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Motor Recovery and Structural Brain Improvement with Hydrogen-Oxygen Nanobubble (NB-HHO) Therapy in Acute Thrombotic Stroke: A Case Report

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Case Report

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Abstract

Background

Ischemic stroke is a leading cause of long-term disability and standard therapies often fail to achieve complete recovery, particularly in patients with vascular comorbidities. Hydrogen-Oxygen Nanobubble (NB-HHO) therapy has emerged as a novel adjunct with antioxidant, anti-inflammatory, vascular protective, and neuroplasticity-enhancing properties.

Case Presentation: A 48-year-old woman with hypertension, dyslipidemia and type 2 diabetes presented with a first-ever acute thrombotic stroke and complete left hemiplegia (NIHSS 11, MMSE 28). She underwent 50 intravenous NB-HHO infusions over three months, combined with physiotherapy. Early cranial nerve recovery was observed by session 4–6, followed by sequential motor milestones culminating in unassisted stepping by session 43. Quantitative MRI showed significant corticospinal tract expansion, new fiber tract formation and improved global efficiency. NIHSS declined from 11 to 6, while MMSE remained stable. Laboratory markers also improved. No major adverse events occurred.

Discussion

Clinical, imaging, and metabolic improvements correlated closely, supporting NB-HHO's potential mechanisms: ROS scavenging, vascular repair, metabolic regulation, and neuroplasticity. The temporal relationship between therapy sessions and milestones suggests a synergistic effect with physiotherapy.

Conclusion

NB-HHO therapy was safe, well tolerated, and associated with accelerated motor and cranial nerve recovery in acute thrombotic stroke. Larger randomized trials are warranted to validate efficacy and establish standardized protocols.

1. Introduction

Ischemic stroke accounts for nearly 80% of all stroke cases worldwide and remains a leading cause of long-term disability and mortality [1,2]. Despite major advances in acute reperfusion therapies such as intravenous thrombolysis and mechanical thrombectomy, their application is restricted by narrow therapeutic time windows, limited availability in many healthcare settings, and potential complications [2]. Beyond the acute phase, stroke management primarily relies on secondary prevention and rehabilitative strategies, yet functional recovery often remains incomplete [3–6]. This is particularly evident in patients with vascular comorbidities such as hypertension, diabetes mellitus and dyslipidemia, which are known to impair neurovascular repair and neuroplasticity [1,2].

Hydrogen-Oxygen Nanobubble (NB-HHO) therapy represents a novel adjunctive approach in this context [7,8]. From a mechanistic standpoint, ischemic stroke may involve excess reactive oxygen species (ROS), mitochondrial stress, inflammatory signaling, endothelial dysfunction, reduced nitric oxide bioavailability,

platelet activation, and microvascular injury, all of which may amplify thrombotic and post-ischemic tissue damage [8]. Molecular hydrogen has been proposed as a selective antioxidant and cytoprotective medical gas because it may modulate highly cytotoxic ROS while preserving physiological ROS required for normal cell signaling [7,8]. Hydrogen-related interventions may also attenuate inflammatory signaling, support mitochondrial function, and protect vascular endothelium [7,8]. Traditional hydrogen delivery methods may be limited by solubility, stability, and tissue penetration, while nanobubble technology may theoretically improve gas stability and bioavailability [7].

Preclinical evidence suggests that hydrogen inhalation may promote neurogenesis and functional recovery after cerebral ischemia [8]. Evidence from metabolic-disease literature also suggests that molecular hydrogen may influence metabolic regulation [7]. Nevertheless, evidence in stroke patients remains limited. This report provides case-based evidence supporting NB-HHO as an adjunct in post-stroke rehabilitation treatment, correlating clinical recovery with quantitative neuroimaging findings.

2. Case Presentation

A 48-year-old married woman with a 10-year history of hypertension, dyslipidemia, and type 2 diabetes mellitus presented on April 7, 2025, with first attack acute thrombotic stroke. On admission, she exhibited complete left hemiplegia, left facial UMN weakness and dysarthria. Neurological scores were NIHSS 11 and MMSE 28 and she was wheelchair-dependent.

Serial NIHSS scores declined progressively from 11 at admission to 6 post-therapy, while MMSE remained stable at 28–30 (Table 1, Fig. 1).

Table 1
Serial NIHSS and MMSE progression during NB-HHO therapy.

Examination	Date	NIHSS score	MMSE score
1	6 May 2025	11	28
10	24 May 2025	10	28
22	3 Jun 2025	7	30
30	16 Jun 2025	6	30
40	28 Jun 2025	6	30
50	14 Jul 2025	6	30

NIHSS declined from 11 at admission to 6 after therapy, reflecting significant neurological recovery, while MMSE remained stable at 28–30, indicating preserved cognitive function throughout treatment.

The patient underwent 50 intravenous NB-HHO infusions from May to July 2025, combined with routine physiotherapy. Standard medications included candesartan 8 mg OD, atorvastatin 20 mg OD, citicoline 500 mg BID, and cilostazol 100 mg OD, dapagliflozin 10 mg OD.

3. Clinical Improvement

Progressive functional recovery was documented on the left hemiplegic side. Early cranial nerve improvements were observed by session 4–6, with restoration of facial symmetry, clearer articulation and minimal thumb and thigh movement. Motor milestones are summarized in Table 2.

Table 2
Motor recovery milestones on the left hemiplegic side during NB-HHO therapy.

Session	Date	Clinical milestone
4	8 May	Improved facial symmetry (cranial nerve VII), smile line reappeared, minimal thumb movement
6	15 May	Clearer speech articulation (cranial nerve XII), minimal thigh movement
11	21 May	Standing with assistance; biceps/triceps contraction
23	4 June	Stepping with assistance; foot dorsiflexion
35	23 June	Independent standing; finger movement
43	3 July	Independent stepping

Progressive neurological improvements on the left hemiplegic side, including early recovery of cranial nerve VII and XII (facial symmetry and speech articulation), followed by sequential motor milestones in upper and lower extremities. Recovery culminated in independent standing and unassisted stepping within three months.

3.1. Structured Physiotherapy Intervention

A structured, goal-oriented physiotherapy program was delivered alongside the 50- session NB-HHO protocol. The rehabilitation plan was organized in progressive phases according to motor recovery, trunk control, balance capacity, and gait readiness. In the initial phase, therapy focused on prevention of immobility-related complications, maintenance of joint range of motion (ROM), sensory re-education, early muscle facilitation, facial neuromuscular stimulation, and basic trunk activation. The documented interventions included facial massage for left upper motor neuron facial weakness, passive and active-assisted ROM exercises, positioning, abdominal core activation, bridging exercises, and sensory stimulation using rough, soft, sharp, blunt, warm, and cold stimuli. Electrical modalities documented in the physiotherapy chart included low-frequency galvanic/TENS stimulation for facial facilitation and TENS/electrical stimulation at 20 Hz for motor facilitation.

As the patient gained proximal activation and postural control, the program progressed to hip abduction-adduction, heel slide, finger and wrist extension exercises, approximation, supported weight bearing, trunk control in sitting, sit-to-stand training, supported standing, straight-leg raise, weight shifting, step forward-backward training, tiptoe exercise, side stepping, and gait training. Therapy sessions were

generally documented as 60-minute sessions. The progression from bed-level activation to transfer, standing, pre-gait, and gait training is summarized in Table 3. Timeframe Documented

Table 3
Structured physiotherapy program delivered during the 50-session NB-HHO treatment course.

