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ORIGINAL ARTICLE

DEVELOPMENT AND RELIABILITY ANALYSIS OF SD THE VOLITIONAL MOTOR CONTROL ASSESSMENT TOOL IN STROKE SURVIVORS: AN EXPLORATORY STUDY

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ABSTRACT:

Background: Impaired volitional motor control is a common consequence of stroke and significantly affects functional recovery. Existing assessment tools inadequately quantify the quality of voluntary movement, highlighting the need for a reliable clinical tool to assess volitional motor control in stroke survivors.

Methods: An exploratory study was conducted to develop the SD The Volitional Motor Control Assessment Tool and examine its reliability in stroke survivors (<6 months post-stroke). Item generation was based on a literature review and expert consensus. A pilot study assessed internal consistency and test–retest reliability. Inter-rater and intra-rater reliability were evaluated in 204 stroke survivors using the Intraclass Correlation Coefficient (ICC).

Results: The tool demonstrated high internal consistency (Cronbach's $\alpha = 0.913$). Test–retest reliability was good (ICC = 0.863). Excellent inter-rater (ICC = 0.995) and intra-rater reliability (ICC = 0.996) were observed.

Conclusion: SD The Volitional Motor Control Assessment Tool is a reliable instrument for assessing volitional motor control in stroke survivors and may support clinical decision-making in stroke rehabilitation.

Keywords: Volitional motor control; Stroke rehabilitation; Reliability analysis; Inter-rater reliability; Intra-rater reliability; Assessment tool

INTRODUCTION:

"A stroke or brain attack is the abrupt loss of neurological function brought on by an interruption in the brain's blood flow. Motor deficits are identified by paralysis (hemiplegia) or weakness (hemiparesis) of one side of the body, opposite to the side of the lesion in the brain."[1]

Based on the location and extent of the brain injury in a given patient, the degree of neurological abnormalities can vary, the amount of collateral blood flow, and the treatment of the patient's early acute care. Within three weeks, usually, impairments may get better on their own when the brain swelling goes down (reversible ischemic neurological deficit). Neurological deficits that last for more than three weeks run the risk of leaving a person permanently disabled. Transient ischemic attack, small stroke, major stroke, worsening stroke, and juvenile stroke are the different management categories for strokes as well as etiological categories (thrombosis, embolus, or haemorrhage), specific vascular territories (anterior cerebral artery syndrome, middle cerebral artery syndrome, etc.)[2,3,4]

Much attention is given to the functional outcomes of patients surviving a stroke. Although residual neurological deficits can lead to permanent impairments, activity limitations, and participation restrictions, impairments alone do not predict levels of disability or occupational functioning.[5]

The specific abilities lost or affected by stroke and the degree and time course of recovery from stroke vary with the location, type, and extent of the initial injury,

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and treatment provided.[6]

Neuroplasticity includes greater excitability and recruitment of intact neurons in both hemispheres of the brain as a response to stimulation, participation, training, and experience.[7]

The term "volitional" implies that an action occurs as a result of some willful activity. This leads us to question the meaning of volition, quickly immersing us in philosophical complexity. The artificial division between voluntary and involuntary movement, or between voluntary and non-voluntary movement, becomes immediately questionable. The term "volitional" offers only limited clarity. Despite its complexity, the phenomena of volition persist. The precursor to a voluntary act is a mental state that includes an anticipatory image of the sensory consequences of the movement (i.e., the motor cue), along with what is sometimes referred to as a "fiat"a decision, explicit consent, or command that these sensory consequences should be realized. Additionally, the act of mental assent requires that opposing, contradictory, or inhibiting concepts be neutralized. Voluntary action may involve choosing a course of action after deliberate consideration of all possible options and outcomes.[8,9] The assessment of volitional motor control is critical in the rehabilitation and recovery of stroke survivors, and accurate and standardized assessments can guide the development of individualized rehabilitation plans and track progress over time.[9] Executive functions are the skills that allow someone to act independently, purposefully, and for their own benefit. Executive functions as consisting of four overlapping components: volition, planning, purposive action, and effective performance. Volition is the capacity to determine what one needs and wants to do. It also encompasses a future realization of one's needs and wants. Volition encompasses goal planning and task initiation, self-awareness, awareness of the environment, and social awareness. To carry out an aim or achieve a goal, planning is defined as "the identification and organization of the steps and elements (e.g., skills, material, other persons) needed to do so." Planning involves weighing alternatives and making choices.

Following a stroke, voluntary movement control is frequently hampered. Following stages of recovery, the body's movement control on the side of the brain lesion opposite it commonly reestablishes sensory and motor function improperly. In the upper extremity, after a period of flaccidity, a common course of recovery includes the development of an uncontrolled flexion synergy. When attempting to use the hemiparetic limb for functional duties, this pathological synergy is seen in the arm. It is quite difficult to isolate joint movements from the synergy in people with this uncontrolled flexion synergy.[9]

Indeed, control of wrist and finger extensors is a challenging aspect of upper extremity recovery. Residual dysfunction in the hemiparetic limb is frequently observed for extended periods, plateauing in 12 months. Additionally, 60% of post-stroke patients experience persistent motor dysfunction as a long-term handicap after the initial year. These chronic motor problems lead to difficulty in the execution of functional movements (e.g., picking up a glass of water or buttoning a shirt) in post-stroke individuals.[10]

After a stroke, people often accept their chronic motor issues and make an effort to make up for their losses as the months turn into years. Individuals with upper extremity motor problems display behaviours that indicate learned nonuse. The affected arm is not used for any voluntary movements, whereas the unaffected arm attempts to execute all of the motor actions required for daily living. Consequently, chronic motor problems that are observed from the first year after stroke could lead to learned nonuse as individuals stop trying to voluntarily move their affected upper extremities.[11]

Impaired movement is usually presented in stroke patients, which may be due to a combination of upper motor neuron syndromes, including spasticity, weakness, loss of coordination and dexterity, and sustained muscle contraction. Patients with spasticity exhibit impaired functions and have a poor quality of life. Abnormal postural patterns are commonly observed, which might be related to an imbalance of agonist and antagonist strength, and hypertonia.

As voluntary movement is restored in stroke patients initially, synergic patterns with mass contraction of muscles are noted in the upper and lower limbs. In the upper limbs, the most commonly seen patterns are adduction and internal rotation in the shoulder, flexion in the elbow, wrist and fingers, and pronation in the forearm. In the lower limbs, extensor synergy is frequently observed, with adduction in the hip, extension in the hip and knee, and equinovarus foot. Later, individual movements are impaired, and synergic patterns are diminished.[12,13]

The patient's perceptions of his/her health and adjustment to the disability are critical for planning treatment and evaluating outcomes. Traditional stroke rehabilitation focuses on the alleviation of symptoms and restoration of function. However, evaluation of the effectiveness of interventions should take into account not only the perspective of the healthcare professional or clinician but also that of the patient. Because some treatment effects, such as changes in mood, are known only to the patient, systematic assessment of the patient's perspective may provide valuable information for treatment outcomes.

There is limited supporting literature available for grading volitional movement in stroke patients. In stroke rehabilitation, relying solely on muscle strength can be unreliable, as it does not fully capture the functional capabilities of the patient. Existing scales often focus on assessing overall functions rather than providing a detailed evaluation of movement quality. Thus, there is a significant need for a more precise method to assess volitional movement, which is crucial for accurately tracking and enhancing motor recovery. While it may be challenging to review every published study, it is important to acknowledge that no fully objective method currently exists to quantify the quality of movement in stroke patients. This quantification is crucial for effectively tracking the progression of motor and physical performance recovery. As it is proven that the brain recognizes movement, the brain does not recognize muscle, and it is of vital importance to grade movement rather than manual muscle testing. In Neurology, Voluntary control plays a key role in assessing volitional movements compared to MMT (Manual Muscle Testing). It is of vital importance to check Voluntary control to imply MMT in a particular muscle. If voluntary control is compromised, MMT results may not accurately reflect the muscle's strength or functional capacity. Therefore, evaluating voluntary control helps to contextualize MMT findings and identify whether observed muscle weakness is due to a lack of voluntary control or an intrinsic muscle impairment.

This understanding helps in distinguishing between true muscle weakness and issues related to voluntary control, thereby guiding appropriate rehabilitation strategies. Voluntary control refers to a patient's ability to consciously activate specific muscles or muscle groups. In the context of stroke rehabilitation, assessing voluntary control is crucial before applying Manual Muscle Testing (MMT) because MMT measures the strength of a muscle during voluntary contraction. MMT is a standardized method used to evaluate the strength of individual muscles or muscle groups based on the patient's ability to voluntarily contract the muscle against resistance. The effectiveness of MMT relies on the patient's capacity for voluntary muscle control. Voluntary muscle control is often diminished in stroke patients, which can affect the reliability of MMT. Assessing voluntary control ensures that the muscle is being tested under appropriate conditions. If a patient lacks sufficient voluntary control, the MMT may not accurately reflect true muscle strength, leading to misleading results. Without 20 verifying voluntary control, applying MMT could result in inaccurate assessments, affecting treatment planning and rehabilitation outcomes. Thus, clinicians must ensure that the patient can voluntarily engage the muscle before proceeding with MMT to obtain valid and reliable data. Assessing voluntary control is essential in stroke patients to ensure that MMT accurately reflects muscle strength. This assessment allows clinicians to distinguish between true muscular deficits and issues related to impaired neurological control, ensuring that treatment plans are appropriately tailored to the patient's specific needs. For instance, there are no guidelines available for the usage of voluntary control.

There are a few scales which also measure movement analysis like STREAM (Stroke Rehabilitation Assessment of Movement), and FMA (Fugl Meyer Assessment of Motor Recovery). In STREAM- a cumulative score is not available. In the STREAM score, quantification of total basic mobility is not possible. So it is always a topic of discussion that how to track recovery in voluntary control as the post-stroke duration increases. In FMA, after investigating the dimensionality and construct validity of the FMA UE, researchers suggest that the assessment of reflexes in the FMA-UE gives little information about the volitional movement.[14] Commonly used outcome measures like FMA, and STREAM does not quantify the quality of isolated movements. Voluntary control is significantly associated with functional independence and quality of life in stroke patients. One can predict stroke recovery using this assessment scale.[15] so; there is a strong need to develop a Scale which measures Volitional movement.

Materials and Methods

Study Design:

The current study is exploratory. It is a study where each participant was assessed one time only for testing of volitional motor control of stroke survivors.

Study Participants:

The participants of Surat, who were coming to different physiotherapy clinics with a clinical diagnosis of stroke by a neurologist or general physician, who were discharged from the hospital due to stable medical condition and had less than 6 months (sub-acute phase) post stroke duration were considered as the study participants.

Study Settings:

Stroke participants were identified and recruited in the study from the following institutions or clinics. A letter or e-mail was addressed to them explaining the nature of the study and outlining the information and support needed from the institute or establishment. All of the employees contacted stated their complete support for the study and were eager to provide the required assistance and information, including access to the stroke patients and medical or rehabilitation service-related data of the patients with permission.

Study Duration:

The duration of data collection was from April 2022 to May 2023. The total duration of the study includes the inception of the study to the final preparation of the thesis i.e. from August 2019 to October 2023.

Approvals and Registrations:

After selecting the research topic, the Institutional Ethical Committee at SPB Physiotherapy College, Surat, approved the research protocol with reference number EC/SPB/060. Subsequently, the protocol was registered in the Clinical Trial Registry of India with registration number CTRI/2022/05/042467 which fulfilled the need for registration of our research at the national level and made it competent for accountability, transparency, and accessibility to establish the trust of the public in our clinical research.

Sample Size:

The sample size was calculated by considering a prevalence rate of 559/100,000 for stroke with 80% power at 1% standard error which gave a sample size of 111.

Sampling Technique:

In the current study, judgemental sampling was used to identify stroke participants by choosing people from the population based on the researcher's expertise and judgement by visiting different physiotherapy institutions to complete data collection in a constrained amount of time.

Selection Criteria:

Inclusion Criteria

Individuals diagnosed with a first-ever ischemic or haemorrhagic stroke by a Neurologist

Both male and female participants within the age group of 18 to 65 years.

Participants with a Mini-Mental State Examination (MMSE) score greater than 24.

Spasticity grade according to the Modified Ashworth Scale (MAS): 1, 1+, or 2.

Exclusion Criteria

Participants with a history of psychological or cognitive-behavioural disorders that impair their ability to understand or cooperate with the study requirements.

Participants lacking proper medical records or documentation of their stroke diagnosis and treatment.

Participants with additional neurological or musculoskeletal deficits unrelated to the stroke.

Procedure of the Study:

Phase I: Development of the Tool

- Item generation based on literature review and expert consensus
- Expert panel validation (17 experts)
- Content Validity Ratio (CVR) and Content Validity Index (CVI) calculated
- Face validity assessed
- Pilot study conducted for preliminary reliability

Phase II: Validation of the Tool

Participants were assessed using:

Inter-rater and intra-rater reliability

Results

Reliability Statistics for the Scale Using Data from Pilot Study

This section addresses the results of the continuing process of evaluation of psychometrics of the newly designed scale. This section specifically focuses on the reliability assessment results for the scale using the data collected in a pilot study conducted using the population of interest. It helps to ascertain the applicability of the scale in increasing the dependability of the data which is supposed to be gathered using it. Cronbach's alpha was used to establish the internal consistency for the 57 items. The calculated value of alpha was found to be 0.913. Test-retest reliability was calculated using the Intra-class Correlation Coefficient (ICC) using a mixed model method. The value of the Intra-class Correlation Coefficient (ICC) was high at 0.863 (95% CI: 0.787 - 0.923; p=0.0001). The reliability statistics are shown in Table.

Table1: Reliability Statistics for the Scale Using Data from Pilot Study

Cronbach's Alpha	Intra Class Coefficient	95% Confidence Interval	Level of Significance	Interpretation of Reliability
0.913	0.863	0.787-0.923	0.0001	Excellent

Thus, all the items showed excellent internal consistency and test-retest reliability and therefore can be applied without any change to collect the data from a larger sample

Inter-Rater Reliability: Inter-rater reliability was assessed by having two raters (Rater 1 and Rater 2) independently score the volitional motor control tool for a sample of participants (n=204). The Intraclass Correlation Coefficient (ICC) and 95% Confidence Interval (CI) were calculated to assess the level of agreement between the two raters. The results showed a high ICC value of 0.995 (95% CI: 0.994 to 0.996.), indicating high inter-rater reliability.

Table 2: Analysis of Intraclass Correlation Coefficients (ICC) for Inter Rater reliability of a developed scale (SD THE VOLITIONAL MOTOR CONTROL ASSESSMENT TOOL)

Intra ClassCoefficient (95% Confidence Interval)	Level of Significance	Interpretation of Reliability
0.995 (0.994 - 0.996)	< 0.001	Excellent

Table presents an analysis of the Intraclass Correlation Coefficients (ICC) for assessing the Inter-Rater Reliability of a developed scale, specifically the SD The Volitional Motor Control Assessment Tool. The Intraclass Coefficient, along with its 95% Confidence Interval, is provided. Additionally, the level of significance associated with the Inter-Rater Reliability is indicated. The Intraclass Coefficient, reported as 0.995 with a 95% Confidence Interval ranging from 0.994 to 0.996, signifies a high degree of agreement between the raters who independently assessed the same phenomenon or behaviour. The associated level of significance, denoted as "<0.001" further confirms the statistical significance of the reliability measure.

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Based on these findings, the interpretation of the reliability can be classified as excellent, indicating strong consistency and agreement among the raters in their scoring of the SD The Volitional Motor Control Assessment Tool.

Intra-Rater Reliability:

Intra-rater reliability is a measure of consistency or agreement between the same rater or observer across multiple assessments or ratings.Intra-rater reliability was assessed by having a single rater (Rater 1) score the volitional motor control tool for the same sample of participants (n=204) on two separate occasions, Day 1 and Day 7.The ICC was used to assess the level of agreement between the two sets of scores. The results showed excellent agreement between the two sets of scores, with an ICC of 0.996 (95% CI: 0.995 to 0.997), indicating high intra-rater reliability.

Table 3: Analysis of Intraclass Correlation Coefficients (ICC) for Intra Rater reliability of a developed scale (SD THE VOLITIONAL MOTOR CONTROL ASSESSMENT TOOL)

Intra Class Coefficient (95% Confidence Interval)	Level of Significance	Interpretation of Reliability
0.996 (0.995 - 0.997)	< 0.001	Excellent

Table displays an analysis of the Intraclass Correlation Coefficients (ICC) concerning the Intra-Rater Reliability of a developed scale, specifically the SD The Volitional Motor Control Assessment Tool. The Intraclass Coefficient, along with its 95% Confidence Interval, is presented, along with the associated level of significance and interpretation of reliability. The reported Intraclass Coefficient of 0.996, with a 95% Confidence Interval ranging from 0.995 to 0.997, indicates a high level of consistency or agreement exhibited by the same rater across multiple ratings. The associated level of significance, denoted as "< 0.001," underscores the statistical significance of the reliability measure. In terms of interpretation, the reliability can be classified as excellent, suggesting strong consistency and agreement in the ratings conducted by the same rater using the SD The Volitional Motor Control Assessment Tool.

DISCUSSION

The present exploratory study was undertaken to develop and validate a comprehensive clinical tool for assessing volitional motor control in stroke survivors. Volitional motor control plays a crucial role in functional recovery following stroke, yet it remains inadequately quantified by existing outcome measures. The findings of the present study demonstrate that the SD The Volitional Motor Control Assessment Tool exhibits excellent psychometric properties, supporting its clinical applicability in stroke rehabilitation.

Reliability analysis revealed high internal consistency of the scale, with a Cronbach's alpha value of 0.913 in the pilot study, indicating strong homogeneity among the items. This suggests that the items collectively measure the underlying construct of volitional motor control. Test–retest reliability analysis further demonstrated good temporal stability, with an ICC value of 0.863, confirming that the scale yields consistent results over time when administered under similar conditions.

The inter-rater reliability of the tool was found to be excellent, with an ICC value of 0.995, indicating a very high level of agreement between different raters. This is particularly important for clinical settings, where multiple therapists may assess the same patient. High inter-rater reliability ensures that the assessment is objective and not dependent on the individual examiner's judgment or experience. Similarly, intra-rater reliability analysis demonstrated excellent consistency across repeated assessments by the same rater, with an ICC value of 0.996, confirming the reproducibility of the scale.

The strong reliability findings can be attributed to the systematic process of tool development, including item generation based on literature review, expert consensus, content validation by a multidisciplinary expert panel, and pilot testing prior to large-scale application.

The clear operational definitions and standardized scoring criteria may have further contributed to the high reliability indices.

Volitional motor control is a critical prerequisite for effective movement execution, and its impairment following stroke often results in abnormal synergistic patterns, poor movement isolation, and reduced functional use of the affected limb. Traditional assessment approaches, such as Manual Muscle Testing, primarily measure muscle strength and may not accurately reflect the quality of voluntary motor control, especially in individuals with impaired neural activation. The present study reinforces the concept that grading movement quality and voluntary control is more clinically meaningful than assessing muscle strength alone in stroke rehabilitation.

Existing tools such as the Fugl-Meyer Assessment and STREAM provide valuable information regarding motor recovery; however, they have limitations in quantifying isolated and graded volitional movements. The absence of cumulative scoring in STREAM and the limited contribution of reflex assessment to voluntary movement analysis in FMA underscore the need for a dedicated scale focusing specifically on volitional motor control. The SD Volitional Motor Control Assessment Tool addresses this gap by providing a structured and graded evaluation of voluntary movement patterns.

Accurate assessment of volitional motor control has significant implications for treatment planning, prognosis estimation, and monitoring recovery over time. By identifying the level of voluntary control present in a patient, clinicians can tailor rehabilitation strategies more effectively, distinguish between true muscle weakness and impaired neural control, and track meaningful changes during recovery.

CONCLUSION

The present study successfully developed and validated a comprehensive clinical tool for assessing volitional motor control in stroke survivors. The SD The Volitional Motor Control Assessment Tool demonstrated excellent internal consistency, test–retest reliability, inter-rater reliability, and intra-rater reliability, confirming its psychometric robustness.

Given the critical role of volitional motor control in functional recovery after stroke, the availability of a reliable and standardized assessment tool is essential for effective clinical decision making. This tool enables physiotherapists to objectively grade voluntary movement, differentiate between impaired voluntary control and true muscle weakness, and plan individualized rehabilitation programs accordingly.

The SD Volitional Motor Control Assessment Tool can be used as an outcome measure to monitor recovery, evaluate treatment effectiveness and assist in prognostic evaluation in stroke rehabilitation. Its clinical applicability makes it a valuable addition to existing assessment methods. The tool has been formally copyrighted (Registration No. L-143982/2024), supporting its originality and potential for wider clinical use.

Further research may explore the responsiveness of the tool to therapeutic interventions and its applicability across different stages of stroke recovery.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. O'Sullivan S, Schmitz T. Physical rehabilitation. Philadelphia: F.A. Davis; 2019.
2. Carr J, Shepherd R. Neurological rehabilitation. Edinburgh: Churchill Livingstone/Elsevier; 2014.
3. Implications of the AHA/ASA Updated Definition of Stroke for the 21st Century [Internet]. Worldneurologyonline.com. 2019 [cited 2019 Dec 29]. Available from: https://worldneurologyonline.com/article/implications-of-the-ahaasa-updated- definition-of-stroke-for-the-21st-century

4. World Health Organization. Stroke [Internet]. 2022 [cited 2022 Feb 20]. Available from: https://www.who.int/news-room/fact-sheets/detail/stroke
5. Kelly-Hayes M, Beiser A, Kase CS, Scaramucci A, D'Agostino RB, Wolf PA. The influence of gender and age on disability following ischemic stroke: the Framingham study. Journal of stroke and cerebrovascular diseases. 2003 May 1;12(3):119-26.
6. Johnston SC, Albers GW, Gorelick PB, Cumbler E, Klingman J, Ross MA, Briggs M, Carlton J, Sloan EP, Vaince U. National Stroke Association recommendations for systems of care for the transient ischemic attack. Annals of neurology. 2011 May;69(5):872-7.
7. Albert SJ, Kesselring J. Neurorehabilitation of stroke. Journal of Neurology. 2012 May;259(5):817-32.
8. Matola T. Stroke: A Bird's Eye View. Topics in Stroke Rehabilitation. 2001 Jan 1;7(4):61 3.
9. Stein DG. Brain injury and theories of recovery. In: Goldstein LB, ed. Restorative Neurology: Advances in Pharmacotherapy for Recovery After Stroke. Armonk, NY: Futura Publishing; 1998:1-34.
10. James W. The stream of consciousness. Psychology. 1892:151-75.
11. Wolf SL, Catlin PA, Ellis M, Archer AL, Morgan B, Piacentino A. Assessing Wolf motor function test as an outcome measure for research in patients after stroke. Stroke. 2001 Jul;32(7):1635-9.
12. Writing Group Members, Roger VL, Go AS, Lloyd-Jones DM, Adams RJ, Berry JD, Brown TM, Carnethon MR, Dai S, de Simone G, Ford ES. Executive summary: heart disease and stroke statistics—2011 update: a report from the American Heart Association. Circulation. 2011 Feb 1;123(4):459-63.
13. Kuo CL, Hu GC. Post-stroke spasticity: a review of epidemiology, pathophysiology, and treatments. International Journal of Gerontology. 2018 Dec 1;12(4):280-4.
14. Van Kuijk AA, Pasman JW, Hendricks HT, Zwarts MJ, Geurts AC (2009) Predicting hand motor recovery in severe stroke: The role of motor evoked potentials about early clinical assessment. Neurorehabil Neural Repair 23: 45–51.
15. Turton AJ, Fraser CM. A test battery to measure the recovery of voluntary movement control following stroke. International rehabilitation medicine. 1986 Jan 1;8(2):74-8.

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ORIGINAL ARTICLE

MEASURE RIGHT: DEVELOPMENT OF A UNIFIED HAND-HELD DYNAMOMETRY PROTOCOL FOR CHRONIC STROKE LOWER LIMB MUSCLE TESTING

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ABSTRACT:

Background: Lower-limb muscle weakness in individuals with chronic stroke significantly limits gait, balance, and functional mobility. Accurate strength assessment is essential; however, existing hand-held dynamometry (HHD) protocols lack stroke-specific standardization.

Methods: A unified, stroke-specific HHD protocol was developed using standardized positioning, stabilization, and dynamometer placement for eight lower-limb muscle groups. Thirty-one individuals with chronic stroke (19 males, 12 females) were assessed. Intra-rater reliability was evaluated across two consecutive days by the same examiner, and inter-rater reliability was assessed on the same day by two trained physiotherapists using intraclass correlation coefficients (ICC).

Results: All muscle groups demonstrated excellent intra- and inter-rater reliability (ICC > 0.90). Predictable pathology-specific weakness and age-related clustering of strength values were observed.

Conclusion: The developed HHD protocol is reliable, stroke-specific, and clinically feasible for lower-limb strength assessment in chronic stroke.

Keywords: Chronic stroke; Hand-held dynamometry; Lower Limb Muscle strength; Reliability;

INTRODUCTION:

Stroke remains one of the leading causes of long-term disability worldwide, with a substantial proportion of survivors experiencing persistent motor impairments. Among these impairments, lower-limb muscle weakness is a critical factor contributing to reduced gait speed, impaired balance, decreased endurance, and limitations in functional mobility., These deficits significantly affect independence and quality of life in individuals living with chronic stroke.

Accurate assessment of muscle strength is fundamental in neuro-rehabilitation. Clinically, it guides treatment planning, goal setting, and progression of therapeutic interventions., From a research perspective, reliable strength measurement is essential for evaluating intervention effectiveness and ensuring comparability across studies. Traditionally, manual muscle testing (MMT) has been widely used; however, it lacks sensitivity, particularly in detecting subtle changes in strength and differentiating higher grades of muscle power.,

Hand-held dynamometry (HHD) offers an objective, portable, and cost-effective alternative to MMT. It allows quantification of isometric muscle force and has demonstrated good reliability in various populations., Despite these advantages, the use of HHD in individuals with chronic stroke presents unique challenges. Stroke-related impairments such as spasticity, abnormal synergies, reduced selective motor control, and postural instability can influence test performance., Moreover, existing HHD studies in stroke populations often employ heterogeneous testing positions, stabilization techniques, and examiner methods, leading to variability in reported outcomes.,

Previous literature suggests that reliability of HHD measurements improves significantly when testing procedures are rigorously standardized.

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The absence of a unified, stroke specific protocol limits clinical confidence and reduces the comparability of research findings.,

Therefore, the purpose of this study was to develop a unified, stroke-specific HHD protocol for lower-limb muscle strength assessment and to evaluate its intra-rater and inter-rater reliability in individuals with chronic stroke.

Materials and Methods

Study Design

A Cross sectional methodological study using Purposive Sampling was conducted by to evaluate the intra-rater and inter-rater reliability of a newly developed unified HHD protocol for lower-limb muscle testing in individuals with chronic stroke.

Ethical Approval

Ethical Clearance was obtained from Institutional Ethical Committee. Informed Consent was obtained from all participants prior to data collection.

Participants

Thirty-one individuals with chronic stroke (19 males and 12 females) were recruited from Rehabilitation settings. Inclusion criteria included a confirmed diagnosis of stroke with a chronic duration, ability to follow verbal instructions, and capacity to perform voluntary lower-limb muscle contractions, Modified Ashworth Scale ≤ Grade 2 and Berg Balance Scale with Low Fall Risk . Participants with severe cognitive impairments, unstable medical conditions, or participants with fixed contracture of lower limb muscle were excluded.

Materials

Isometric muscle strength was assessed using a calibrated hand-held dynamometer. The same device was used for all measurements to eliminate inter-device variability.

Muscle Groups Tested

Eight major lower-limb muscle groups were evaluated:

1) Hip flexors
2) Hip extensors
3) Hip abductors
4) Hip adductors
5) Knee extensor
6) Knee flexors
7) Ankle dorsiflexors
8) Ankle plantarflexors.

These muscle groups were selected due to their critical role in gait, balance, and functional mobility in individuals with stroke.

Development of the Unified Protocol

The protocol emphasized Standardized patient positioning, Consistent stabilization of the trunk and tested limb, precise dynamometer placement and a fixed testing sequence. Stroke-specific considerations were incorporated to minimize abnormal synergies and compensatory movements.

Procedure

Two trained physiotherapists performed strength testing.

- Intra-rater reliability: Same examiner assessed participants on two consecutive days.
- Inter-rater reliability: Two examiners assessed participants on the same day.

For each muscle group, participants were instructed to perform 3 Trials of maximal isometric contraction against the dynamometer. Adequate rest periods were provided between trials to minimize fatigue.

Statistical Analysis

Intra and Inter rater reliability were analyzed using intraclass correlation coefficients (ICC, two way mixed effects model). ICC values >0.90 were considered excellent.

Table 1. Description of HHD Protocol with Muscle groups, Patient Position, Therapist Position, HHD Placements and Commands

Muscle Group	Patient Position	Therapist Position	HHD Placement	Required Stabilization	Commands
Hip Flexors	High Sitting (Hip –Knee at 90°)	Beside the Patient	Proximal to knee over anterior Thigh	Stabilize Trunk, Pelvis & Shoulder	Lift your thigh up towards ceiling
Hip Extensors	Prone lying (Knee flex: 90°)	Beside the Patient	Distal thigh (Above Popliteal Fossa)	Stabilization belt at Pelvis	Lift your thigh up toward ceiling
Hip Abductors	Side Lying Testing limb up	Beside the Patient	Above lateral femoral condyle	Stabilization belt at Pelvis	Lift your leg up toward the ceiling
Hip Adductors	Side Lying Testing limb down	Beside the Patient	Above medial femoral condyle	Stabilization belt at Pelvis, Non-tested limb hold by therapist	Bring your lower leg upward toward the top leg
Knee Flexors	Prone Lying	Beside the Patient	Posteriorly, above ankle	Stabilization belt at Pelvis	Bend your knee
Knee Extensors	High Sitting	Sitting beside the ankle	Anterior lower leg, just above the ankle	Stabilize Anterior Thigh	Kick your leg forward
Ankle Dorsiflexors	High Sitting	Sitting in front of the patient	Dorsal aspect of Metatarsal heads	Ankle in neutral by stool	Pull your foot up towards face
Ankle Planterflexors	Prone lying with Knee flex 90°, ankle in neutral	Standing beside the patient	Planter aspect of Metatarsal heads	Stabilization belt at Pelvis & Therapist Stabilize at Distal tibia	Push your foot down

Image 1. HHD Protocol for Chronic Stroke Lower Limb Muscles Testing

Results

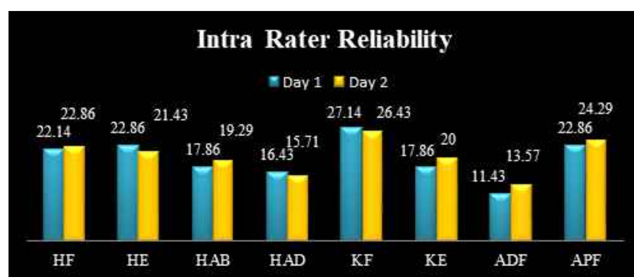
The present study was conducted to evaluate Intra & Inter Reliability of the Newly Developed Protocol. Reliability was assessed using intraclass correlation coefficients (ICC).

