it difficult to isolate the contribution of physical therapy. Future research should use transparent intervention reporting, predefined primary and secondary outcomes, and appropriate comparison groups.

Prospective multicenter studies should stratify infectious, autoimmune, and postinfectious subtypes; distinguish pediatric and adult populations; assess motor, cognitive, behavioral, participation, fatigue, and quality-of-life domains; and develop a core outcome set for encephalitis rehabilitation. Long-term follow-up is needed to determine sustainability and community reintegration [6].

5. Conclusions

Encephalitis can cause complex motor, cognitive, behavioral, and participation restrictions requiring individualized multidisciplinary rehabilitation. The available observational and case-based literature describes improvements in mobility, balance, motor control, and functional independence during multidisciplinary rehabilitation after medical stabilization. However, heterogeneous populations, concurrent treatments, small samples, inconsistent outcome reporting, and the absence of encephalitis-specific randomized trials prevent causal or quantitative conclusions.

The proposed conceptual framework translates recurring literature-based principles into phase-specific, phenotype-responsive considerations for the IRP. It is a flexible clinical reasoning aid rather

than a standardized or validated treatment protocol, and it requires coordination under rehabilitation medical supervision and adaptation to etiology, age, impairments, tolerance, goals, and care setting.

Future prospective studies should evaluate feasibility, safety, acceptability, and effectiveness; define intervention dosage and progression criteria; and use a core set of motor, functional, cognitive, behavioral, participation, fatigue, and quality-of-life outcomes.

Overall, the framework offers a transparent, clinically oriented synthesis of current knowledge and a basis for future validation. It should not be interpreted as evidence of established treatment efficacy.

Abbreviations

10-MWT	10-Meter Walk Test
ADL	Activities of Daily Living
BBS	Berg Balance Scale
CRS-R	Coma Recovery Scale-Revised
EEG	Electroencephalography
FES	Functional Electrical Stimulation
FIM	Functional Independence Measure
FMA	Fugl-Meyer Assessment
fMRI	Functional Magnetic Resonance Imaging
GCS	Glasgow Coma Scale
K-MBI	Korean Modified Barthel Index
MAS	Modified Ashworth Scale
MMSE	Mini-Mental State Examination
MoCA	Montreal Cognitive Assessment
mRS	Modified Rankin Scale
NDT	Neurodevelopmental Therapy
PNF	Proprioceptive Neuromuscular Facilitation
RCT	Randomized Controlled Trial
TUG	Timed Up and Go Test
VR	Virtual Reality
WeeFIM	Functional Independence Measure for Children
WNND	West Nile Neuroinvasive Disease

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Competing Interests

The authors have declared that no competing interests exist.

AI-Assisted Technologies Statement

Artificial intelligence (AI) tools were used solely for basic grammar correction and language refinement in the preparation of this manuscript. Specifically, OpenAI’s ChatGPT was employed to improve the readability and linguistic clarity of the English text. All scientific content, data interpretation, and conclusions were developed independently by the authors. The authors have thoroughly reviewed and edited the AI-assisted text to ensure its accuracy and accept full responsibility for the content of the manuscript.

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