Phase	Sessions	Therapeutic objective	Core interventions	Documented modality/tools
Early facilitation	1–10	Maintain ROM, prevent immobility, sensory re-education and early trunk/limb activation; improve facial symmetry.	Facial massage; passive/active-assisted ROM; positioning; abdominal core; bridging; trunk control and sitting; sensory stimulation.	Galvanic/TENS facial stimulation; TENS/electrical stimulation 20 Hz; sensory tools.
Activation and transfer	11–24	Improve proximal limb activation, sitting balance, supported standing, transfers, and paretic-side weight bearing.	Heel slide; finger/wrist extension; approximation; supported weight bearing; sit-to-stand; supported standing; straight-leg raise; weight shifting.	Electrical stimulation/TENS; therapist-assisted task-specific training.
Pre-gait	25–34	Improve dynamic standing control, lateral weight transfer, and readiness for stepping.	Sit-to-stand without hand support; supported standing; tiptoe; forward/backward step; side stepping.	Progressive task-specific practice according to tolerance and safety.
Gait and mobility	35–50	Improve independent standing, dynamic balance, stepping, and functional walking.	Side stepping; gait training; unsupported standing; step initiation and walking practice.	Therapist-supervised gait and balance-oriented practice.

3.2. Functional Independence and Balance Assessments

Functional recovery was evaluated using serial Barthel Index and Berg Balance Scale (BBS) assessments at therapy sessions 1, 10, 20, 30, 40, and 50. These measures were added to objectively complement neurological scores and motor milestones by documenting activities of daily living and balance-related fall risk.

Table 4
Serial Barthel Index scores during NB-HHO therapy and physiotherapy.

Session	Barthel Index	Dependence category	Clinical interpretation
1	30	Severe	Marked dependence for transfers, mobility, toileting, bathing, and stairs.
10	45	Severe	Early gains, particularly continence/toileting, but major assistance remained necessary.
20	55	Severe	Improved transfer and mobility, but ADL independence remained limited.
30	55	Severe	Relative plateau despite ongoing motor recovery.
40	65	Moderate	Meaningful improvement in transfer and mobility.
50	70	Moderate	Improved ADL independence, with assistance still needed in selected domains.

The Barthel Index is a standardized measure of activities of daily living. The Barthel Index increased from 30 at therapy session 1 to 70 at therapy session 50, indicating a transition from severe dependence to moderate dependence. The most relevant gains were observed in urinary continence, toilet use, transfer ability, mobility, and limited stair negotiation.

Table 5
Serial Berg Balance Scale scores during NB-HHO therapy and physiotherapy.

Session	BBS score	Risk category	Clinical interpretation
1	0/56	High fall risk / severe impairment	No functional standing balance documented.
10	4/56	High fall risk / severe impairment	Very early postural control only.
20	5/56	High fall risk / severe impairment	Minimal balance gain; standing unsafe without assistance.
30	18/56	High fall risk / severe impairment	Emerging transfer and standing, but high fall risk persisted.
40	26/56	Moderate fall risk / moderate impairment	Improved transfer, unsupported standing, and postural control.
50	31/56	Moderate fall risk / moderate impairment	Improved balance; complex balance tasks remained limited.

The Berg Balance Scale is a standardized measure of functional balance. The BBS score increased from 0/56 to 31/56, reflecting improvement from severe balance impairment/high fall risk to moderate balance impairment/moderate fall risk. Despite this improvement, tasks requiring advanced dynamic

balance, such as alternate foot placement and single-leg stance, remained limited at the end of observation (Fig. 2).

3.3. Manual Muscle Testing Progression

Serial Manual Muscle Testing (MMT) (Fig. 3) was used to quantify segmental motor recovery of the left hemiplegic upper and lower extremities throughout the combined NB- HHO and physiotherapy program. The serial MMT profile showed early proximal

activation, followed by gradual improvement of distal and weight-bearing motor components. Upper-extremity recovery was most evident at the shoulder and elbow, whereas lower-extremity recovery showed a more pronounced and functionally relevant increase across hip, knee, and ankle muscle groups, consistent with the observed progression from assisted standing to gait training.

MMT scores are presented as actual segmental grades rather than averaged values, because segment-specific reporting is more clinically interpretable and better reflects the patient's motor recovery pattern. The format below lists upper-extremity scores as shoulder/elbow/wrist/fingers and lower-extremity scores as hip/knee/ankle/toes.

Table 6
Serial segmental MMT progression of the left upper and lower extremities during NB-HHO therapy with physiotherapy.

Session group	Upper MMT (shoulder/elbow/wrist/fingers)	Lower MMT (hip/knee/ankle/toes)	Clinical interpretation
1–5	0/0/0/0	0/0/0/0	Complete left hemiplegia; no voluntary movement.
6–9	1/1/1/1	2/1/1/1	Early trace upper-limb contraction and proximal lower-limb activation.
10	2/1/1/1	2/1/1/1	Early active movement with gravity eliminated, especially shoulder and hip.
11	2/1/1/1	2/2/2/1	Improved lower-limb activation; assisted standing began.
12–20	2/2/1/1	3/2/2/1	Better proximal upper-limb control and antigravity hip movement.
21	2/2/1/1	3/2/2/1	Gains maintained with better standing tolerance.
22	2/2/1/1	3/3/2/1	Knee strength reached antigravity level.
23–24	2/2/1/1	3/3/3/1	Broader antigravity recovery; assisted stepping began.
25–27	2/2/1/1	3/3/3/1	Lower-limb recovery continued; dorsiflexion strengthened.
28–34	2/2/1/1	3/3/3/1	Recovery maintained; sit-to-stand and side-stepping progressed.
35–42	2/2/2/2	3/3/3/2	Wrist/finger movement emerged; gait training began.
43–50	2/2/2/2	3/3/3/2	Stepping without hand support began; distal upper-limb weakness persisted.

Clinical note: The segmental MMT findings are concordant with the milestone-based clinical recovery pattern. Lower-extremity recovery was more prominent than upper-extremity recovery, with hip, knee, and ankle strength improving to 3/5 by the later treatment phase, corresponding to assisted stepping, independent standing, and initiation of unassisted stepping. Upper-extremity recovery remained partial and predominantly proximal, consistent with minimal finger movement and persistent distal weakness.

3.4. Laboratory Findings

Laboratory monitoring showed HbA1c improved from 8.4% (May) to 6.3% (June), while LDL decreased from 135.7 to 95.7 mg/dL. Renal and hepatic function remained stable (Fig. 4).

3.5. Neuroimaging Findings

Quantitative MRI (July 18, 2025) revealed significant structural changes: corticospinal tract volume increased from 4,891 to 16,204 mm^3; mean FA (fractional anisotropy) improved from 0.49 to 0.54; global efficiency rose from 0.46 to 0.54; and new fiber tracts emerged (0 → 768 mm^3), suggesting neural reorganization and axonal sprouting (Fig. 5).

4. Discussion

This case illustrates accelerated and multidimensional recovery in a patient with acute thrombotic stroke and multiple vascular comorbidities. Severe baseline hemiplegia and comorbid hypertension and diabetes are clinically relevant because vascular risk factors can worsen neurovascular injury and functional prognosis after stroke [1,2]. The use of a phased, task-specific rehabilitation program was consistent with contemporary stroke rehabilitation principles [3–6]. The potential adjunctive role of NB-HHO remains hypothesis-generating and biologically plausible based on molecular hydrogen literature [7,8]. In this patient, the recovery trajectory from minimal thumb movement to independent standing and unassisted stepping occurred during a structured rehabilitation course aligned with contemporary stroke rehabilitation principles [3–6].