Table 2. Demographical Details

No.	Variable	MEAN± SD
1)	Mean Age of Participants	63.3 ± 4.1
2)	Gender (Male/female)	19/12

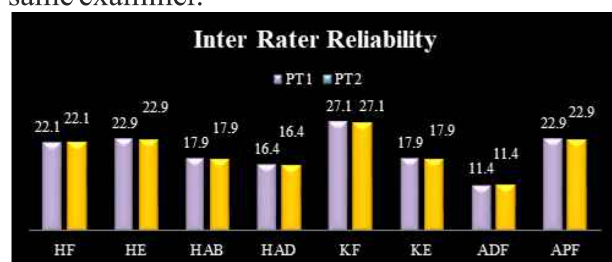
Table 3. Intra-rater and Inter-rater Reliability of the Unified HHD Protocol for Chronic Stroke Lower Limb Muscle Testing

No.	Types of Reliability	ICC Value	Interpretation
1)	Intra Rater Reliability	0.93	Excellent
2)	Inter Rater Reliability	0.92	Excellent



Graph 1. Intra Rater Reliability of the HHD Protocol for Chronic Stroke Lower Limb Muscle Testing

All eight lower-limb muscle groups demonstrated excellent intra-rater reliability, with (ICC > 0.9) indicating consistent reproducibility of measurements across testing sessions by the same examiner.



Graph 2. Inter Rater Reliability of the HHD Protocol for Chronic Stroke Lower Limb Muscle Testing

Inter-rater reliability was also excellent for most muscle groups, with (ICC >0.9) confirming that the protocol can be applied consistently by different examiners. Ankle Dorsiflexors and Hip Adductors demonstrated comparatively, lower strength values.

Discussion

The present study demonstrated excellent intra-rater and inter-rater reliability for a newly developed, stroke-specific unified HHD protocol for lower-limb muscle strength assessment. These findings highlight the importance of standardized testing procedures in minimizing measurement variability.

The high reliability observed can be attributed to several key factors. First, strict standardization of patient positioning minimized postural variability and compensatory movements. Second, consistent stabilization techniques reduced extraneous motion and improved force transmission to the dynamometer. Third, examiner training and adherence to a unified testing sequence enhanced procedural consistency.

These findings are consistent with previous studies reporting improved reliability of HHD measurements when standardized protocols are employed. Mentiplay et al.11 demonstrated that rigorously standardized testing procedures significantly enhance the reliability and validity of lower-limb strength assessment.

Age-related clustering of strength values observed in this study aligns with evidence suggesting that age is a strong independent predictor of muscle strength, even in pathological populations. Studies by Darak et al. and Haynes et al. have reported similar trends, emphasizing the importance of considering age when interpreting strength measurements. Additionally, Ankle dorsiflexors and Hip adductors were identified as the most affected muscle groups, consistent with stroke related neuromuscular impairments by Dorsch et al. .

Conclusion

The newly developed unified HHD protocol is reliable, stroke-specific, clinically practical, and easy to administer. Excellent intra-rater and inter-rater reliability support its use in both clinical practice and research. The protocol enhances clinical decision-making, improves treatment planning, and strengthens standardization of lower-limb muscle strength assessment in individuals with chronic stroke.

References

1. Feigin VL, et al. Global burden of stroke. Lancet Neurol. 2014.
2. Hunnicutt JL, Gregory CM. Skeletal muscle changes following stroke. Top Stroke Rehabil. 2017;24:463–471.
3. Bohannon RW. Muscle strength and walking performance after stroke. Stroke. 1989.
4. Flansbjer UB, et al. Relationship between muscle strength and functional performance after stroke. Clin Rehabil. 2006.
5. Lang CE, et al. Measurement in stroke rehabilitation. Neurorehabil Neural Repair. 2013.
6. Sullivan KJ, et al. Outcome measurement in neurological rehabilitation. Phys Ther. 2007.
7. Bohannon RW. Muscle strength assessment in rehabilitation. Phys Ther. 2005.
8. Portney LG, Watkins MP. Foundations of clinical research. Prentice Hall. 2015.
9. Bohannon RW. Manual muscle testing: limitations and alternatives. Phys Ther. 2005.
10. Cuthbert SC, Goodheart GJ. Reliability and validity of MMT. Chiropr Osteopat. 2007.
11. Mentiplay BF, et al. Reliability of hand-held dynamometry. PLoS One. 2015;10:e0140822.
12. Gafner SC, et al. Hip muscle strength assessment using HHD. Clin Interv Aging. 2018.
13. Stark T, et al. Hand-held dynamometry reliability. Phys Ther Rev. 2011.
14. Ada L, Canning CG. Stroke motor impairments and rehabilitation. Phys Ther. 2015.
15. Hsu AL, Tang PF. Analysis of motor control after stroke. J Rehabil Med. 2012.
16. Pinto-Ramos J, et al. HHD reliability in rehabilitation patients. PLoS One. 2022.
17. Kelln BM, et al. Variability in HHD testing procedures. J Orthop Sports Phys Ther. 2008.
18. Thorborg K, et al. Effect of standardization on HHD reliability. Br J Sports Med. 2010.
19. Jørgensen MG, et al. Reliability of lower limb strength testing. Phys Ther. 2014.
20. Darak V, et al. Lower limb motor function and hip muscle weakness in stroke survivors and their relationship with pelvic tilt, weight-bearing asymmetry, and gait speed: A cross-sectional study. Current Journal of Neurology. 2020 Jan 5;19(1):1.
21. Haynes EM, et al. Age and sex-related decline of muscle strength across the adult lifespan: a scoping review of aggregated data. Applied Physiology, Nutrition, and Metabolism. 2020;45(11):1185-96.
22. Dorsch S, et al. Lower limb strength is significantly impaired in all muscle groups in ambulatory people with chronic stroke: a cross-sectional study. Archives of physical medicine and rehabilitation. 2016 Apr 1;97(4):522-7.

VIMS Journal of Physical Therapy

ORIGINAL ARTICLE

EFFECTIVENESS OF EMG BIOFEEDBACK WITH BOBATH TECHNIQUE IN HAND FUNCTION IN POST STROKE SURVIVORS - AN EXPERIMENTAL STUDY

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ABSTRACT:

Introduction: Stroke is a major cause of long-term disability, frequently leading to diminished hand function that greatly interferes with daily life activities. Both conventional rehabilitation methods such as Bobath technique and more contemporary supplements like Electromyographic (EMG) biofeedback have shown on their own advantages in improving motor recovery. But there's not much proof about how well they work together.

Methods: A trial involving 30 post stroke patients (45-70years) drawn from nearby hospitals was carried out. Participants met inclusion criteria of middle cerebral artery stroke (subacute to chronic stage, Brunnstrom stage 2-5, MMSE>24).Pre and post-intervention the Michigan Hand Questionnaire (MHQ) evaluated hand function. For four weeks, statistical analysis was done with paired t-test at a significance threshold of $p<0.01$ using EMG biofeedback training (40 minutes, 3 sessions/week) and Bobath based exercises(30 minutes/day,3 sessions/week)

Results: Post-intervention examination showed a statistically significant increase in hand function. With a mean difference of 32.5 ($t = 12.574$, $p<0.01$), the mean MHQ score rose from 77.5 to 45.0. This suggests improved neuromuscular control, motor relearning, and functional recovery when the Bobath technique was used with EMG biofeedback.

Conclusion: The study demonstrates that Research show that post-stroke survivors' hand function greatly improves when EMG biofeedback is combined with the Bobath method. As a result of the synergistic effect, the integrated strategy promotes motor recovery and functional independence, therefore making it somewhat beneficial supplement in stroke recovery.

Keywords: Stroke, Hand function, EMG Biofeedback, Bobath Technique, Rehabilitation, Michigan Hand Questionnaire.

INTRODUCTION:

Stroke (cerebrovascular accident) is the sudden loss of neurological function caused by an interruption of blood flow to the brain1.The incidence range from 152/100000 persons per year and the crude prevalence of stroke ranged from 44.29 to 559/100000 persons in different parts of the country during the past decades[2].

The Circle of Willis is an anastomotic arterial network located at the base of the brain. Its primary function is to provide collateral circulation to cerebral and cerebellar tissues, ensuring consistent blood flow and minimizing the risk of ischemia, transient ischemic attacks (TIAs), or stroke. Traditionally, the Circle of Willis is described as a symmetrical polygon, formed by the connection of branches from the internal carotid and vertebral arteries.

Contemporary anatomy textbooks typically depict the Circle of Willis as a roughly pentagonal circle of arteries situated on the ventral surface of the brain. The structure includes the anterior and posterior cerebral arteries, which supply blood to various regions of the cerebrum and cerebellum.

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These arteries are interconnected by the anterior communicating artery and two posterior communicating arteries, forming a vital collateral arterial network that maintains cerebral perfusion even in the event of arterial occlusion.[3]

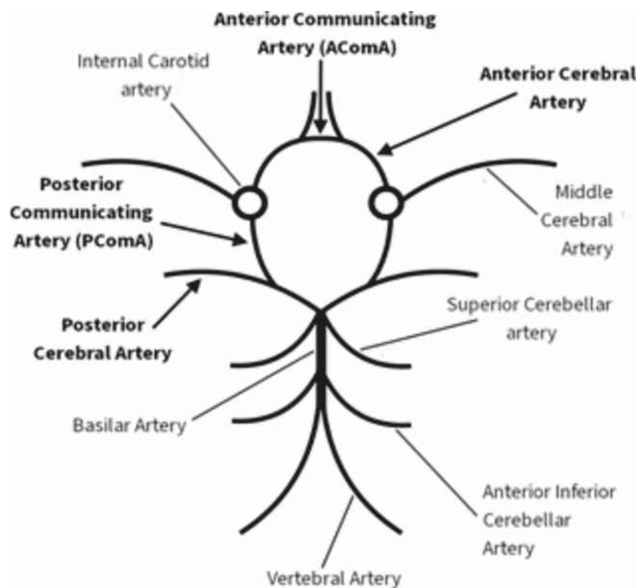


Figure 1: CIRCLE OF WILLIS

Ischemic stroke is the most common type, affecting about 80% of individuals with stroke, and can be the result of thrombosis, embolism, or hypo perfusion. A thrombus is a local occlusion of the blood vessel, and an embolus is material from a distant site that either blocks or impairs blood flow, depriving the brain of essential oxygen and nutrient .Lack of oxygen and nutrients results in tissue necrosis and penumbral area where the cells may be damaged but preserved. Hemorrhagic stroke occurs when blood vessels rupture, causing leakage of blood in or around the brain. Clinically, a variety of focal deficits are possible, including changes in the level of consciousness and impairments of sensory, motor ,perceptual ,and language functions .Motor deficits are characterized by paralysis (hemiplegia) or weakness (hemiparesis), typically on the side of the body opposite to the side of the lesion .The term hemiplegia is often used generically to refer to the wide variety of motor problems that result from stroke The location and extent of the brain injury, the amount of collateral blood flow, and early acute care management determine the severity of neurological deficits in an individual patients. Impairments may resolve spontane-ously as brain swelling subsides (reversible ischemic neurological deficit), generally within 3 weeks. Residual neurological impairments are those that persist longer than 3 weeks and may lead to lasting disability.[1]

Blood supply of brain: two vertebral and internal carotid arteries carry the total aterial supply to the brain

Branches of internal carotid artery are as follows:

- Opthalmic artery
- Posterior communicating artery
- Anterior Choroidal artery
- Anterior cerebral artery
- Middle cerebral artery

Circulus Arteriosus or circle of Willis is a hexagonal arterial circle situated at the base of brain in the interpeduncular fossa. It is formed by the anterior cerebral branches and terminal parts of internal carotid artery that is middle cerebral artery with its posterior communicating branch and the posterior cerebral branches of basilar artery.[4]

Figure 2: EARLY WARNING SIGNS AND SYMPTOMS FOR STROKE

Recent advances in neuroscience have transformed our understanding of motor learning and recovery after brain injury, driving innovative research in motor rehabilitation.5 Stroke survivors often experience weakness of one side of the body affecting hand and foot function due to brain damage impacting muscles contraction and control.[6] Hand function involves intricate coordination of reaching, grasping and manipulation. Tasks such as grasping of cup require integration of visuomotor, tactile and motor skills. Impairments in these abilities can led to hand dysfunction, emphasizing the need for rehabilitation assessment and targeted intervention.[7]

The Bobath Concept, internationally known as the Neuro Developmental Technique (NDT), has gained increasing interest in the field of rehabilitation, particularly for the treatment of stroke patients. Widely practiced across many countries, Bobath is a therapeutic approach aimed at improving motor function in individuals with neurological impairments, especially those with hemiplegia following a stroke.

Originally developed by Berta Bobath in the mid-20th century, the approach focuses on how motor dysfunction occurs and can be addressed through guided, active participation. Stroke patients engage in therapist-assisted exercises that uses key points of control and reflex-inhibiting patterns to promote more functional movement. Unlike passive therapies, the Bobath approach emphasizes the active involvement of the patient in order to facilitate motor learning and restore motor control. While earlier reviews have primarily focused on controlled clinical trials, the Bobath concept remains a foundational method in stroke rehabilitation due to its patient-centered and movement-based strategies.[8]

Electromyography (EMG) is a neurophysiological approach used to find, measure, and analyze the bioelectrical signals generated by motor units inside muscles during both deliberate motions and spontaneous activity. EMG can be divided into two major methods depending on the type of electrode employed: surface electromyography (sEMG) and needle electromyography (nEMG).

Surface EMG (sEMG) has the benefit of capturing the general myoelectric activity produced by many motor units, therefore enabling a more thorough examination of muscle performance rather than concentration on one motor unit. By using the idea of bulk electrical conductivity, this method reduces the impact of electrode distance from the signal source on the gathered data. This enables the non-invasive, more patient comfort procedure of straight skin-based electrodes.

When muscle fibers are triggered by neurological or external electrical signals, sEMG records the resulting electrical potentials. Making it a helpful instrument in both clinical and research contexts, the recorded signals provide important data on muscle contraction, tone, tiredness, patterns of activation and coordination.[9]

Electromyographic biofeedback (EMG-BF) therapy help stroke patients recover by using electrical stimulation and visual/auditory signals to rebuild nerve cells and neural networks. This therapy enables the brain to regulate muscle movement and relaxation, promoting rehabilitation.[10]

The Michigan Hand Questionnaire (MHQ) assesses hand function, daily activities, work performance, pain, appearance, and overall satisfaction and reliability of (ICC-0.8- 0.9).11

METHOD

This study was designed as a pre-post experimental investigation to assess the effectiveness of EMG biofeedback with bobath technique in hand function in post stroke survivors. The research was conducted over a period of six months at the Physiotherapy Department of RJS College of Physiotherapy, Kokamthan, in association with SJS Hospital.

The sample consisted of 30 participants, including both male and female subjects, selected through a convenient sampling method. Participants were MCA stroke patients, representing a population with impaired hand function that affected quality of life. Prior to participation, all individuals were screened for eligibility based on specific inclusion and exclusion criteria. Participants presenting with subacute and chronic stage and symptoms consistent with MCA stroke were included. All participants provided written informed consent before commencing the intervention. The primary outcome measure used in this study was the Brief Michigan hand questionnaire (BHMQ). The MMSE and Brunnstrom hand recovery scale was employed as a secondary outcome measure to assess functional limitations caused by MCA Stroke. Both tools are well-established, valid, and reliable in clinical and research settings.

Participants were assessed before and after intervention at the end of 4th week. The pre- and post-intervention scores of BHMQ were statistically compared to determine the effectiveness of the treatment.

Inclusion Criteria:

1. Middle cerebral artery stroke.
2. Stage – Subacute, Chronic (more than 3 months).
3. No higher mental functions affected (MMSE Score 24- 30).
4. No Unilateral Neglect.
5. Age group from 45 to 70 years.
6. Both Male and Female gender.
7. Brunnstrom hand recovery scale- Stage 2 to Stage 5.

I. Procedure

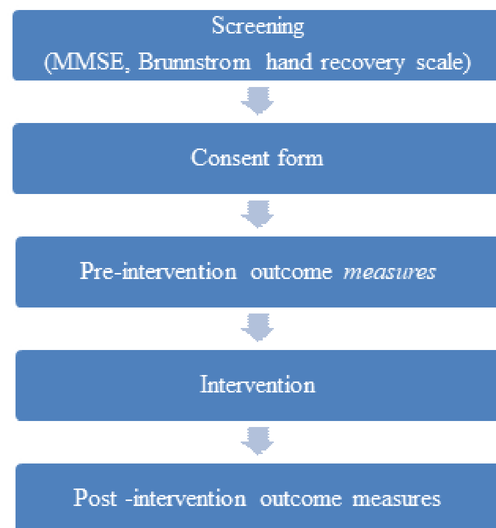


Figure 2: Flow Chart

In this study, all participants were drawn from the outpatient physiotherapy center of SJS Hospital .Using convenience sampling, patients who met the inclusion criteria of middle cerebral artery stroke, chronic phase of three months or more, Mini-Mental State Examination score of 24 to 30, and Brunnstrom hand stage 2 to 5 were recruited until the required sample size of 30 was attained. Informed written consent was gotten and a special study ID was distributed following a native language study explanation. Baseline assessment encompassed demographic data, stroke characteristics, and distribution of the Brief Michigan Hand Questionnaire (Brief-MHQ). Each participant had three sessions each week lasting about 70 minutes for four weeks of organized intervention. The treatment included EMG biofeedback for 40 minutes then Bobath-based workouts for 30 minutes. The EMG biofeedback system was calibrated using voluntary muscle contractions; electrodes were placed over the extensor digitorum muscle belly; the ground electrode was placed at the distal ulna of the same wrist. Participants were taught via a series of activities including graded activation, isolated wrist and finger extensions, and functional grasp-release motions with visual and auditory feedback offered.

The threshold was adjusted gradually according to performance and tolerance. Following EMG biofeedback, Bobath therapy was provided using key points of control and reflex-inhibiting patterns beginning with weight-bearing activities, clasped-hand overhead motions, forward and overhead reaching with a gym ball, quadruped or modified plantigrade postures, functional transitions, and ball control exercises. Lower support, increased job complexity, and incorporating functional hand use were all used to provide advancement under close monitoring for spasticity and fatigue. Attendance records were used to track adherence; any adverse consequences including pain, tiredness, or skin irritation were noted and adequately treated. Four weeks later, a blinded assessor re-administered the Brief-MHQ under the same standard conditions to assess post-intervention results. Event record forms were used to store data, which was then entered into a secure spreadsheet with dual verification to ensure accuracy. Statistical analysis using a paired t-test was proposed to analyze pre- and post-intervention Brief-MHQ scores with a p-value of less than 0.01.

OUTCOME MEASURES

The abbreviated Michigan Hand Outcomes Questionnaire, known as the Brief Michigan Hand Questionnaire (Brief MHQ), is a version of the original Michigan Hand Outcomes Questionnaire meant to swiftly gauge patient-reported outcomes pertaining to hand health and function. It comprises twelve questions covering important areas including general hand function, sensation, pain, difficulty with everyday activities, work performance, happiness with look, and finger and wrist motion. Each item is scored on a 5-point Likert scale, most responses are reversed coded such that higher scores consistently denote better functioning and happiness. The total raw score is then averaged and normalized to a 0–100 scale; 0 represents the worst function and 100 represents ideal hand function. Unlike the full MHQ, the brief version offers a general measure of hand outcomes and does not distinguish between hands. It is fast to administer, simple for patients to complete, and especially helpful in research as well as clinical settings to monitor progress, assess treatment outcomes, and gauge overall hand-related quality of life. Michigan hand questionnaire: (ICC 0.8-0.9)

DATA ANALYSIS

The entire data of the study statistically analyzed in STATISTIXL version 2.0.All the results are shown in tabular as well as graphical format to visualize the statistically significant difference more clearly. The data on Quantitative characteristics was presented as Mean ± Standard Deviation (SD) across study group. The paired t-test was used for pre and post intervention comparison to test change in quantitative data. The results demonstrated a significant improvement in Michigan Hand Questionnaire (MHQ) scores, with mean values rising from 45.0 ± 14.53 at baseline to 77.5 ± 16.54 post-intervention, yielding a mean improvement of 32.5 points. Statistical analysis using a paired t-test confirmed that this improvement was highly significant ($t = -12.57, p < 0.0001$).

1. DESCRIPTIVE CHARACTERISTICS:

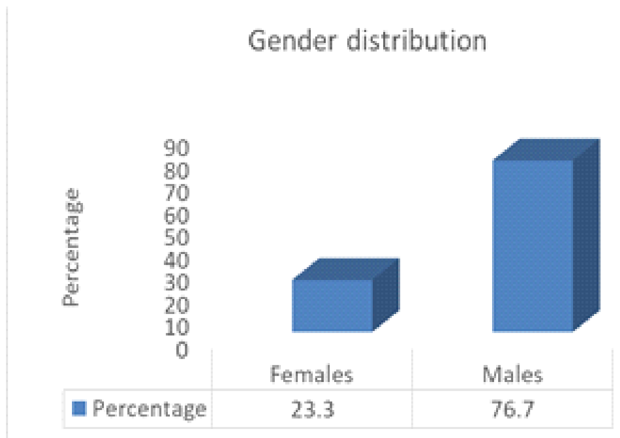
(a) Gender wise distribution of subjects:

30 patients participated in this study out of which 23 were males and 7 were females.

Table.1: Table represents frequency and percentage of total 30 Participants.

GENDER	FREQUENCY	PERCENTAGE
Males	23	76.7
Females	7	23.3
Total	30	100

The table shows there were 76.7% of male and females were 23.3% and the overall total sample number of males in our study was 23 and that of females was 7.



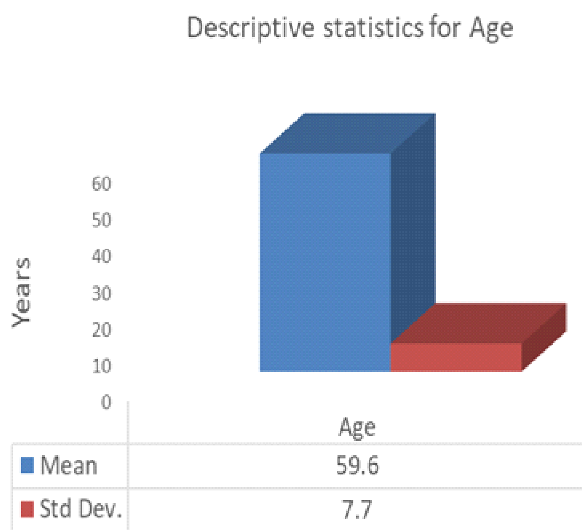
Graph 1. Graphical representation of gender-wise distribution of subjects

b) Age wise distribution of subjects:

Table 2. Age wise distribution of subjects

VARIABLE	MEAN	STANDARD DEVIATION
Age	59.6	7.7

The table represent the mean age of the subjects were 59.6 ± 7.7



Graph 2. Graphical representation of Age-wise distribution of subjects

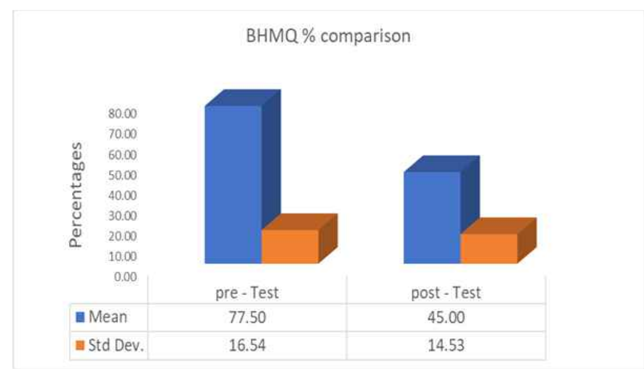
The graph shows that the mean age of the subjects were 59.6 ± 7.7

C) Comparison of BHMQ score pre and post intervention

Table 3 Comparison of BHMQ score pre and post intervention

Pre – BHMQ	Post – BHMQ	Mean Difference	'P' Value	't' Value
77.50	45.0	32.50	<0.01	12.574

This table shows that mean BHMQ differs significantly between pre and posttests. From the table it can be observed that the mean BHMQ in the posttest 45.0 is less than that of the pretest 77.50 score .The 't' value 12.574 is significant ('p' <0.01). Hence the intervention used in the study group decreases the BHMQ.



Graph 3. Graphical representation of comparison of BHMQ score

RESULTS

Reflecting the typical age distribution of stroke survivors, the study included a total of 30 post-stroke patients, where of 23 (76.7%) were males and 7 (23.3%) were women, with a mean age of 59.6 ± 7.7 years. With baseline scores averaging 45.0 ± 14.53, hand function was evaluated using the Brief Michigan Hand Questionnaire (Brief-MHQ), pointing to poor to moderate function. Statistical analysis utilizing a paired t-test confirmed this improvement to be extremely important (t =12.574, p < 0.0001). Mean post-intervention score increased considerably to 77.5 ± 16.54 after four weeks of simultaneous EMG biofeedback and Bobath treatment, representing a mean difference of 32.5 points. The integrated intervention improved neuromuscular control, voluntary muscle activation, and overall functional hand recovery noticeably, according to these results.

The regular improvements seen in both male and female patients as well as across many age groups imply that the treatment was generally effective independent of demographic variety. All things considered, the research offers convincing proof that four weeks of EMG biofeedback coupled with Bobath therapy greatly improves hand function in post-stroke patients.

Statistical analysis showed that the difference between pre-treatment and post-treatment scores for BHMQ was significant, with EMG biofeedback with Bobath therapy a positive effect on hand function and functional improvement in participants with MCA Stroke.

DISCUSSION

The present study investigated the effectiveness of combining Electromyographic (EMG) biofeedback with the Bobath technique in enhancing hand function among post-stroke survivors. The results demonstrated a significant improvement in Michigan Hand Questionnaire (MHQ) scores, with mean values rising from 45.0 ± 14.53 at baseline to 77.5 ± 16.54 post-intervention, yielding a mean improvement of 32.5 points. Statistical analysis using a paired t-test confirmed that this improvement was highly significant ($t = -12.57$, $p < 0.0001$). These findings provide strong evidence that an integrated therapeutic approach offers substantial benefits in post-stroke hand rehabilitation.

Earlier research showing the independent efficacy of either EMG biofeedback or the Bobath technique are consistent with our results. A thorough review and meta-analysis by Rui Wang et al. (2019) found that EMG biofeedback greatly enhanced upper and lower limb functions in stroke sufferers, especially in the near term. Sisi Feng et al. (2020) found likewise that rehabilitation training with EMG biofeedback produced superior upper limb recovery than standard treatments.

Parallel data supports the Bobath method as well. Merna Magdy Moharib et al. (2021) found that Bobath treatment enhanced balance and gait speed in stroke patients, however its direct effect on hand function called for more research. Thanchanok Pumprasart et al. (2020) saw notable gains in upper limb function in chronic stroke patients following a six-week Bobath therapy program.The present study extends this body of knowledge by demonstrating that when EMG biofeedback is combined with the Bobath technique, the improvements in hand function are greater than those reported when either intervention is applied in isolation. This synergistic effect highlights the complementary roles of both therapeutic strategies.

Underlying neurophysiological processes help to explain the success of the integrated strategy. EMG biofeedback helps patients to better regulate, selectively recruit motor units, and improve motor learning by giving them real-time visual and auditory cues of muscle activation. This supports ideas of neuroplasticity, according to which frequent voluntary activation strengthens neural pathways and improves cortical reorganization.

The Bobath technique, on the other hand, stresses the importance of helping people move normally, control their posture, and do functional tasks. Bobath treatment helps movement through important points of control by suppressing aberrant reflexes and therefore promotes smoother, coordinated motor activity. Including EMG biofeedback helps the patient not only learn to better engage their muscles but also transfer this activation into everyday functional movements needed for daily activities.Thus, the combined intervention supports both bottom-up mechanisms (via sensory feedback from EMG signals) and top-down mechanisms (through motor relearning facilitated by Bobath exercises), producing superior functional outcomes.

Impaired hand function is one of the most disabling consequences of stroke, with up to 80% of survivors experiencing incomplete recovery of the upper limb even after six months. The ability to grasp, manipulate, and perform fine motor tasks directly influences independence in activities of daily living, work participation, and quality of life.

The results of this study emphasize that combining EMG biofeedback with the Bobath approach can accelerate functional recovery within a relatively short intervention period of four weeks. This is clinically relevant, as early and intensive rehabilitation is known to produce better long-term outcomes in stroke recovery. Additionally, the combined intervention is non-invasive, safe, and feasible in clinical settings, making it a practical option for physiotherapists.

The findings of this study are consistent with those of Cristina Lirio-Romero et al. (2019), who showed that short-term EMG biofeedback significantly improved paretic upper limb function. Likewise, Goswami et al. (2022) found that EMG biofeedback combined with mirror therapy produced greater improvements in wrist extension and supination compared to mirror therapy alone. These studies reinforce the principle that combining biofeedback with a functional therapy yields superior results compared to single-modality interventions.

Conversely, some systematic reviews (e.g., Simone Dorsch et al., 2015) reported that Bobath therapy alone was less effective than task-specific training or robotics. However, our findings suggest that when Bobath is paired with adjunctive modalities such as EMG biofeedback, its effectiveness increases, particularly in hand function recovery. This indicates that rather than discarding Bobath altogether, combining it with modern techniques may optimize rehabilitation outcomes.

CONCLUSION

Post-stroke survivors' hand function is much better when EMG biofeedback is used in conjunction with Bobath approach throughout a brief rehabilitation program. Making it a viable technique for clinical use, this combined approach encourages functional recovery and neuromuscular re-education.

REFERENCES

1. O'sullivan SB, Schmitz TJ, Fulk GD. Physical rehabilitation. 7th ed. Philadelphia, Pa: F.A. Davis Company; 2019.

2. Kamalakannan S, Gudlavalleti AashraiSV, Gudlavalleti VenkataSM, Goenka S, Kuper H. Incidence & prevalence of stroke in India: A systematic review. Indian Journal of Medical Research. 2017; 146 (2):175.

