RESEARCH PAPER

An Educational and Evidence-Based Nursing – physiotherapy Protocol for Optimizing Identification, Monitoring, and Management of Modifiable Stroke Risk Factors and Functional, Mental & Social Recovery During Inpatient Rehabilitation

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Abstract

Background: Stroke remains one of the leading causes of long-term disability, cognitive impairment, and secondary vascular events globally. While acute medical interventions have substantially lowered early mortality, long-term functional independence and secondary prevention heavily depend on the quality, coordination, and educational efficacy of inpatient interdisciplinary rehabilitation. In conventional post-acute settings, nursing care and physical therapy frequently operate in departmental silos, missing vital therapeutic windows for functional cross-training, consistent risk-factor monitoring, patient-tailored secondary prevention education, and psychosocial reintegration.

Objective: To establish, evaluate, and provide an operationalized, evidence-based nursing–physiotherapy collaborative clinical and educational protocol specifically designed for inpatient stroke rehabilitation units to simultaneously optimize modifiable secondary risk factor management and foster functional, neuropsychiatric, and social participation outcomes.

Methods: This protocol was formulated via an integrative synthesis of clinical practice guidelines, neurorehabilitation trials, and adult health education models. It bridges clinical workflows across three distinct phases: Phase I (Comprehensive Admission Triaging, Biomarker Profiling, and Sensorimotor Baseline Mapping; Days 1–3), Phase II (Active Co-Treatment, Task-Specific High-Intensity Neurorehabilitation, and Behavioural Self-Management Education; Days 4–18), and Phase III (Community Re-Entry Simulation, Family Empowerment, and Transition Planning; Days 19 to Discharge). Standardized operational metrics include glycaemic, blood pressure, and lipid management protocols, high-dose functional task practice, neurocardiac reconditioning, early screening and management of post-stroke depression, cognitive-communication adaptations, and caregiver hands-on mastery.

Results & Expected Clinical Impact: Structured co-management models between rehabilitation nurses and physical therapists significantly mitigate secondary stroke recurrence hazards, shorten functional plateau intervals, enhance independence in basic and instrumental activities of daily living (ADLs/iADLs), attenuate post-stroke depression and anxiety symptoms, and reduce 30-day readmission and post-discharge caregiver burnout.

Conclusion: The interdisciplinary nursing–physiotherapy protocol provides an actionable, standardized clinical architecture. By embedding patient and family health education directly into physical exercise, daily physiological monitoring, and ward routines, inpatient rehabilitation facilities can systematically bridge physiological stabilization, neuromuscular recovery, and psychosocial reintegration.

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Introduction and Clinical Rationale

Stroke is a catastrophic cerebrovascular disruption characterized by high rates of persistent hemiparesis, postural instability, sensory deficits, cognitive-communication impairments, and severe affective dysregulation (Feigin et al., 2021). The

worldwide burden of stroke continues to surge, driven by an aging demographic, epidemiological shifts, and suboptimal population-level control of metabolic and vascular comorbidities (Feigin et al., 2021). While endovascular thrombectomy and intravenous thrombolysis have revolutionized hyperacute stroke management, the overwhelming majority of stroke survivors transition into subacute phases marked by moderate to severe residual physical and neuropsychological impairments (Bernhardt et al., 2017).

Inpatient rehabilitation facilities (IRFs) provide a critical therapeutic window wherein neuroplastic adaptation, functional restoration, and behavioural modifications can be catalysed (Winstein et al., 2016). Contemporary post-acute rehabilitation, however, frequently suffers from operational fragmentation (Clarke et al., 2018). Nursing personnel and physical therapists routinely conduct separate assessments, utilize non-aligned documentation systems, and execute interventions independently. Nurses predominantly shoulder acute medical management, medication administration, tissue viability preservation, bowel and bladder continence training, and safety monitoring. Concurrently, physical therapists deliver specialized exercise therapy, neurodevelopmental re-education, balance training, and gait reconditioning during scheduled 45- to 60-minute therapy blocks (Winstein et al., 2016).

1. **Sedentary Ward Time and Missed Neuroplastic Windows:** Outside scheduled physiotherapy gym sessions, patients spend upward of 75% of daytime hours immobilized in bed or seated passively beside the bed (Bernhardt et al., 2004; Bernhardt et al., 2017). This extensive sedentary behaviour promotes learned non-use, secondary musculoskeletal contractures, venous stasis, and rapid cardiovascular deconditioning (Billinger et al., 2014).
2. **Disconnected Health Literacy Delivery:** Secondary stroke risk reduction education is often relegated to unstructured, passive pamphlet distribution near the day of discharge (Cameron et al., 2016). When education is decoupled from experiential physiological monitoring and functional practice, patients fail to conceptualize the direct link between daily behavioural choices—such as medication adherence, physical activity, dietary sodium limitation, and smoking cessation—and long-term cerebrovascular health (Boehme et al., 2017).
3. **Overlooked Post-Stroke Neuropsychiatric and Social Decline:** Post-stroke depression (PSD), cognitive impairment, and social isolation are pervasive, affecting between 30% and 50% of stroke survivors (Robinson et al., 2016). In siloed care, affective and cognitive barriers are frequently misattributed to patient lack of motivation or fatigue, blunting active physical therapy engagement and delaying functional milestones (Towfighi et al., 2017).

To dismantle these barriers, this clinical protocol formalizes a dual-translational model where evidence-based nursing care and neurophysiotherapy merge into a unified, round-the-clock rehabilitative ecosystem. Through synchronized clinical assessments, co-treatment interventions, and an educational continuum, the protocol addresses modifiable stroke risk factors in lockstep with motor re-education, emotional resilience, and community reintegration.

Pathophysiological Foundations and Neuroplastic Mechanisms

The Neuroplasticity Paradigm: Time-Sensitive Synaptogenesis and Motor Map Reorganization

Rehabilitation does not merely accommodate permanent neurological deficits; it actively directs functional and structural cortical reorganization (Kleim et al., 2008). In the immediate subacute phase following focal cerebral ischemia or intracerebral haemorrhage, the brain enters a transient state of heightened neuroplastic sensitivity (Bernhardt et al., 2017). Peri-infarct tissue exhibits substantial genetic upregulation of growth-promoting factors, axonal sprouting, down-regulation of inhibitory gamma-aminobutyric acid (GABA)-ergic pathways, and synaptogenesis (Kleim et al., 2008; Murphy et al., 2009).