The stepwise clinical improvements are further illustrated in Fig. 4, which summarizes the temporal dynamics of neurorecovery. Early cranial nerve gains were evident by the fourth and sixth infusions, with restoration of facial symmetry and clearer speech articulation, followed by sequential motor milestones culminating in unassisted stepping. These findings suggest that NB-HHO may facilitate corticobulbar as well as corticospinal recovery, broadening its neurorestorative potential.

Serial NIHSS scores improved from 11 (moderate stroke) at admission to 6 (mild stroke) at the end of therapy, confirming objective neurological recovery, while MMSE remained stable at 28–30, indicating preserved cognitive function. Importantly, the progression of clinical milestones—standing with assistance at session 11, assisted stepping at session 23, and independent standing at session 35—closely paralleled quantitative MRI findings, including corticospinal tract expansion (4,891 → 16,204

mm³) and increased global efficiency (0.46 → 0.54). This concordance reinforces the interpretation that NB-HHO facilitated both structural and functional reorganization of motor pathways.

The therapeutic plausibility of NB-HHO is supported by several interconnected mechanisms relevant to ischemic and thrombotic brain injury [7,8]. First, selective modulation of cytotoxic ROS may reduce oxidative damage to neurons, glia, mitochondrial membranes, and vascular endothelium while preserving physiological redox signaling [7,8]. Second, attenuation of ROS-mediated endothelial dysfunction may improve nitric oxide bioavailability, microvascular regulation, and capillary integrity, thereby theoretically limiting the pro-thrombotic and inflammatory environment after ischemic stroke [7,8]. Third, mitochondrial support may improve cellular energy metabolism in post- ischemic tissue, which is essential for neuronal survival and activity-dependent neuroplasticity [7]. Fourth, the observed metabolic improvement in HbA1c and LDL may indirectly support vascular repair and rehabilitation response. Finally, the emergence of new fiber tracts and improved network efficiency on quantitative MRI provides structural support for a neuroplasticity-oriented interpretation, although causality cannot be established in a single case.

NB-HHO was safe and well tolerated, with only mild transient dizziness reported. Laboratory monitoring confirmed stable renal and hepatic function. The consistent metabolic, vascular and neurological improvements suggest systemic as well as neural benefits.

The addition of structured rehabilitation data strengthens the clinical interpretation of this case. The physiotherapy program followed a phased, task-specific trajectory, progressing from ROM preservation, sensory re-education, trunk activation, and supported weight bearing to sit-to-stand, dynamic standing, side stepping, and gait training. This progression paralleled the observed motor milestones and provides a plausible rehabilitative framework for translating neural recovery into functional gains [3–6].

The Barthel Index and BBS findings further demonstrate that recovery was not limited to isolated motor signs. The Barthel Index was used to quantify activities of daily living [9]. The Berg Balance Scale was used to quantify functional balance and fall-risk- related postural control [10]. In this case, Barthel Index improved from 30 to 70, indicating a transition from severe to moderate dependence, while BBS improved from 0/56 to 31/56, indicating improvement from severe balance impairment/high fall risk to moderate balance impairment/moderate fall risk. These functional gains were temporally consistent with the transition from wheelchair dependence and complete hemiplegia to supported standing, independent standing, and initial unassisted stepping [3–6,9,10].

Nevertheless, these functional measures should be interpreted cautiously. The Barthel Index, BBS, and MMT trends were derived from clinical documentation and therapy charts rather than a prospective blinded assessment protocol. In addition, the patient received multimodal rehabilitation, pharmacotherapy, metabolic optimization, and NB-HHO therapy concurrently; therefore, causality cannot be attributed to a single intervention. Future studies should incorporate prospectively scheduled standardized functional scales, blinded assessors, and predefined rehabilitation protocols.

The serial segmental MMT findings provide an additional impairment-level correlate for the functional gains observed on the Barthel Index and Berg Balance Scale. The earlier and larger improvement in lower-extremity MMT supports the clinical observation that recovery was driven primarily by restoration of antigravity and weight- bearing motor capacity, whereas upper-extremity recovery remained more limited and predominantly proximal. This dissociation is important for interpretation of the case, as improvement in ambulation-related outcomes may occur before complete distal upper-limb recovery in patients undergoing intensive post-stroke rehabilitation [3–6].

Limitations of this report include its single-case, uncontrolled design, the absence of biomarker assessment for oxidative stress and inflammation, and limited follow-up to assess the durability of recovery. Nevertheless, the integration of clinical, neuroimaging, and functional scale data strengthens the validity of the observed outcomes, consistent with current recommendations to use standardized outcome measures in stroke rehabilitation.

Future directions should include randomized controlled trials with standardized NB-HHO protocols, advanced neuroimaging (connectivity and perfusion studies), and

biomarker profiling to clarify mechanisms and confirm efficacy in diverse stroke populations. Biomarker panels should specifically include oxidative-stress and endothelial markers, such as ROS-related oxidative damage markers, inflammatory markers, nitric oxide-related indices, and mitochondrial/metabolic markers, so that the proposed ROS- endothelial-mitochondrial mechanism can be tested prospectively.

5. Conclusions

NB-HHO therapy was safe, well tolerated, and associated with accelerated recovery of motor and cranial nerve function, preservation of cognitive performance, and evidence of structural brain repair in a patient with acute thrombotic stroke. These clinical and functional outcomes were assessed using standardized measures aligned with stroke rehabilitation recommendations. The proposed ROS-modulating, metabolic, and neurorepair mechanisms remain biologically plausible but require prospective validation. Larger controlled trials are warranted to confirm efficacy, clarify mechanisms, and establish standardized treatment protocols.

Abbreviations

The following abbreviations are used in this manuscript:

ADL Activities of daily living

BBS Berg Balance Scale

BID Twice Daily

FA Fractional Anisotropy

HbA1c Glycated Hemoglobin

MMSE Mini-Mental State Examination

MMT Manual Muscle Testing

MRI Magnetic Resonance Imaging

NB-HHO Hydrogen–Oxygen Nanobubble

NIHSS National Institutes of Health Stroke Scale

OD Once Daily

ROM Range Of Motion

ROS Reactive Oxygen Species

TENS Transcutaneous Electrical Nerve Stimulation

UMN Upper Motor Neuron.

Declarations

Ethics Approval:

This retrospective case report was prepared using clinical records. Formal ethics committee approval was not obtained for this report. Patient confidentiality was maintained.

Informed Consent

Statement: Written informed consent was obtained from the patient for publication of this paper and the anonymized clinical information contained herein.\

Conflicts of Interest:

The authors declare no conflict of interest.

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Author Contributions:

Conceptualization, M.M.A.D. and A.T.H.; methodology, M.M.A.D., R.A. and A.T.H.; investigation, M.M.A.D., R.A., L.A.A., A.T.H., G.S., T.T., and E.E.S.; data curation, M.M.A.D., R.A., L.A.A., T.T.; clinical supervision, A.T.H., R.A., S., G.S., and E.E.S.; validation, A.T.H., G.S., E.E.S., and S.; writing—original draft preparation, M.M.A.D., A.T.H., and L.A.A.; writing—review and editing, A.T.H., R.A., G.S., E.E.S., and S.; visualization, M.M.A.D. and A.T.H.; supervision, A.T.H., R.A., S., G.S., and E.E.S. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement:

All data relevant to this case report are included in the manuscript. Further patient-level clinical records are not publicly available to protect the patient's privacy and confidentiality.