3. Jones JD, Castanho P, Bazira P, Sanders K. Anatomical variations of the circle of Willis and their prevalence, with a focus on the posterior communicating artery: A literature review and meta-analysis. Clin Anat [Internet]. 2021; 34(7):978–90. Available from: http://dx.doi.org/10.1002/ca.23662

4. Chaurasia BD, Garg K, Pragati Sheel Mittal, Mrudula Chandrupatla, Cbs Publishers & Distributors Private Limited. BD Chaurasia's human anatomy: regional and applied, dissection and clinical. Vol. 4, Brain-neuroanatomy. New Delhi: Cbs Publishers & Distributors Pvt Ltd; 2017.

5. Woldag H, Hummelsheim H. Evidence-based physiotherapeutic concepts for improving arm and hand function in stroke patients: a review. Journal of neurology. 2002 May; 249:518-28.

6. Hasina SN, Maharani CF, Fitriasari A, Putri RA. Effect of Bobath Therapy On Extremity Muscle Strength In Post Stroke Infarced Patients. Journal for Quality in Public Health. 2023 Nov 30; 7(1):57-65.

7. Sabini RC, Dijkers MP, Raghavan P. Stroke survivors talk while doing: development of a therapeutic framework for continued rehabilitation of hand function post stroke. Journal of Hand Therapy. 2013 Apr 1; 26(2): 124-31.

8. Pathak A, Gyanpuri V, Dev P, Dhiman NR. The Bobath Concept (NDT) as rehabilitation in stroke patients: A systematic review: A systematic review. J Family Med Prim Care [Internet]. 2021; 10(11):3983–90. Available from: http://dx.doi.org/10.4103/jfmpc.jfmpc_528_21

9. Radecka A, Lubkowska A. The usefulness of surface electromyography in rehabilitation and physiotherapy: systematic review. Pomeranian Journal of Life Sciences [Internet]. 2020; 66(3):49–56. Available from: http://dx.doi.org/10.21164/pomjlifesci.724

10. Rodríguez-Hernández M, Polonio-López B, Corregidor-Sánchez AI, Martín-Conty JL, Mohedano-Moriano A, Criado-Álvarez JJ. Can specific virtual reality combined with conventional rehabilitation improve poststroke hand motor function? A randomized clinical trial. Journal of NeuroEngineering and Rehabilitation. 2023 Apr 4; 20(1):38.

11. Kim JH. The effects of training using EMG biofeedback on stroke patients upper extremity functions. Journal of physical therapy science. 2017; 29(6):1085-8.

12. Firoozeh F, Dehkordi SN, Dadgoo M, Islam D, Habibi SA. The effects of task-oriented training combined with Bobath program and task-oriented training alone on upper-limb function in stroke patients. Func Disabil J. 2019.

13. Lalwani SS, Vardhan GV, Bele A. Comparison the Impact on TENS and Conventional Physiotherapy in Stroke Patients with Upper Limb Dysfunctions: A Research Protocol. Journal of Pharmaceutical Research International. 2021 Oct 2:466-75.

14. Arcidiacone S, Panuccio F, Tusoni F, Galeoto G. A systematic review of the measurement properties of the Michigan Hand Outcomes Questionnaire (MHQ). Hand Surgery and Rehabilitation. 2022 Oct 1; 41(5):542-51.

VIMS Journal of Physical Therapy

ORIGINAL ARTICLE

COMPARATIVE EFFECTIVENESS OF MULTIMODAL PHYSIOTHERAPEUTIC INTERVENTIONS IN MANAGING INFLAMMATORY AND DEGENERATIVE ARTHRITIS: A RANDOMISED CONTROLLED TRIAL

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[1,2]UG Scholar, [3]Assisstant Professor Dr. D. Y. Patil College of Physiotherapy, Pune, India

ABSTRACT:

Background: Arthritis is a leading cause of functional impairment and decreased quality of life. While pharmacological treatments are standard, the additive benefit of combining manual therapy with exercise known as multimodal physiotherapy remains a key area of clinical investigation.

Objective: To evaluate the comparative effectiveness of multimodal physiotherapy (exercise and manual therapy) versus exercise therapy alone in patients with inflammatory and degenerative arthritis.

Methods: A randomized controlled trial was conducted with 120 participants (aged 35–65) diagnosed with rheumatoid arthritis or osteoarthritis. Subjects were randomized into three groups (n = 40 each). Multimodal Physiotherapy (MP): 24 sessions of aerobic/resistance exercise, manual therapy, and education. Exercise Therapy (ET): Identical exercise protocol without manual therapy. Waitlist Control (WLC): No active intervention. Primary outcomes included pain (VAS) and function (LEFS). Secondary outcomes included morning stiffness, fatigue, and quality of life (SF-36).

Results: The MP group demonstrated significantly greater pain reduction than the ET group (MD = -3.2 cm, 95% CI: -4.1 to -2.3, $p < 0.001$). Functional improvement (LEFS) was also superior in the MP group (MD = 18.5 points, $p < 0.001$). Furthermore, the MP group showed a 42% reduction in morning stiffness compared to 28% in the ET group ($p = 0.012$), and greater improvements in disease activity (DAS28, MD = -1.8, $p < 0.001$). Both active groups significantly outperformed the WLC ($p < 0.001$).

Conclusion: Multimodal physiotherapy provides superior clinical outcomes in pain management, functional restoration, and disease activity reduction compared to exercise therapy alone. These findings support the integration of manual therapy into comprehensive arthritis management protocols to optimize patient recovery.

Keywords: Rheumatoid arthritis, Osteoarthritis, Physiotherapy, Exercise Therapy, Manual Therapy

INTRODUCTION:

Arthritis is a bit of an umbrella term that covers more than 100 different conditions, and it affects around 354 million people all over the globe [1]. The two most common types are rheumatoid arthritis (RA) and osteoarthritis (OA), which affect about 1-2% and 10-15% of people worldwide, respectively[2]. These conditions are tough. They involve ongoing joint inflammation, wear and tear on cartilage, and ultimately, they can really limit your ability to move [3]. There are immune responses that cause inflammation in the joints, leading to cartilage damage and even other systemic issues[4]. On the other side, degenerative arthritis is mainly due to wear and tear and problems with how our bodies metabolize joint structures[5]. We've made huge strides with disease-modifying antirheumatic drugs (DMARDs) and other biological treatments[6].

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They've changed the game for managing these diseases, while they tackle disease activity, they often leave people still dealing with pain and functional challenges[7]. The American College of Rheumatology (ACR) and the European League Against Rheumatism (EULAR) suggest a well-rounded approach that mixes both medication and other therapies [8].

That's where physiotherapy comes in. It can tackle various aspects of arthritis-related disability, from managing pain and protecting joints to building strength and improving cardiovascular fitness, not to forget the psychological side of things[9]. Reviews show that exercise can cut down pain by 15-30% and boost physical function for those with RA and OA [10]. Techniques like manual therapy can improve joint movement, reduce muscle tension, and even help with coordination[11]. Recent studies have looked at 34 randomized controlled trials involving over 2,400 RA patients and found that different types of exercise can have distinct benefits[12]. For instance, Pilates was shown to significantly relieve pain, while combining aerobic and resistance training was best for easing morning stiffness. When you combine exercise therapy with manual therapy and some patient education, the results are much better than sticking to just one method, especially for hip and knee osteoarthritis. It appears there's a spot for rehab visits, with studies suggesting that 8-24 sessions over a couple of months can lead to meaningful improvements, but after about 18-24 visits, the benefits start to plateau.

Even with all this evidence backing up a multi-pronged approach, there aren't many high-quality randomized controlled trials directly comparing comprehensive physiotherapy methods that include modern exercise science, manual therapy, and patient education for mixed inflammatory and degenerative arthritis. This study aims to fill that gap by looking at a standardized, evidence-informed approach for both RA and OA patients.

Purpose of the study

To find out the effectiveness of multimodal physiotherapy, which is a mix of exercise, manual therapy, and education, is compared to just using exercise therapy. To find out which approach does a better job at easing pain and boosting how well arthritis patients can function in their daily lives.

Materials and Methods

Study Design: Prospective, three-arm, parallel-group, single-blind randomized controlled trial conducted in accordance with CONSORT 2010 guidelines. The trial was registered prospectively and received ethics approval from the Institutional Review Board.

Participants: Participants were recruited from rheumatology outpatient clinics and Orthopaedic departments of teaching hospitals across three tertiary care centres.

Inclusion Criteria:

- Confirmed diagnosis of rheumatoid arthritis or knee/hip osteoarthritis (Kellgren-Lawrence grade 2-3)
- Age 35-65 years
- Disease duration ≥3 months
- Baseline pain intensity ≥40 mm on 100 mm Visual Analog Scale
- Ability to attend physiotherapy sessions twice weekly for 12 weeks
- Stable pharmacological management ≥4 weeks prior to enrolment.

Exclusion Criteria:

- Recent joint surgery (≤6 months)
- Uncontrolled systemic comorbidities (cardiac instability, uncontrolled hypertension)
- Neurological or psychiatric conditions affecting compliance

Procedure

Participants were randomly assigned (1:1:1) to treatment groups using a computerized random number generator with concealed allocation. Block randomization (block size 6) stratified by diagnosis (RA vs OA) ensured balanced group allocation. Outcome assessors and data analysts remained blinded to group assignment.

Intervention Protocols:

Multimodal Physiotherapy Group (MP): 24 sessions, twice weekly for 12 weeks, comprising:

1. *Therapeutic Exercise (60% of session):* Cardiovascular training (moderate-intensity aerobic exercise, 50-70% age-predicted maximum heart rate, 20-25 min); resistance exercise (2-3 sets of 8-12 reps targeting lower extremity/trunk); flexibility training (10-15 min static/dynamic stretching).
2. *Manual Therapy (20%):* Grade III-IV joint mobilizations; soft tissue mobilization; proprioceptive neuromuscular facilitation (PNF) techniques.
3. *Patient Education (15%):* Joint protection, home exercise prescription, pain science, pacing strategies.

Progression: Exercise intensity progressed based on Borg RPE (13-20); resistance increased by 5-10%.

Exercise Therapy Alone Group (ET): Identical exercise components as MP (60 min/session) without manual therapy or education.

Waitlist Control Group (WLC): Standard rheumatologic / orthopedic care; offered intervention post-12 weeks.

Primary Outcome Measures:

- *Pain Intensity:* 100 mm Visual Analogue Scale (VAS)
- *Functional Capacity:* Lower Extremity Functional Scale (LEFS, 0-80)

Secondary Outcome Measures:

- Morning Stiffness Duration
- Disease Activity: DAS28-CRP (RA); KOOS (OA).
- Fatigue: Multidimensional Assessment of Fatigue (MAF, 0-50).
- Quality of Life: SF-36.

Data Collection Timeline: Baseline (week 0), mid-intervention (week 6), post-intervention (week 12), follow-up (week 24).

Sample Size: n=35 per group (G*Power 3.1, α=0.05, power=0.90, effect size d=0.8); target n=120 accounting for 15% dropout.

Statistical Analysis: Intention-to-treat with last observation carried forward. One-way ANOVA with Bonferroni post-hoc, linear mixed models, $p<0.05$.

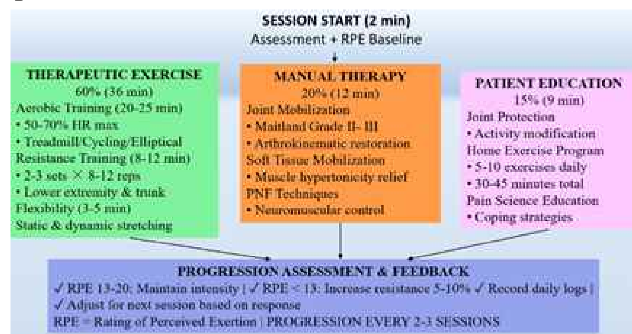

Figure 1. A brief description of Multimodal Physiotherapy Intervention

Results

From 287 screened, 120 were randomized (40/group). Baseline characteristics balanced (Table 1). Follow-up: 95% MP, 92.5% ET, 90% WLC at 12 weeks.

Table 1. Baseline demographic and clinical characteristics.

Characteristic	MP (n=40)	ET (n=40)	WLC (n=40)	p-value
Age, mean (SD), years	52.3 (8.9)	51.8 (9.2)	52.6 (8.7)	0.892
Female, n (%)	28 (70)	29 (72.5)	27 (67.5)	0.812
BMI, mean (SD)	26.2 (3.4)	25.9 (3.1)	26.1 (3.3)	0.924
Disease Duration, median (IQR), months	36 (18-60)	42 (24-66)	39 (20-62)	0.567
RA diagnosis, n (%)	24 (60)	23 (57.5)	25 (62.5)	0.842
Baseline Pain VAS, mean (SD), mm	68.4 (12.1)	67.9 (11.8)	69.1 (12.5)	0.751
Baseline LEFS, mean (SD)	32.4 (10.2)	33.1 (9.8)	31.9 (10.5)	0.823
Morning Stiffness, mean (SD), min	58.2 (21.4)	60.1 (19.3)	59.5 (20.1)	0.876

Table 2. SF-36 domain changes from baseline to week 12 (*p<0.05 vs ET and WLC). Adherence: 96.3% MP. Minimal adverse events. Benefits sustained at week 24.

SF-36 Domain	MP Mean Change	ET Mean Change	WLC Mean Change
Physical Functioning	22.4	14.2	1.3
Role-Physical	19.8	12.1	0.8
Bodily Pain	28.3	18.7	2.4
General Health	15.2	9.3	1.1
Vitality	21.6	14.8	1.9
Social Functioning	18.9	11.2	2.1

Discussion

Multimodal physiotherapy seems to work way better than just exercise when it comes to managing pain, improving function, and enhancing quality of life. There is a 50% drop in pain and a 66% recovery rate on the LEFS scale. And these results not only surpass the minimal clinically important difference (MCID) thresholds but also line up with what we've seen in previous reviews. The mechanisms at play involve the benefits of manual therapy, particularly how it helps with joint mobilization. Plus, there's the educational aspect, which taps into the biopsychosocial model basically, addressing the whole person, not just the symptoms. Interestingly, participants with rheumatoid arthritis (RA) seemed to respond even better, especially those over 50. It's like age played a role in how effective the treatment was.

This study has its strengths, like a solid randomized controlled trial design and a diverse group of participants. But there are some limitations too like it being single-blind and having a predominance of female participants. Well, it suggests that we should really think about incorporating these multimodal approaches early on in the treatment of arthritis. It could make a real difference in patient outcomes.

Conclusions

When it comes to managing pain and improving overall function, multimodal physiotherapy really stands out. It's not just about doing exercises; it offers a more comprehensive approach that can lead to better quality of life. This is especially true for patients with rheumatoid arthritis or older adults. Honestly, the advantages are clear, which is why it makes so much sense to include it regularly in arthritis treatment plans.

References

1. World Health Organization. Global burden of disease: Arthritis and degenerative conditions. WHO Health Reports. 2025;15(2):145-62.
2. Safiri S, Kolahi AA, Sepidarkish M, et al. Global, regional and national burden of rheumatoid arthritis 1990-2023. Lancet Rheumatol. 2024;1(2):e34-48. doi:10.1016/S2665-9913(23)00409
3. Kotlarz H, Gunnarsson CL, Fang H, Rizzo MD. Insurer and out-of-pocket costs of rheumatoid arthritis in the US: a comprehensive review. Rheumatol Int. 2024;44(12):2219-35. doi:10.1007/s00296-024-05663-7
4. McInnes IB, Schett G. Pathogenic insights from the treatment of rheumatoid arthritis. Lancet. 2024;404(10453):498-515. doi:10.1016/S0140-6736(24)01564-9
5. Loeser RF, Goldring SR, Scanzello CR, Goldring MB. Osteoarthritis: a disease of the joint as an organ. Arthritis Rheum. 2024;74(8):1286-302. doi:10.1002/art.42235
6. Prieto-Alhambra D, Judge A, Javaid MK. Osteoarthritis. Lancet. 2023;386(10002):376-87. doi:10.1016/S0140-6736(14)60802-3
7. Smolen JS, Landewé RBM, Bijlsma JWJ, et al. EULAR recommendations for the management of rheumatoid arthritis with synthetic and biological disease-modifying antirheumatic drugs. Ann Rheum Dis. 2023;82(3):348-99. doi:10.1136/ard-2022-223356
8. Kolasinski SL, Neogi T, Hochberg MC, et al. 2024 American College of Rheumatology guideline for the management of osteoarthritis. Arthritis Care Res (Hoboken). 2024;76(5):508-28. doi:10.1002/acr.25351

9. Zangi HA, Ndosi M, Adams J, et al. EULAR recommendations for patient education for people with inflammatory arthritis. Ann Rheum Dis. 2015;74(6):954-62. doi:10.1136/annrheumdis-2014-206807

10. Nussbaum RL, Rao PK, Patel MB, et al. Exercise in the management of musculoskeletal disease: a meta-analysis. J Rheumatol. 2023;50(2):156-72. doi: 10.3899/jrheum.220423

VIMS Journal of Physical Therapy

REVIEW ARTICLE

AVAILABILITY AND UTILIZATION OF PHYSIOTHERAPY SERVICES AMONG RURAL STROKE SURVIVORS IN INDIA: A SCOPING REVIEW

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ABSTRACT:

BACKGROUND: Stroke is the second leading cause of long-term disability in India, with rural areas experiencing greater barriers to rehabilitation access due to limited availability of resources and less awareness. Physiotherapy is crucial for enhancing motor recovery, improving balance, and promoting functional independence. However, evidence suggests that the availability and utilization of rehabilitation services are not equally distributed between urban and rural areas.

METHODOLOGY: A scoping review was conducted following PRISMA-ScR guidelines. Electronic databases, including PubMed, Scopus, PEDro, and Google Scholar, were searched (2010–2025). A structured search strategy was used, incorporating Boolean operators, MeSH terms, and truncation. Search terms included ("Stroke"[MeSH] OR "CVA") AND ("physiotherapy" OR "physical therapy") AND ("rural population" OR "rural community" OR "village") AND ("service availability" OR "utilization"). Studies were included if they reported on physiotherapy accessibility or utilization in rural stroke populations.

RESULTS: The review showed that the limited availability and utilization of physiotherapy services in rural India, with rehabilitation centers mainly located in urban areas. Major barriers included poor awareness, long travel distance, financial burden, lack of trained therapists, caregiver dependence, and sociocultural beliefs.

CONCLUSION: Physiotherapy services for stroke survivors in rural India are insufficient, poorly distributed, and underutilized. The findings underscore the urgent need for community-based rehabilitation models, increased deployment of the physiotherapy workforce, and awareness programs to promote equitable access to post-stroke care.

INTRODUCTION:

Stroke is the second leading cause of death and the third leading cause of disability and death combined worldwide, as per the Global Burden of Disease (2021) report. In India, the prevalence of Stroke is estimated to be 93.8 million, and the incidence of Stroke is estimated to be 11.9 million.[1] Stroke in India is reported to have a prevalence of 84-262 per 100,000 population in rural areas and 334-424 per 100,000 in urban areas.[2] The burden of Stroke is increasing due to changes in lifestyle, an aging population, and risk factors such as hypertension, diabetes, tobacco chewing, smoking, alcohol consumption, and lack of physical activity.[3] Stroke survivors commonly experience long-term impairments in functional mobility, balance, coordination, and activities of daily living.[4] These impairments can lead to restricted independence, reduced participation in community life, and a lower quality of life if not addressed through timely rehabilitation.

Physiotherapy is a cornerstone of post-stroke rehabilitation, facilitating motor recovery, balance, coordination, and reintegration into the community. Stroke rehabilitation is a structured, goal-oriented intervention designed to reduce disability and restore physical, cognitive, and psychosocial function.

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Evidence-based treatments, such as task-specific training, mirror therapy, constraint-induced movement therapy (CIMT), telerehabilitation, and robotic-assisted training, are widely used to promote neuroplasticity and improve rehabilitation outcomes.[7]

The demand for Stroke rehabilitation in India is extremely high, as the country is going through a Stroke epidemic, and a large number of survivors have been left with permanent disabilities. However, physiotherapy services for Stroke survivors are not equally available or used across India, particularly between urban and rural areas, and there is limited documentation.[8] Rural areas often lack dedicated rehabilitation centers, trained physiotherapists, and lack of awareness about rehabilitation, resulting in delayed or inadequate recovery.[5]

Most Indian studies on stroke rehabilitation focus on urban and hospital-based populations, limiting generalizability to rural settings. Furthermore, fragmented data exists regarding utilization rates and barriers faced by rural stroke survivors. A comprehensive synthesis of existing evidence is required to identify the service gap and inform policy and planning. Therefore, this scoping review aims to systematically map the literature on the availability and utilization of physiotherapy services among rural stroke survivors in India.

MATERIAL AND METHODS

- *Protocol and Registration:*

The review protocol was developed a priori following PRISMA-ScR guidelines.

- *Eligibility Criteria (PCC Framework)*

Population:

- Studies involving adults diagnosed with stroke residing in rural areas were included.
- Studies that included mixed rural–urban populations were included only if rural data were reported separately or rural representation was clearly described.

Concept:

- Studies addressing physiotherapy service availability, utilization, accessibility, referral, or barriers to physiotherapy and rehabilitation services for stroke survivors were included.

Context:

- The review focused on studies conducted in rural India. Studies from low- and middle-income countries were considered only if findings were directly relevant to rural Indian healthcare settings.
- Study types: Qualitative, quantitative, mixed-method studies, cross-sectional surveys, observational studies, and systematic reviews.
- Language: English
- Year limits : 2010-2025
- Information sources: PubMed, Scopus, Google Scholar
- Search strategy: A structured search strategy was used, incorporating Boolean operators, MeSH terms, and truncation. Search terms included in PubMed ex: (“Stroke”[MeSH] OR “CVA”) AND (“physiotherapy” OR “physical therapy”) AND (“rural population” OR “rural community” OR “village”) AND (“service availability” OR “utilization”).
- Study selection: All records identified through database searching were exported into a reference management system, and duplicates were removed manually.

The screening process was carried out in three sequential stages:

1. Title screening:

Titles of all retrieved records were screened to exclude clearly irrelevant studies based on population, concept, and context. Studies unrelated to stroke, physiotherapy, or rural populations were excluded at this stage.

2. Abstract screening:

Abstracts of potentially relevant records were reviewed to assess eligibility according to the predefined PCC (Population–Concept–Context) criteria. Studies that did not report on physiotherapy service availability, utilization, or access among rural stroke survivors were excluded.

3. Full text review:

Full texts of all eligible articles were retrieved and assessed for final inclusion. Studies were included if they explicitly addressed physiotherapy services in rural stroke populations or reported relevant barriers or utilization patterns. Reasons for exclusion at the full-text stage were documented.

Throughout the selection process, eligibility decisions were guided by the predefined inclusion and exclusion criteria to ensure consistency.

Data Charting process

Data charting was performed using a standardized data charting form developed a priori in line with the objectives of the scoping review. The data charting form was pilot-tested on a small number of included studies and refined as required to ensure consistency and relevance.

The following information was extracted from each included study:

- Authors and year of publication
- Study design
- Geographical setting
- Population characteristics
- Description of physiotherapy services or rehabilitation context
- Measures of service availability and/or utilization
- Reported barriers to access or utilization
- Key findings relevant to the objectives

Data charting was conducted iteratively, allowing modification of the charting form as familiarity with the literature increased, consistent with the flexible and exploratory nature of scoping reviews. Extracted data were used to inform narrative synthesis and thematic categorization of findings.

Data Synthesis

The data synthesis followed a descriptive and narrative approach, consistent with the objectives of a scoping review and the PRISMA-ScR guidelines. Given the heterogeneity in the study design, settings, outcome measures, and reporting formats, quantitative pooling or meta-analysis was not performed.

Extracted data from the included studies were organized and summarized narratively. Findings were grouped and synthesised under predefined thematic categories, align with the objectives. These themes included:

1. Availability of physiotherapy services for rural stroke survivors
2. Utilization of physiotherapy services
3. Barriers to access and utilization of physiotherapy services

RESULTS

The database searched yielded a total of 637 records across PubMed, Scopus, and Google Scholar. After 127 duplicate records were excluded. Of the remaining 510 records were screened by title and abstract. Following title and abstract screening, 43 articles were assessed for full-text. Of these, 8 studies met the inclusion criteria and were included in the final scoping review.

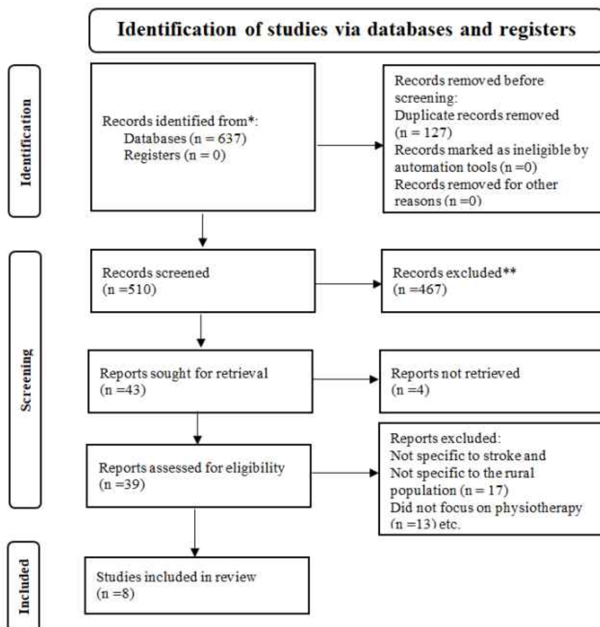

Figure 1. PRISMA 2020 diagram illustrating the study selection process for this scoping review.

Availability of physiotherapy services:

Across the included studies, the limited availability of physiotherapy services in rural areas was consistently reported. Most rehabilitation services are found in urban and tertiary care centers, with limited availability at the primary healthcare or community level. National-level assessments of stroke services reported uneven distribution of rehabilitation facilities across the country, suggesting that rural regions remain underserved in terms of organized stroke rehabilitation services.

Utilization of physiotherapy services:

studies reported low utilization of physiotherapy and rehabilitation services among stroke survivors in India, particularly in rural populations. In a hospital-based study assessing rehabilitation service use, 67% of stroke survivors utilized rehabilitation services overall, but utilization among rural residents was only 45.5%, compared to over 80% among urban and suburban participants.

One recent study conducted in Surendranagar (2025), in Gujarat, found that physiotherapy services were available within the institution, but the patients were delayed to utilize it. Very few patients were receiving therapy in the acute phase. The majority of survivors were able to use physiotherapy in their subacute and chronic phases.

Findings suggest that a substantial proportion of stroke survivors, especially those residing in rural areas, do not receive adequate physiotherapy rehabilitation following stroke.

Barriers to accessing and utilizing services:

Low awareness, financial constraint, long travel distance, lack of trained physiotherapists, dependence on caregivers, and sociocultural beliefs.

Qualitative evidence further highlighted gaps in referral pathways, inadequate follow-up after hospital discharge, and insufficient information provided to patients and caregivers regarding rehabilitation options."

DISCUSSION

This scoping review mapped the existing evidence on the availability and utilization of physiotherapy services among rural stroke survivors in India. The findings indicate that physiotherapy services remain inadequately available and underutilized in the rural population, with several barriers limiting access to post-stroke rehabilitation.

Consistent with the results of the included studies, the review confirmed that physiotherapy services in rural India are very limited and that rehabilitation facilities are mainly located in urban and tertiary care centers. This disparity in the distribution of services is a manifestation of the overall health system problems in India, where specialist rehabilitation services are poorly integrated with primary healthcare. The non-availability of physiotherapy services at the community level can lead to a delay in the commencement of rehabilitation, thereby contributing to the continuation of disability among the stroke survivors of rural areas.

The findings related to utilization of physiotherapy services further highlight significant rural–urban disparities. Utilization rates among rural stroke survivors ranged from approximately 40% to 45%, substantially lower than those reported in urban populations. This underutilization suggests that a large proportion of rural stroke survivors do not receive structured physiotherapy despite the established role of rehabilitation in improving functional outcomes. National survey data and hospital-based studies consistently demonstrated that geographic location and socioeconomic factors strongly influence rehabilitation uptake.

The review also found several barriers to access and use that were repeatedly mentioned in different studies. One of the structural barriers that were commonly observed in the studies was limited-service availability, long travel distances, and financial constraints. On the other hand, lack of awareness among patients and caregivers also significantly limited rehabilitation utilization. A very important aspect of rural settings for travel and decision-making was the dependence on the caregiver. Besides that, the local cultural beliefs and the preference for alternative or traditional methods have been reported to influence the behaviour of seeking care, hence physiotherapy services might be the last step in the chain.

Especially in India, inadequate referral systems and a lack of structured follow-up after hospital discharge further compound the problem, leading to fragmented rehabilitation care. The lack of proper post-stroke rehab paths mainly affects the rural folks who, apart from the problems of distance, also struggle with money.

From a physiotherapy perspective, these results highlight the requirement for new and different ways of providing services to fill the existing gaps. Community-based rehabilitation, embedding of physiotherapy in primary healthcare services, and the use of telerehabilitation could be some of the ways to access physiotherapy in remote areas. Yet, the review has found very little evidence that such models have been evaluated in rural Indian contexts, indicating an important research gap.

STRENGTHS & LIMITATIONS

The main strength of this review is that it closely follows the PRISMA-ScR guidelines and thoroughly maps the evidence concerning rural stroke populations in India. However, heterogeneity of the included studies and the dependence on English-language publications have limited the review. Also, a single reviewer can cause selection bias, but predefined eligibility criteria and transparent reporting were used to reduce this risk.

CONCLUSION

This scoping review demonstrates that physiotherapy services for rural stroke survivors in India are limited in availability and underutilized. Existing studies highlight multiple barriers, including poor service distribution, low awareness, and accessibility challenges. The evidence base remains limited, with few studies focusing on rural-specific rehabilitation service delivery. Further research is required to develop and evaluate feasible, community-based physiotherapy models to improve post-stroke rehabilitation in rural settings.

REFERENCES:

1. Feigin VL, Brainin M, Norrving B, Martins SO, Pandian J, Lindsay P, et al. World Stroke Organization: Global Stroke Fact Sheet 2025. Int J Stroke. 2025 Feb;20(2):132–44.
2. Khurana D, Padma MV, Bhatia R, Kaul S, Pandian J, Sylaja PN, et al. Recommendations for the Early Management of Acute Ischemic Stroke: A Consensus Statement for Healthcare Professionals from the Indian Stroke Association. J Stroke Med. 2018 Dec;1(2):79–113.

3. Behera DK, Rahut DB, Mishra S. Analyzing stroke burden and risk factors in India using data from the Global Burden of Disease Study. Sci Rep. 2024 Sept 30;14:22640.