This spontaneous biological window requires early, meaningful, task-specific sensorimotor input to guide cortical map re-allocation (Kwakkel et al., 2004). Kleim and Jones delineated core principles of neuroplasticity that dictate modern neurorehabilitation:

- *Use It or Lose It:* Neural circuits that are not actively engaged rapidly degrade.
- *Use It and Improve It:* Targeted functional training drives structural circuit adaptation.
- *Specificity:* The nature of the training dictating the plastic reorganization.
- *Repetition and Intensity Matter:* Induction of stable synaptic changes requires high volumes of repetitions performed near physiological challenge thresholds (Lang et al., 2009).
- *Salience and Transference:* Plasticity is markedly elevated when tasks possess perceived functional and personal meaning to the survivor (Kleim et al., 2008).

When nursing and physical therapy execute uncoordinated approaches, these neuroplastic principles fail to manifest. For instance, if a physical therapist spends 45 minutes retraining sit-to-stand

mechanics using paretic lower-extremity loading, but ward nursing staff subsequently utilize a passive mechanical lift or allow the patient to stand entirely through non-paretic compensation during daytime transfers, the neural drive for paretic limb motor cortical representation is undermined. The protocol resolves this through standardized motor task guidelines executed consistently across therapy gym sessions and ward floor activities.

Neurovascular Coupling, Exercise Physiology, and Cerebral Hemodynamic

Engaging stroke survivors in repetitive functional movement demands precise understanding of post-stroke neurovascular pathophysiology. Autoregulation of cerebral blood flow (CBF) is frequently damaged following ischemic or haemorrhagic stroke, leaving cerebral perfusion pressure directly contingent upon systemic mean arterial pressure (MAP) (Boehme et al., 2017). Overzealous pharmacological lowering of systemic blood pressure can precipitate hypoperfusion within the vulnerable ischemic penumbra, exacerbating neurological injury (Whelton et al., 2018). Conversely, uncontrolled hypertensive spikes during strenuous rehabilitation can compromise blood-brain barrier integrity, accelerate cerebral edema, or induce secondary haemorrhagic transformation (Powers et al., 2019).

Physical therapists and rehabilitation nurses must maintain dynamic hemodynamic surveillance (Billinger et al., 2014). Tailored submaximal aerobic and resistance training stimulates vascular endothelial growth factor (VEGF) and brain-derived neurotrophic factor (BDNF) release, enhancing vascular elasticity, improving systemic insulin sensitivity, lowering baseline resting arterial tone, and encouraging peri-infarct angiogenesis (Ploughman et al., 2009; Saunders et al., 2016). By aligning nursing pharmacological scheduling with physiotherapy mobility sessions, the patient's hemodynamic window is systematically maintained in an optimal perfusion band that supports safe neuroplastic exertion.

Systematic Identification and Surveillance of Modifiable Risk Factors

Recurrent stroke accounts for nearly 25% of the 15 million strokes occurring worldwide annually, carrying significantly greater disability and case-fatality rates than index events (Boehme et al., 2017). Modifiable risk factors explain more than 90% of the population-attributable risk of stroke globally (O'Donnell et al., 2016). The inpatient rehabilitation phase offers a protected, monitored environment to identify, monitor, and treat these triggers while empowering patients with the behavioural skills required for sustained risk reduction.

Arterial Hypertension: Chrono pharmacology and Exercise Titration

Hypertension stands as the single most critical modifiable risk factor for both ischemic and haemorrhagic stroke (O'Donnell et al., 2016; Whelton et al., 2018). Guidelines generally recommend a target resting blood pressure of less than 130/80 mmHg for secondary stroke prevention, provided critical intracranial or extracranial arterial stenosis is absent (Whelton et al., 2018).

- **Nursing Responsibility:** Execution of standardized blood pressure checks (seated, supine, standing) to screen for orthostatic hypotension—a frequent complication following bed rest and autonomic disruption. Antihypertensive medications (e.g., ACE inhibitors, ARBs, thiazide diuretics, calcium channel blockers) must be scheduled to prevent hypotensive dips that coincide with physical therapy blocks, as well as to eliminate post-awakening hypertensive surges (Powers et al., 2019).
- **Physiotherapy Responsibility:** Dynamic vital sign tracking. Physical therapists establish individual baseline resting pressures prior to exercise, assess response at peak aerobic or functional loads, and record recovery clearance rates (Billinger et al., 2014). An exercise systolic blood pressure (SBP) exceeding 220 mmHg or diastolic blood pressure (DBP) exceeding 110 mmHg, or a paradoxical drop in SBP > 10 mmHg below baseline accompanied by light-headedness or diaphoresis, prompts immediate cessation of the session, return to a semi-recumbent posture, and urgent nursing re-evaluation.

Dysglycemia, Insulin Resistance, and Glycaemic Variability

Elevated admission blood glucose, persistent post-stroke hyperglycaemia, and wide glycemic variability severely impair neurovascular recovery, increase infarct volume via lactic acidosis and free radical generation, and elevate the hazard of symptomatic haemorrhagic transformation (Boehme et al., 2017). Moreover, pre-existing and newly unmasked type 2 diabetes mellitus markedly degrades microvascular repair.

- **Collaborative Protocol Mandates:** Capillary blood glucose profiling conducted prior to meals and before high-intensity physical therapy. If pre-exercise blood glucose drops below 100 mg/dL (5.5 mmol/L), nurses provide a 15- to 30-gram complex carbohydrate snack with protein prior to therapy to prevent exertion-induced neuroglycopenia. When capillary blood glucose exceeds 250 mg/dL (13.9 mmol/L), urine or blood is screened for ketones; vigorous aerobic exertion is deferred until adequate hydration and insulin coverage stabilize glucose levels

below 200 mg/dL. Physical therapists communicate exertion intensity, enabling nurses to anticipate increased late-stage insulin sensitivity and prevent delayed nocturnal hypoglycaemia.

Atherogenic Dyslipidaemia and Lipid-Lowering Pharmacotherapy

Atherosclerotic cardiovascular disease remains a major etiologic driver of large-artery stroke and transient ischemic attacks. Clinical guidelines mandate high-intensity statin therapy (e.g., Atorvastatin 80 mg or Rosuvastatin 20–40 mg daily) to achieve a minimum 50% reduction in low-density lipoprotein cholesterol (LDL-C) and an absolute target of LDL-C < 70 mg/dL (1.8 mmol/L), or < 55 mg/dL (1.4 mmol/L) in recurrent or very high-risk vascular profiles (Boehme et al., 2017; Grundy et al., 2019).