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Figures

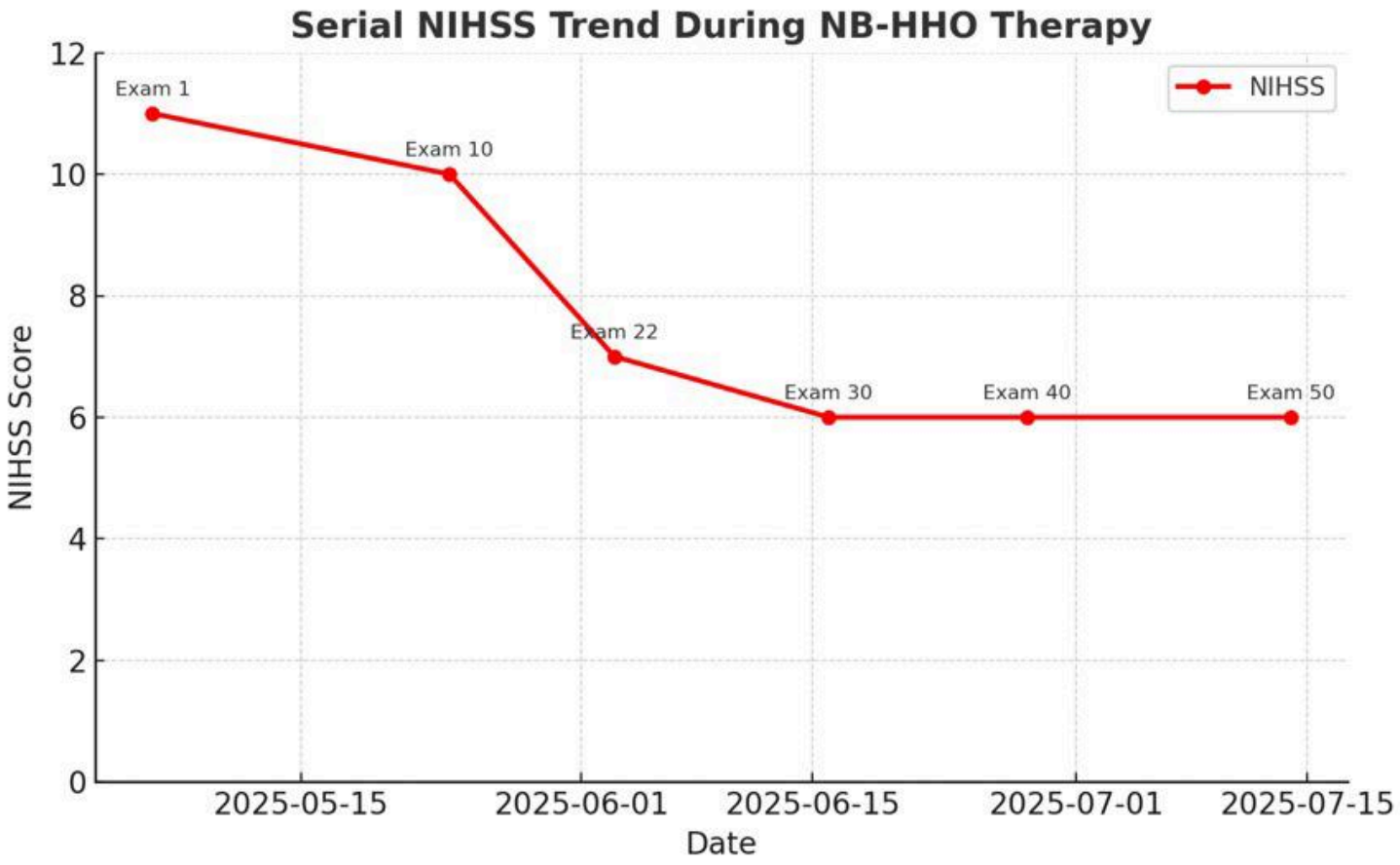


Figure 1

(A) Serial NIHSS progression during NB-HHO therapy Temporal dynamics of neurological recovery documented with standardized scales. NIHSS scores declined from 11 at admission to 6 after therapy, indicating significant improvement in motor and cranial nerve function. MMSE scores remained stable at 28–30, reflecting preserved cognitive function throughout the recovery period.