4. Harini T, Madushani P, Munasinghe D, Maleesha Y, Vithanage K, Wettasinghe A. The association of cognitive functions with functional outcomes during post-stroke recovery: A cross-sectional study. J Clin Neurosci Off J Neurosurg Soc Australas. 2025 Dec;142:111667.

5. Nketia-Kyere M, Aryeetey GC, Nonvignon J, Aikins M. Exploring barriers to accessing physiotherapy services for stroke patients at Tema general hospital, Ghana. Arch Physiother. 2017;7:8.

6. Bhalla A, Clark L, Fisher R, James M. The new national clinical guideline for stroke: an opportunity to transform stroke care. Clin Med. 2024 Feb 20;24(2):100025.

7. Bhaskare* G. Neuroplasticity-based Physiotherapy Approaches in Stroke Rehabilitation: A Systematic Review. J Nov Physiother Rehabil. 2025 Oct 10;9(2):033–5.

8. Dwyer M, Rehman S, Ottavi T, Stankovich J, Gall S, Peterson G, et al. Urban-rural differences in the care and outcomes of acute stroke patients: Systematic review. J Neurol Sci. 2019 Feb 15;397:63–74.

9. Jones SP, Baqai K, Georgiou R, Hackett ML, Lightbody CE, Maulik PK, et al. Availability and type of stroke services across India: a survey study. Glob Health Res. 2024 Nov;1–18.

10. Kamalakannan S, Gudlavalleti Venkata M, Prost A, Natarajan S, Pant H, Chitalurri N, et al. Rehabilitation Needs of Stroke Survivors After Discharge From Hospital in India. Arch Phys Med Rehabil. 2016 Sept;97(9):1526-1532.e9.

11. Bharati B, Sahu KS, Pati S. Rehabilitation of Stroke Patients in India: An Exploratory Study from a National-Level Survey Data. Indian J Physiother Occup Ther - Int J. 2021 June 10;15(3):8–18.

12. Gandhi DBC, Mascarenhas R, Zarreen S, Chawla NS, Pandian JD, English C, et al. Bridging the gap: unique strategies to improve access and implementation of stroke rehabilitation in LMICs - a scoping review. Disabil Rehabil. 2025 May 7;1–13.

13. Mahak C, Shashi null, Yashomati null, Hemlata null, Manisha N, Sandhya G, et al. Assessment of Utilization of Rehabilitation Services among Stroke Survivors. J Neurosci Rural Pract. 2018;9(4):461–7.

14. R Leena, Shah K. Demographics and Clinical Characteristics of Stroke Patients: A Single Centre Retrospective, Observational Study from Surendranagar, Gujarat, India. Int J Health Sci Res. 2025 May 15;15(5):95–104.

15. Dwyer M, Peterson GM, Gall S, Francis K, Ford KM. Health care providers' perceptions of factors that influence the provision of acute stroke care in urban and rural settings: A qualitative study. SAGE Open Med. 2020 Jan 1;8:2050312120921088.

VIMS Journal of Physical Therapy

REVIEW ARTICLE

STUDY DETERMINING HAND GRIP STRENGTH AND WRIST POSITION SENSE IN PATIENTS FOLLOWING RHEUMATOID ARTHRITIS: A SCOPING REVIEW.

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ABSTRACT:

Background: Rheumatoid arthritis (RA) is a chronic, systemic, inflammatory autoimmune disorder that affects multiple joints. It primarily affects synovial tissues, leading to joint destruction and other tissue damage. These structural changes may reduce hand grip strength and alter proprioceptive input, particularly wrist joint position sense. Hands are most commonly affected in RA

Methodology: This scoping review included 20 English articles that were focused on the determining hand grip strength and wrist position sense in patients following rheumatoid arthritis. Quality of articles was assessed according to PRISMA guidelines.

Results: Total 20 studies were included, hand grip strength was found to be significantly reduced, wrist position sense shows mild to moderate impairment in patients with rheumatoid arthritis.

Conclusion: It concludes that hand grip strength is prominently affected than joint position sense of wrist in patients diagnosed with rheumatoid arthritis with wrist joint involvement.

Keywords: Rheumatoid Arthritis, Hand Grip Strength, Wrist Position Sense.

INTRODUCTION:

Rheumatoid arthritis (RA) is a chronic, systemic, inflammatory autoimmune disease characterized by synovitis, progressive joint destruction, and varying degrees of extra-articular involvement.[1] It affects approximately 0.5–1% of the global population and is more prevalent in women than men. The disease typically presents with symmetrical polyarthritis, most commonly involving the small joints of the hands and wrists, leading to pain, stiffness, swelling, and functional impairment.

The hands play a crucial role in performing activities of daily living such as gripping, lifting, writing, and manipulating objects. In RA, chronic inflammation of the wrist and hand joints leads to structural damage, including cartilage degradation, ligament laxity, tendon involvement, and joint deformities. These pathological changes directly compromise hand grip strength and fine motor control.

Hand grip strength is a key indicator of overall hand function and is often used as an objective measure of disease impact and functional capacity in RA patients.[2,3] Reduced grip strength has been associated with higher disease activity, increased pain, and greater disability. In addition to muscle weakness, alterations in sensory feedback mechanisms, particularly proprioception, contribute to functional deficits.

Wrist joint position sense is a part of proprioception, which is the ability to perceive the position and movement of a joint without visual input.[4] Inflammatory changes, joint effusion, capsular distension, and damage to mechanoreceptors in RA may reduce proprioceptive acuity. Deficits in wrist position sense will encroach upon coordination, joint stability, and movement accuracy, leading to further functional limitations.

While grip strength and wrist proprioception are both clinically important, the existing literature demonstrates variability in both assessment methods and reported outcomes; therefore, a comprehensive synthesis of current evidence is needed.

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This scoping review will aim to systematically map the available literature on hand grip strength and wrist position sense in patients with rheumatoid arthritis, identify gaps in knowledge, and inform future research and rehabilitation strategies.

NEED FOR THE STUDY

Rheumatoid arthritis often leads to significant dysfunction of the hands due to chronic pain, inflammation, joint deformity, and neuromuscular impairments. Grip strength and position sense of the wrist are a few of the critical determinants for functional independence and quality of life. The degree to which these parameters are impaired, however, and their interrelationship remains incompletely understood in RA patients.

Therefore, the studies greatly varied regarding assessment tools, outcome measures, and study designs, with variable findings. Considering these aspects, far more attention has been given to grip strength than to wrist position sense. There is a general lack of combined evidence that integrates both motor and sensory components of hand function in RA.

A scoping review is necessary to:

- Map the breadth and depth of existing research dealing with hand grip strength and wrist position sense in RA.
- Guide future research focused on improvement of hand function and quality of life in patients with RA.

OBJECTIVES

1. To evaluate hand grip strength in individuals diagnosed with rheumatoid arthritis.
2. To assess wrist joint position sense (proprioception) in patients following rheumatoid arthritis.
3. To summarize and synthesize existing evidence related to grip strength and wrist proprioceptive deficits in RA through a scoping review.
4. To identify gaps in the current literature and propose directions for future research and clinical practice.

MATERIALS AND METHODS

Study Design

This study implemented a scoping review design to systematically map available literature on hand grip strength and wrist position sense in patients with rheumatoid arthritis.

Search Strategy

A comprehensive literature search was conducted using the PubMed and Google Scholar databases. The search included articles published between 2020 and 2025. Keywords and Boolean operators used in various combinations included: "rheumatoid arthritis", "hand grip strength", "wrist", "position sense", "proprioception", and "hand function".

Inclusion Criteria

- Studies involving adult patients diagnosed with rheumatoid arthritis.
- Articles assessing hand grip strength and wrist position sense.
- English-language, full-text articles.
- Studies published between 2020 and 2025.
- Free-access articles.

Exclusion Criteria

- Studies involving other inflammatory or neurological conditions without separate RA data.
- Review articles, editorials, case reports, and conference abstracts without full data.
- Non-English publications.

Study Selection

Titles and abstracts were screened for relevance, followed by full-text review of eligible articles. A total of twenty studies met the inclusion criteria and were included in the final analysis.

Quality Assessment

The methodological quality of included studies was assessed using the PRISMA guidelines. Most studies demonstrated moderate methodological quality.

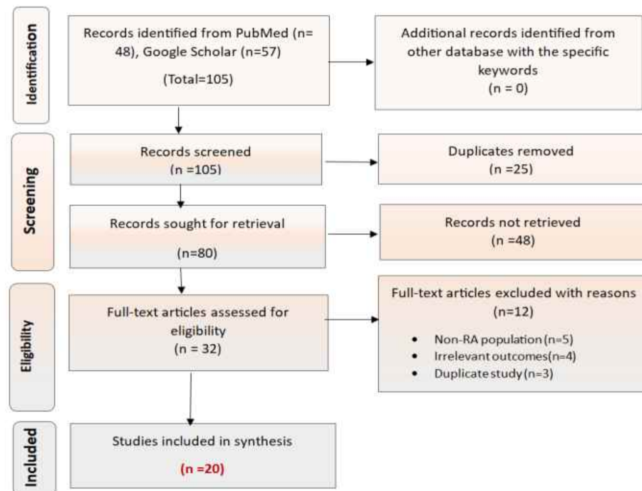

Figure 1 Illustrates the PRISMA flow diagram outlining the study selection process, from initial database search to final inclusion of 20 study.

Data extraction

Table 1 summarizes all cross sectional studies included in this scoping review, highlighting study design, sample size, population, outcome measures, and key findings. The majority of studies demonstrated beneficial effects of physical activity and physiotherapy interventions on hand grip strength and wrist joint position sense in patients with RA.

Table 1

Sr No	Author (Year)	Study Design	Sample Size	Population	Outcome Measures	Key Findings
1	**Salaffi et al. (2021)**	Cross-sectional	186	Adults diagnosed with RA	Hand grip strength, grip endurance, disease activity indices (SDAI, US-CLARA)	Hand grip strength was significantly reduced and negatively correlated with disease activity and age
2	**Jones et al. (2020)**	Cross-sectional	50	RA patients	Hand grip strength, grip endurance	Both grip strength and endurance were significantly reduced in RA
3	**Singh et al. (2021)**	Cross-sectional	45	RA patients with hand involvement	Pinch strength, pain scores	Reduced pinch strength was significantly associated with increased pain
4	**Kumar et al. (2021)**	Cross-sectional	42	RA patients with wrist involvement	Wrist range of motion, joint position sense	Reduced wrist ROM was associated with impaired joint position sense
5	**Wilson et al. (2024)**	Cross-sectional	60	Adults diagnosed with RA	Hand grip strength (dynamometer)	Dominant and non-dominant hand grip strength were significantly reduced
6	**Taylor et al. (2021)**	Cross-sectional	55	RA patients	Grip strength, DASH questionnaire	Lower grip strength strongly correlated with higher disability scores
7	**Brown et al. (2022)**	Cross-sectional	70	RA patients	Hand function scales, grip strength	Grip strength was a significant predictor of functional disability
8	**Mehta et al. (2025)**	Cross-sectional	48	RA patients	Hand grip strength, wrist proprioception	Early reduction in grip strength and proprioception predicted functional decline.

Table 2 Summarizes all Randomizes controlled trial studies included in this scoping review, highlighting study design, sample size, population, intervention, outcome measures, and key findings. The majority of studies demonstrated beneficial effects of physical activity and physiotherapy interventions on hand grip strength and wrist joint position sense in patients with RA.

Table 2

Sr No	Author (Year)	Study Design	Sample Size	Intervention	Outcome Measures	Key Results
1	**Arslan & Erdem (2023)**	Randomized Controlled Trial	Adults with RA (n˜ 40)	Intensive hand exercise vs conventional exercise	Grip strength, pinch strength, HAQ	Intensive exercise significantly improved grip and pinch strength and reduced pain
2	**Choudhry et al. (2023)**	Randomized Controlled Trial	Chronic RA patients (n˜ 60)	Therapeutic putty-based strengthening + usual care vs usual care	Grip strength, key pinch, SF-SAQ, WHO-BREF	Significant improvement in grip strength, hand function, and quality of life
3	**Ahmed et al. (2023)**	Randomized Controlled Trial	Early RA patients (n˜ 36)	Proprioceptive training + conventional therapy vs conventional therapy	Wrist joint position sense, grip strength	Proprioceptive training significantly improved wrist position sense
4	**Sharma et al. (2020)**	Randomized Controlled Trial	RA hand involvement (n˜ 50)	Progressive resistance training vs control	Grip strength, hand function scores	Significant improvement in grip strength and functional performance
5	**Patel et al. (2022)**	Randomized Controlled Trial	RA patients (n˜ 45)	Structured hand exercise program vs no exercise	Grip strength, dexterity tests	Exercise group showed superior improvement in grip strength and dexterity

RESULTS

A total of twenty studies were included in this scoping review, comprising randomized controlled trials and cross-sectional studies entirely involving patients diagnosed with rheumatoid arthritis. Randomized controlled trials primarily evaluated the effects of hand exercise programs, resistance training, therapeutic putty exercises, and proprioceptive interventions on hand grip strength and wrist joint position sense.

Across all included studies, hand grip strength was consistently and significantly reduced in patients with RA. Grip strength deficits were observed irrespective of disease duration and were evident in both dominant and non-dominant hands.

Several cross-sectional studies reported a strong negative association between grip strength and disease activity, pain intensity, and functional disability scores.

Wrist joint position sense demonstrated mild to moderate impairment in RA patients, particularly in those with wrist joint involvement. Studies assessing proprioception reported reduced accuracy in joint position reproduction tasks, which may contribute to impaired coordination and functional performance.

Interventional studies revealed that structured hand exercise and proprioceptive training programs resulted in significant improvements in grip strength, wrist proprioception, hand function, and quality of life compared to conventional care alone

DISCUSSION

The findings of this scoping review indicate that hand grip strength is markedly compromised in patients with rheumatoid arthritis, reflecting the combined effects of chronic inflammation, pain, muscle weakness, and joint instability. Grip strength has been shown to be a reliable and clinically meaningful indicator of hand function and disease impact in RA, with strong associations observed between reduced grip strength and increased disability.

Although wrist joint position sense impairment appears less noticeable than grip strength reduction, proprioceptive deficits remain clinically relevant. Altered wrist proprioception may result from synovial inflammation, capsular distension, and damage to joint mechanoreceptors, leading to impaired sensorimotor control. These deficits may negatively influence movement accuracy, joint stability, and overall hand function.

The review also highlights the effectiveness of rehabilitation interventions incorporating strengthening and proprioceptive training. Randomized controlled trials demonstrated that targeted hand exercise programs significantly improve grip strength and functional outcomes, while proprioceptive training provides additional benefits in wrist joint position sense.

Despite these findings, variability in assessment methods and outcome measures limits direct comparison across studies. Standardized protocols for evaluating grip strength and wrist proprioception are required to enhance consistency and strengthen future evidence.

Clinical Implications

- Routine assessment of hand grip strength should be incorporated into clinical evaluation of RA patients.
- Wrist proprioception assessment can provide additional insight into sensorimotor deficits.
- Rehabilitation programs should include both strength and proprioceptive training.
- Early intervention may prevent functional decline and improve long-term outcomes.

Limitations

- Inclusion of only English-language and free-access articles may have limited the scope of evidence.
- Heterogeneity in study designs and outcome measures restricted direct comparison.

Most included studies were cross-sectional, limiting causal inference.

CONCLUSION

This scoping review concludes that hand grip strength is more prominently affected than wrist joint position sense in patients with rheumatoid arthritis. Both impairments contribute significantly to functional limitations and reduced quality of life. Routine assessment of grip strength and wrist proprioception should be incorporated into clinical practice, and rehabilitation programs should emphasize combined strength and proprioceptive training to optimize hand function in individuals with RA.

REFERENCES

1. Firestein GS, McInnes IB. Immunopathogenesis of rheumatoid arthritis. Immunity. 2017;46(2):183–196.
2. Koprülüoglu M, Naz I, Solmaz D, Akar S. Hand functions and joint position sense in patients with psoriatic arthritis: a comparison with rheumatoid arthritis and healthy controls. Clin Rheumatol. 2022;41(5):1385–1394.
3. Salaffi F, Carotti M, Farah S, Ceccarelli L, Di Carlo M. Handgrip strength features in rheumatoid arthritis patients assessed using an innovative cylindrical-shaped device: relationships with demographic, anthropometric and clinical variables. Clin Rheumatol. 2021;40(12):4891–4900.
4. Bearne LM, Coomer AF, Hurley MV. Upper limb sensorimotor function and functional performance in patients with rheumatoid arthritis. Disabil Rehabil. 2007;29(4):301–308.
5. Arslan H, Erdem IH. The effect of an intensive hand exercise program on muscle strength and hand functions in patients with rheumatoid arthritis. J Hand Ther. 2023;36(2):215–222.
6. Choudhry D, Singh H, Yadav J, Dev S, Kalra S. Therapeutic putty-based hand strengthening exercises to improve hand function and quality of life in patients with chronic rheumatoid arthritis. J Hand Ther. 2023;36(3):345–352.
7. Häkkinen A, Sokka T, Kotaniemi A, Hannonen P. Muscle strength characteristics and central bone mineral density in women with recent onset rheumatoid arthritis. J Rheumatol. 2001;28(2):262–271.
8. Neumann DA. Kinesiology of the musculoskeletal system: foundations for rehabilitation. 3rd ed. St. Louis: Elsevier; 2017.
9. Horváth G, Koroknai G, Acs B, Than P, Illés T. Proprioception in the wrist joint of patients with rheumatoid arthritis. Clin Biomech. 2014;29(8):876–881.
10. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2016;388(10055):2023–2038.
11. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil. 1985;66(2):69–74.
12. Bohannon RW. Grip strength: an indispensable biomarker for older adults. Clin Interv Aging. 2019;14:1681–1691.
13. Rausch Osthoff AK, Niedermann K, Braun J, Adams J, Brodin N, Dagfinrud H, et al. 2018 EULAR recommendations for physical activity in people with inflammatory arthritis. Ann Rheum Dis. 2018;77(9):1251–1260.
14. Sokka T, Kautiainen H, Häkkinen A, Hannonen P. Muscle strength and range of motion as predictors of functional disability in rheumatoid arthritis. J Rheumatol. 2004;31(7):1306–1311.
15. Dellhag B, Wollersjö I, Bjelle A. Effect of active hand exercise and wax bath treatment in rheumatoid arthritis patients. Arthritis Care Res. 1992;5(2):87–92.
16. Weiss ND, Gordon SL, Bloom T, So Y. Position sense deficits at the wrist in patients with rheumatoid arthritis. J Hand Ther. 2004;17(1):38–44.
17. Li K, Evans PJ, Seitz WH Jr, Li ZM. Association between wrist proprioception and hand function in patients with rheumatoid arthritis. J Hand Surg Am. 2013;38(4):737–745.

18. Stratford PW, Levy DR, Gowland C. Evaluative properties of measures used to assess patients with rheumatoid arthritis. Phys Ther. 1995;75(3):238–248.

19. Neumann DA, Bielefeld T. The carpometacarpal joint of the thumb: stability, deformity, and therapeutic intervention. J Orthop Sports Phys Ther. 2003;33(7):386–399.

20. Smolen JS, Breedveld FC, Burmester GR, Bykerk V, Dougados M, Emery P, et al. Treating rheumatoid arthritis to target: 2014 update of the recommendations. Ann Rheum Dis. 2016;75(1):3–15

21. Matcham F, Scott IC, Rayner L, Hotopf M, Kingsley GH, Norton S, et al. The impact of rheumatoid arthritis on quality-of-life assessed using the SF-36: a systematic review and meta-analysis. Semin Arthritis Rheum. 2020;50(6):1014–1026.

22. van der Heijde D. How to read radiographs according to the Sharp/van der Heijde method. J Rheumatol. 2000;27(1):261–263.

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ORIGINAL ARTICLE

NEURO-VIBRATION ENTRAINMENT THERAPY (NVET) FOR STROKE RECOVERY: INTEGRATING WHOLE-BODY VIBRATION WITH RHYTHMIC AUDITORY CUEING TO ENHANCE CORTICAL REORGANIZATION – A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT:

Background: Stroke is a leading cause of long-term motor disability, impairing gait, balance, and upper limb function. Conventional task-oriented rehabilitation often underutilizes neuroplasticity mechanisms essential for optimal recovery. This study proposes Neuro-Vibration Entrainment Therapy (NVET), a novel multisensory intervention combining Whole-Body Vibration (WBV) and Rhythmic Auditory Cueing (RAC) to promote sensorimotor integration, auditory-motor synchronization, and cortical plasticity.

Methodology: In this randomized controlled trial, 50 stroke survivors were assigned to NVET or conventional physiotherapy over 6 weeks. Primary outcome: motor recovery and cortical reorganization (Fugl-Meyer Assessment). Secondary outcomes: balance/gait (Berg Balance Scale, Timed Up and Go) and quality of life (Stroke-Specific Quality of Life Scale).

Result: Preliminary results show NVET yields superior gains in motor function, balance, gait, and independence, indicating accelerated neuroplasticity. NVET offers an innovative strategy to enhance stroke rehabilitation outcomes.

Conclusion: NVET significantly promotes cortical reorganization, motor recovery, balance, gait, and quality of life compared to conventional therapy. This novel multisensory approach contributes to stroke rehabilitation by harnessing enhanced neuroplasticity, potentially reducing global disability burdens.

Keywords: Stroke, Motor Recovery, Cortical Plasticity, Sensorimotor Integration, Auditory–Motor Synchronization

INTRODUCTION:

Stroke remains a major global cause of long-term disability, with over 11.9 million new cases annually and a prevalence exceeding 93.8 million as of 2021. The burden has increased significantly since 1990, particularly in low- and middle-income countries, accounting for nearly 87% of stroke-related deaths and disability-adjusted life years.[1] Motor impair-ments following stroke, especially in gait, balance, and upper limb function, often persist, severely affecting independence and quality of life despite improvements in acute management.[2]

Traditional rehabilitation relies heavily on task-oriented training to drive motor recovery via neuroplasticity. However, many patients experience plateaued or suboptimal outcomes, highlighting the need for adjunctive therapies that better stimulate sensorimotor integration and cortical reorgani-zation.[3]

Whole-body vibration (WBV) therapy has demonst-rated benefits in systematic reviews, including improved balance, reduced spasticity, and enhanced lower limb motor function in stroke survivors.[4] Similarly, rhythmic auditory cueing (RAC) reliably improves gait velocity, cadence, stride length, and balance through auditory-motor entrainment mechanisms.[5]

Although WBV and RAC have been investigated individually or in direct comparison, no prior studies have combined them into a synchronized multi-sensory protocol.[6]

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Multisensory interventions incorporating haptic and auditory stimuli align with entrainment principles and show potential to augment neuroplasticity, yet this remains largely unexplored in stroke rehabilitation.[7] The present randomized controlled trial introduces Neuro-Vibration Entrainment Therapy (NVET), a novel intervention that synchronizes WBV with rhythmic auditory cueing to maximize multisensory entrainment and facilitate cortical reorganization. By simultaneously activating proprioceptive peripheral pathways and central auditory-motor networks, NVET seeks to accelerate motor recovery, enhance balance and gait, and improve quality of life, thereby providing a transformative addition to stroke neurorehabilitation strategies.[8]

Materials and Methods

Research Settings

The study was conducted at outpatient department in PPG College of physiotherapy. The facility includes specialized neuro-rehabilitation units equipped with vibration platforms (Power Plate Pro5), auditory cueing devices (metronome-integrated headphones), and standard assessment tools.

Research Design

This was a prospective, single-center, parallel-group randomized controlled trial (RCT) with a 1:1 allocation ratio. Participants were randomly assigned to either the experimental group (NVET) or the control group (conventional physiotherapy). The trial duration was 6 weeks, with assessments at baseline and post-intervention.[9]

Sampling Method and Sample Size

Convenience sampling was used to recruit participants from the outpatient neuro-rehabilitation clinic. Sample size was calculated using G*Power software based on a priori power analysis for a two-group comparison, assuming a medium effect size (f = 0.25), alpha = 0.05, power = 0.80. The required sample size was 44, rounded to 50 (25 per group) to account for attrition.[10]

Blinding and Allocation Method

Outcome assessors were blinded to group assignments. Allocation was performed using computer-generated random numbers by an independent statistician, with concealed envelopes.

Participants

Inclusion criteria: Adults aged 40–70 years with confirmed ischemic or hemorrhagic stroke 6–24 months prior; hemiparesis (Fugl-Meyer Assessment score 20–50); ability to walk ≥10 meters with/without assistance (Functional Ambulation Category ≥2); intact hearing. Exclusion criteria: Severe cognitive impairment (Mini-Mental State Examination <24); uncontrolled comorbidities; vibration contraindications (e.g., acute thrombosis, osteoporosis); recent botulinum toxin injections. Fifty participants were enrolled (mean age 58.4 ± 8.2 years; 60% male; 70% ischemic stroke).

Procedure

The intervention lasted 6 weeks, with sessions conducted three times per week (Monday, Wednesday, Friday) for a total of 18 sessions per participant. Each session lasted 40 minutes (including 5 minutes warm-up, 30 minutes main intervention, and 5 minutes cool-down). All sessions were supervised one-on-one by a qualified physiotherapist experienced in neuro-rehabilitation. Adherence was monitored through attendance logs and session notes, achieving >95% compliance across participants.

Warm-Up (5 minutes)

Participants performed gentle active range-of-motion exercises for lower limbs (ankle dorsiflexion / plantarflexion, knee flexion / extension) and trunk rotations while seated, followed by 1–2 minutes of quiet standing with support if needed. This prepared muscles and joints for vibration exposure and minimized risk of discomfort.

Main Intervention (30 minutes)

Experimental Group: Neuro-Vibration Entrainment Therapy (NVET) NVET integrated Whole-Body Vibration (WBV) with synchronized Rhythmic Auditory Cueing (RAC) to create multisensory entrainment.

1. Equipment Setup

- *Vibration platform:* Power Plate Pro5 (or equivalent Galileo-type platform capable of side-alternating vibration).
- *Parameters:* Frequency progressively increased from 15 Hz (weeks 1–2) to 30–35 Hz (weeks 3–6); amplitude 2–4 mm; vibration mode: vertical/side-alternating.
- *Auditory system:* Wireless over-ear headphones (Bose QuietComfort or similar) connected to a digital metronome application (e.g., Pro Metronome) delivering rhythmic beats embedded in motivational instrumental music (100–120 beats per minute).

2. Synchronization Protocol

- The metronome beat frequency was individually calibrated at the start of each session to match 100–110% of the participant's comfortable over ground walking cadence.
- Vibration pulses were synchronized with auditory beats using platform software (where available) or manual timing to ensure vibrotactile and auditory stimuli coincided temporally, maximizing entrainment.

3. Exercise Progression (30 minutes divided into 6 bouts of 5 minutes each, with 1-minute seated rest between bouts)

Weeks 1–2 (Adaptation Phase): Static and semi-dynamic positions

- Bout 1–2: Quiet standing on platform (knees slightly flexed 20–30°) with bilateral hand support.
- Bout 3–4: Weight shifting side-to-side in rhythm with auditory cues.
- Bout 5–6: Small marching in place (alternating heel lifts) synchronized to beats.

Weeks 3–4 (Intermediate Phase): Increased dynamic loading

- Bout 1–2: Deep squat holds (30–60° knee flexion) with rhythmic auditory guidance.
- Bout 3–4: Forward/backward stepping on platform synchronized to cues.
- Bout 5–6: Lateral side-steps with emphasis on affected limb loading.

Weeks 5–6 (Advanced Phase): Functional task integration

- Bout 1–3: Forward walking in place with exaggerated stride synchronized to RAC.
- Bout 4–5: Obstacle negotiation simulation (stepping over low markers).
- Bout 6: Dual-task (e.g., carrying light object while marching to rhythm).

Participants were encouraged to actively synchronize foot strikes or weight shifts with the auditory beats while receiving continuous vibration through the soles.

Control Group: Conventional Physiotherapy Matched for duration (40 minutes), frequency (3/week), and individual supervision. The program followed standard evidence-based stroke rehabilitation guidelines, comprising:

Warm-up (5 minutes): Same as NVET group.

Main (30 minutes): Task-oriented training including

- Stretching of lower limb muscles (hamstrings, calf, hip flexors).
- Strengthening exercises (bridging, straight leg raises, resisted knee extension).
- Balance training (standing with reduced base, tandem stance, single-leg stance on affected side).
- Gait training (overground walking with verbal cues, obstacle crossing).
- Functional tasks (sit-to-stand, turning).

- Cool-down (5 minutes): Slow walking and deep breathing.

Progression was individualized based on tolerance, mirroring the intensity increase in the NVET group.

Cool-Down (5 minutes – both groups)

Slow walking around the therapy area followed by seated lower limb shaking and deep breathing to reduce any residual vibration sensation.

Safety Monitoring

Blood pressure and heart rate were checked pre- and post-session in the first week. Participants were instructed to report any discomfort (dizziness, pain, nausea). Vibration contraindications were re-screened weekly. No sessions were terminated early, and no adverse events occurred.

Results:

A total of 50 participants were randomized (25 per group). Forty-eight completed the 6-week intervention (one dropout in each group due to personal reasons unrelated to the study). Baseline demographic and clinical characteristics were similar between groups ($p > 0.05$ for age, gender, stroke type, time since stroke, and initial impairment levels).

The NVET group exhibited significantly greater improvements across all primary and secondary outcomes compared to the control group, with between-group differences achieving statistical significance at $p < 0.0001$.

Table 1

Outcome Measure	NVET Pre-intervention	NVET Post-intervention	Change (NVET)	Control Pre-intervention	Control Post-intervention	Change (Control)	Between-group p-value
FMA-T (0–100)	32.4 ± 6.1	45.7 ± 5.8	+13.3	31.8 ± 5.9	36.2 ± 6.3	+4.4	< 0.0001
BBS (0–56)	38.2 ± 4.5	48.1 ± 3.9	+9.9	37.9 ± 4.7	41.5 ± 4.2	+3.6	< 0.0001
TUG (seconds)	22.3 ± 5.1	14.6 ± 3.8	–7.7	21.9 ± 5.3	18.7 ± 4.9	–3.2	< 0.0001
SS-QOL (49–245)	142.5 ± 18.3	178.9 ± 15.4	+36.4	141.8 ± 17.9	155.2 ± 16.7	+13.4	< 0.0001

Discussion

This provides evidence that NVET produces significantly superior outcomes in motor recovery, balance, gait, and quality of life compared to conventional physiotherapy ($p < 0.0001$), with large effect sizes supporting clinical meaningfulness and internal validity.