- **Interdisciplinary Focus:** Nurses ensure statin adherence, systematically screen for statin-associated muscle symptoms (SAMS) or rhabdomyolysis, and evaluate liver function panels. Physical therapists distinguish between normal, exercise-induced, localized delayed-onset muscle soreness (DOMS) and diffuse, bilateral, proximal muscle aching or myopathy induced by lipid-lowering pharmacotherapies, alerting the medical and nursing team if serum creatine kinase testing is warranted.

Cardioembolic Sources, Atrial Fibrillation, and Anticoagulation Safety

Atrial fibrillation (AF) confers a five-fold increase in the risk of stroke, generating high rates of recurrent, often devastating embolic events (Kirchhof et al., 2016). Inpatient rehabilitation demands strict monitoring for occult paroxysmal AF via telemetry or continuous pulse palpation.

- **Clinical Protocol Mandates:** Initiation of direct oral anticoagulants (DOACs; apixaban, rivaroxaban, dabigatran, edoxaban) or vitamin K antagonists (warfarin, targeting an INR between 2.0 and 3.0) per cardiological and neurological guidelines (Kirchhof et al., 2016). Nurses deliver targeted education regarding bleeding risks, monitor for occult gastrointestinal or urinary haematuria, evaluate soft-tissue hematomas, and reinforce medication consistency. Physical therapists integrate fall risk reduction and dual-task balance retraining to mitigate head-injury hazards, ensuring that fear of falling does not prompt unnecessary clinical immobilization.

Obstructive Sleep Apnea (OSA)

Post-stroke OSA affects more than 60% of survivors and is directly linked to refractory nocturnal hypertension, disrupted cerebral autoregulation, prolonged motor recovery windows, and recurrent stroke (Towfighi et al., 2017).

- **Protocol Steps:** All admissions undergo screening utilizing the STOP-Bang Questionnaire or the Berlin Questionnaire. Suspected patients receive nocturnal pulse oximetry or overnight polysomnography. Nurses facilitate positive airway pressure (PAP) therapy desensitization, correct mask leaks, and track nightly adherence. Physical therapists leverage positional therapy adaptations, avoiding supine positioning during ward rest hours and encouraging daylight aerobic exercise to optimize normal circadian sleep-wake cycles.

Operational Structure of the Inpatient Rehabilitation Protocol

The nursing–physiotherapy protocol is structured into three chronological and functional phases spanning the standard inpatient rehabilitation trajectory. Each phase outlines specific collaborative milestones, shared clinical goals, educational tasks, and target outcomes.

Phase I: Comprehensive Admission Triaging, Biomarker Profiling, and Sensorimotor Baseline Mapping (Days 1–3)

1. Joint Clinical Intake and Functional Stratification

Within 24 hours of admission to the rehabilitation unit, a joint assessment is conducted by the primary rehabilitation nurse and the lead physical therapist. This joint intake prevents patient exhaustion caused by fragmented, duplicate interviews, accelerates interprofessional communication, and sets shared functional and physiological benchmarks.

PHASE I: JOINT ASSESSMENT BATTERY

Domain	**Clinical Instrument / Metric**	**Primary Evaluator / Synergy Focus**
Sensorimotor & Motor Control	Fugl-Meyer Assessment (FMA-LE/UE)Trunk Impairment Scale (TIS)	**Physical Therapist**(Nurse validates baseline for transfers)
Functional Status & Daily Living	Functional Independence Measure (FIM)or Section GG Functional	**Joint Evaluation**(Establishes bed-to-chair assistance level)

	Abilities	
Skin & Tissue Integrity	Braden Scale for Predicting Pressure Sore Risk	**Rehabilitation Nurse**(PT integrates offloading in wheelchair)
Dysphagia & Nutrition	Standardized Swallowing Screen(e.g., Yale Swallow Protocol)	**Joint Screen (RN/SLP/PT)**(Upright positioning safety during meals)
Cognitive & Neuropsychiatric	MoCA or Mini-Mental State Exam Patient Health Questionnaire-9 (PHQ-9)	**Joint Assessment**(Adapting communication & emotional baseline)

2. Physiological Profiling and Safe Mobilization Parameters

Simultaneously, the patient's biomarker profile is mapped. Continuous telemetry is reviewed for occult atrial dysrhythmias. Resting blood pressure is charted every four hours across day and night cycles to detect nocturnal non-dipping patterns. Orthostatic vitals are formally recorded at 1-minute and 3-minute intervals upon rising from supine to sit, and sit to stand.

- **Mobilization Contraindications & Stop-Criteria:** Early mobilization is titrated carefully, taking into account trials like AVERT, which demonstrate that very early (within 24 hours), unmonitored, high-frequency, out-of-bed mobilization can be detrimental in select hemodynamically unstable patients (Bernhardt et al., 2017). Mobilization out of bed is initiated only when:
    - Resting heart rate is between 50 and 100 beats per minute.
    - Systolic blood pressure remains within the patient-specific therapeutic auto-regulatory window (typically 120–180 mmHg for acute ischemic stroke without thrombolysis; 110–140 mmHg post-intracerebral haemorrhage; or 120–160 mmHg post-thrombolysis).
    - Peripheral arterial oxygen saturation (SpO_2) remains ≥ *92%* on room air or stable baseline supplemental oxygen.
    - No evolving neurological deficits or fluctuating consciousness (GCS < 13 or an acute increase in NIHSS ≥ *2* points).

3. Therapeutic Positioning and Secondary Complication Prevention

From the day of admission, the patient is shielded against common secondary musculoskeletal and neurovascular complications:

- **Paretic Shoulder Preservation:** The flaccid or subluxed paretic glenohumeral joint is at extreme risk of traction neuropathy, impingement, and complex regional pain syndrome (CRPS) (Winstein et al., 2016). Staff and family are trained never to pull on the paretic arm during transfers or repositioning. When the patient is seated, the upper extremity is supported with a custom lap-tray, arm trough, or dynamic shoulder suspension sling.
- **Bed Positioning Protocols:** A 2-hour rotational positioning schedule is initiated. Lateral positioning onto the hemiparetic side is managed to prevent direct pressure over the greater trochanter and head of the humerus, using supportive wedge pillows between the knees and behind the spine to inhibit hypertonicity and preserve passive range of motion.
- **Aspiration Prophylaxis:** Strict 90-degree upright head-and-trunk positioning is enforced for all oral intake, maintained for at least 30 minutes post-prandially.