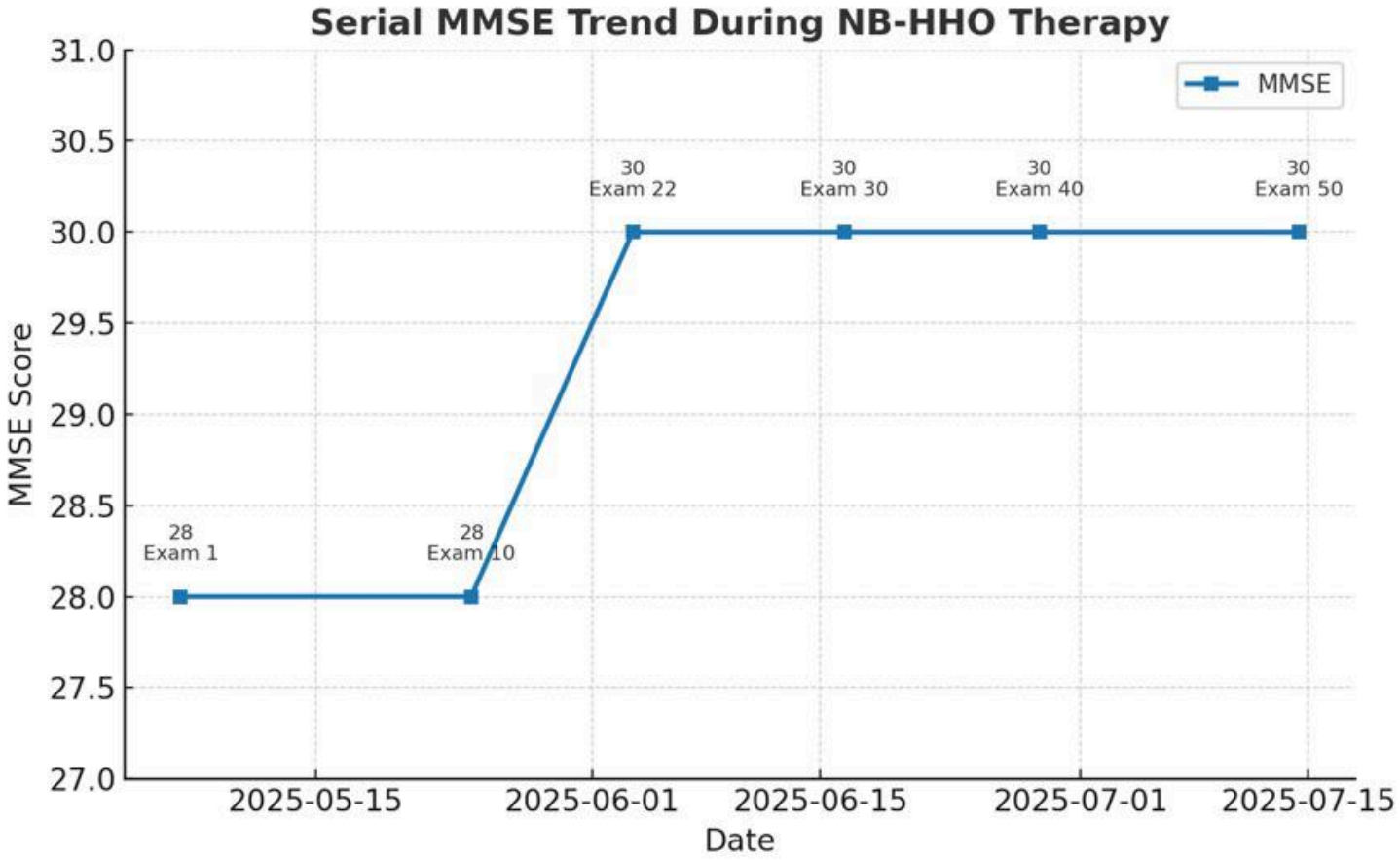


Figure 2

(B) MMSE progression during NB-HHO therapy Temporal dynamics of neurological recovery documented with standardized scales. NIHSS scores declined from 11 at admission to 6 after therapy, indicating significant improvement in motor and cranial nerve function. MMSE scores remained stable at 28–30, reflecting preserved cognitive function throughout the recovery period.

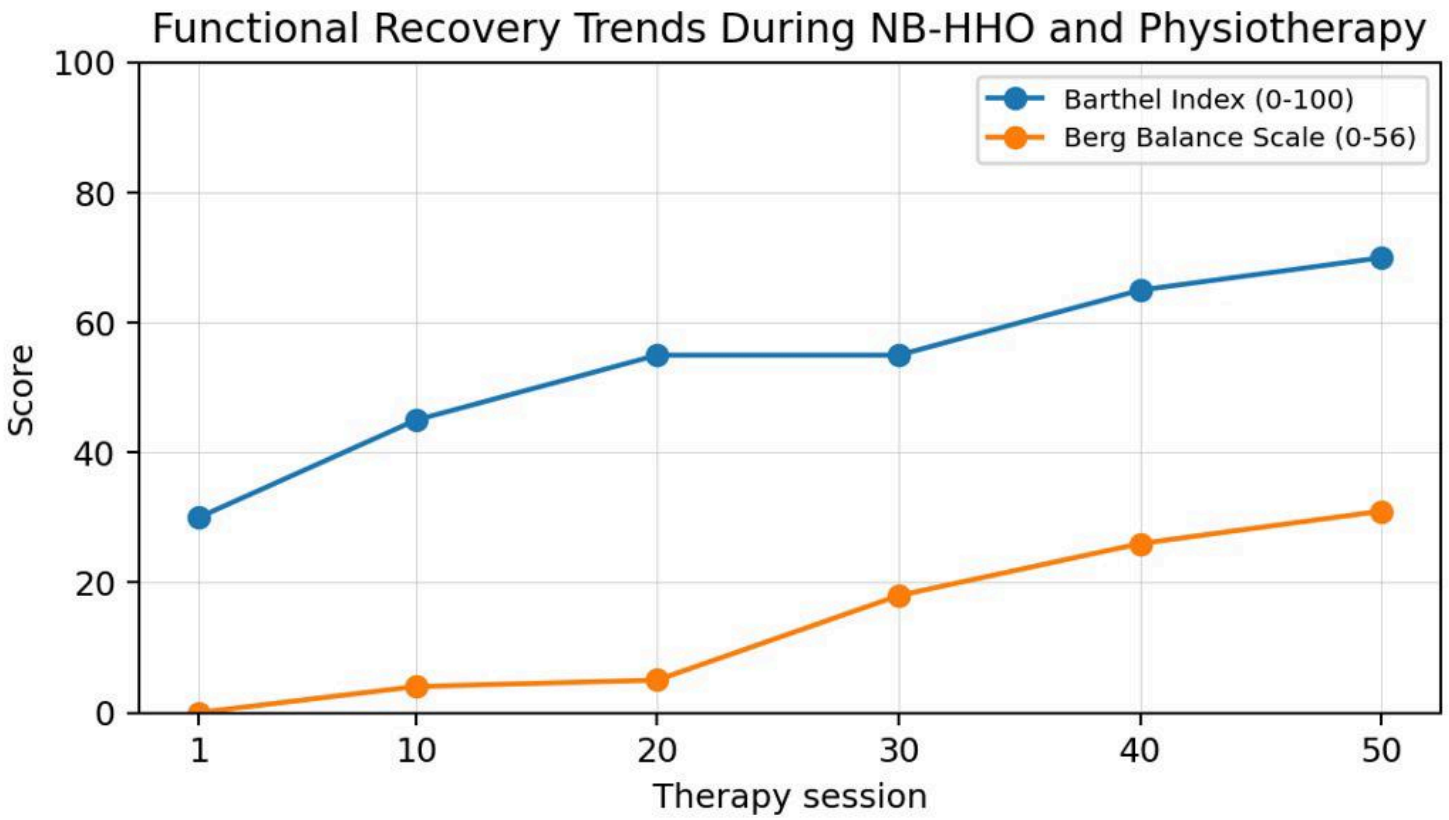


Figure 3

Trends in Barthel Index and Berg Balance Scale scores during the combined NB-HHO and physiotherapy program.