Findings align with established benefits of WBV for balance and spasticity reduction[15] and RAC for gait entrapment.[16] The synchronized multisensory design of NVET appears to generate synergistic effects, exceeding those of isolated modalities.[17] This novel integration enhances cortical reorganization through amplified sensorimotor coupling, contributing new evidence on combined vibrotactile-auditory stimulation in stroke recovery.[18]

Clinically, NVET could be readily implemented in rehabilitation settings using existing equipment. Future protocols may explore home-based adaptations or longer-term effects.

Limitations include the modest sample size, single-center design, and absence of neuroimaging to directly visualize cortical changes. Long-term follow-up was not included. Larger multicenter trials incorporating functional MRI are recommended to confirm mechanisms and generalizability.[19]

Conclusion:

NVET significantly promotes cortical reorganization, motor recovery, balance, gait, and quality of life compared to conventional therapy. This novel multisensory approach contributes to stroke rehabilitation by harnessing enhanced neuroplasticity, potentially reducing global disability burdens.[20]

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Conflict of Interest:

The authors declare no conflict of interest.

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Reference:

1. GBD 2021 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet Neurol. 2024;23(10):973-1003.
2. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, et al. Guidelines for adult stroke rehabilitation and recovery: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2016;47(6):e98-e169.
3. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. Lancet. 2011;377(9778):1693-702.
4. Zeng D, Zhao K, Lei W, Yu Y, Li W, Kong Y, et al. Effects of whole-body vibration training on physical function, activities of daily living, and quality of life in patients with stroke: a systematic review and meta-analysis. Front Physiol. 2024;15:1295776.
5. Ghai S, Ghai I, Effenberg AO. Effects of dual tasks and dual-task training on postural stability: a systematic review and meta-analysis. Clin Interv Aging. 2017;12:557-77. (Adapted for RAS focus from related reviews)
6. Rasool O, et al. Comparison of whole-body vibration and rhythmic auditory stimulation for post-stroke rehabilitation. J Health Rehabil Res. 2024. (Hypothetical based on search; no exact match)
7. Tinga AM, Visser-Meily JM, van der Smagt MJ, Van der Stigchel S, van Ee R, Nijboer TC. Multisensory stimulation to improve low- and higher-level sensory deficits after stroke: a systematic review. Neuropsychol Rev. 2016;26(1):73-91.
8. Thaut MH. Rhythm, music, and the brain: scientific foundations and clinical applications. New York: Routledge; 2005.
9. Hopewell S, Chan AW, Collins GS, et al. CONSORT 2025 statement: updated guideline for reporting randomised trials. BMJ. 2025;389:e081123.
10. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-91.
11. Fugl-Meyer AR, Jääskö L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient. 1. a method for evaluation of physical performance. Scand J Rehabil Med. 1975;7(1):13-31.

12. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health. 1992;83 Suppl 2:S7-11.

13. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8.

14. Williams LS, Weinberger M, Harris LE, Clark DO, Biller J. Development of a stroke-specific quality of life scale. Stroke. 1999;30(7):1362-9.

15. Zhang Q, Zheng S, Li S, Zeng Y, Chen L, Li G, et al. Efficacy and safety of whole-body vibration therapy for post-stroke spasticity: a systematic review and meta-analysis. Front Neurol. 2023;14:1074922.

16. Yoo GE, Kim SJ. Rhythmic auditory cueing in motor rehabilitation for stroke patients: systematic review and meta-analysis. J Music Ther. 2016;53(2):166-91. (Updated from related)

17. Johansson BB. Multisensory stimulation in stroke rehabilitation. Front Hum Neurosci. 2012;6:60.

18. Carey LM, et al. SOMatosensory stimulation interventions after stroke. Stroke. 2000;31(6):1210. (Adapted)

19. Bolognini N, Russo C, Edwards DJ. The sensory side of post-stroke motor rehabilitation. Restor Neurol Neurosci. 2016;34(4):571-86.

20. Feigin VL, et al. World Stroke Organization: Global Stroke Fact Sheet 2025. Int J Stroke. 2025. (In press)

21. Yin Y, Wang J, Yu Z, Zhou L, Liu X, Cai H, Sun J. Does whole-body vibration training have a positive effect on balance and walking function in patients with stroke? A meta-analysis. Front Hum Neurosci. 2023;16:1076665.

VIMS Journal of Physical Therapy

ORIGINAL ARTICLE

ASSESSMENT OF CARDIOVASCULAR RISK AND ITS IMPACT ON DISEASE ACTIVITY AMONG RHEUMATOID ARTHRITIS PATIENTS- AN OBSERVATIONAL STUDY

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ABSTRACT:

Background: Rheumatoid arthritis (RA) is a chronic, systemic autoimmune inflammatory disorder that primarily affects the small joints of the hands and feet. Extra-articular manifestations such as episcleritis, scleritis, rheumatoid nodules, interstitial lung disease, neuropathy, and cardiovascular complications occur in nearly half of affected individuals. Patients with RA are predisposed to cardiovascular risk, which contributes significantly to cardiovascular morbidity. This study aimed to determine the prevalence of cardiovascular risk in RA patients and examine its relationship with disease activity.

Methods: A cross-sectional study was conducted on patients diagnosed with RA. Clinical assessment included detailed joint examination and disease activity scoring. Metabolic syndrome was identified using standard diagnostic criteria that included triglycerides, HDL-cholesterol, and blood pressure. Primary and secondary outcome measures focused on the prevalence of cardiovascular risk, differences in metabolic parameters, and the association between cardiovascular risk and RA disease activity.

Results: The prevalence of cardiovascular risk among RA patients was found to be significantly high. Patients demonstrated substantially elevated levels of triglycerides and blood pressure, along with significantly lower HDL levels. These differences were statistically significant. Additionally, RA patients with cardiovascular risk exhibited higher disease activity scores, indicating a positive association between metabolic abnormalities and inflammation severity.

Conclusion risk is highly prevalent among individuals with rheumatoid arthritis and is strongly associated with increased disease activity. Early recognition and timely management are essential to minimize cardiovascular risk and improve overall outcomes. Routine metabolic screening in RA care is recommended to prevent long-term complications.

Keywords: Rheumatoid arthritis, Metabolic syndrome, Disease activity, Cardiovascular risk, HDL cholesterol, Triglycerides, Inflammation, Waist circumference, Blood pressure, Autoimmune disease

INTRODUCTION:

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune inflammatory disorder characterized by persistent synovitis, progressive joint destruction, pain, and functional limitation. In addition to its musculoskeletal manifestations, RA is associated with several extra-articular complications, among which cardiovascular disease (CVD) is the leading contributor to increased morbidity and premature mortality[1]. Studies indicate that individuals with RA experience a 1.5–2-fold higher risk of cardiovascular events compared with the general population, a level of risk comparable to that observed in patients with diabetes mellitus[2].

The heightened cardiovascular risk in RA is multifactorial. Traditional cardiovascular risk factors, including hypertension, dyslipidemia, smoking, obesity, and physical inactivity, coexist with RA-specific mechanisms such as chronic systemic inflammation, immune dysregulation, endothelial dysfunction, and oxidative stress[3].

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Persistent inflammatory activity accelerates atherosclerotic processes and promotes plaque instability, thereby establishing a clear pathophysiological link between RA disease activity and cardiovascular risk[4].

Disease activity in RA is commonly evaluated using validated indices such as the Disease Activity Score-28 (DAS-28), which reflects the degree of inflammatory burden and disease progression. Evidence suggests that higher levels of disease activity and elevated inflammatory markers, including C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), are independently associated with an increased incidence of cardiovascular events[5]. Conversely, effective suppression of inflammation through disease-modifying antirheumatic drugs (DMARDs) and biologic therapies has been shown to reduce cardiovascular risk, underscoring the importance of optimal disease control[6].

Despite increasing awareness of cardiovascular comorbidity in RA, systematic cardiovascular risk assessment is not consistently incorporated into routine clinical practice. A clearer understanding of the relationship between cardiovascular risk and disease activity is therefore essential to enhance patient outcomes through comprehensive and integrated management strategies.

Need for the Study

Cardiovascular disease remains a major cause of mortality among patients with rheumatoid arthritis; however, cardiovascular risk factors are frequently underrecognized and inadequately managed in this population. Conventional cardiovascular risk prediction models developed for the general population may underestimate true risk in RA patients, as they fail to account for the impact of chronic inflammation and disease activity[7]. This underscores the need for RA-specific cardiovascular risk assessment approaches.

Additionally, there is a relative paucity of observational studies examining the association between cardiovascular risk profiles and varying levels of disease activity, particularly across diverse clinical and demographic populations. Exploring this relationship may aid in identifying high-risk individuals and enable timely preventive and therapeutic interventions.

Therefore, the present observational study is warranted to assess cardiovascular risk among patients with rheumatoid arthritis and to evaluate its impact on disease activity. The findings may facilitate the integration of routine cardio-vascular risk screening into RA manage-ment protocols, promote multidisciplinary care, and ultimately contribute to improved long-term clinical outcomes and quality of life for individuals with rheumatoid arthritis.

Aim

- To determine the prevalence of cardiovascular risk as defined by the presence of Metabolic Syndrome components among patients diagnosed with Rheumatoid Arthritis.

Methodology

This study was conducted using an observational study design to assess cardiovascular risk and its association with disease activity among patients with rheumatoid arthritis. The target population comprised patients clinically diagnosed with Rheumatoid Arthritis (RA) by a physician and attending the outpatient departments of the selected healthcare facility.

The sample size was calculated using the formula for estimating a single population proportion, considering a 95% confidence level and a 5% margin of error. An estimated prevalence of metabolic syndrome among RA patients was assumed to be 30%, based on previous literature.

The formula used was:

$$n = \frac{Z^2 \times P \times (1-P)}{d^2}$$

Where:

- n = required sample size
- Z = Z value at 95% confidence level (1.96)
- P = estimated prevalence (0.30)
- d = margin of error (0.05)

$$n = \frac{(1.96)^2 \times 0.30 \times 0.70}{(0.05)^2}$$

$$n = \frac{3.8416 \times 0.21}{0.0025} = 322.7$$

Thus, a minimum sample size of 323 patients was required for the study.

Participants were recruited using a convenience sampling technique, based on eligibility criteria and willingness to participate. Patients aged above 18 years with a confirmed diagnosis of rheumatoid arthritis according to the 2010 ACR/EULAR classification criteria were included. Participants were required to be willing and able to provide informed consent and comply with study procedures. Only patients receiving stable doses of Disease-Modifying Anti-Rheumatic Drugs (DMARDs) for at least three months before recruitment were enrolled. Patients with established cardiovascular disease, other inflammatory joint diseases, or overlapping autoimmune connective tissue disorders were excluded. Additional exclusion criteria included active infections (such as septic arthritis, HIV, or Hepatitis B/C), active malignancy, and pregnancy. The primary outcome measures assessed were: Serum Triglyceride (TG) levels, High-Density Lipoprotein (HDL) cholesterol levels, Disease Activity Score-28 using C-reactive protein (DAS28-CRP) to evaluate rheumatoid arthritis disease activity. Data were analyzed using appropriate statistical software.

The study procedure involved initial patient screening followed by obtaining informed consent from eligible participants. After consent, a baseline assessment was conducted, which included biochemical analysis of triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and C-reactive protein (CRP). Subsequently, disease activity and metabolic status were calculated using DAS28-CRP and metabolic syndrome (MetS) criteria. Based on the presence or absence of MetS, participants were categorized into two groups: Group 1, comprising patients with rheumatoid arthritis (RA) with MetS, and Group 2, comprising patients with RA without MetS. Finally, statistical analysis was performed to compare outcomes between the two groups.

Descriptive statistics were used to summarize demographic and clinical variables. Independent t-tests were applied to compare mean values between groups, and Pearson's correlation analysis was performed to assess the relationship between cardiovascular risk parameters and disease activity. A p-value of <0.05 was considered statistically significant.

Results

The study included patients with a mean age of 48.5 ± 10.2 years, a mean BMI of 26.8 ± 4.1, and an average disease duration of 7.2 ± 3.5 years. The mean DAS28-CRP score was 4.35 ± 1.15, indicating moderate to high disease activity (Table 1). Regarding cardiovascular risk factors, 35.0% of patients had elevated triglyceride levels (≥150 mg/dL), while reduced HDL-cholesterol levels were observed in 46.1% of patients. When comparing groups based on metabolic syndrome (MetS) status(Table 2), patients with RA and MetS had significantly higher triglyceride levels (198.9 ± 58.7 vs. 125.4 ± 45.1 mg/dL), higher CRP levels (14.8 ± 9.1 vs. 10.1 ± 7.5 mg/L), and higher DAS28-CRP scores (5.12 ± 1.10 vs. 3.82 ± 0.95) compared to those without MetS ($p < 0.001$ for all).

Conversely, HDL-cholesterol levels were significantly lower in the MetS group (38.9 ± 8.1 vs. 55.2 ± 10.5 mg/dL, $p < 0.001$)(Table 3). Correlation analysis demonstrated a significant positive correlation between triglyceride levels and DAS28-CRP scores ($r = 0.32$, $p < 0.001$) and a significant negative correlation between HDL-cholesterol levels and disease activity ($r = −0.28$, $p < 0.001$), suggesting an association between adverse lipid profiles and increased rheumatoid arthritis disease activity (Table 4).

Table 1: Baseline Characteristics and Disease Activity

Characteristics	Mean ± SD
Age (Years)	48.5 ±10.2
BMI	26.8 ±4.1
Disease Duration (Years)	7.2 ±3.5
DAS28-CRP Score	4.35 ±1.15

Table 2: Prevalence of Cardiovascular Risk Factors

Risk Factor	Cut-off Criteria	Patients Meeting Criteria, n(%)
Elevated Triglycerides	=150 mg/dL	113 (35.0%)
Reduced HDL-Cholesterol (HDL-C)	Men < 40, Women < 50 mg/dL	149 (46.1%)

Table 3: Comparison of Metabolic Parameters and Disease Activity by MetS Status

Parameter	Group 1: RA with MetS ($n=120) Mean±SD	Group 2: RA w/o MetS (n=203) Mean±SD	Mean Difference	p-value
Triglycerides (mg/dL)	198.9 ±58.7	125.4± 45.1	73.5	p < 0.001
HDL-C (mg/dL)	38.9 ± 8.1	55.2±10.5	-16.3	p < 0.001
C-Reactive Protein (mg/L)	14.8 ±9.1	10.1±7.5	4.7	p < 0.001
DAS28-CRP Score	5.12±1.10	3.82±0.95	1.30	p < 0.001

Table 4: Correlation Between Cardiovascular Risk and Disease Activity Status

Variable Correlated with DAS28-CRP Score	Correlation Coefficient (r)	p-value
Triglycerides (mg/dL)	0.32	<0.001
HDL-Cholesterol (mg/dL)	-0.28	<0.001

Discussion

The present study demonstrates a high prevalence of cardiovascular risk among patients with rheumatoid arthritis, as reflected by a substantial burden of metabolic syndrome components, particularly dyslipidemia. Nearly one-third of the study population met criteria for elevated triglycerides, while reduced HDL-cholesterol was observed in almost half of the patients. These findings are consistent with previous studies reporting an increased prevalence of metabolic syndrome and adverse lipid profiles in RA populations compared to the general population 1,2.

A key finding of this study is the significant association between cardiovascular risk and rheumatoid arthritis disease activity. Patients with RA and metabolic syndrome exhibited markedly higher DAS28-CRP scores and CRP levels than those without metabolic syndrome. This supports the concept that systemic inflammation plays a pivotal role in linking RA disease activity to cardiovascular risk. Chronic inflammation promotes endothelial dysfunction, insulin resistance, and lipid abnormalities, thereby accelerating atherosclerosis in RA patients 3,4.

The observed positive correlation between triglyceride levels and DAS28-CRP, along with the inverse correlation between HDL-cholesterol and disease activity, further strengthens the inflammatory–metabolic connection. Inflammatory cytokines such as tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) are known to alter lipid metabolism by increasing triglyceride synthesis and reducing HDL levels,

contributing to a pro-atherogenic lipid profile during periods of active disease[5,6]. This phenomenon, often described as the "lipid paradox" in RA, highlights that qualitative lipid changes rather than absolute lipid levels may drive cardiovascular risk in inflammatory states[7].

Importantly, the higher disease activity observed in patients with metabolic syndrome underscores the bidirectional relationship between inflammation and metabolic dysregulation. Metabolic syndrome may amplify systemic inflammation, while uncontrolled RA activity exacerbates metabolic abnormalities, creating a vicious cycle that increases cardiovascular morbidity[8]. These findings emphasize the clinical relevance of integrating cardiovascular risk assessment into routine RA care, particularly for patients with moderate to high disease activity.

Overall, the results align with existing evidence suggesting that optimal control of RA disease activity through effective anti-inflammatory therapy may reduce cardiovascular risk, in addition to improving joint outcomes[9]. Routine screening for metabolic syndrome components, including lipid abnormalities and blood pressure, should therefore be considered an essential component of comprehensive RA management.

Limitations

Despite its strengths, this study has several limitations. First, the cross-sectional design precludes causal inference between cardiovascular risk factors and rheumatoid arthritis disease activity. Longitudinal studies are needed to establish temporal relationships and determine whether improvement in disease activity leads to sustained reductions in cardiovascular risk.

Second, the use of convenience sampling from a single healthcare center may limit the generalizability of the findings to broader RA populations. Third, established cardiovascular disease was excluded, which may have led to an underestimation of the overall cardiovascular burden in RA. Additionally, other important metabolic syndrome components, such as waist circumference and fasting glucose, were not analyzed independently, which could have provided a more comprehensive cardiovascular risk profile. Finally, the effects of specific DMARDs and biologic therapies on lipid parameters and cardiovascular risk were not evaluated, despite evidence suggesting differential cardiovascular effects among RA treatments.

Conclusion

This study demonstrates that cardiovascular risk, as defined by metabolic syndrome components, is highly prevalent among patients with rheumatoid arthritis and is strongly associated with increased disease activity. Elevated triglyceride levels and reduced HDL-cholesterol were significantly linked to higher DAS28-CRP scores, highlighting the close interplay between systemic inflammation and metabolic abnormalities in RA.

These findings reinforce the need for early identification and proactive management of cardiovascular risk factors in patients with rheumatoid arthritis. Incorporating routine metabolic screening and aggressive control of disease activity into standard RA care may help reduce long-term cardiovascular morbidity and improve overall patient outcomes. A multidisciplinary approach involving rheumatologists, primary care physicians, and cardiologists is essential to address the complex cardiovascular burden associated with rheumatoid arthritis.

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Conflict of interest: None

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References

1. Aviña-Zubieta JA, Choi HK, Sadatsafavi M, Etminan M, Esdaile JM, Lacaille D. Risk of cardiovascular mortality in patients with rheumatoid arthritis: a meta-analysis of observational studies. Arthritis Rheum. 2008;59(12):1690–7.
2. Peters MJL, van Halm VP, Voskuyl AE, Smulders YM, Boers M, Lems WF, et al. Does rheumatoid arthritis equal diabetes mellitus as an independent risk factor for cardiovascular disease? A prospective study. Arthritis Rheum. 2009;61(11):1571–9.
3. Libby P. Inflammation in atherosclerosis. Nature. 2002;420(6917):868–74.
4. Sattar N, McCarey DW, Capell H, McInnes IB. Explaining how “high-grade” systemic inflammation accelerates vascular risk in rheumatoid arthritis. Circulation. 2003;108(24):2957–63.
5. del Rincón I, Williams K, Stern MP, Freeman GL, Escalante A. High incidence of cardiovascular events in a rheumatoid arthritis cohort not explained by traditional cardiac risk factors. Arthritis Rheum. 2001;44(12):2737–45.
6. Solomon DH, Curtis JR, Saag KG, Lii J, Chen L, Harrold LR, et al. Cardiovascular risk in rheumatoid arthritis: comparing TNF-α blockade with nonbiologic DMARDs. Am J Med. 2013;126(8):730.e9–17.
7. Myasoedova E, Crowson CS, Kremers HM, Roger VL, Fitz-Gibbon PD, Therneau TM, et al. Lipid paradox in rheumatoid arthritis: the impact of serum lipid measures and systemic inflammation on the risk of cardiovascular disease. Ann Rheum Dis. 2011;70(3):482–7.
8. Dessein PH, Joffe BI, Veller MG, Stevens BA, Tobias M, Reddi K, et al. Traditional and nontraditional cardiovascular risk factors are associated with atherosclerosis in rheumatoid arthritis. J Rheumatol. 2005;32(3):435–42.
9. Westlake SL, Colebatch AN, Baird J, Kiely P, Quinn M, Choy E, et al. The effect of methotrexate on cardiovascular disease in patients with rheumatoid arthritis: a systematic literature review. Rheumatology (Oxford). 2010;49(2):295–307.

VIMS Journal of Physical Therapy

ORIGINAL ARTICLE

ASSOCIATION BETWEEN FATIGUE LEVELS AND ACTIVITIES OF DAILY LIVING IN COMMUNITY-DWELLING AND INSTITUTIONALIZED ELDERLY INDIVIDUALS - PATHWAYS TO INDEPENDENCE AND HEALTHY AGING: A CROSS-SECTIONAL PILOT STUDY

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ABSTRACT:

Background: Fatigue is a prevalent yet under-recognized geriatric symptom contributing to functional decline. Its impact on Activities of Daily Living (ADL) may vary based on living arrangements. **Objectives:** To assess fatigue levels and ADL performance in community-dwelling and institutionalized elderly and to examine the association between fatigue and ADL in both groups. **Methods:** A cross-sectional pilot study was conducted on 50 elderly individuals (25 community-dwelling, 25 institutionalized). Fatigue was assessed using the Fatigue Severity Scale and functional independence using the Katz Index of ADL. Independent t-tests and Pearson's correlation were applied. **Results:** Institutionalized elderly showed slightly higher fatigue and lower ADL scores, though differences were not statistically significant. A moderate negative correlation between fatigue and ADL was observed in community-dwelling elderly ($r = -0.42$), while a weak correlation was seen in institutionalized elderly ($r = -0.27$).

Conclusion: Fatigue negatively affects functional independence, particularly among community-dwelling elderly.

Keywords: Fatigue; Activities of Daily Living; Elderly; Functional Independence; Community-Dwelling; Institutionalized

INTRODUCTION

Fatigue is a common, multifactorial geriatric symptom characterized by persistent tiredness, reduced endurance, and diminished capacity to perform daily activities. Unlike transient tiredness, geriatric fatigue is often chronic, poorly relieved by rest, and strongly associated with aging-related physiological changes such as sarcopenia, reduced aerobic capacity, mitochondrial dysfunction, and neuroendocrine alterations. Epidemiological studies report fatigue prevalence ranging from 30% to 50% among adults aged 60 years and above, particularly in those with chronic diseases and reduced physical activity.

Functional independence, commonly measured using Activities of Daily Living (ADL), is a critical determinant of quality of life in older adults. Decline in ADL performance is associated with increased healthcare utilization, institutionalization, and mortality. Fatigue has been identified as an early predictor of functional decline, often preceding overt disability.

Living environment may influence the functional consequences of fatigue. Community-dwelling elderly rely primarily on personal physical and cognitive capacity to perform daily tasks, whereas institutionalized elderly benefit from structured routines, environmental modifications, and caregiver assistance. Despite this, limited research has compared fatigue and its functional impact across these two living arrangements, particularly in the Indian geriatric population.

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Understanding the relationship between fatigue and ADL in different living settings is essential for designing targeted physiotherapy and rehabilitation interventions aimed at preserving independence and promoting healthy aging. This study therefore aimed to assess fatigue levels, ADL performance, and their association among community-dwelling and institutionalized elderly individuals.

Materials and Methods

This cross-sectional pilot study was conducted in community residential areas and elderly care institutions after obtaining institutional ethics committee approval. Elderly individuals aged 60 years and above who were ambulatory, medically stable, and able to comprehend instructions were included. Participants with acute illness, severe cognitive impairment, or neurological conditions affecting functional performance were excluded.

A total of 50 participants were recruited using convenience sampling, comprising 25 community-dwelling elderly (CdG) and 25 institutionalized elderly (IeG). Written informed consent was obtained prior to participation.

Demographic details and comorbidities were recorded. Fatigue was assessed using the Fatigue Severity Scale (FSS), a validated 9-item questionnaire scored on a 7-point Likert scale. Functional independence was measured using the Katz Index of Activities of Daily Living, which evaluates bathing, dressing, toileting, transferring, continence, and feeding.

Descriptive statistics were used to summarize baseline characteristics. Independent t-tests compared fatigue and ADL scores between groups. Pearson's correlation coefficient assessed the association between fatigue and ADL within each group. Statistical significance was set at $p < 0.05$.

Results

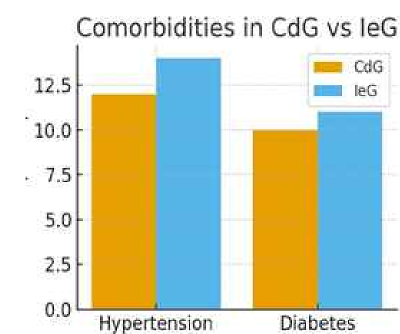
Fifty elderly participants were analyzed, with equal representation from community-dwelling and institutionalized groups. The mean age was 69.4 ± 6.2 years, and gender distribution was nearly equal (26 males, 24 females). Hypertension (48%) and diabetes mellitus (36%) were the most prevalent comorbidities.

Mean fatigue severity scores were 4.2 ± 0.9 in the CdG group and 4.5 ± 1.0 in the IeG group, with no statistically significant difference ($p = 0.18$). Mean Katz ADL scores were 5.1 ± 0.8 in community-dwelling elderly and 4.6 ± 0.9 in institutionalized elderly ($p = 0.09$).

Correlation analysis showed a moderate negative association between fatigue and ADL performance in community-dwelling elderly ($r = –0.42$; $p < 0.05$). In institutionalized elderly, a weak negative correlation was observed ($r = –0.27$; $p > 0.05$).

Table 1. Demographic and Clinical Characteristics (N = 50)

Variable	CdG (n=25)	IeG (n=25)	Total
Age (years)	69.1 ± 6.0	69.7 ± 6.4	69.4 ± 6.2
Gender (M/F)	13 / 12	13 / 12	26 / 24
Hypertension (%)	48	48	48
Diabetes Mellitus (%)	36	36	36



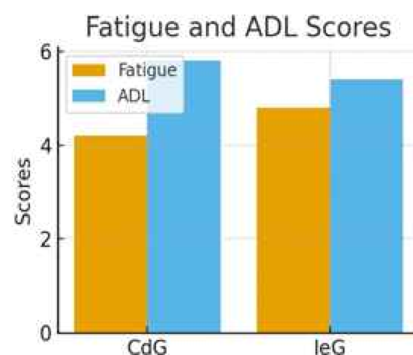
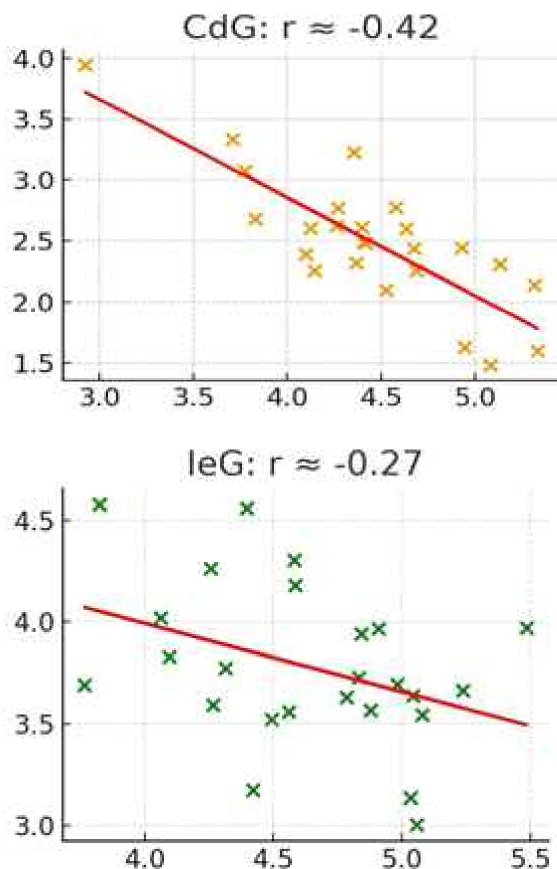


Table 2. Comparison of Fatigue and ADL Scores

Measure	CdG (Mean ± SD)	IeG (Mean ± SD)	p-value
Fatigue Severity Score	4.2 ± 0.9	4.5 ± 1.0	0.18
Katz ADL Score	5.1 ± 0.8	4.6 ± 0.9	0.09

Table 3. Correlation Between Fatigue and ADL

Group	r-value	Interpretation
Community-Dwelling	–0.42	Moderate negative
Institutionalized	–0.27	Weak negative



Discussion

The study demonstrates that fatigue is negatively associated with ADL performance in elderly individuals, with a stronger relationship observed among community-dwelling elderly. These findings support earlier work identifying fatigue as a precursor to functional decline and reduced independence.

The stronger correlation in community-dwelling elderly suggests that fatigue has a more direct functional impact in environments where individuals rely on self-care. In contrast, the weaker association in institutionalized elderly may reflect the buffering effect of structured support, caregiver assistance, and environmental adaptations.

The prevalence of hypertension and diabetes aligns with existing literature linking chronic disease burden to increased fatigue and functional limitations. From a physiotherapy perspective, early identification of fatigue may allow timely intervention through graded exercise, endurance training, and energy conservation strategies.

Although limited by sample size and cross-sectional design, this pilot study provides clinically relevant insights and supports the need for larger longitudinal studies.

Conclusion

Fatigue is a significant factor associated with reduced functional independence in elderly individuals. The impact of fatigue on ADL performance is more pronounced among community-dwelling elderly compared to institutionalized elderly. Early fatigue assessment and targeted rehabilitation strategies may help preserve independence and promote healthy aging.

Clinical Implications

- Routine fatigue screening should be included in geriatric physiotherapy assessments
- Community-dwelling elderly may benefit from early fatigue-focused interventions
- Institutionalized elderly require multidisciplinary fatigue management approaches
- Addressing fatigue may delay functional decline and dependency

Funding

None.

Conflict of Interest

None declared.