Phase II: Active Co-Treatment, Task-Specific High-Intensity Neurorehabilitation, and Behavioural Self-Management Education (Days 4–18)

Phase II represents the high-intensity therapeutic phase of inpatient rehabilitation, where the patient receives at least 3 hours of physical, occupational, and speech therapy per day, alongside continuous restorative nursing care.

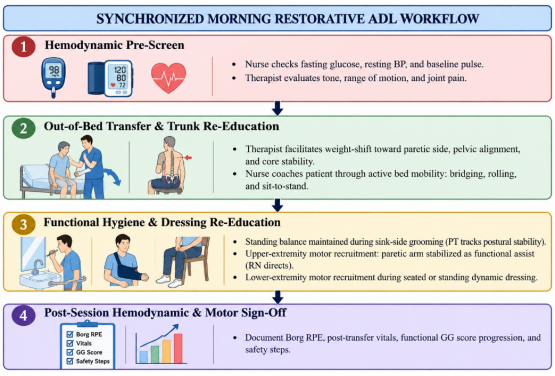
1. The Synchronized Morning ADL and Restorative Mobility Session

Instead of treating morning hygiene as a passive task to complete quickly, nurses and physical therapists coordinate their schedules to transform the morning routine into a high-yield functional therapy block:

- **The Clinical Scenario:** At 08:00, the primary nurse and physical therapist enter the patient's room together. The physical therapist facilitates motor activation, postural alignment, and weight-bearing on the paretic lower limb, while the nurse guides the patient through toileting, sink-side grooming, and dressing.
- **Biomechanical Execution:** The patient is prompted to complete sit-to-stand

transitions without relying entirely on the non-paretic upper limb. The physical therapist provides manual cues at the pelvis to facilitate anterior pelvic tilt and symmetrical loading of the feet. The nurse guides hemiplegic dressing strategies: dressing the paretic limb first, undressing it last, and selecting non-restrictive garments that accommodate mobility.

- **Cognitive Integration:** Multi-step grooming tasks (washing face, brushing teeth) are structured to challenge executive planning, spatial orientation, and visual neglect, reinforcing compensatory scanning strategies into the hemi spatial field.



2. High-Repetition, Task-Specific Neurophysical Training

During designated gym hours, physical therapy delivers high-intensity, evidence-based neurorehabilitation aimed at maximizing motor recovery and cardiovascular reconditioning:

- **Overground and Body-Weight-Supported Treadmill Training (BWSTT):** Patients who exhibit severe paresis receive BWSTT to enable early, repetitive, rhythmic stepping patterns, stimulating central pattern generators (CPGs) in the spinal cord and driving cortical re-mapping without danger of falls (Lang et al., 2009; Veerbeek et al., 2014). As motor recruitment improves, patients are graduated to overground walking across variable terrains, negotiating inclines, architectural obstacles, and curbs.
- **Constraint-Induced Movement Therapy (CIMT) Principles:** For patients with at least 10 degrees of active wrist extension and 10 degrees of active finger extension, the non-paretic upper extremity is restrained for up to 90% of waking hours during intensive daily training blocks, forcing functional engagement of the paretic arm in functional grasping, reaching, and manipulation tasks (Kwakkel et al., 2015). On the rehabilitation floor, nurses reinforce these gains by requiring the patient to utilize the paretic arm for holding cups, stabilizing plates, opening doors, or turning light switches.
- **High-Dose Task-Specific Repetition:** Motor retraining requires high repetition volumes—often hundreds of movement cycles per session—to achieve permanent synaptic changes (Lang et al., 2009). The physical therapy protocol mandates minimum thresholds:
    - Sit-to-Stand: Minimum of 50 to 100 repetitions daily, split across gym and ward settings.
    - Stepping / Gait Cycles: Minimum of 1,000 to 2,000 steps per rehabilitation day, tracked via calibrated real-time accelerometery or pedometry.
- **Cardiorespiratory Aerobic Reconditioning:** Utilizing recumbent steppers, cycle ergometers, or arm-leg ergometers, patients engage in aerobic intervals for 20 to 45 minutes, 3 to 5 days per week (Billinger et al., 2014). Intensity is prescribed between 40% and 70% of heart rate reserve (HRR), or a rating of perceived exertion (RPE) of 11 to 14 on the Borg 6–20 scale. Aerobic exercise directly upregulates BDNF, improving both motor learning consolidation and vascular compliance (Ploughman et al., 2009; Saunders et al., 2016).

3. Ward-Based Environmental Restructuring: Eliminating Inactive Sedentary Time

To counteract the sedentary nature of standard ward environments, this protocol establishes a Restorative Milieu:

- **Restorative Dining Programs:** Patients are transported out of their rooms to a communal dining room for breakfast and lunch. This simple environmental change mandates independent or assisted propulsion of wheelchairs, ambulation down the corridors, upright social engagement with peers, and active functional reach during meals.
- **Nurse-Supervised "En-Route" Mobility Tasks:** Rather than being wheeled passively down hallways to appointments, patients are ambulated by trained nursing personnel with assistive devices (hemi-walkers, quad canes) whenever distance and safety profiles permit.
- **Environmental Enriched Hallway Circuits:** Hallway walls feature visual markers and spatial targets where patients, accompanied by nurses or caregivers, complete standing balance challenges, lateral weight-shifting exercises, and reading/cognitive checks stationed along the ward.

Phase III: Community Re-Entry Simulation, Family Empowerment, and Transition Planning (Days 19 to Discharge)

The concluding phase focuses on testing functional and self-care independence, transferring management responsibilities to the patient and family unit, and organizing post-discharge safety networks.