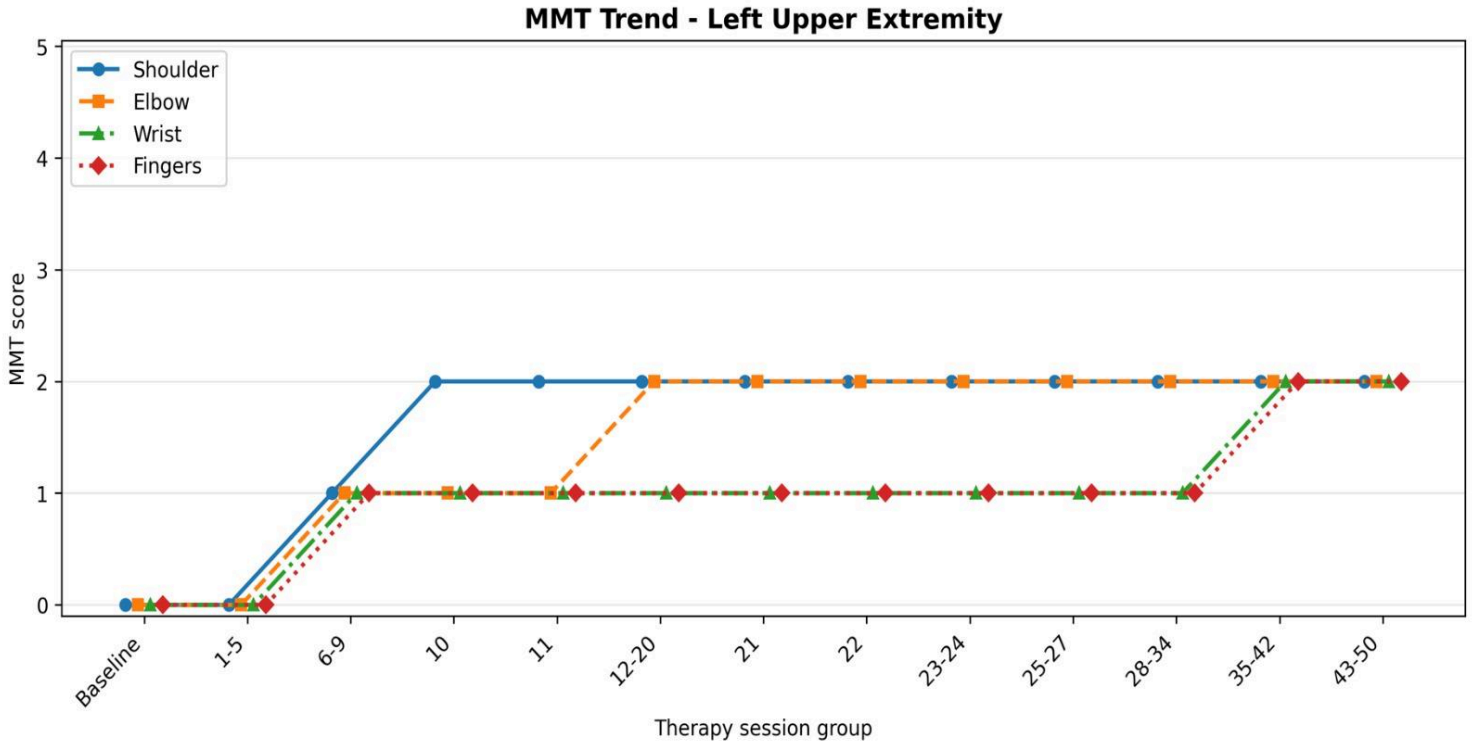


Figure 4

A. Serial segmental MMT trend of the left upper extremity during the combined NB-HHO and physiotherapy program. Markers are horizontally offset only to improve visibility where values overlap; y-values represent actual MMT scores

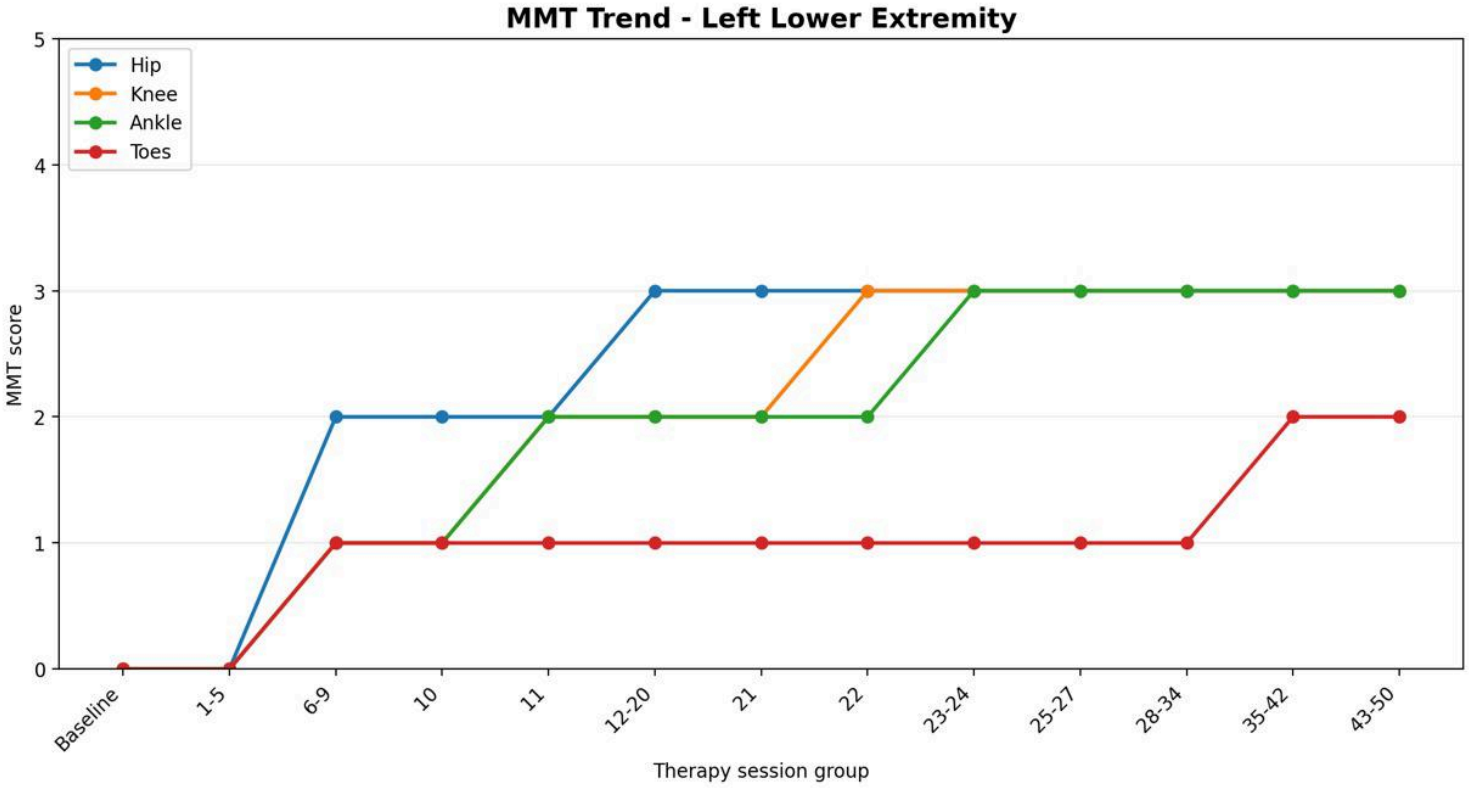


Figure 5

B. Serial segmental MMT trend of the left lower extremity during the combined NB-HHO and physiotherapy program. The segmental MMT trends indicate that lower-extremity recovery progressed earlier and reached higher motor grades than upper-extremity recovery. This pattern is clinically consistent with the patient's rehabilitation milestones, including supported standing, independent standing, and initiation of unassisted stepping during later treatment sessions.