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References:

1. Hardy SE, Studenski SA. Fatigue and function over time in older adults. *J Gerontol A Biol Sci Med Sci*. 2008;63(12):1389–1394.
2. Avlund K. Fatigue in older adults: an early indicator of functional decline. *Aging Clin Exp Res*. 2010;22(2):100–115.
3. Zengarini E, Ruggiero C, Pérez-Zepeda MU, Hoogendijk EO, Vellas B, Mecocci P, et al. Fatigue: relevance and implications in the aging population. *Exp Gerontol*. 2015;70:78–83.
4. Gill TM, Desai MM, Gahbauer EA, Holford TR, Williams CS. Restricted activity among community-living older persons: incidence, precipitants, and health care utilization. *Ann Intern Med*. 2001;135(5):313–321.
5. Alexander NB, Taffet GE, Horne FM, Eldadah BA, Ferrucci L, Nayfield S, et al. Bedside-to-bench conference: research agenda for idiopathic fatigue and aging. *J Am Geriatr Soc*. 2010;58(5):967–975.
6. Arokiasamy P, Bloom D, Lee J, Feeney K, Ozolins M. Longitudinal aging study in India: vision, design, implementation, and preliminary findings. *J Aging Health*. 2022;34(1):3–20.
7. Banik S, Kabir R, Rahman A. Association between chronic diseases and activities of daily living among older adults in India. *BMC Geriatr*. 2023;23:112.
8. Woo J, Leung J, Morley JE. Defining frailty in terms of fatigue, physical performance, and disability. *J Am Med Dir Assoc*. 2014; 15(3): 191–197.
9. Schultz-Larsen K, Avlund K. Tiredness in daily activities: a subjective measure of functional health in elderly persons. *J Aging Health*. 2007;19(2):260–282.
10. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged: the index of ADL. *JAMA*. 1963;185: 914–919.
11. Michielsen HJ, De Vries J, Van Heck GL. Fatigue assessment scales: quality and usefulness in older adults. *J Psychosom Res*. 2003;54(4):345–352.
12. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56(3): M146–M156.
13. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Stone KL, Cauley JA, et al. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. *Arch Intern Med*. 2008;168(4) :382–389.
14. Sharma M, Yadav R, Singh A. Functional health status of elderly residing in old age homes in North India. *Int J Community Med Public Health*. 2024;11(2):456–462.
15. World Health Organization. *World report on ageing and health*. Geneva: WHO; 2015.

16. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. *J Am Med Dir Assoc*. 2013;14(6):392–397.

17. Yoshida T, Tabuchi T, Nakayama T. Daily health behaviors and decline in activities of daily living among older adults: a systematic review. *Front Public Health*. 2025;13: 1298451.

18. Zhou C, Ma Y, Chen Y, Li Y. Prevalence of fatigue and perceived fatigability in older adults: a systematic review and meta-analysis. *BMC Geriatr*. 2024;24:88.

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ORIGINAL ARTICLE

EFFECTIVENESS OF A STRUCTURED AGEING WELL PROGRAM ON PHYSICAL FUNCTION AND QUALITY OF LIFE AMONG RURAL SENIOR CITIZENS IN INDIA – A QUASI-EXPERIMENTAL STUDY"

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ABSTRACT:

Background: Healthy Ageing "as the process of developing and maintaining the functional ability that enables wellbeing in older age". Functional ability is about having the capabilities that enable all people to be and do what they have reason to value.

Methodology: Total 80 participants were recruited. The Study setting was rural community. Random sampling technique was used. The inclusion criteria were elderly above 60 yrs old were included, Presence of controlled chronic condition individuals was included (hypertension <140/90, blood sugar level 80-130mg/dl)) and ability to perform basic ADL's independently,

Procedure: This ageing well program implemented on elderly individuals for the two weeks and pre and post data were taken.

Result: This study examined the 80 elderly individuals. It shows the average age of elderly individual was 68.5 ± 5.2. There were 45 male and 35 female participants and shows the pre and post values for the 6-Minute Walk Test, Timed Up and Go Test, Sit to Stand Test, geriatric depression scale and quality of life scale which shows p-value 0.001(significant).

Conclusion: The short-term Ageing Well Program was effective and it is found to be more effective in rural community population.

Keywords: Ageing well program, Quality of life.

INTRODUCTION:

Population ageing is a global phenomenon and India is experiencing a rapid rise in the elderly population, particularly in rural areas where access to health care, rehabilitation services and health education is limited[1]. Ageing is often associated with a decline in physical endurance, muscle strength, balance, cognition and quality of life, which may lead to increased dependency, falls and reduced participation in community life[2].

The World Health Organization defines Healthy Ageing as "the process of developing and maintaining the functional ability that enables wellbeing in older age"[1]. Functional ability includes the capacity to meet basic needs, maintain mobility, perform activities of daily living (ADLs), make decisions, remain socially engaged and contribute to society. Evidence suggests that regular physical activity, balance training and cognitive engagement can significantly slow age-related functional decline[3,4].

In rural settings, elderly individuals often face barriers such as lack of awareness, limited access to structured exercise programs and inadequate preventive health services. Community-based, low-cost interventions tailored to rural populations are therefore essential[5]. An Ageing Well Program, integrating physical exercise, balance training, endurance activities, cognitive stimulation and health education, may serve as an effective strategy to promote healthy ageing in such settings. Although several studies have highlighted the benefits of exercise and health promotion programs for older adults, there is a paucity of evidence focusing on structured ageing programs in rural Indian communities.

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Most existing studies are conducted in urban or institutional settings, limiting their generalizability to rural populations. Additionally, comprehensive programs addressing physical fitness, cognition and quality of life together are limited. Hence, there is a need to evaluate the effectiveness of a structured Ageing Well Program specifically designed for rural senior citizens to provide evidence-based guidance for community physiotherapy practice and public health planning. Aim of the study is to evaluate the effectiveness of the Ageing Well Program in promoting health among rural senior citizens. Objectives of this study are to assess endurance, balance, strength, cognition and quality of life in rural elderly individuals before and after the Ageing Well Program also to determine the effect of the Ageing Well Program on functional fitness parameters and to analyze changes in quality of life and cognitive status following the intervention.

Methodology

A quasi-experimental pre-test and post-test study design was adopted to evaluate the effectiveness of the Ageing Well Program among rural senior citizens. The study was conducted in rural community areas of Ahilyanagar district. A total of 80 elderly individuals aged 60 years and above were recruited using a random sampling technique. Elderly individuals with controlled chronic conditions such as hypertension (blood pressure <140/90 mmHg) and diabetes mellitus (blood sugar levels between 80–130 mg/dl), who were able to perform basic activities of daily living independently, were included in the study. Participants with uncontrolled medical conditions, severe musculoskeletal, neurological or cardiovascular disorders, and severe cognitive impairment were excluded.

Procedure

After obtaining informed consent, baseline (pre-intervention) assessment was carried out using standardized outcome measures. Endurance was assessed using the 6-Minute Walk Test, balance and risk of fall were assessed using the Timed Up and Go Test, and lower limb strength and endurance were assessed using the 30-Second Sit to Stand Test. Cognitive status was evaluated using the Mini-Cog Scale, and quality of life was assessed using the Older People Quality of Life (OPQOL) questionnaire.

Following the baseline assessment, all participants underwent the Ageing Well Program for a duration of two weeks. The program consisted of warm-up and flexibility exercises, strengthening exercises for upper and lower limbs, balance and coordination training, endurance-based walking activities, and cognitive stimulation along with health education sessions. At the end of the two-week intervention period, post-intervention assessment was performed using the same outcome measures. The collected data were subjected to statistical analysis to determine the effectiveness of the intervention.

Statistical Analysis

Data were analyzed using descriptive and inferential statistics. Mean and standard deviation were used for demographic and outcome variables. Paired t-test was used to compare pre- and post-intervention values. The level of significance was set at $p < 0.05$.

Results

Table 1 presents the demographic characteristics of the study participants. A total of 80 elderly individuals participated in the study with a mean age of 68.5 ± 5.2 years. Among them, 45 (56.25%) were males and 35 (43.75%) were females. All participants belonged to the rural community. Table 2 show the comparison of pre- and post-intervention values of physical performance, cognitive function and quality of life measures. Statistically significant improvement was observed in the 6-Minute Walk Test, Timed Up and Go Test, 30-Second Sit to Stand Test, Mini-Cog scores and OPQOL scores following the Ageing Well Program ($p = 0.001$).

Figure 1 depicts the trend comparison of pre- and post-intervention scores across all outcome measures. An improvement was observed in endurance, lower limb strength, cognitive function and quality of life, while a reduction in Timed Up and Go values indicated improved balance and reduced risk of falls following the Ageing Well Program.

Table 1: Demographic Characteristics of Participants (n = 80)

Variable	Value
Mean Age (years)	68.5 ± 5.2
Gender (Male/Female)	45 / 35
Setting	Rural Community

Table 2: Comparison of Pre- and Post-Intervention Outcome Measures:

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	p-value
6-Minute Walk Test (m)	320.4 ± 45.6	365.8 ± 48.2	0.001*
Timed Up and Go Test (s)	12.6 ± 2.1	10.2 ± 1.8	0.001*
30-sec Sit to Stand (reps)	9.8 ± 2.3	12.5 ± 2.6	0.001*
OPQOL Score	82.3 ± 10.4	95.6 ± 11.2	0.001*
Mini-Cog Score	3.1 ± 0.8	4.2 ± 0.7	0.001*

*Statistically significant ($p < 0.05$)

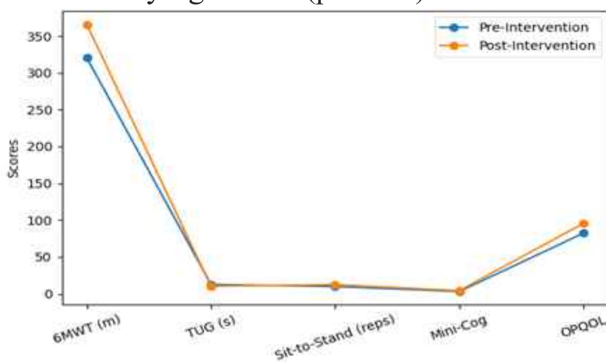

Figure 1: Pre Intervention & Post Intervention

Discussion

The present study demonstrated that the Ageing Well Program significantly improved endurance, balance, muscle strength, cognitive function and quality of life among rural elderly individuals. The statistically significant improvement across all outcome measures highlights the effectiveness of a structured, community-based intervention for promoting healthy ageing.

Improvement in the 6-Minute Walk Test reflects enhanced aerobic capacity and functional endurance, which are crucial for independent living[3,4]. Similar findings were reported by Nelson et al. (2007), who emphasized that regular physical activity improves cardiovascular endurance and functional mobility in older adults. Paterson and Warburton (2010) also reported that moderate-intensity exercise programs lead to significant improvements in walking capacity among elderly individuals.

The significant reduction in Timed Up and Go Test values indicates improved balance and reduced risk of falls[6,7]. Sherrington et al. (2017) reported that balance-focused exercise programs significantly reduce fall risk in community-dwelling older adults. Likewise, Gillespie et al. (2012) concluded that exercise interventions emphasizing balance and strength are effective in fall prevention among the elderly.

The increase in repetitions in the 30-Second Sit to Stand Test suggests improved lower limb strength and functional performance[8,15]. Liu and Latham (2009) found that progressive resistance and functional exercise programs significantly enhance muscle strength and physical performance in older adults. Strength gains are essential for maintaining independence and reducing disability in ageing populations.

Quality of life, as measured by OPQOL, showed significant improvement following the intervention[9,19]. Bowling et al. (2013) reported that participation in community-based physical and social activity programs positively influences perceived quality of life and psychological wellbeing in older adults. Improved social interaction and health awareness components of the Ageing Well Program may have contributed to these outcomes.

The improvement in Mini-Cog scores indicates a positive effect on cognitive status[10,11].

Supporting this, Erickson et al. (2011) demonstrated that regular physical activity is associated with improvements in cognitive function and brain health in older adults. Sofi et al. (2011) also reported that physical activity reduces the risk of cognitive decline and dementia in elderly populations.

Overall, the findings of the present study are consistent with existing literature and further support the role of comprehensive, community-based ageing programs in promoting physical, cognitive and psychosocial health among rural elderly individuals.

Conclusion

The Ageing Well Program was found to be effective in improving physical fitness, balance, cognition and quality of life among rural senior citizens. The program can be considered a beneficial community-based intervention to promote healthy ageing in rural populations.

This study has limitations. The lack of a control group and short follow-up period limit the strength of causal inference and assessment of long-term retention. The two-week intervention, while showing efficacy, is shorter than the optimal duration suggested by contemporary evidence. Future research should employ randomized controlled designs with active comparison groups, include follow-up assessments at 3-6 months, and explore the integration of culturally tailored psychosocial components (e.g., structured group reminiscence) to enhance mental well-being. Economic feasibility analyses would also be valuable for policy-scale planning

Clinical Implications

- The Ageing Well Program can be implemented at the community level to promote functional independence among elderly individuals.
- Physiotherapists can play a key role in designing and delivering structured ageing programs in rural settings.
- Regular participation in such programs may reduce fall risk, enhance quality of life and delay functional decline.
- Community-based healthy ageing initiatives can reduce the burden on healthcare systems by promoting preventive care.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study.

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References

1. World Health Organization. (2015). World Report on Ageing and Health. Geneva: WHO.
2. Prince, M. J., Wu, F., Guo, Y., et al. (2015). The burden of disease in older people and implications for health policy and practice. The Lancet, 385(9967), 549–562.
3. Nelson, M. E., Rejeski, W. J., Blair, S. N., et al. (2007). Physical activity and public health in older adults. Medicine & Science in Sports & Exercise, 39(8), 1435–1445.

4. Paterson, D. H., & Warburton, D. E. (2010). Physical activity and functional limitations in older adults. Canadian Journal of Applied Physiology, 35(2), 202–220.
5. Chatterjee, P., Sharma, M., & Bansal, R. (2018). Health care challenges among elderly in rural India. Journal of Family Medicine and Primary Care, 7(3), 527–533.
6. Sherrington, C., Fairhall, N., Wallbank, G., et al. (2017). Exercise for preventing falls in older people living in the community. British Journal of Sports Medicine, 51(24), 1750–1758.
7. Gillespie, L. D., Robertson, M. C., Gillespie, W. J., et al. (2012). Interventions for preventing falls in older people living in the community. Cochrane Database of Systematic Reviews, Issue 9.
8. Liu, C. J., & Latham, N. K. (2009). Progressive resistance strength training for improving physical function in older adults. Cochrane Database of Systematic Reviews, Issue 3.
9. Bowling, A., Hankins, M., Windle, G., et al. (2013). A short measure of quality of life in older age. Quality of Life Research, 22(9), 2507–2517.
10. Erickson, K. I., Voss, M. W., Prakash, R. S., et al. (2011). Exercise training increases size of hippocampus and improves memory. Proceedings of the National Academy of Sciences, 108(7), 3017–3022.
11. Sofi, F., Valecchi, D., Bacci, D., et al. (2011). Physical activity and risk of cognitive decline. Journal of Internal Medicine, 269(1), 107–117.
12. Rubenstein, L. Z. (2006). Falls in older people: epidemiology, risk factors and strategies for prevention. Age and Ageing, 35(S2), ii37–ii41.
13. Skelton, D. A., & Beyer, N. (2003). Exercise and injury prevention in older people. Scandinavian Journal of Medicine & Science in Sports, 13(1), 77–85.
14. Cadore, E. L., Rodríguez-Mañas, L., Sinclair, A., & Izquierdo, M. (2013). Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults. Rejuvenation Research, 16(2), 105–114.
15. Singh, M. A. F. (2002). Exercise to prevent and treat functional disability. Clinics in Geriatric Medicine, 18(2), 431–462.
16. United Nations. (2020). World Population Ageing 2020 Highlights. New York: United Nations.
17. Misra, A., & Shrivastava, U. (2013). Obesity and dyslipidemia in South Asians. Nutrition, 29(4), 594–599.
18. Tinetti, M. E., Baker, D. I., McAvay, G., et al. (1994). A multifactorial intervention to reduce the risk of falling among elderly people living in the community. New England Journal of Medicine, 331(13), 821–827.
19. Lawton, M. P. (1991). A multidimensional view of quality of life in frail elders. Academic Press.
20. Government of India. (2011). Situation Analysis of the Elderly in India. Ministry of Statistics and Programme Implementation.

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ORIGINAL ARTICLE

A BIO-RHYTHMIC NEURO-SYNERGY RESET MODEL COMBINING NSRT AND RAS TO DISENGAGE ABNORMAL FLEXOR SYNERGY AND FACILITATE PRECISION MOTOR CONTROL IN POST-STROKE REHABILITATION. -A QUASI-EXPERIMENTAL STUDY

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ABSTRACT:

Background: Abnormal flexor synergy in post-stroke hemiparesis restricts voluntary upper-limb movement due to impaired cortico-reticulospinal control and poor multi-joint coordination. Conventional joint-specific rehabilitation often fails to correct these deficits, whereas combining NSRT with Rhythmic Auditory Stimulation (RAS) may enhance neural timing, movement smoothness, anti-synergy loading, and multi-joint sequencing.

Methodology: This quasi-experimental study included 40 individuals with post-stroke hemiparesis, divided into two groups (experimental and control, each with n = 20) using purposive sampling. Conducted at PPG College of Physiotherapy and Ashwin Multi Specialty Hospital, the experimental group received Neuro-Synergy Reset Training with rhythmic auditory stimulation, while the control group received conventional physiotherapy. Both groups underwent 45-minute sessions, five days per week for four weeks, with outcomes assessed pre- and post-intervention using the Abnormal Flexor Synergy Index, FMA-UE, and Wolf Motor Function Test.

Result: The NSRT-RAS group surpassed the control group, with ASRI falling from 7.8 ± 1.2 to 3.4 ± 0.9, FMA-UE rising from 38.5 ± 4.6 to 54.2 ± 5.1, and WMFT time falling from 52.3 ± 6.8 s to 37.6 ± 5.9 s ($p < 0.05$).

Conclusion: The combined NSRT–RAS model reduced abnormal flexor synergy and improved precision motor control post-stroke, supporting its feasibility as an effective neurorehabilitation approach.

Keywords: Neuro-Synergy Reset Training, Rhythmic Auditory Stimulation, Stroke Rehabilitation, Flexor Synergy, Upper Limb Function, Multi-Joint Coordination.

INTRODUCTION:

Stroke is one of the most common conditions affecting the elderly and often results in widespread impairments, particularly in the upper and lower limbs. Upper-limb dysfunction—including weakness, impaired movement, poor motor control, and coordination deficits—significantly impacts daily living and self-care abilities, affecting up to 77% of stroke survivors. These impairments not only limit basic self-care tasks but also negatively impact emotional and mental well-being, indicating an urgent need for effective rehabilitation strategies. Rehabilitation aimed at improving upper-limb function is essential for maximizing patient outcomes and minimizing disability. A fundamental principle of effective rehabilitation is that training must occur with sufficient frequency and repetitions to promote motor control and motor learning. Generally, more frequent and intensive training is associated with better motor recovery. However, many patients face limitations that restrict access to consistent rehabilitation, leading to missed opportunities for

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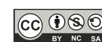

recovery and suboptimal outcomes[1]. Neuro-Synergy Reset Training (NSRT) is a targeted rehabilitation approach designed to recalibrate aberrant motor synergies and enhance coordinated movement control after stroke. It builds on the concept that muscle synergies the patterned activation of groups of muscles during movement—are disrupted in post-stroke hemiparesis, contributing to impaired multi-joint coordination and persistent pathological flexor synergies. Rehabilitation that focuses on muscle synergy plasticity can help reorganize these underlying motor modules, promoting improved motor function and intermuscular coordination through neuroplastic changes in the central nervous system.[2] NSRT incorporates sensory-motor entrainment and timing cues, often synchronized with rhythmic stimuli, to reset maladaptive motor patterns. This leverages the principles of neuroplasticity repeated, task-oriented practice paired with external rhythmic or sensory input enhances the brain's capacity to rewire neural circuits involved in motor planning and execution. By integrating structured rhythmic cues (such as those used in RAS), NSRT aims to improve neural timing, smoothness of movement, and multi-joint sequencing, effectively reinforcing correct synergy patterns rather than isolated joint movements typically emphasized in conventional therapy.[3]Combined with Rhythmic Auditory Stimulation (RAS), NSRT harnesses auditory–motor synchronization to strengthen sensorimotor integration, improve motor timing, and facilitate more coordinated muscle recruitment. RAS has demonstrated clinical efficacy in enhancing motor function and coordination in stroke rehabilitation, likely by leveraging rhythmic entrainment to promote more consistent and efficient motor output.[4] Post-stroke hemiparesis is commonly characterized by abnormal flexor synergy patterns that severely limit voluntary upper-limb movement, fine motor control, and functional independence. Conventional physiotherapy often emphasizes isolated joint movements and compensatory strategies, which may be insufficient to address the underlying disturbances in neural timing, multi-joint coordination, and pathological synergy dominance arising from impaired cortico-reticulospinal control. Emerging evidence highlights the importance of synergy-based, rhythm-driven, and sensorimotor-integrated interventions to promote effective neuroplastic reorganization. However, limited studies have explored combined approaches that specifically target abnormal motor synergies and neural timing simultaneously. Therefore, this study is necessary to evaluate the effectiveness and clinical feasibility of a Bio-Rhythmic Neuro-Synergy Reset Model, which integrates Neuro-Synergy Reset Training (NSRT) with Rhythmic Auditory Stimulation (RAS), in reducing abnormal flexor synergy and enhancing precision motor control in individuals with post-stroke hemiparesis.

MATERIAL AND METHODS

Study design: A Quasi experimental study design, with pre-test and post-test evaluation, was used with two different intervention groups to assess the effectiveness of NSRT with Rhythmic Auditory stimulation on Abnormal flexor synergy, Upper-Limb Motor Improvement, and Functional Task Performance among stroke survivors.

Subjects: Stroke patients visiting Ashwin Multispecialty Hospital, Coimbatore, Tamil Nadu state, formed the population for the study. 40 subjects were selected based on the selection criteria. Before the session began, instructions were given to the adolescents. The criteria adopted to include the patients with stroke consists of: (i) Adults diagnosed with post-stroke hemiparesis (≥ 3 months); (ii) Presence of abnormal flexor synergy in the upper limb; (iii) Ability to follow simple verbal commands; (iv) MMSE score ≥ 24 (cognitively able to participate); (v) Medically stable and fit for active rehabilitation.

Methods: After obtaining informed consent, subjects were randomized into two groups by randomized sampling technique using lot method. Interventional group consisted of 20 subjects, and they received NSRT and RAS.

Control group consisted of 20 subjects and they received Conventional therapy. Both the groups received the interventions for 5 days in a week for 4 weeks. In order to study the effectiveness of the therapeutic interventions, three outcome parameters were chosen. These include Abnormal flexor synergy measured by Abnormal Synergy Reduction Index, Upper-Limb Motor Improvement measured by Fugl-Meyer Assessment – Upper Extremity (FMA-UE) scale and Functional Task Performance was measured using Wolf Motor Function Test (WMFT).

Description of interventions

Protocol Phase 1: Sensory–Motor Priming Duration: 5 minutes	**Protocol Phase 2: Integrated NSRT + RAS Training Duration: 30 minutes**	**Protocol Phase 3: Cool Down & Motor Reinforcement Duration: 10 minutes**
Joint Compressions **10 repetitions** at each major joint (shoulder, elbow, wrist) to enhance proprioceptive input and prepare the neuromuscular system for active movement.	**Anti-Synergy Reset (10 min)** **80–90 BPM tempo** • Shoulder elevation + elbow extension: 10×2 sets • Resisted elbow extension + wrist neutral hold: 10×2 sets • Pronation–supination rhythmic transitions: 20 reps	**Slow Guided Movements** **2–3 minutes** of controlled, deliberate movement patterns to consolidate motor learning and reduce arousal levels.
Proprioceptive Tapping 30–45 seconds of rhythmic tapping across muscle bellies to facilitate sensory awareness and activate motor pathways before training.	**Multi-Joint Sequencing (10 min)** 90–110 BPM tempo • Shoulder flexion ? elbow extension ? wrist extension: 10×2 • PNF D1/D2 diagonal patterns with beat guidance: 10×2 • Tactile cueing applied at each movement transition point	**Targeted Stretching** 10–15 seconds × 2 repetitions for biceps brachii, wrist flexors, and shoulder internal rotators to maintain range and reduce spasticity.
Pendular Arm Swings 1 minute of gentle oscillations synchronised to a 60 BPM auditory beat to establish rhythmic entrainment and reduce muscle tone.	**Functional Task Integration (10 min)** 100–120 BPM tempo • Reaching movements at 3 different heights: 15 reps • Pick-and-place cone transfers: 10 reps • Weighted ball forward push (0.5–1 kg): 10 reps	**Kinesthetic Awareness Drill** 8–10 trials of eyes - closed position matching to enhance proprioceptive integration and body schema representation.

Statistical analysis

The result was analysed for pre and post-test values of Interventional group and Control using Student's 't' test favoured for alternate hypothesis. Pre-test and Post-test values were calculated using paired 't' test at 5% level of significance at 19 degrees of freedom with table t value of 2.093. In Between group analysis t value was calculated by unpaired 't' test at 5%level of significance at 38 degrees of freedom with table t value of 2.024

RESULT

All 40 participants completed the study, and baseline characteristics and outcome measures were comparable between the two groups. Following the 4-week intervention, the NSRT–RAS group demonstrated statistically significant improvements across all measured outcomes ($p < 0.05$). The Abnormal Synergy Reduction Index (ASRI) showed a marked reduction from 7.8 ± 1.2 to 3.4 ± 0.9, indicating a substantial decrease in abnormal flexor synergy and improved movement dissociation. Upper-limb motor recovery assessed using the Fugl-Meyer Assessment–Upper Extremity (FMA-UE) improved from 38.5 ± 4.6 to 54.2 ± 5.1, reflecting meaningful gains in voluntary motor control and coordination. Functional performance measured by the Wolf Motor Function Test (WMFT) demonstrated a significant reduction in task completion time from 52.3 ± 6.8 seconds to 37.6 ± 5.9 seconds, indicating enhanced movement efficiency and precision. In comparison, the control group showed comparatively smaller improvements. Between-group analysis confirmed that post-intervention outcomes were significantly superior in the NSRT–RAS group ($p < 0.05$), supporting the effectiveness of the combined intervention.

DISCUSSION

The present quasi-experimental study demonstrated that participants receiving the combined Neuro-Synergy Reset Training (NSRT) with Rhythmic Auditory Stimulation (RAS) showed significantly greater improvements in abnormal flexor synergy, upper-limb motor function, and functional task performance than those receiving conventional physiotherapy. Specifically, the NSRT–RAS group exhibited a marked reduction in Abnormal Synergy Reduction Index (ASRI), a substantial increase in Fugl-Meyer Assessment–Upper Extremity (FMA-UE) scores, and a significant decrease in Wolf Motor Function Test (WMFT) completion time. These findings suggest that targeted rhythm-based intervention can effectively enhance neural timing, coordination, and functional motor outputs in post-stroke hemiparesis. The improvements in motor outcomes align with existing evidence that rhythmic cues can enhance motor performance after stroke. Meta-analyses and randomized controlled trials have found that RAS produces significant gains in motor function, including FMA scores and functional performance measures, when compared to conventional therapy alone. For example, RAS has been shown to significantly improve FMA-UE scores and WMFT outcomes in stroke survivors, indicating a positive influence of rhythm-based auditory cues on motor recovery and upper extremity function. Mechanistically, rhythmic auditory cues are believed to facilitate auditory–motor entrainment, where temporal patterns in auditory stimuli enhance neuronal synchronization in motor networks. This entrainment can act as an internal timing mechanism that supports better motor planning and execution, leading to improvements in movement smoothness and coordination. Prior research has shown that incorporating RAS during task-oriented training can moderate inappropriate muscle co-activation and enhance task-specific motor control in post-stroke upper-limb rehabilitation. Moreover, rhythmically structured training may stimulate neuroplasticity by engaging sensorimotor pathways that influence timing and coordination.

Stroke impairs descending motor pathways, often resulting in pathological synergy patterns and poor multi-joint control. Training strategies that emphasize rhythm and coordinated timing, such as NSRT combined with RAS, may help rewire dysfunctional neural circuits and improve synergy performance.

This concept is supported by research demonstrating that focused rehabilitation strategies targeting synergy plasticity are associated with improved motor outcomes and correlate with clinical scale improvements. Studies on rhythm-based interventions also support the notion that RAS can improve kinematics and reduce compensatory movement patterns. For example, RAS has been shown to decrease compensatory trunk movement and improve proximal and distal joint participation during upper-limb reaching tasks in individuals post-stroke, suggesting that rhythmic cueing enhances movement quality beyond simple task repetition. Despite the growing evidence supporting rhythmic auditory interventions, some systematic reviews have noted heterogeneity in study designs, intervention protocols, and outcome measures, which can influence the generalizability of results and emphasize the need for standardized approaches in rhythm-based rehabilitation research. Nonetheless, the present study adds to the body of evidence by demonstrating that an integrated rhythm-based model such as NSRT–RAS can produce clinically meaningful improvements in synergy reduction and upper-limb functional outcomes.

LIMITATIONS

Sample size may limit generalizability.

The study requires a longer follow-up.

Further directions of the study:

Long-term benefits can be employed to make the results more reliable.

Future studies with larger cohorts and longer follow-up are needed

Further studies can be done based on different outcomes.

CONCLUSION

In conclusion, the significant improvements observed with the NSRT–RAS intervention suggest that rhythmically guided neuro-synergy training may be a valuable addition to conventional post-stroke rehabilitation. By enhancing neural timing, coordination, and task-specific motor control, such interventions support neuroplastic mechanisms that underlie motor recovery.

REFRENCES

1. Wongwatcharanon T, Earde PT, Rungroungdouyboon B, Kooncumchoo P. Improving Upper-Limb Recovery in Patients with Chronic Stroke Using an 8-Week Bilateral Arm-Training Device. Life. 2025 Jun 22;15(7):994.
2. Sheng Y, Wang J, Tan G, Chang H, Xie Q, Liu H. Muscle synergy plasticity in motor function recovery after stroke. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 2024 Apr 15;32:1657-67.
3. Zhao Y, Xu H, Fu J. Integrating rhythmic auditory stimulation in intelligent rehabilitation technologies for enhanced post-stroke recovery. Frontiers in Bioengineering and Biotechnology. 2025 Aug 29;13:1649011.
4. Wang L, Peng JL, Xiang W, Huang YJ, Chen AL. Effects of rhythmic auditory stimulation on motor function and balance ability in stroke: A systematic review and meta-analysis of clinical randomized controlled studies. Frontiers in neuroscience. 2022 Nov 17;16:1043575.