1. Experiential Community Re-Entry Simulation

Rehabilitation gym environments feature flat floors and controlled ambient settings that rarely reflect the physical and cognitive complexity of the real world. Phase III incorporates realistic functional challenges:

- **The Architectural and Environmental Challenge:** Patients practice ambulating or wheeling across uneven terrain (grass, gravel, asphalt cracks, curb ramps), negotiating commercial revolving doors, and ascending/descending public transportation mock-up stairs.
- **Dual-Task Gait and Cognitive Navigation:** Patients walk through bustling hospital corridors, cafeteria spaces, and gift shops while simultaneously performing cognitive tasks (e.g., carrying an open cup of water, counting backward by threes, reading a shopping list, searching for specific wall signs) (Bowen et al., 2013). This dual-task testing screens for subtle gait instability and executive interference that could precipitate falls in busy home and community settings.
- **Instrumental Activities of Daily Living (iADLs) in Simulated Suites:** Utilizing the rehabilitation facility's transitional living apartment, nurses and therapists observe patients independently executing complex multi-step tasks: safely boiling water on an induction cooktop, carrying laundry with an assistive device, transferring in and out of a standard tub or low toilet, and retrieving dropped items from the floor using assistive reaches.

2. The Formal Dyadic Caregiver Mastery Assessment

Informal caregivers (spouses, adult children, domestic partners) often experience high levels of anxiety, depression, and physical strain upon patient discharge (Cameron et al., 2016). To mitigate post-discharge failure, the protocol utilizes an objective Caregiver Practical Competency Checklist. Prior to discharge, caregivers must independently perform and explain the following clinical tasks without verbal prompting from staff:

- Execution of safe, ergonomic bed-to-chair and chair-to-car transfers utilizing appropriate body mechanics and assistive equipment.
- Verbalization of the rationale, dosage, frequency, and major side effects of every prescribed medication.
- Demonstration of accurate home automated blood pressure and capillary blood glucose measurement, including appropriate recording in a health log and recognition of physician call-in thresholds.
- Safe swallowing assistance, including preparation of prescribed dietary consistencies (e.g., mechanically altered solids, nectar-thick liquids) and execution of chin-tuck postures or pacing techniques.
- Proper application and skin inspection protocols for ankle-foot orthoses (AFOs) or resting hand splints.

3. Structured Care Transitions and Telehealth Continuity Setup

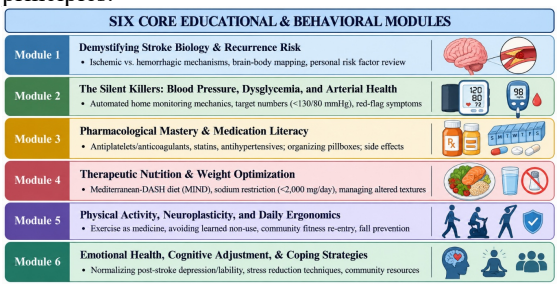
Hospital-to-home transitions represent the point of highest vulnerability for medication errors, falls, and loss to medical follow-up (Naylor et al., 2004; Winstein et al., 2016):

- **Discharge Medication Reconciliation and Teach-Back:** The nurse and patient systematically review every discharge medication. The patient uses the "teach-back" method to explain why they take each drug, what symptoms require urgent attention, and when prescriptions must be refilled.
- **Direct Outpatient Therapy Scheduling:** Outpatient physical therapy, occupational therapy, and primary neurology appointments are confirmed and scheduled prior to discharge, with transportation arrangements established.
- **Setup of Remote Patient Monitoring (RPM):** The patient is supplied with a validated digital home blood pressure monitor and, where indicated, a glucometer. Staff provide instruction on pairing devices with hospital patient portals or recording values in a physical logbook.
- **The 48-Hour and 7-Day Follow-Up Nurse Calls:** A dedicated rehabilitation nurse conducts telephone follow-ups at 48 hours and 7 days post-discharge, systematically screening for medication discrepancies, fall incidents, skin breakdown, mental status declines, and caregiver distress.

Integrating Comprehensive Patient and Caregiver Education

Education must not be an isolated event occurring during the final hours of an inpatient stay; it must be an ongoing, experiential, and interactive process integrated into daily care routines (Cameron et al., 2016; Hoffmann et al., 2007). Cognitive impairments, executive dysfunction, aphasia, and psychological distress necessitate varied educational delivery methods tailored to adult learning

principles.



Adult Learning Paradigms and Health Literacy Adaptations

Traditional didactic lecturing is largely ineffective for individuals recovering from acute neurological injury (Hoffmann et al., 2007). The protocol applies Knowles' Adult Learning Theory (Andragogy) and the Health Belief Model:

- **Relevance and Immediacy:** Stroke survivors are motivated when education directly applies to real-life challenges. For example, rather than providing an abstract lecture on vascular resistance, the nurse teaches blood pressure mechanics while the patient is actively exercising on a cycle ergometer, demonstrating how vessels adapt to physiological work.
- **Multimodal Information Delivery:** Visual diagrams, physical 3D vascular models, digital video modules, tactile demonstrations, and plain-language printed materials are deployed concurrently. Written materials are systematically formatted to a 5th-to-6th-grade reading level, utilizing high-contrast, large-print (minimum 14-point font) layouts.
- **Aphasia-Friendly Communication Strategies:** For the approximately 30% of stroke survivors living with expressive, receptive, or global aphasia, educational materials must be adapted (Brady et al., 2016). Pictographic communication books, visual scales, simplified sentences, single-concept illustrations, and gestures are systematically used. Clinicians allow ample processing time (at least 15–30 seconds), maintain direct eye contact, eliminate background auditory distractions, and continually verify comprehension through non-verbal return demonstrations or multi-choice pointing.

Experiential Health Literacy: The "Measure-Record-Act" Framework

To foster genuine self-efficacy, patients transition from passive recipients of care into active health managers through the daily "Measure-Record-Act" workflow:

- **Step 1: Measurement:** During morning rounds, the nurse guides the patient in applying their own automated blood pressure cuff to their non-paretic arm, pressing the start button, and observing the cycle.
- **Step 2: Recording:** The patient enters the resulting systolic, diastolic, and pulse values into a personal paper or tablet-based logbook. The physical therapist reviews these readings with the patient before therapy, asking: *"Looking at your blood pressure this morning, are your numbers within our green safety zone for exercise?"*
- **Step 3: Action:** If blood pressure is elevated, the nurse guides the patient through a brief clinical decision-making pathway: taking prescribed morning medications, practicing 5 minutes of guided diaphragmatic breathing, and observing how systemic values normalize. This experiential feedback transforms an abstract number on a screen into a tangible biological state that the patient learns to control.

Functional, Cognitive, Affective, and Social Recovery Domains

A comprehensive rehabilitation protocol must address the full spectrum of recovery across motor, cognitive, affective, and social domains.