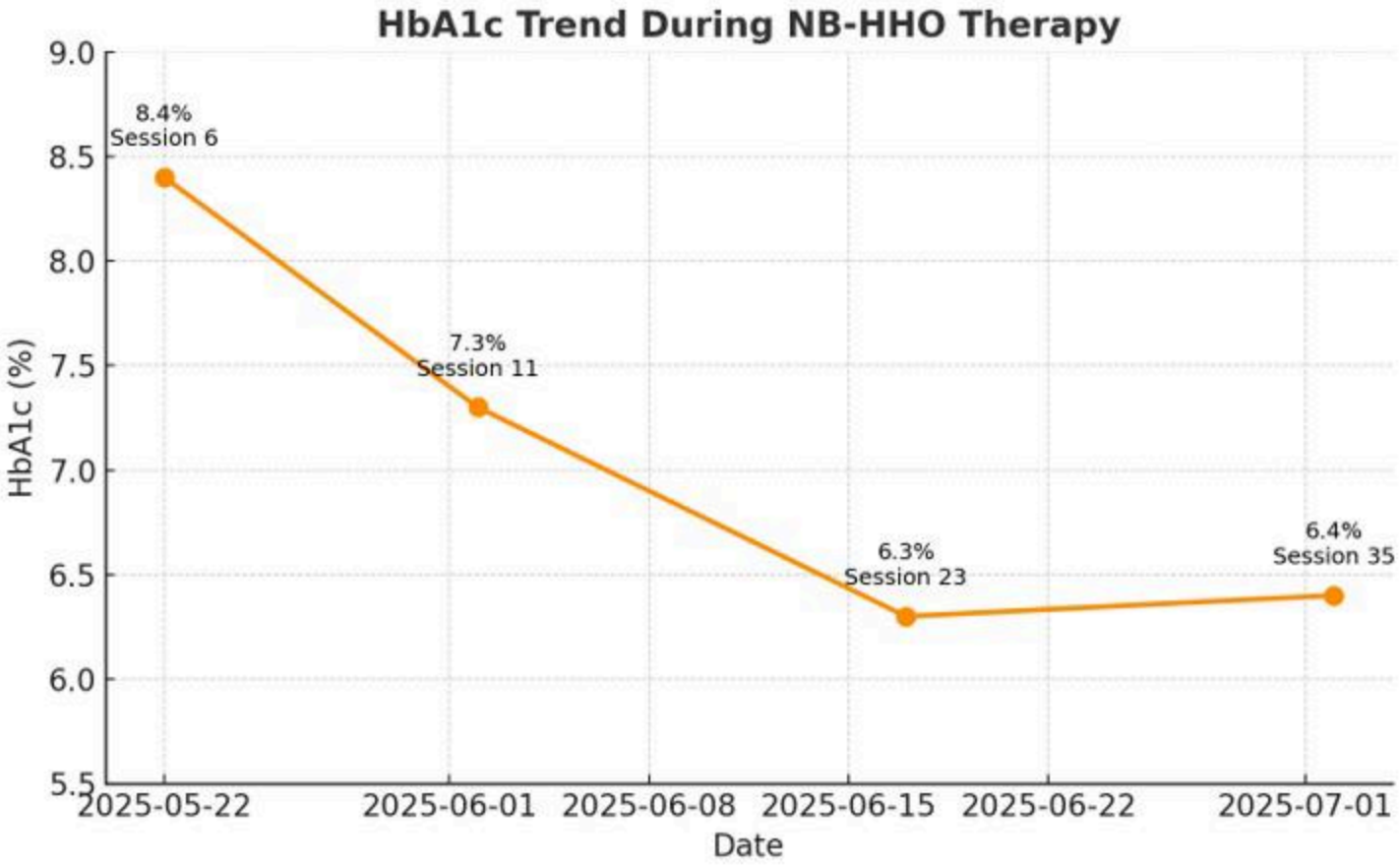


Figure 6

(A) HbA1c trends during NB-HHO therapy HbA1c decreased from 8.4% to 6.3%, while LDL cholesterol declined from 135.7 mg/dL to 95.7 mg/dL across treatment sessions, indicating systemic metabolic benefit.

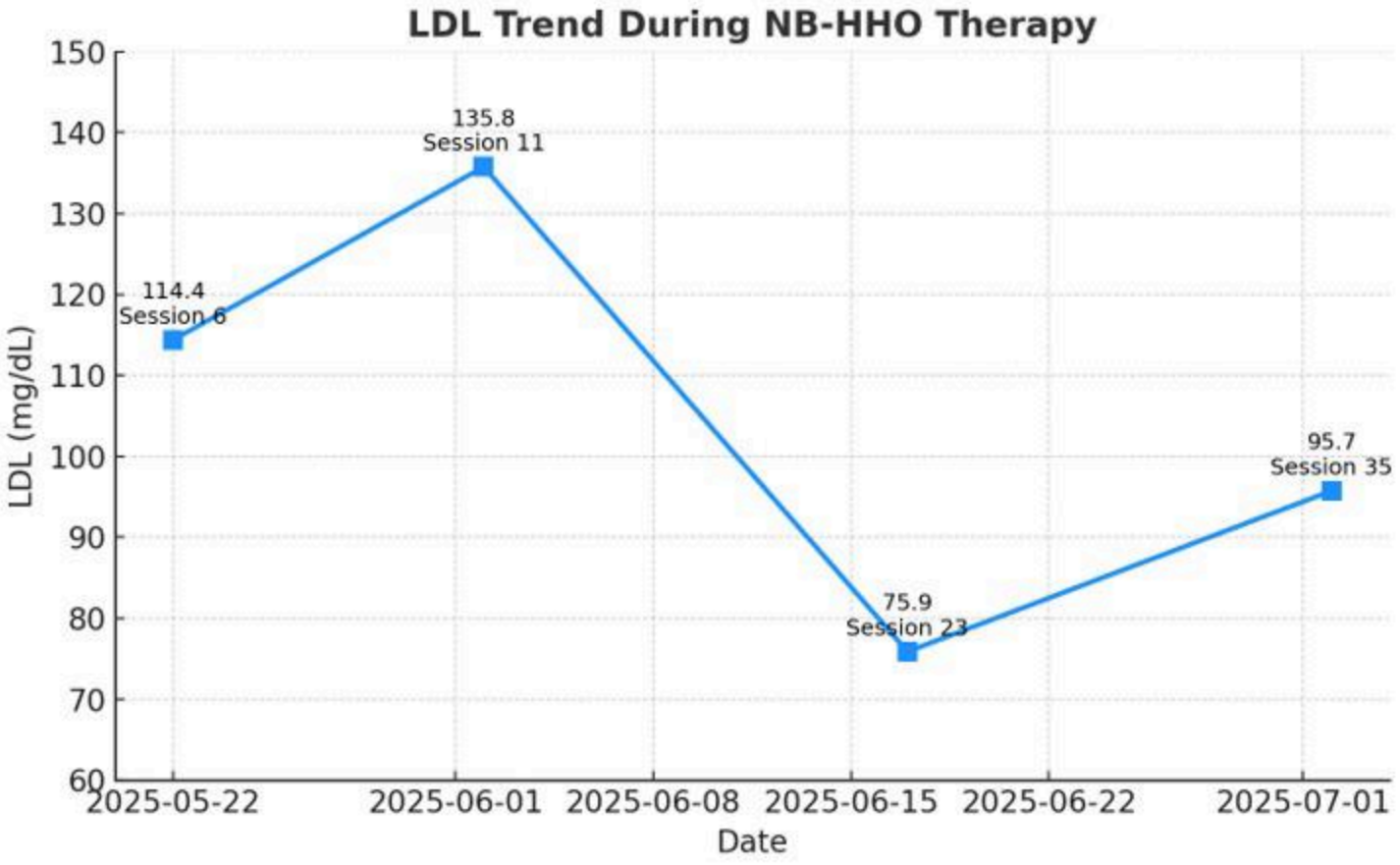


Figure 7

(B) LDL trends during NB-HHO therapy HbA1c decreased from 8.4% to 6.3%, while LDL cholesterol declined from 135.7 mg/dL to 95.7 mg/dL across treatment sessions, indicating systemic metabolic benefit.