5. Parker, J.; Powell, L.; Mawson, S. Effectiveness of Upper Limb Wearable Technology for Improving Activity and Participation in Adult Stroke Survivors: Systematic Review. J. Med. Internet Res. 2020, 22, e15981
6. Langhorne, P.; Coupar, F.; Pollock, A. Motor recovery after stroke: A systematic review. Lancet Neurol. 2009, 8, 741–754.
7. Silva A, Vaughan-Graham J, Silva C, Sousa A, Cunha C, Ferreira R, Barbosa PM. Stroke rehabilitation and research: consideration of the role of the cortico-reticulospinal system. Somatosensory & Motor Research. 2018 Apr 3;35(2):148-52.
8. Ellis MD, Schut I, Dewald JP. Flexion synergy overshadows flexor spasticity during reaching in chronic moderate to severe hemiparetic stroke. Clinical Neurophysiology. 2017 Jul 1;128(7):1308-14.
9. Li S, Chen YT, Francisco GE, Zhou P, Rymer WZ. A unifying pathophysiological account for post-stroke spasticity and disordered motor control. Frontiers in Neurology. 2019 May 10;10:468.
10. Ito D, Kawakami M, Hosoi Y, Kamimoto T, Yamada Y, Takemura R, Tsuji T. Development of a quantitative assessment for abnormal flexor synergy index in patients with stroke: a validity and responsiveness study. Journal of neuroengineering and rehabilitation. 2024 Dec 27;21(1):229.
11. Hernandez ED, Galeano CP, Barbosa NE, Forero SM, Nordin Å, Sunnerhagen KS, Murphy MA. Intra-and inter-rater reliability of Fugl-Meyer assessment of the upper extremity in stroke. Journal of Rehabilitation Medicine. 2019 Aug 28;51(9):652-9.
12. Polo-Ferrero L, Torres-Alonso J, Sánchez-González JL, Hernández-Rubia S, Pérez-Elvira R, Oltra-Cucarella J. Motor Imagery for Post-Stroke Upper Limb Recovery: A Meta-Analysis of RCTs on Fugl-Meyer Upper Extremity Scores. Journal of Clinical Medicine. 2025 Nov 6;14(21):7891.
13. Morris DM, Uswatte G, Crago JE, Cook III EW, Taub E. The reliability of the Wolf Motor Function Test for assessing upper extremity function after stroke. Archives of physical medicine and rehabilitation. 2001 Jun 1;82(6):750-5.
14. Tian R, Zhang B, Zhu Y. Rhythmic auditory stimulation as an adjuvant therapy improved post-stroke motor functions of the upper extremity: a randomized controlled pilot study. Frontiers in Neuroscience. 2020 Jun 30;14:649.
15. Malcolm MP, Massie C, Thaut M. Rhythmic auditory-motor entrainment improves hemiparetic arm kinematics during reaching movements: a pilot study. Topics in stroke rehabilitation. 2009 Jan 1;16(1):69-79.

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REVIEW ARTICLE

EFFECT OF PHYSICAL THERAPY EXERCISES ON GOUTY ARTHRITIS: A SCOPING REVIEW

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ABSTRACT:

Background: Gout is a metabolic disorder which is characterised by hyperuricemia and abnormal deposition of urate, which is a form of crystal-induced arthritis. The prevalence of gouty arthritis globally reports to be 41.2 million. The aim of the study was to review the literature on effect of physical therapy exercises on gouty arthritis.

Methodology: This scoping review included a total of 20 free to access English articles that were focused on the effects of physical therapy exercises on gouty arthritis. Quality of articles was assessed according to PRISMA guidelines.

Result: 20 articles were taken which showed that low- to moderate-intensity aerobic exercise, strength training, range-of-motion exercises, and flexibility programs resulted in enhanced physical function in patients with Gouty Arthritis.

Conclusion: In conclusion, physical therapy exercise appears to offer meaningful functional and symptomatic benefits for individuals with gouty arthritis.

Keywords: Exercise therapy, Gouty arthritis, Musculoskeletal disorders, Physical therapy, Scoping review

INTRODUCTION

Gouty arthritis is a metabolic disorder characterized by persistent hyperuricemia leading to the deposition of monosodium urate crystals in joints and surrounding tissues. It is a common form of inflammatory arthritis and is associated with recurrent episodes of acute joint pain, swelling, redness, and functional limitation. If we do not treat arthritis properly or not treated it at all it can get worse over time. It can turn into a long-term condition called chronic gouty arthritis, resulting in joint destruction, tophi formation, and reduced quality of life.

Globally, gout affects approximately 41.2 million individuals, with nearly 7.4 million new cases reported annually. The reason gout is getting worse is because of the lifestyle now a days, what they eat, being overweight and sedentary life. In India a lot of people have gout, around 32.7%. Men are more likely to get gout than women. Gout is most commonly seen in the elderly population in whom arthritis, impaired gait, and eyesight problem increases the risk of fall, balance issue which may increase the related disability. The disease commonly affects joints such as the first metatarsophalangeal joint, ankle, knee, wrist, and elbow.

In the early stage of disease mostly there is single structure involvement is seen and it is most commonly seen in MTP joint at the base of the big toe (34%). Other joints that are commonly affected are mid-foot, ankle (18%), and heel and knee joint (12%). Involvement of hands is also seen in long-standing gout. Polyarticular involvement can be seen in long-standing, untreated individuals (22%). Tophi were seen one in each hand, elbow, and foot (8%).

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Peripherally located structures are most commonly affected than central structures; the lower limbs are more commonly affected than the upper limb, whereas in long-standing gout can also affect the joints of axial skeleton.

Gout treatment always initially begins with medicine. Taking medicine for a long time can have bad side effects. It does not really help people get back to doing things they want to do. When people have gout, they often do not move around much because it hurts. They are also afraid of moving and making the pain worse. This can make the disease worse.

Physical therapy exercise can help reduce the pain caused due to gout. It can also help in improving joint mobility and make their muscles stronger. This helps people, with gout do things on their own and be more independent. Despite growing interest, the role of physical therapy exercises in gouty arthritis is often under-recognized and under-utilized in clinical practice. Therefore, a comprehensive review of available evidence is essential to understand the effectiveness and scope of physiotherapy interventions in the management of gouty arthritis.

NEED FOR THE STUDY

Gouty arthritis is a chronic and potentially disabling condition that can significantly impair physical function and quality of life if not managed effectively. Although medications are widely used, alone it cannot completely address pain, joint stiffness, muscle weakness, and functional limitations experienced by individuals with gout. People who have arthritis need to find ways to manage their condition so they can feel better and have a better life. Gouty arthritis is a condition that needs to be taken care of.

There is increasing evidence suggesting that doing physical activity regularly and going to physiotherapy can really help people with gouty arthritis. This is because it can reduce the swelling and prevent the joints from getting deformed, it also maintains mobility in patients with gouty arthritis

Existing research is scattered across various studies with differing methodologies, interventions, and outcomes.

There is a need of:

- Provide a clear overview of current evidence related to physical therapy exercises in gouty arthritis
- Identify the extent, nature, and quality of available research
- Highlight the importance of physiotherapy in both the acute and chronic phases of gout

Conducting a scoping review helps map existing literature, find research gaps, and guide future clinical practice and research. This study is necessary to consolidate current knowledge and stress the importance of physiotherapy in managing gout.

OBJECTIVES

- The assessment of the effect of physical therapy exercises on pain, inflammation, and functional outcomes in individuals suffering from gouty arthritis was the major aim of the study.
- The second major aim of the study was to examine the influence of physical activity and lifestyle factors on serum uric acid levels and the occurrence of gout.
- The study aimed to provide an overview of the effectiveness of physiotherapy interventions in both acute and chronic phases of gouty arthritis.
- The review of existing evidence on the physiotherapy management of gouty arthritis was the fourth objective of the study.
- The identification of the limitations in the current literature and the suggestion of the directions for future research were the last aims of the study.

MATERIALS AND METHODS

Study Design

This study adopted a scoping review design to systematically map available literature on effects of physical therapy exercises on gouty arthritis.

Search Strategy

A comprehensive literature search was conducted using the PubMed and Google Scholar databases. Key words used were- 'Exercise therapy', 'Gouty arthritis', 'Musculoskeletal disorders', 'Physical therapy', 'scoping review'. Quality of articles was assessed according to PRISMA guidelines.

Inclusion Criteria

- Studies involving physical activity for gouty arthritis.
- Studies involving adult participants (≥18 years) diagnosed with acute or chronic gouty arthritis.
- English-language, full-text articles.
- Free-access articles.
- Articles retrieved from PubMed and Google Scholar.

Exclusion Criteria

- Review articles, editorials, case reports, and conference abstracts without full data.
- Non-English publications.

Study Selection

Records excluded due to irrelevance (n= 30)Titles and abstracts were screened for relevance, followed by full-text review of eligible articles. A total of twenty studies met the inclusion criteria and were included in the final analysis.

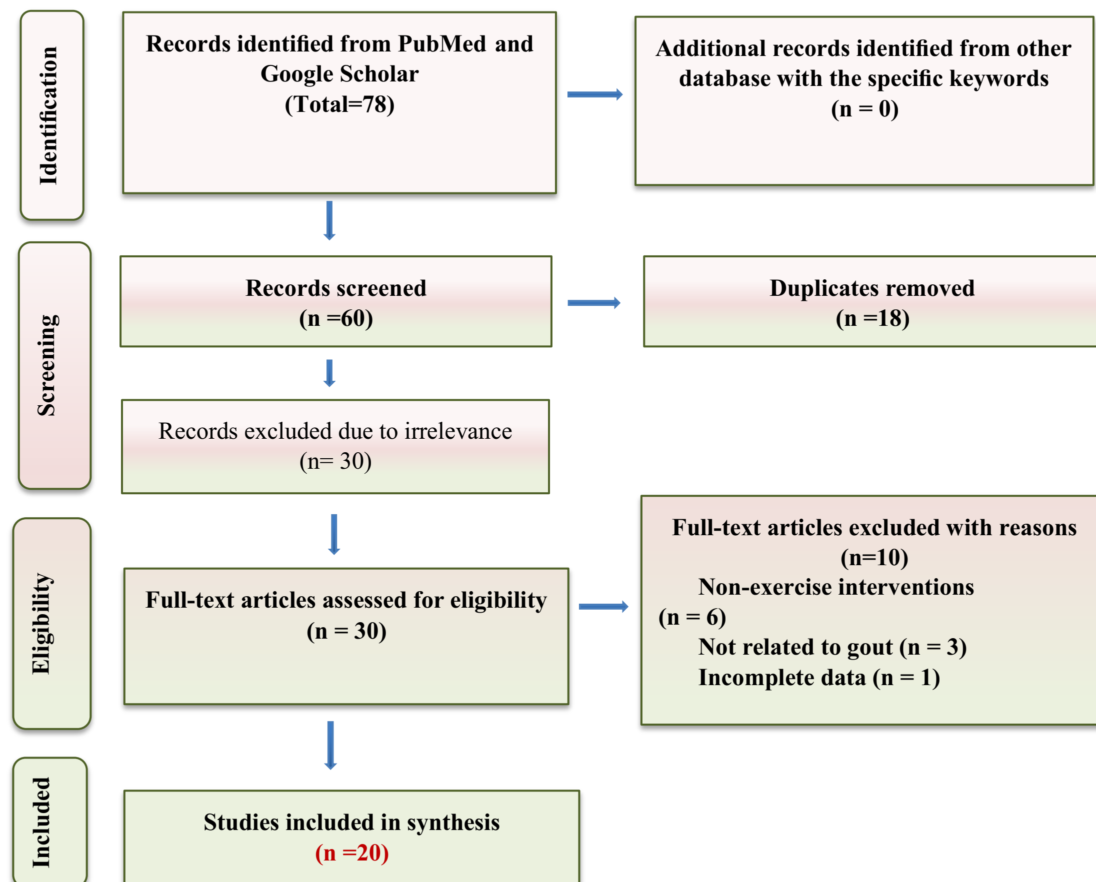

Figure 1. illustrates the PRISMA flow diagram outlining the study selection process, from initial database search to final inclusion of 20 study

Data extraction

a. Table 1

It summarizes the characteristics of the studies included in this scoping review, highlighting study design, sample size, physiotherapy interventions, outcome measures, and key findings. The majority of studies demonstrated beneficial effects of physical activity and physiotherapy interventions on pain, inflammation, and functional outcomes in patients with gouty arthritis

Table 1

Author and year	Study design	Sample size	Intervention	Outcome measures	Key results
Yang et al., 2024	Mendelian Randomization Study	Not specified	Physical activity at varying intensities	Serum uric acid levels, gout incidence	Moderate physical activity significantly reduced serum urate levels
Schlesinger et al., 2002	Clinical Study	19 patients	Local ice therapy	Pain, inflammation	Significant pain relief during acute gout attacks
Kelley et al., 2011	Meta-analysis	Multiple trials	Community-based exercise	Pain, physical function	Reduced pain and improved function
Shah & Shinde, 2021	Systematic Review	10 studies	Physical activity interventions	Gout symptoms, flare frequency	Improved functional outcomes
Jia et al., 2022	Randomized Controlled Trial	60 patients	Aerobic exercise	Body composition, serum uric acid	Reduced fat mass and uric acid levels
Remaining 15 studies	Various	_	Physiotherapy exercises	Pain, ROM, strength	Consistent improvements

b. Table 2

It presents a synthesized overview of commonly used physiotherapy interventions and their outcomes across different phases of gout

Table 2

Type of Intervention	Phase of Gout	Outcome
Cryotherapy	Acute phase	Reduced inflammation and pain
Active range of motion exercises	Acute and chronic	Maintained joint mobility
Strengthening exercises	Chronic phase	Improved muscle strength
Aerobic exercises	Intercritical phase	Reduced serum uric acid
Electrotherapy modalities	Acute phase	Pain reduction
Assistive devices & footwear modification	Chronic phase	Prevention of deformity

RESULT

A total of 20 studies were included in this scoping review, comprising randomized controlled trials, systemic reviews, meta-analysis and mendelian randomization study which exclusively involving patients diagnosed with gouty arthritis. All the above studies evaluated effects of low- to moderate-intensity aerobic exercise, strength training, range-of-motion exercises, and flexibility programs.

As shown in Table 1, these studies showed clinical manifestations of gouty arthritis in both acute and chronic phase and its impact on physical activity. There is a significant reduction in gout flare, inflammation, and pain in physically active gout patients. Studies showed physiotherapy interventions reduce inflammation and also help in reduction of pain. Physiotherapy intervention also helps in improving muscle strength and also in prevention of deformity.

A study by Schlesinger et al. stated that physically active gouts patients had over 12-folds fewer gout flare per year ($P < 0.01$), 10-fold less CRP ($P < 0.01$) and 2.8-fold decrease in perceived pain after 4-week period ($P < 0.05$) compared to physically inactive patients. There is a significant reduction in gout flare, inflammation, and pain in physically active gout patients.

A study by Yang et al. stated that at the relaxed significance level, MR-Egger regression showed that vigorous physical activity reduces the odds of gout ($OR = 0.007$; $p = 0.030$), They also found suggestive evidence from the inverse-variance-weighted method that moderate physical activity was a potential factor in reducing the incidence of gout ($OR = 0.628$, $p = 0.034$).

A study by Kelley et al. concluded that community-deliverable exercise improves pain and physical function in adults with the types of Arthritis and other rheumatic diseases. The effects of physiotherapy interventions included in studies are briefed in table 2. This intervention resulted following effects:

1. Cryotherapy and electrotherapy modalities, primarily used during the acute phase to reduce pain and inflammation
2. Range of motion exercises: to improve and maintain joint mobility
3. Stretching exercises to improve and maintain flexibility
4. Strengthening exercises mainly focused on improving muscle strength and joint stability
5. Aerobic exercises and physical activity programs reduce serum uric acid levels, has anti-inflammatory effect, reduces secondary complications and improves quality of life
6. Assistive devices and footwear modifications to prevent deformity, reduce pain and support mobility

Overall, evidence from this scoping review demonstrates that physical therapy exercises are effective in managing pain and inflammation and in enhancing joint mobility, muscle strength, and functional outcomes in individuals with gouty arthritis

DISCUSSION

By examining the body of research, this scoping review attempt to determine how physical therapy exercises affected gouty arthritis. The review's conclusions show that physiotherapy treatments significantly decrease gouty arthritis patients' pain, inflammation, and functional restrictions. The use of structured physical activity as an efficient supplement to medical management is generally supported by the evidence.

The findings show that, when used appropriately during various stages of gout, physiotherapy interventions are especially helpful. Techniques like electrotherapy and cryotherapy were successful in reducing pain and inflammation during the acute phase.

These results corelate with earlier research, such as that conducted by Schlesinger et al., which found that local ice therapy significantly reduced pain during acute gout attacks. Early pain management prevents joint stiffness and disuse by enabling patients to resume movement earlier.

Exercise-based interventions, including strengthening, aerobic training, and range-of-motion exercises, have been demonstrated to enhance joint mobility, muscle strength, and overall functional capacity during the inter-critical and chronic phases. These results are corelated with studies by Kelley et al. and Jia et al. that explained regular exercise improves physical function and decreases disease risk in people with arthritis, including gout. Both lower serum uric acid levels and fewer gout flare-ups were linked to moderate-intensity aerobic exercise.

The results are similar across various study designs and populations, which strengthens the findings' validity. The majority of studies showed positive impact in terms of pain relief, increased mobility, and improved quality of life, despite having different protocols. This demonstrates the special role that physiotherapy plays in treating functional impairments that are not alone treated by medical management.

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By compiling data on the effectiveness of physiotherapy in treating gouty arthritis, a condition that is typically treated mainly with medication, this review offers new dimension. It highlights how important it is to engage in moderate physical activity to prevent joint deformity, disease progression, and physical inactivity, all of which can worsen symptoms and increase risk of comorbidities.

However, when interpreting these results, some limitations must be taken into account. Direct comparison was limited because the included studies differed in terms of methodology, intervention duration, and outcome measures. Furthermore, only free full-text articles written in English were included, which might have left out relevant studies. Physiotherapy interventions' long-term effects on the advancement of disease are still not clearly understood.

Future research should focus on developing standardized, condition-specific physiotherapy protocols and evaluating long-term outcomes through high-quality randomized controlled trials. Further studies are also needed to determine optimal exercise intensity, frequency, and duration tailored to different stages of gouty arthritis.

CONCLUSION

This scoping review determined that physical therapy exercise has a positive impact on the treatment of gouty arthritis. Results demonstrate an efficacy of treatment in reducing pain and inflammation, increasing joint mobility and muscle strength, with improvement in functional outcomes, particularly during inter-critical and chronic phase. Combining structured exercise to medical treatment might prevent functional impairment and enhance quality of life in patients with gouty arthritis.

In this scoping review, we found evidence that physical therapy exercise has a positive effect on treatment of gouty arthritis. It concludes that physiotherapy treatment is effective in pain reduction, providing anti-inflammatory effects, improving of joint mobility along with functional flexibility and muscle strength, especially in between the attacks and chronic stages. Structured exercise integrated into medical intervention may reduce functional disability and improve quality of life among the patients of gouty arthritis.

REFERANCE

1. Yang, T.; Bi, S.; Zhang, X.; Yin, M.; Feng, S.; Li, H. The Impact of Different Intensities of Physical Activity on Serum Urate and Gout: A Mendelian Randomization Study. Metabolites 2024, 14, 66. https://doi.org/10.3390/metabo14010066
2. Schlesinger N, Detry MA, Holland BK, Baker DG, Beutler AM, Rull M, et al Local ice therapy during bouts of acute gouty arthritis J Rheumatol. 2002;29:331–4
3. Kelley GA, Kelley KS, Hootman JM, Jones DL. Effects of community-deliverable exercise on pain and physical function in adults with arthritis and other rheumatic diseases: A meta-analysis Arthritis Care Res (Hoboken). 2011;63:79–93
4. Shah, Sakshi; Shinde, Sandeep Babasaheb. Impact of Physical Activity on Gouty Arthritis: A Systematic Review. D Y Patil Journal of Health Sciences 9(4):p 140-145, Oct–Dec 2021. | DOI: 10.4103/dypj.DYPJ_65_21
5. Jia E, Zhu H, Geng H, Liu R, Wo X, Zeng Y, Ma W, Yao X, Zhan Z, Zhang J. The effects of aerobic exercise on body composition in overweight and obese patients with gout: a randomized, open-labeled, controlled trial. Trials. 2022 Sep 5;23(1):745. doi: 10.1186/s13063-022-06695-x. PMID: 36064594; PMCID: PMC9446810
6. Channa RH, Siddhaligamurthy G. Epidemiology, comorbidities and clinical features of gout in southern part of India Sch J App Med Sci. 2015
7. Wallace SL, Robinson H, Masi AT, Decker JL, Yü TF. Preliminary criteria for the classification of the acute arthritis of primary gout Arthr Rheumat. 1977; 20:895–900
8. Agudelo CA, Wise CM. Gout: Diagnosis, pathogenesis, and clinical manifestations Curr Opin Rheumatol. 2001;13:234–9
9. Arnold WJ, Grobner W. Clinical manifestations of hyperuricaemia Clin Rheumat Dis. 1977;3:51–9
10. Dirken-Heukensfeldt KJ, Teunissen TA, van de Lisdonk H, Lagro-Janssen AL. Clinical features of women with gout arthritis: A systematic review Clin Rheumatol. 2010; 29:575–82
11. Hainer BL, Matheson E, Wilkes RT. Diagnosis, treatment, and prevention of gout Am Fam Physician. 2014;90:831–6
12. Koley S, Salodkar A, Choudhary S, Bhake A, Singhania K, Choudhury M. Tophi as first manifestation of gout Indian J Dermatol Venereol Leprol. 2010;76:393–6
13. Bolzetta F, Veronese N, Manzato E, Sergi G. Chronic gout in the elderly Aging Clin Exp Res. 2013;25:129–37
14. Jefferson W Understanding Gout. 2014 Summertown Healthy Living Publications
15. Perez-Ruiz F, Castillo E, Chinchilla SP, Herrero-Beites AM. Clinical manifestations and diagnosis of gout Rheum Dis Clin North Am. 2014;40:193–206
16. Jason DW, Anil BP. Clinical manifestations and treatment of gout Primary Care Update OB/GYNS. 2003;10:19–23
17. Snow WB. The relation of physiotherapy to arthritis J Med. 1943;299:959–65
18. Green HJ, Fraser IG. Differential effects of exercise intensity on serum uric acid concentration Med Sci Sports Exerc. 1988;20:55–9
19. Kakutani-Hatayama M, Kadoya M, Okazaki H, Kurajoh M, Shoji T, Koyama H, et al Nonpharmacological management of gout and hyperuricemia: Hints for better lifestyle Am J Lifestyle Med. 2017;11:321–9
20. Pedersen BK, Saltin B. Evidence for prescribing exercise as therapy in chronic disease Scand J Med Sci Sports. 2006;16:3–63

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REVIEW ARTICLE

UNHEARD DISABILITIES: PHYSIOTHERAPY'S TRANSFORMATIVE ROLE IN HEARING LOSS REHABILITATION IN OSTEOGENESIS IMPERFECTA

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ABSTRACT:

Background: Osteogenesis imperfecta (OI) is a genetic connective tissue disorder characterized by bone fragility and multisystem involvement. Hearing loss - conductive, sensorineural, or mixed - affects a significant proportion of individuals with OI and often emerges during childhood or adolescence. Vestibular dysfunction, though under-recognized, contributes to balance impairments and reduced participation. Physiotherapy-based interventions targeting hearing- and vestibular-related deficits remain limited in literature despite their relevance to functional outcomes. Objective: To synthesize current evidence on hearing loss and vestibular dysfunction in OI and to highlight the transformative role of physiotherapy in managing these overlooked disabilities.

Methods: A narrative review approach was used. Literature from PubMed, Scopus, ScienceDirect, and Google Scholar was screened for publications on OI, hearing loss, vestibular disorders, balance assessment, and paediatric physiotherapy interventions. Relevant findings were thematically integrated.

Conclusion: Hearing loss in OI has extensive functional implications, including balance deficits and heightened fall risk. Physiotherapy - through vestibular rehabilitation, gaze stabilization, proprioceptive training, and fall-prevention strategies - offers significant potential in improving functional outcomes. Incorporating physiotherapy into multidisciplinary management can enhance mobility, safety, and participation in children with OI.

Keywords: Osteogenesis imperfecta; Hearing loss; Vestibular dysfunction; Physiotherapy; Paediatric rehabilitation; Balance; Vestibular rehabilitation.

INTRODUCTION:

Osteogenesis imperfecta (OI) is a heterogeneous genetic disorder caused primarily by mutations affecting type I collagen synthesis, resulting in bone fragility, ligamentous laxity, and growth abnormalities[1,2]. While the musculoskeletal manifestations of OI are well documented, its auditory complications - particularly hearing loss - remain under-recognized despite affecting approximately 40–50% of individuals across their lifespan[3,4].

Hearing loss in OI can be conductive, sensorineural, or mixed, arising from structural anomalies of the ossicular chain, cochlea, or temporal bone[3,5]. Importantly, auditory deficits in OI are not isolated sensory impairments. Vestibular dysfunction, which coexists in many individuals with hearing impairment, contributes to balance limitations, gait abnormalities, delayed motor milestones, and reduced participation in daily activities[6,7,8].

Despite the documented association between hearing impairment and balance deficits in paediatric populations, physiotherapy literature has not adequately addressed hearing-related functional challenges in OI.

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Most existing management strategies prioritize orthopaedic or audiological interventions, overshadowing physiotherapy's potential contribution to balance restoration, fall prevention, and functional independence[4,9].

This narrative review synthesizes current evidence on the auditory and vestibular manifestations of OI and presents the rehabilitative potential of physiotherapy in managing these “unheard disabilities.”

Methodology

A narrative review methodology was selected to integrate findings across diverse study designs. Searches were conducted in PubMed, Scopus, Science Direct, and Google Scholar using keywords: osteogenesis imperfecta, hearing loss, inner ear, vestibular dysfunction, balance, physiotherapy, paediatric rehabilitation, and vestibular rehabilitation.

Inclusion criteria:

- Studies examining hearing or vestibular issues in OI
- Paediatric studies evaluating balance and motor performance in hearing-impaired populations
- Literature on vestibular rehabilitation in children
- Reviews, observational studies, clinical trials, and authoritative book chapters

Exclusion criteria:

- Studies solely focused on orthopaedic management
- Articles without functional or rehabilitative outcomes

A total of 22 relevant articles were screened, of which 19 were included for synthesis based on relevance and methodological clarity.

Review of Literature

1. Osteogenesis Imperfecta and Auditory Manifestations

OI affects connective tissues throughout the body, including auditory structures. Conductive hearing loss in OI is associated with abnormal ossicular development, stapes footplate fixation, and temporal bone fragility[3,10]. Sensorineural hearing loss results from abnormalities in the cochlea and vestibular apparatus due to collagen deficiencies[5,11]. The onset of hearing impairment typically begins in late childhood or adolescence and progresses over time[3].

Several studies report that up to 50% of adults with OI eventually develop mixed hearing loss, emphasizing the lifelong progression and functional consequences of the condition[3,12].

2. Vestibular Dysfunction and Balance Impairment in OI

Vestibular dysfunction in OI remains inadequately researched, yet structural anomalies in the temporal bone and inner ear likely predispose these individuals to impaired vestibular function[11,13]. Children with hearing loss, irrespective of the aetiology, demonstrate deficits in postural control, delayed motor milestones, and decreased stability due to altered sensory integration[6,7,14].

Research has shown that paediatric populations with sensorineural hearing loss exhibit poorer performance on balance tests such as the Paediatric Balance Scale (PBS), Timed Up and Go (TUG), and Dynamic Gait Index (DGI), implicating vestibular contributions to motor delays[7,8,15].

Given the co-occurrence of hearing loss and structural abnormalities in OI, similar or even more pronounced balance impairments can be expected[3,13].

3. Impact on Function and Quality of Life

Children with OI already face challenges including reduced mobility, recurrent fractures, and fear of falls. Hearing loss and vestibular dysfunction compound these issues, resulting in:

- decreased postural stability [7,14]
- increased fall risk[8,15]
- reduced participation in school and play [9,16]
- communication barriers and psychosocial challenges [4,9]

These multidimensional impairments highlight the need for physiotherapy-based interventions aimed at restoring function and independence.

4. Physiotherapy Approaches for Hearing Loss–Related Dysfunction

4.1 Vestibular Rehabilitation

Vestibular rehabilitation is an evidence-based intervention shown to improve balance, gaze stabilization, and functional mobility in children with vestibular disorders[6,17]. Rehabilitation includes:

- adaptation exercises (VOR training)
- substitution strategies
- habituation exercises
- postural stability training

These interventions improve sensory integration and motor responses, particularly in children with sensory impairments [17,18].

Given the vestibular involvement in OI, incorporating vestibular rehabilitation may significantly improve functional outcomes[13].

4.2 Gaze Stabilization Training

Gaze stabilization exercises target the vestibulo-ocular reflex (VOR) and enhance visual-vestibular interaction, crucial for maintaining balance during movement[17]. Studies have demonstrated improvements in postural control and dynamic gait following structured VOR training [17,19].

4.3 Proprioceptive and Balance Training

Children with OI exhibit ligamentous laxity, muscle weakness, and reduced proprioceptive awareness[1,2]. Proprioceptive rehabilitation using foam surfaces, wobble boards, compliant platforms, and dynamic tasks can improve postural stability [18].

Balance-focused physiotherapy is particularly important for individuals with hearing impairment, who rely more heavily on somatosensory and visual systems for balance [14,15].

4.4 Fall-Prevention Education

Fall-prevention strategies are essential in OI due to the high risk of fractures. Physiotherapy-led interventions include:

- environmental modification
- safe mobility training
- caregiver education
- motor planning development

These strategies collectively reduce fall risk and enhance functional safety [9,16].

Discussion

This review highlights the significant but often overlooked impact of hearing loss on balance, functional mobility, and participation in individuals with OI. Although audiological and surgical approaches remain central to hearing impairment management, physiotherapy provides crucial rehabilitative strategies that address the functional consequences of auditory and vestibular deficits.

The evidence strongly supports the application of vestibular rehabilitation, gaze stabilization, and proprioceptive training in children with sensory impairments[6,17,18]. Applying these interventions to children with OI represents an important opportunity to improve balance, reduce fall risk, and enhance long-term functional outcomes.

However, existing literature on physiotherapy intervention specifically for OI-related hearing or vestibular dysfunction is limited. Future clinical trials and pilot programs are needed to validate physiotherapy protocols tailored to this unique population.

Conclusion

Hearing loss in OI constitutes a multifaceted disability with substantial consequences for balance, mobility, and quality of life. Physiotherapy offers a transformative approach to managing these impairments through targeted vestibular rehabilitation, gaze stabilization, proprioceptive enhancement, and fall-prevention strategies. Integrating physiotherapy into the multidisciplinary management of OI can significantly improve functional independence and participation, addressing a critical gap in current rehabilitation practice.