MULTIDIMENSIONAL RECOVERY MATRIX: INTERVENTIONS & MEASURES

Recovery Domain	Targeted Evidence-Based Interventions	Primary Standardized Outcome Measures
Sensorimotor & Locomotor Function	• Task-Specific Circuit Training• Functional Electrical Stimulation• Body-Weight Supported Treadmill• Constraint-Induced Movement Therapy	• Fugl-Meyer Assessment (FMA)• 10-Meter Walk Test (10MWT)• 6-Minute Walk Test (6MWT)• Action Research Arm Test (ARAT)
Posture, Balance, & Fall Prevention	• Dual-Task Postural Training• Proprioceptive Perturbation Boards• Environmental Obstacle Courses	• Berg Balance Scale (BBS)• Functional Ambulation Categories (FAC)• Fall Efficacy Scale–

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Cognitive-Executive & Perceptual	• Goal Management Training (GMT)• Visual Scanning & Prism Adaptation• Internal Memory Compensation Aids	• Montreal Cognitive Assessment (MoCA)• Trail Making Test A & B• Behavioural Inattention Test (BIT)
Neuropsychiatric & Affective Adaptation	• Scheduled Behavioural Activation• Mindful Breathing & Relaxation• Pharmacotherapy (SSRI Consultation)	• Patient Health Questionnaire (PHQ-9)• Generalized Anxiety Disorder Scale (GAD-7)• Stroke-Specific Quality of Life (SS-QOL)
Social & Role Reintegration	• Peer Support Circles & Group Meals• Family Systems Counselling• Vocational & Leisure Re-Engagement	• Reintegration to Normal Living Index• Modified Rankin Scale (mRS)• Zarit Burden Interview (Caregivers)

Motor Function, Postural Control, and Fall Risk Mitigation

Hemiparesis, sensory loss, and hemi-spatial neglect disrupt postural symmetry, shifting the centre of mass toward the non-paretic side and precipitating high fall rates (Winstein et al., 2016). Falls during inpatient rehabilitation delay recovery, extend hospital stays, cause catastrophic fractures, and induce post-fall anxiety that limits patient mobility.

- **Targeted Interventions:** The physical therapy protocol emphasizes dynamic weight shifting, reactive balance recovery strategies (ankle, hip, and stepping responses), and trunk control re-education using the Trunk Impairment Scale as a guide (Verheyden et al., 2006). Neuromuscular electrical stimulation (NMES) and functional electrical stimulation (FES) are applied to the paretic tibialis anterior muscle during the swing phase of gait to counteract foot drop, promote active dorsiflexion, and optimize toe-clearance (Veerbeek et al., 2014).
- **Cross-Disciplinary Ward Safety:** Nurses ensure that the patient's environment aligns with their motor capabilities. Non-skid footwear is inspected; personal items and call lights are positioned within the intact visual and physical field; and bedside commodes are stabilized. If an ankle-foot orthosis is prescribed, nurses ensure it is donned correctly for all out-of-bed transfers, preventing ankle inversions or falls.

Cognitive Rehabilitation and Executive Function Retraining

Approximately 50% of stroke survivors experience cognitive deficits affecting attention, executive functioning, working memory, or visual perception (Bowen et al., 2013). Cognitive deficits directly correlate with poorer functional outcomes and increased caregiver stress:

- **Protocol Strategies:** Cognitive rehabilitation is embedded within physical tasks. Goal Management Training (GMT)—incorporating "Stop, State the Goal, Split into Steps, and Check"—is deployed when teaching complex mobility and self-care sequences. Visual neglect (frequently seen in right hemisphere lesions) is targeted through structured visual exploration training, anchoring cues, and prism adaptation therapy (Bowen et al., 2013).
- **Communication and Memory Aids:** Rehabilitation nurses reinforce orientation through standardized whiteboard calendars in the patient's room, detailing daily schedules, names of their care team, and individualized recovery goals. Memory books, smartphone alarms, and pill-box organizers are introduced early in Phase II, allowing the patient to develop compensation strategies before returning home.

Post-Stroke Depression (PSD), Anxiety, and Affective Adaptation

Post-stroke depression affects roughly one-third of survivors at any point during recovery, significantly decreasing rehabilitation engagement, blunting neuroplastic gains, and increasing mortality (Hackett et al., 2014; Robinson et al., 2016). Emotional lability (pseudobulbar affect) and generalized anxiety are also common:

- **Surveillance and Screening:** Routine

screening with the Patient Health Questionnaire-9 (PHQ-9) occurs at admission and weekly thereafter. Any score ≥ 10, or any positive response to the self-harm item, triggers a formal psychiatric evaluation.

- **Behavioural Activation Protocol:** Nurses and physical therapists counteract withdrawal and anhedonia through behavioural activation. Daily rehabilitation achievements are documented visually on a "Recovery Milestone Board" placed in the patient's room, providing concrete proof of functional gains (e.g., *"Today I walked 50 feet with the hemi-walker; last week I could only stand for 30 seconds"*).
- **Pharmacotherapy Integration:** Selective serotonin reuptake inhibitors (SSRIs), such as escitalopram or sertraline, are considered in consultation with the medical team for moderate-to-severe PSD. Beyond their antidepressant properties, SSRIs may modulate neuroplasticity and motor recovery through up-regulation of neurotrophins, independent of depressive symptom remission (Robinson et al., 2016).

Social Reintegration, Intimacy, and Leisure Exploration

Restoring motor function without addressing social identity and interpersonal roles leaves the survivor isolated. Inpatient rehabilitation must lay the groundwork for community participation:

- **Peer Support Integration:** Phase II and III incorporate weekly "Stroke Peer Mentorship Circles," connecting current inpatients with community-dwelling stroke survivors who have successfully navigated recovery. These peer interactions normalize fears, reduce loneliness, and provide practical models for community living.
- **Sexuality and Intimacy Counselling:** Post-stroke sexuality is frequently neglected due to clinician discomfort or time constraints. Nurses provide proactive, confidential counselling addressing concerns regarding sexual activity, positional modifications for hemiplegia, autonomic dysregulation, and reassuring patients that sexual intercourse does not elevate the risk of recurrent stroke when baseline exercise tolerance is established (Billinger et al., 2014).
- **Resumption of Hobbies and Avocational Roles:** Occupational and physical therapists modify recreational tools (e.g., adapted gardening tools, digital accessibility interfaces, single-handed card holders) to help patients re-engage with personal hobbies prior to leaving the facility.