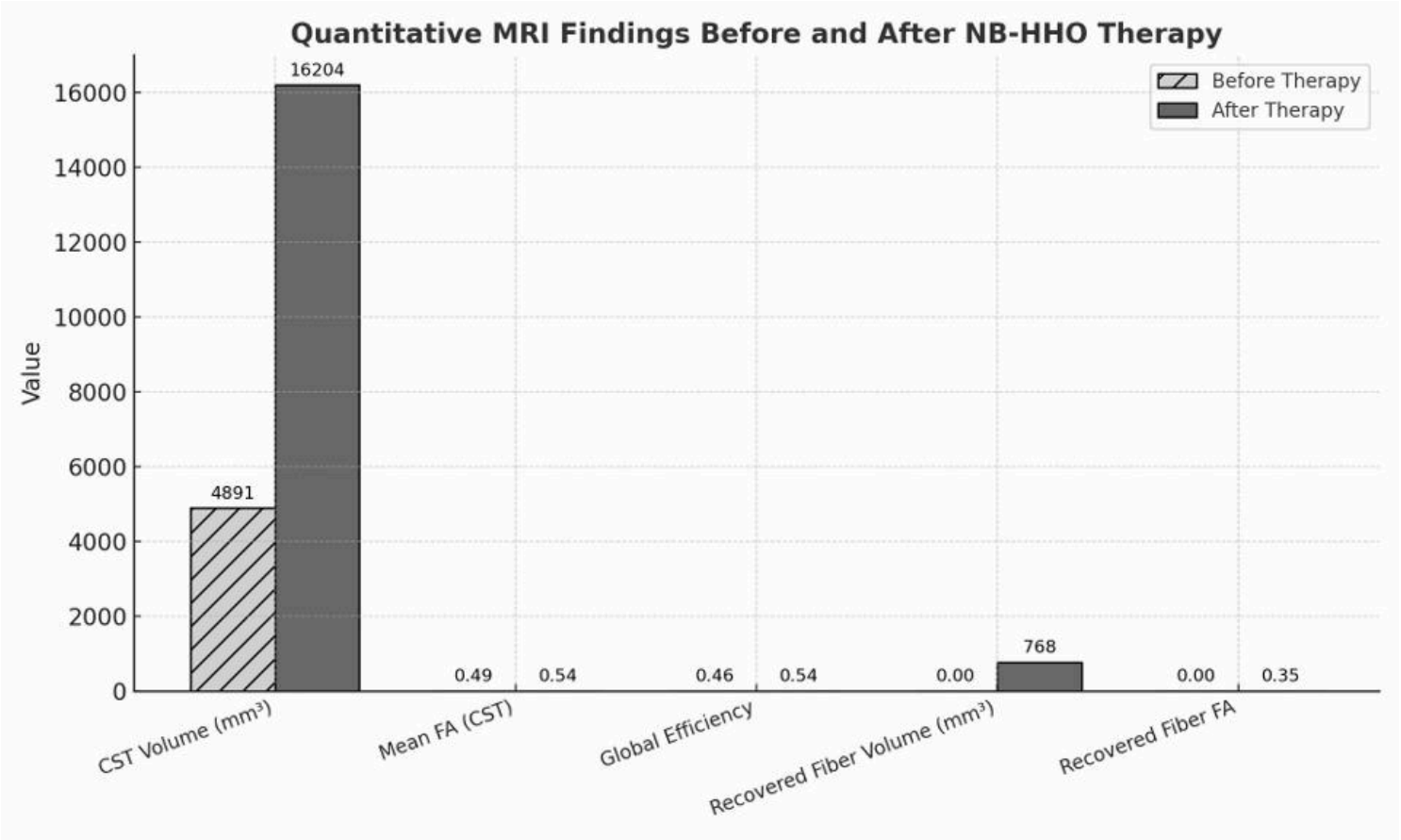


Figure 8

Quantitative MRI findings before and after NB-HHO therapy Comparison of structural brain metrics pre- and post-therapy. Corticospinal tract volume increased three- fold (4,891 → 16,204 mm³), mean fractional anisotropy and global efficiency improved, and new fiber tracts emerged, indicating enhanced white matter integrity and network connectivity.

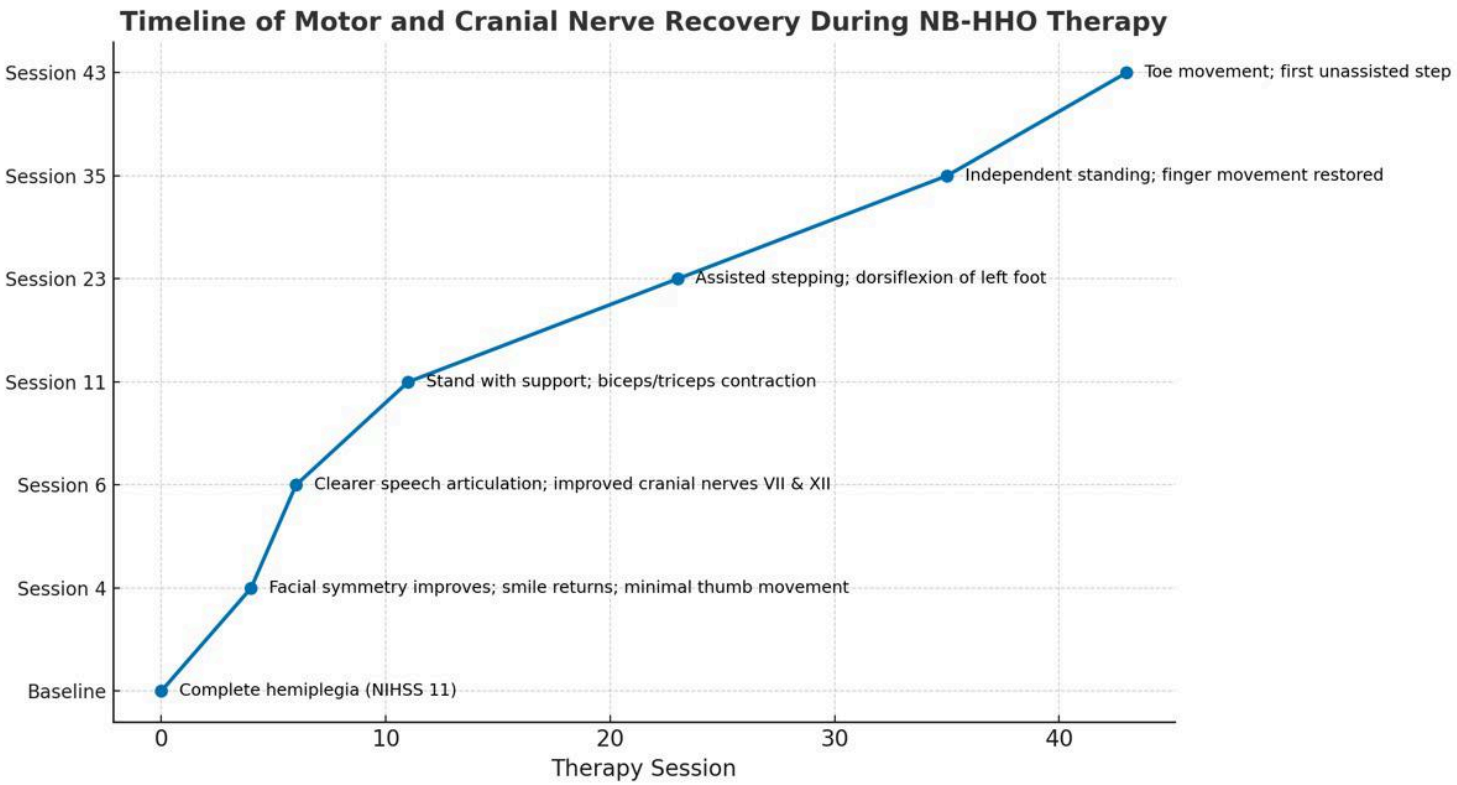


Figure 9

Timeline of motor and cranial nerve recovery milestones Temporal dynamics of functional neurorecovery on the left hemiplegic side, starting with early cranial nerve improvements (facial symmetry and speech, sessions 4–6) and progressing to major motor milestones, culminating in independent standing and unassisted stepping (sessions 35–43).

Supplementary Files

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- SuplementaryfilesDjokaetal.2026.zip