Implementation of Framework, Quality Metrics, and Continuous Improvement

Adopting a complex interdisciplinary protocol requires structured implementation strategies, continuous fidelity monitoring, and objective quality metrics to ensure long-term clinical utility (Damschroder et al., 2009).

Interdisciplinary Leadership and Champion Networks

Systemic implementation barriers—such as departmental tribalism, competing staff schedules, and staffing constraints—are addressed through the Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2009). Each rehabilitation unit appoints dedicated clinical champions: an Advanced Practice Rehabilitation Nurse and a Senior Neurologic Physical Therapist. These champions facilitate daily morning huddles, conduct real-time peer coaching, and review uncompleted protocol tasks.

7.2 Staff Training, Simulation Labs, and Interprofessional Competencies

Prior to unit rollout, nursing and therapy staff complete an 8-hour interprofessional continuing education program incorporating high-fidelity simulation:

- **Module A (Biomechanical Handling):** Nurses practice manual facilitation techniques, pelvic stabilization, and body mechanics guided by physical therapy instructors, eliminating unsafe pulling on paretic limbs.
- **Module B (Hemodynamic Exercise Surveillance):** Physical therapists practice interpretation of complex cardiac telemetry strips, pharmacology timing dynamics, and recognition of subtle stroke recurrence symptoms (BE-FAST: Balance, Eyes, Face, Arm, Speech, Time).
- **Module C (Communication & Crisis De-escalation):** Staff practice supported conversation techniques for aphasia, cognitive compensation cues, and behavioural redirection strategies for post-stroke confusion or agitation.

Standardized Electronic Health Record (EHR) Documentation Flowsheets

Fragmented paper charting obscures clinical trends. The protocol utilizes a synchronized EHR flowsheet accessible by both nursing and physiotherapy staff:

SYNCHRONIZED EHR FLOWSHEET INTERFACE

Clinical Metric	**Time Stamp: 08:30**	**Time Stamp: 11:30**	**Time Stamp: 15:30**
Provider	Primary	Inpatient	Restorative

Logged In	RN	PT	RN / PT
Resting / Active BP	126/78 mmHg	142/84 mmHg (Active)	122/76 mmHg
Capillary Blood Glucose	114 mg/dL	Not indicated	138 mg/dL (Post-prandial)
Mobility Task Done	Sit-to-Stand (×15)	Gait 400 m (BWSTT)	Corridor Walk 50 m (Hemi-walker)
Borg RPE (6–20)	9 (Very Light)	13 (Somewhat Hard)	11 (Fairly Light)
Modifiable Risk Education	Sodium restriction	Aerobic exercise	Medication reconciliation (Teach-back)
Adverse Events	None	Transient dizziness	None

Quantitative Quality Metrics and Key Performance Indicators (KPIs)

To maintain clinical efficacy and drive continuous quality improvement (CQI) via Plan-Do-Study-Act (PDSA) cycles, the following balanced scorecard is audited on a monthly basis:

1. **Process Fidelity Indicators:**
    - Percentage of eligible patients receiving a joint RN–PT intake within 24 hours of admission (Benchmark: $> 90\%$).
    - Completion rate of the daily synchronized morning restorative ADL session (Benchmark: $> 85\%$).
    - Percentage of discharged patients with a validated Caregiver Practical Competency Checklist (Benchmark: $> 95\%$).
2. **Clinical Outcome Indicators:**
    - Mean change in Section GG Self-Care and Mobility scores from admission to discharge (aiming for statistically significant functional improvement relative to case-mix index).
    - Rate of in-facility falls per 1,000 patient-days (Benchmark: < 3.0 falls/1,000 days; zero falls with major injury).
    - Percentage of patients achieving target blood pressure (< 130/80 mmHg) at the time of discharge (Benchmark: $> 85\%$).
3. **System-Level & Transition Indicators:**
    - All-cause 30-day acute care hospital readmission rate (Target: $< 8\%$).
    - Recurrent cerebrovascular event rate during inpatient rehabilitation stay (Target: $< 1\%$).
    - Patient and caregiver satisfaction measured via the Stroke-Specific Quality of Life scale (SSQOL) and Zarit Burden Interview at 30 days post-discharge.

Clinical Case Study: Protocol Application in Practice

To illustrate the concrete application of this protocol across an entire inpatient stay, consider the following clinical case study:

Patient Profile and Baseline Presentation

- **Patient:** Mr. J.H., a 64-year-old retired civil engineer.
- **Diagnosis:** Acute ischemic stroke within the territory of the right middle cerebral artery (MCA), characterized by dense left-sided hemiparesis, left hemi spatial neglect, facial asymmetry, and mild dysarthria.
- **Comorbidities:** Longstanding, poorly managed primary arterial hypertension, newly diagnosed type 2 diabetes mellitus, atherogenic dyslipidaemia, and class I obesity (BMI 31.4 kg/m^2).
- **Social History:** Lives in a two-story home with his 62-year-old wife; four entrance steps with a single handrail.

Phase I Application (Days 1–3)

Upon admission to the rehabilitation unit:

- **Joint RN–PT Evaluation:** Performed at 14:00 on Day 1. FMA-LE score is 14/34; FMA-UE score is 8/66. Trunk Impairment Scale is 11/23. The patient requires maximum assistance of two persons for sit-to-stand and bed-to-chair transfers. Section GG score for mobility is 2 (substantial/maximal assistance).
- **Physiological Surveillance:** Blood pressure upon arrival is 168/96 mmHg; non-fasting glucose is 210 mg/dL; telemetry reveals normal sinus rhythm without pauses or ectopy. Orthostatic checks reveal no postural drops.
- **Early Preventative Interventions:** Left shoulder subluxation of two finger-breadths is measured; an arm trough is installed on his wheelchair and a supportive sling is fitted for standing. A two-hour lateral positioning protocol is established in bed, with high-contrast anchor cues affixed to the left bed rail to address left-sided neglect. A STOP-Bang score of 6 indicates

high OSA risk; overnight pulse oximetry confirms oxygen desaturations to 84%, prompting initiation of auto-titrating CPAP.

Phase II Application (Days 4–18)

- **Morning Synchronized ADLs:** Every morning at 08:00, the primary nurse and physical therapist co-lead grooming and dressing. Mr. J.H. practices standing at the sink with weight distributed evenly onto his left lower extremity, monitored by the therapist, while the nurse guides left-hand placement as a stabilizer and coaches dressing of the paretic left arm first.
- **High-Dose Task Practice:** In the therapy gym, Mr. J.H. undergoes 45 minutes of body-weight supported treadmill training daily, accumulating 1,200 steps per session, supplemented by 45 minutes of overground gait training and 30 minutes of recumbent cycling at 60% of his heart rate reserve (monitored by the therapist to keep peak exercise blood pressure below 175/95 mmHg).
- **Restorative Ward Milieu:** Nurses ensure Mr. J.H. ambulates to the dining room for lunch and dinner utilizing a hemi-walker with contact guard assistance, eliminating passive wheelchair transport.
- **Experiential Education:** Daily "Measure-Record-Act" cycles are performed. Mr. J.H. applies his blood pressure cuff and logs his readings. With his nurse, he tracks how his blood pressure normalizes from 155/92 mmHg down to 124/78 mmHg following regular dosing of his ACE inhibitor, low-sodium dietary choices, and aerobic physical therapy.
- **Affective & Cognitive Management:** On Day 7, a PHQ-9 score of 12 (moderate depression) is identified, driven by frustration over left-arm weakness. A daily milestone tracking board is established, demonstrating his progression from zero active finger extension to active mass grasp. Escitalopram 10 mg is initiated following interdisciplinary consultation.

Phase III Application (Days 19–22)

- **Simulated Community Navigation:** Mr. J.H. successfully ascends and descends the 4-step practice stairs with a single handrail and a quad cane under physical therapy supervision. He navigates a simulated grocery aisle in the occupational therapy suite while carrying items in a shoulder satchel to practice dual-tasking.
- **Caregiver Mastery Assessment:** On Day 20, Mrs. H. independently manages a car transfer, demonstrates proper placement of Mr. J.H.'s left-arm sling, details all seven discharge medications using the teach-back method, and accurately measures and records his blood pressure and capillary blood glucose.
- **Discharge Status (Day 22):** Blood pressure at discharge is 122/76 mmHg; HbA1c has improved to 7.1%; LDL-C is 64 mg/dL. Functional status: FMA-LE is 28/34; FMA-UE is 24/66. Section GG mobility score has improved to 5 (setup or clean-up assistance), and he ambulates 150 meters independently with a quad cane and minimal supervision. Outpatient physical therapy and neurology follow-ups are confirmed, a home CPAP unit is delivered, and remote patient monitoring blood pressure tracking is connected.
- **Post-Discharge Outcome:** A follow-up call at 48 hours and 7 days by the rehabilitation nurse confirms medication compliance and safe home navigation with zero falls or emergency department visits.

Discussion and Future Directions

The integration of nursing care and physical therapy into a synchronized clinical protocol addresses long-standing structural inefficiencies in post-acute stroke recovery. Conventional models that divide care into clinical silos fail to capitalize on the biological window of post-stroke neuroplasticity (Bernhardt et al., 2017). By restructuring daily routines into therapeutic opportunities—transforming a morning dressing routine into a balance and limb-loading exercise, or an aerobic cycling session into a real-time lesson on hemodynamic control—this protocol bridges the gap between acute medical stabilization, functional rehabilitation, and long-term secondary prevention (Billinger et al., 2014; Winstein et al., 2016).

A central strength of this protocol lies in its dual educational and physiological focus. Modifiable risk factors such as hypertension, diabetes, and dyslipidaemia are often treated passively during hospitalization (Boehme et al., 2017; O'Donnell et al., 2016). When patients are engaged in daily self-monitoring and observe the physiological impact of their medications and physical exertion firsthand, their health literacy and self-efficacy improve significantly. Concurrently, addressing post-stroke depression, anxiety, and social isolation through structured screening, behavioural activation, and peer mentorship prevents psychological complications from derailing functional recovery (Hackett et al., 2014; Robinson et al., 2016).

Overcoming Practical Implementation Challenges

Implementing this interdisciplinary protocol requires navigating real-world clinical constraints:

- **Staffing Ratios and Time Constraints:** In high-volume inpatient units, staffing shortages can make joint RN–PT sessions

difficult to schedule. Facilities can address this by prioritizing joint sessions during the critical first 3 to 5 days, establishing standardized transfer handoffs, and utilizing trained rehabilitation technicians to support co-treatment sessions.

- **Cultural Resistance to Interdisciplinary Integration:** Shifting away from departmental silos requires strong institutional leadership and clear shared goals. Mutual simulation labs, joint continuing education, and unified EHR documentation foster cross-disciplinary respect and break down traditional territorial boundaries between nursing and physical therapy teams.

Future Horizons: Digital Therapeutics, Robotics, and Biomarker-Guided Rehabilitation

The future of collaborative stroke rehabilitation will increasingly incorporate technological and digital innovations:

- **Robotic Exoskeletons and Wearable Sensors:** Integrating wearable inertial measurement units (IMUs) will allow continuous, real-time monitoring of limb usage and gait parameters throughout the day, automatically alerting nurses and therapists when a patient remains inactive for extended periods. Robotic gait orthoses and upper-limb exoskeletons can relieve physical strain on clinicians during high-repetition therapy sessions, allowing staff to focus on movement quality, cognitive dual-tasking, and physiological monitoring.
- **Artificial Intelligence and Predictive Analytics:** Advanced clinical decision support systems embedded within electronic health records can analyse dynamic hemodynamic trends, functional trajectories, and cognitive scores to predict individual recovery curves, early functional plateaus, and fall risks, enabling clinicians to proactively adapt therapy plans.
- **Tele-Rehabilitation and Remote Monitoring Ecosystems:** As inpatient stays shorten, extending the collaborative nursing–physiotherapy protocol into the home via cloud-connected blood pressure cuffs, digital glucometers, virtual reality motor coaching, and secure video visits will be essential to sustain functional gains and prevent secondary cerebrovascular events across the recovery continuum.

Conclusion

The complex pathophysiology of stroke demands a coordinated, comprehensive rehabilitation strategy. In isolation, neither physiological nursing stabilization nor intermittent physical therapy sessions can address the multifaceted motor, cognitive, affective, and vascular challenges confronting stroke survivors. By integrating evidence-based nursing care with specialized neurophysiotherapy within an educational, three-phase framework, inpatient rehabilitation facilities can systematically enhance neuroplastic adaptation, mitigate secondary stroke risk factors, accelerate functional recovery, and support long-term psychosocial reintegration for both patients and their families.

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