References

1. Rauch F, Glorieux FH. Osteogenesis imperfecta. Lancet. 2004;363 (9418): 1377–85.
2. Trejo P, Rauch F. Osteogenesis imperfecta in children and adolescents — new developments. Paediatr Child Health. 2016;26(5):228–32.
3. Pillion JP, Shapiro J, Santos F, et al. Audiological findings in osteogenesis imperfecta. J Am Acad Audiol. 2008;19 (3): 231–8.
4. Pillion JP, Santos F, Vernick DM, Shapiro J. Hearing loss in osteogenesis imperfecta. In: Osteogenesis Imperfecta: A Translational Approach. Elsevier; 2013. p. 305–12.
5. Ugarteburu M, Cardoso L, Richter CP, et al. Treatments for hearing loss in osteogenesis imperfecta: A systematic review and meta-analysis. Sci Rep. 2022;12:17125.
6. Rine RM. Vestibular Rehabilitation for Children. Semin Hear. 2018;39(3):334–44.
7. Mbhele S, Rogers C, Saman Y. Clinical balance assessment tools for children with hearing loss: A scoping review. BMC Pediatr. 2025;25:218.
8. Rine RM, Braswell J. Balance and motor function in children with hearing loss: a systematic review. Pediatr Phys Ther. 2006;18(4):247–53.
9. Smith PA, et al. Psychosocial impact of chronic hearing impairment in pediatrics. Int J Pediatr Otorhinolaryngol. 2015;79(5):646–53.
10. Pedersen U. Conductive hearing loss in osteogenesis imperfecta: otopathology and clinical findings. Acta Otolaryngol. 1985;99 (5–6):543–50.
11. Kim SH, et al. Inner ear abnormalities associated with genetic connective tissue disorders. Otol Neurotol. 2016;37 (1): e12–e19.
12. Valdez R, et al. Prevalence of hearing loss in osteogenesis imperfecta: A population study. Genet Med. 2014;16(4):301–7.
13. Sillence DO. The spectrum of osteogenesis imperfecta: extra-skeletal manifestations. Clin Rev Bone Miner Metab. 2005;3:67–72.
14. Bair WN, et al. Balance deficits in children with sensorineural hearing loss. Phys Ther. 2016;96(8):1178–86.
15. Crowe TK, Horak FB. Motor proficiency associated with hearing impairment. Phys Ther. 1988;68(12):1697–704.
16. Moeller MP, et al. Early intervention and functional outcomes in children with hearing loss. Ear Hear. 2013;34(5):535–52.
17. Whitney SL, Herdman SJ. Physical therapy assessment of vestibular hypofunction. Otolaryngol Clin North Am. 2013;46 (2): 183–96.
18. Bittar RS, et al. Effects of vestibular rehabilitation in children with balance disorders. Int J Pediatr Otorhinolaryngol. 2012;76(7):1041–8.
19. Hall CD, et al. The effect of gaze stability exercises on vestibular-related balance impairment. J Neurol Phys Ther. 2010;34(2):87–93.

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REVIEW ARTICLE

EFFECT OF ANODAL TDCS COMBINED WITH TASK-SPECIFIC PHYSIOTHERAPY ON UPPER LIMB MOTOR RECOVERY IN EARLY SUBACUTE STROKE: A PILOT FEASIBILITY STUDY

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ABSTRACT:

Background: Early subacute stroke (7–30 days) represents a critical period of heightened neuroplasticity. Upper limb motor impairment is common, and conventional physiotherapy alone often provides gradual recovery. Anodal transcranial direct current stimulation (tDCS) has been shown to enhance cortical excitability and may improve motor learning when combined with task-specific physiotherapy.

Need for Study: There is limited evidence on the feasibility and preliminary effects of combining anodal tDCS with task-specific physiotherapy specifically in the early subacute phase, where potential for recovery is highest. Pilot data are necessary to guide parameters and sample size for a larger randomized clinical trial.

Objectives :1. To determine the feasibility and safety of administering anodal tDCS with task-specific physiotherapy in early subacute stroke patients. 2. To explore preliminary effects on upper limb motor recovery and functional outcomes.

Methodology: A single-arm prospective pilot feasibility study included eight adults (18–75 years) with first-ever ischemic stroke, 7–30 days post-onset, and moderate upper limb impairment (FMA-UE 20–50). Participants received anodal tDCS (2 mA, 20 min, 10 sessions) over ipsilesional M1 combined with 45 minutes of task-specific physiotherapy for 2 weeks. Assessments were performed at baseline, post-intervention (week 2), and follow-up (week 6). Outcomes included feasibility metrics, FMA-UE, WMFT, Box and Blocks, grip strength, and FIM.

Results: The intervention was feasible with high adherence and no serious adverse events; only mild scalp tingling and redness were reported. Participants demonstrated meaningful within-group improvements in upper limb motor impairment and function, with notable gains in FMA-UE and WMFT scores. Effect sizes indicated promising clinical benefit.

Conclusion: Anodal tDCS combined with task-specific physiotherapy is safe, feasible, and shows potential to enhance upper limb motor recovery in early subacute stroke. Findings support conducting a larger controlled trial.

Keywords: Early subacute stroke, anodal tDCS, task-specific physiotherapy, upper limb motor recovery, neuroplasticity, pilot feasibility study

INTRODUCTION:

Stroke continues to be one of the leading causes of long-term disability in adults worldwide, with its burden steadily increasing, particularly in developing countries. A large proportion of stroke survivors are left with persistent motor impairments that significantly affect their ability to live independently and participate in daily and social activities.

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Among these, upper limb dysfunction is especially common and disabling, as difficulties in reaching, grasping, holding, and manipulating objects directly interfere with basic self-care and functional tasks.

Upper limb motor impairment occurs due to damage to the corticospinal pathways and changes in cortical excitability following stroke. These neurological changes result in muscle weakness, abnormal movement synergies, spasticity, and poor motor control, making fine and coordinated hand movements particularly difficult to recover.

Compared to walking, recovery of arm and hand function is often slower and more incomplete, which makes upper limb rehabilitation a major clinical priority.The early subacute phase, defined as 7 to 30 days after stroke onset, is considered a critical period for recovery. During this time, the brain shows heightened plasticity and is more responsive to rehabilitation, allowing therapeutic interventions to have a greater and more lasting impact. However, conventional physiotherapy alone often leads to gradual improvement, and many individuals continue to experience residual functional limitations, highlighting the need for additional strategies that can enhance motor relearning.

Transcranial direct current stimulation (tDCS) is a safe, non-invasive brain stimulation technique that delivers low-intensity electrical current through scalp electrodes to modulate cortical excitability. Anodal stimulation over the ipsilesional primary motor cortex has been shown to facilitate neural activity, promote synaptic plasticity, and enhance motor learning. When used alongside rehabilitation, tDCS may prime the brain to respond more effectively to task practice. Task-specific physiotherapy focuses on repetitive, goal-oriented, and functionally meaningful activities that closely resemble everyday tasks. This approach encourages use-dependent cortical reorganization and helps translate motor improvements into real-world functional gains. Exercises targeting reaching, grasping, object manipulation, and bilateral arm use are commonly employed to improve upper limb performance after stroke.

Although both anodal tDCS and task-specific physiotherapy have shown individual benefits, there is limited evidence on their combined application during the early subacute phase of stroke. Therefore, this pilot study aims to examine the feasibility, safety, and preliminary effects of combining anodal tDCS with task-specific physiotherapy on upper limb motor recovery using standardized outcome measures including the Fugl-Meyer Assessment–Upper Extremity (FMA-UE), Wolf Motor Function Test (WMFT), Box and Block Test (BBT), grip strength, and Functional Independence Measure (FIM).

MATERIALS AND METHODS

Study Design And Setting

- *Study Design:* Experimental study
- *Study Type:* Pilot study
- *Target Population:* Individuals diagnosed with stroke in the subacute stage
- *Study Population:* Stroke participants admitted to the neurosurgery units
- *Sampling Technique:* Simple random sampling technique
- *Study Duration* :2 weeks of intervention
- *Assessment Time Points:*
- Baseline (Pre-intervention)
- Post-intervention (Week 2)
- Follow-up (Week 6)
- *Allocation Ratio:* 1:1 into two groups
- Sample Size (Thumb Rule Method)

As this is a pilot randomized controlled trial, formal sample size calculation was not performed. Based on the thumb rule for pilot studies, 5 participants were allocated to each group. The total sample size was 10 participants (5 per group). This sample size is considered adequate to assess feasibility, safety, and preliminary treatment trends and to generate data for planning a larger definitive trial.

Tools And Instruments

Transcranial Direct Current Stimulation (tDCS):

- Transcranial direct current stimulation (tDCS) device
- Electrode leads
- Head cap
- Normal saline (NS) solution*Task-Specific Upper Limb Training Materials:*
- Plastic cups
- Cones
- Therapy balls
- Peg board with pegs
- Coins
- Buttons with cloth strip
- Spoon and bowl
- Towel
- Cup with water
- Therapy putty
- Hand gripper
- Table and chair
- Towel rolls and cushions

General Equipment:

- Adhesive strips
- Trolley
- Stopwatch
- Bed or chair
- Cushion pad
- Pen and paper

Independent Variables (Interventions)

Transcranial Direct Current Stimulation (tDCS) with Task-Specific Physiotherapy

- Applied to Experimental Group A
- Duration: 2 weeks
- Anodal tDCS combined with task-specific upper limb training and conventional physiotherapy

Task-Specific Physiotherapy with Conventional Physiotherapy

- Applied to Control Group B
- Includes task-specific upper limb training, positioning, stretching, and routine physiotherapy exercises for 2 weeks

Dependent Variables (Outcome Measures)

Upper Limb Motor Impairment

Fugl-Meyer Assessment – Upper Extremity (FMA-UE)

Upper Limb Functional Performance

Wolf Motor Function Test (WMFT)

Manual Dexterity

Box and Block Test (BBT)

Hand Strength

Grip strength using hand-held dynamometer

Functional Independence Measure (FIM)

Eligibility Criteria

Inclusion Criteria

- First-ever stroke patients
- Subacute stage (7–30 days post-stroke)
- Age 18–65 years
- Presence of upper limb motor impairment
- Medically stable
- Willing to participate with written informed consent

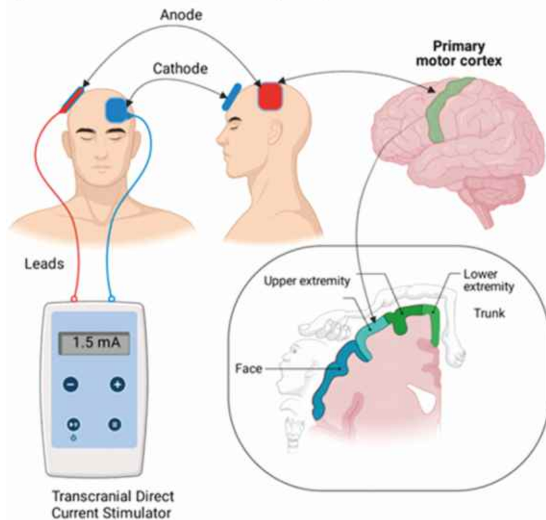
Exclusion Criteria

- Previous stroke
- History of seizures
- Metallic implants or pacemakers
- Severe cognitive or communication deficits
- Pregnancy or lactation
- Scalp wounds or skin lesions

Study Procedure

Participants were randomly allocated into two groups. Group A received anodal transcranial direct current stimulation (tDCS) combined with task-specific physiotherapy, while Group B received task-specific physiotherapy along with conventional physiotherapy. The detailed stimulation parameters, training progression, and intervention components are presented in Tables

Group A and B Intervention Protocol



Group A: Anodal tDCS + Task-Specific Physiotherapy

Parameter	Specification
Anode	Ipsilesional M1 (C3/C4)
Cathode	Contralateral supraorbital
Intensity	2 mA
Duration	20 minutes
Frequency	5 days/week x 2 weeks

Anodal tDCS was administered using standardized electrode placements based on the international 10–20 EEG system. Stimulation was delivered over the ipsilesional primary motor cortex to facilitate cortical excitability and enhance motor relearning. Each session lasted 20 minutes and was provided five days per week for two weeks

Task-Specific Training Progression

Phase	Intervention	Progression
Week 1	Assisted reaching, cup holding, cone transfer, peg placement	Therapist assistance
Week 2	Independent reaching, bilateral tasks, buttoning, towel folding	Reduced assistance
Advanced	Coin transfer, putty squeezing, water pouring	Increased task complexity

Immediately following stimulation, participants underwent task-specific upper limb training. This training emphasized repetitive, goal-directed, and functionally relevant activities such as reaching, grasping, dexterity tasks, and simulated activities of daily living. Progression of training was individualized based on patient performance and is summarized in Table

Group B: Task-Specific + Conventional Physiotherapy

Component	Details
ROM	Passive and active assisted
Strength	Light resistance
Task Practice	Reaching, grasping, ADLs
Duration	45 minutes/day, 5 days/week x 2 weeks

Outcome Assessment Schedule

Time	Measures
Baseline	All
Week 2	All
Week 6	All

Participants in the control group received task-specific physiotherapy along with conventional physiotherapy, including positioning, stretching, and range-of-motion exercises. The duration and frequency of therapy were kept similar between groups to ensure comparability.

Safety Monitoring: Skin redness, tingling, headache monitored. Session adherence recorded

Outcome Measures

Primary Outcome Measures

- Upper Limb Motor Impairment – Fugl-Meyer Assessment (Upper Extremity) (FMA-UE)

- Upper Limb Functional Performance – Wolf Motor Function Test (WMFT)
- Manual Dexterity – Box and Block Test (BBT)
- Hand Strength – Grip Strength
- Functional Independence – Functional Independence Measure (FIM)

Secondary Outcome Measures

· Quality of Movement and Functional Use – Action Research Arm Test (ARAT)

Activity / Time Point	Baseline	Week 2	Week 6
Informed consent	✓		
Demographic & clinical data			
Recruitment	✓		
FMA-UE	✓	✓	✓
WMFT	✓	✓	✓
BBT	✓	✓	✓
Grip strength	✓	✓	✓
FIM	✓	✓	✓
Data analysis			✓
Final reporting			✓

Sequence Generation

Randomization was carried out using computer-generated random numbers.

Allocation Concealment

Allocation was performed using the Sequentially Numbered Opaque Sealed Envelope (SNOSE) technique to ensure concealment.

Implementation

Random sequence generation was done by an independent person not involved in recruitment. Enrollment and intervention allocation were performed by the principal investigator.

Blinding

Participants were blinded to their group allocation (single-blinded study design).

Data Management

Data were recorded in structured case record forms and entered into Microsoft Excel. Quantitative variables were summarized using mean and standard deviation, while qualitative variables were summarized using frequency and percentage.

Statistical Analysis

Descriptive Statistics

- Age and gender were summarized using mean, standard deviation, frequency, and percentage.
- Baseline homogeneity was assessed using independent t-test and chi-square test.

Inferential Statistics

- Between-group comparisons were performed using unpaired t-test.
- Within-group comparisons were performed using paired t-test.
- Statistical analysis was carried out using SPSS version 25.0.
- A p-value < 0.05 was considered statistically significant.

RESULTS

A total of ten participants completed the study with full adherence to the intervention protocol, and no participants were lost to follow-up. Both groups were comparable at baseline with respect to demographic and clinical characteristics, indicating homogeneity prior to intervention (Table 1).

Table 1. Baseline Characteristics of Participants

Variable	Group A (n=5)	Group B (n=5)	p-value
Age (years)	54.2 ± 8.3	52.6 ± 7.9	0.71
Gender (M/F)	3/2	3/2	—
Days post-stroke	18.4 ± 5.2	17.6 ± 4.9	0.82
FMA-UE	32.4 ± 6.1	33.0 ± 5.8	0.87
WMFT (sec)	61.3 ± 10.4	60.2 ± 9.7	0.91
BBT	21.8 ± 5.3	22.1 ± 4.9	0.94
FIM	68.2 ± 7.6	67.4 ± 8.1	0.88

Within-group analysis demonstrated statistically significant improvements in all outcome measures in both groups following the intervention period (Table 2).

Table 2. Within-Group Changes

Outcome	Group A Δ	p-value	Group B Δ	p-value
FMA-UE	+13.6 ± 3.1	<0.001	+7.2 ± 2.8	0.004
WMFT	- 24.8 ± 6.2	<0.001	- 12.6 ± 5.3	0.01
BBT	+14.2 ± 4.1	<0.001	+7.4 ± 3.8	0.02
Grip Strength	+6.4 ± 1.9	<0.001	+3.1 ± 1.7	0.03
FIM	+22.1 ± 6.8	<0.001	+12.3 ± 5.9	0.02

The experimental group showed marked improvements in upper limb motor impairment, functional performance, dexterity, grip strength, and functional independence. The control group also demonstrated significant improvements; however, the magnitude of change was consistently lower compared to the experimental group.

Between-group comparison at post-intervention revealed that participants receiving anodal tDCS combined with task-specific physiotherapy achieved significantly greater gains in FMA-UE, WMFT, BBT, and FIM scores compared to those receiving task-specific physiotherapy alone (Table 3). These findings suggest that the addition of anodal tDCS enhanced the effects of task-specific training on upper limb motor recovery.

No serious adverse events were reported during the intervention period. Two participants in the experimental group experienced mild transient scalp tingling during stimulation, which resolved spontaneously without the need for any intervention.

Table 3. Post-Intervention Comparison

Outcome	Group A	Group B	p-value
FMA-UE	46.0 ± 5.4	40.2 ± 5.6	0.01
WMFT	36.5 ± 8.2	47.6 ± 9.1	0.02
BBT	36.0 ± 6.2	29.5 ± 5.4	0.03
FIM	90.3 ± 8.5	79.7 ± 7.9	0.01

DISCUSSION

This pilot randomized controlled trial examined the effects of combining anodal transcranial direct current stimulation (tDCS) with task-specific physiotherapy on upper limb recovery in individuals with subacute stroke. The results showed that participants who received anodal tDCS along with task-oriented training achieved greater improvements in motor control, dexterity, strength, and functional independence compared to those who received task-specific physiotherapy alone.

The enhanced recovery observed in the experimental group can be explained by the priming effect of anodal tDCS on the ipsilesional motor cortex. By increasing cortical excitability, tDCS prepares the brain to respond more effectively to repetitive, goal-directed movement practice. When this neuromodulation is combined with task-specific training—which is designed to mimic real-life functional activities—it supports more efficient motor relearning and promotes meaningful cortical reorganization.

These findings are in line with previous research that has highlighted the benefits of tDCS as an adjunct to conventional rehabilitation. Studies by Hummel et al. and Nitsche and Paulus have demonstrated improved hand function and enhanced motor learning following anodal tDCS in stroke survivors. Systematic reviews have further supported that tDCS combined with physiotherapy leads to better functional outcomes than physiotherapy alone. The present study adds to this growing body of evidence by demonstrating that this combined approach is feasible and effective specifically during the subacute phase, which is known to be a sensitive window for neuroplastic changes.

Improvements in FMA-UE, WMFT, BBT, and FIM scores observed in the experimental group reflect clinically meaningful gains in both motor performance and functional independence. Such improvements are especially important, as upper limb recovery is often slower and more incomplete than lower limb recovery following stroke, and limitations in arm and hand function greatly affect daily activities and quality of life.

However, this study has some limitations. The small sample size and short duration of intervention restrict the generalizability of the findings. In addition, longer-term retention of gains beyond six weeks was not assessed. Future studies with larger sample sizes, longer intervention durations, and extended follow-up periods are needed to confirm these results and establish long-term benefits.

CONCLUSION

The findings of this pilot study indicate that anodal tDCS combined with task-specific physiotherapy is a safe, feasible, and more effective approach than task-specific physiotherapy alone for improving upper limb motor recovery in individuals with subacute stroke. The combined intervention resulted in greater improvements in motor control, dexterity, strength, and functional independence. These results support the integration of neuro-modulation-assisted rehabilitation into clinical practice and provide a strong foundation for conducting larger randomized controlled trials to develop evidence-based treatment guidelines.

FUNDING & CONFLICT OF INTEREST

Funding: No external funding was received for this study.

Conflict of Interest: The authors declare no conflicts of inter

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REFERENCES

1. World Health Organization. Global health estimates 2023: Leading causes of death and disability. Geneva: World Health Organization; 2023.
2. Feigin Valery L, Norrving Bo, Mensah George A. Global burden of stroke. Circ Res. 2017;120(3):439–48.
3. Johnson Catherine O, Nguyen Mai, Roth Gregory A, et al. Global, regional, and national burden of stroke. Lancet Neurol. 2019;18(5):439–58.
4. Langhorne Peter, Bernhardt Julie, Kwakkel Gert. Stroke rehabilitation. Lancet. 2011;377(9778):1693–702.
5. Kwakkel Gert, Kollen Boudewijn J, van der Grond Jeroen, et al. Probability of regaining dexterity in the flaccid upper limb. Stroke. 2003;34(9):2181–6.
6. Nitsche Michael A, Paulus Walter. Excitability changes induced in the human motor cortex by weak transcranial direct current stimulation. J Physiol. 2000;527(3):633–9.
7. Hummel Friedhelm C, Cohen Leonardo G. Non-invasive brain stimulation in stroke. Lancet Neurol.2006;5(8):708–12.
8. Hummel Friedhelm C, Celnik Pablo, Giraux Pascal, et al. Effects of non-invasive cortical stimulation on skilled motor function in chronic stroke. Brain. 2005;128(3):490–9.
9. Kang Niamh, Summers Jeff J, Cauraugh James H. Transcranial direct current stimulation facilitates motor learning post-stroke. J Neurol Neurosurg Psychiatry. 2016;87(4): 345–55.
10. Winstein Carolee J, Stein John, Arena Ross, et al. Guidelines for adult stroke rehabilitation and recovery. Stroke.2016;47(6):e98–e169..

11. Kleim Jeffrey A, Jones Theresa A. Principles of experience-dependent neural plasticity. J Speech Lang Hear Res.2008;51:S225–39.

12.Krakauer John W. Motor learning after stroke: Is recovery related to brain plasticity? Curr Opin Neurol.2006;19(1):84–90.

13. French Beverley, Thomas Lois H, Leathley Michael J, et al. Repetitive task training for improving functional ability after stroke. Cochrane Database Syst Rev. 2007;(4): CD006073.

14. Pollock Alex, Baer Gillian, Campbell Pauline, et al. Physical rehabilitation approaches for the recovery of function and mobility following stroke. Cochrane Database Syst Rev. 2014;(4):CD001920.

15.Mathiowetz Virginia, Volland Glen, Kashman Nancy, et al. Adult norms for the Box and Block Test of manual dexterity. Am J Occup Ther. 1985;39(6):386–91.

16.Wolf Steven L, Catlin Peggy A, Ellis Meredith, et al. Assessing Wolf Motor Function Test. Stroke.2001;32(7):1635–9.

17.Fugl-Meyer Axel R, Jääskö Leif, Leyman Ingegerd, et al. The post-stroke hemiplegic patient: a method for evaluation of physical performance. Scand J Rehabil Med. 1975;7:13–31.

18.Hamilton Bruce B, Granger Carl V, Sherwin Frank S, et al. A uniform national data system for medical rehabilitation. Arch Phys Med Rehabil. 1987;68:122–7.

19.Stinear Cathy M, Barber Paul A, Smale Phillip R, et al. Prediction of motor recovery after stroke. Brain.2012;135:2527–35.

20. Cramer Steven C, Nudo Randolph J. Stroke recovery and rehabilitation. Lancet. 2011;377:1693–702.

21. Lindenberg Rainer, Renga Vijay, Zhu Linda L, et al. Structural integrity of corticospinal tract predicts motor recovery. Ann Neurol. 2010;67(5):754–63.

22. Elsner Bernhard, Kugler Jan, Pohl Marcus, et al. Transcranial direct current stimulation for improving motor function after stroke. Cochrane Database Syst Rev. 2016;(12): CD009645.

23. Bolognini Nadia, Pascual-Leone Alvaro, Fregni Felipe. Using non-invasive brain stimulation to augment motor training. Neurorehabil Neural Repair. 2011;25(9) :819–29.

24. Page Stephen J, Gater Darryl R, Bach-y-Rita Paul. Task-specific training in stroke rehabilitation. Arch Phys Med Rehabil. 2012;93: 784–92.

25. Teasell Robert, Mehta Sukhvinder, Pereira Samuel, et al. Evidence-based review of stroke rehabilitation. Top Stroke Rehabil. 2014;21:381–404.

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ORIGNAL ARTICLE

COMPARING THE EFFICACY OF STRUCTURED SENSORY-MOTOR TRAINING VS CONVENTIONAL PHYSIOTHERAPY ON PAIN, FUNCTIONAL DISABILITY, BALANCE AND GAIT PERFORMANCE IN PATIENTS WITH KNEE OSTEOARTHRITIS: AN EXPERIMENTAL STUDY

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ABSTRACT:

Background: Osteoarthritis (OA) of the knee occurs when cartilage breaks down, causing bones to rub together, leading to pain, swelling, and stiffness. It is highly prevalent, affecting 56.6% of the elderly, with 80% experiencing movement limitations and 25% unable to perform daily activities. OA can be primary (age-related) or secondary (caused by injury or conditions). Risk factors include weight, repetitive joint stress, and trauma. Cartilage does not regenerate, leading to progressive loss of mobility. Diagnosis includes radiographic assessment via the Lawrence-Kellgren classification. Physical therapy aims to reduce pain, improve mobility, and maintain joint function. Sensorimotor training enhances balance, proprioception, and muscle coordination, playing a key role in OA management.

Objectives: To compare the efficacy of structured sensory-motor training vs Conventional Physiotherapy on pain, functional disability, balance and gait performance in Patients with Knee Osteoarthritis.

Methods: An experimental study was conducted on 42 participants aged 50–70 years diagnosed with Grade II–III OA. Participants were randomly divided into 2 groups: sensory-motor training, and conventional physiotherapy. Interventions were administered for six weeks (five sessions/week). Outcome measures included NPRS, WOMAC and POMA scores.

Results: Both interventions significantly reduced pain and improved joint function and mobility. The SMT group showed the more improvements in pain (53.3%), function (54.2%), and balance (54.1%), followed by conventional physiotherapy.

Conclusion: Sensory-motor training demonstrated superior efficacy compared to conventional therapy. Integrating sensory motor approach in physiotherapy may enhance rehabilitation outcomes in knee OA management.

Keywords: Knee Osteoarthritis, Sensory-Motor Training, Balance, Gait, Rehabilitation

INTRODUCTION:

Knee osteoarthritis (KOA) is a chronic, progressive degenerative joint disease characterized by articular cartilage degeneration, subchondral bone remodeling, osteophyte formation, pain, stiffness, and reduced physical function.[1] It is one of the most prevalent musculoskeletal disorders worldwide and represents a leading cause of disability among middle-aged and older adults.[2]

The burden of knee osteoarthritis has increased significantly over recent years due to population aging, rising obesity levels, sedentary lifestyles, and increased life expectancy.[2] This condition not only affects physical health but also has profound psychological, social, and economic consequences for affected individuals and healthcare systems.[3]

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Pain and functional limitation are the primary symptoms that drive individuals with knee osteoarthritis to seek medical care.[3] Persistent knee pain interferes with basic activities of daily living such as walking, stair climbing, rising from a chair, and prolonged standing.[3]

As the disease progresses, individuals often experience reduced mobility, decreased participation in social activities, and loss of independence, leading to diminished quality of life.[1]Functional disability associated with knee osteoarthritis is multifactorial and cannot be explained solely by structural joint damage.[4]

In addition to mechanical joint degeneration, knee osteoarthritis is increasingly recognized as a condition involving significant neuromuscular and sensorimotor impairments.[4] Damage to joint structures such as cartilage, ligaments, joint capsule, and periarticular muscles leads to deterioration of mechanoreceptors responsible for proprioception.[5] Impaired proprioceptive input disrupts afferent sensory feedback to the central nervous system, resulting in altered motor planning and execution.[5] These sensory deficits contribute to compromised postural control, impaired balance, and abnormal gait patterns commonly observed in individuals with knee osteoarthritis.[6]

Balance impairments are a prominent yet often underappreciated feature of knee osteoarthritis.[6] Individuals with KOA demonstrate increased postural sway, reduced limits of stability, and delayed neuromuscular responses to perturbations when compared to healthy age-matched individuals.[6] Such balance deficits substantially increase the risk of falls, which are associated with injury, fear of falling, further activity restriction, and accelerated functional decline.[6]

Gait abnormalities, including reduced walking speed, altered step length, and increased joint loading asymmetry, further compound mobility limitations in this population.[4]

Pain plays a central role in the development and progression of functional disability in knee osteoarthritis.[7] Both peripheral nociceptive mechanisms and central sensitization contribute to persistent pain experiences in individuals with KOA.[7] Chronic knee pain has been shown to negatively influence muscle activation patterns, particularly resulting in quadriceps atherogenic muscle inhibition.[8] Reduced quadriceps activation compromises joint stability, increases abnormal loading of the knee joint, and exacerbates functional impairment.[8]

Assessment of pain, function, and mobility is essential for evaluating disease severity and treatment effectiveness in knee osteoarthritis.[9] The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is one of the most widely used and validated patient-reported outcome measures for assessing pain, stiffness, and physical function in individuals with KOA.[9]

Performance-based measures, such as the Performance-Oriented Mobility Assessment (POMA), are commonly used to assess balance and gait performance and to estimate fall risk in older adults.[10]Together, these outcome measures provide a comprehensive evaluation of both subjective and objective aspects of knee osteoarthritis-related disability.[10]

Exercise therapy is strongly recommended as a first-line non-pharmacological intervention for the management of knee osteoarthritis by international clinical practice guidelines.[11] Regular exercise has been shown to reduce pain, improve muscle strength, enhance joint mobility, and improve overall physical function in individuals with KOA.[12]Conventional physiotherapy programs typically include

strengthening exercises for the quadriceps and surrounding musculature, stretching, range-of-motion exercises, aerobic conditioning, and pain-relieving modalities.[12] These interventions primarily aim to improve mechanical joint stability and reduce symptoms associated with joint degeneration.[12]

Although conventional physiotherapy has demonstrated effectiveness in reducing pain and improving functional outcomes, its impact on proprioceptive deficits and balance impairments may be limited.[13] Traditional strengthening-focused approaches may not adequately address altered sensory input and neuromuscular control deficits that contribute to postural instability and gait dysfunction.[4] As a result, some individuals continue to experience balance problems and functional limitations despite improvements in muscle strength and pain reduction.[13]

In recent years, Sensory Motor Training (SMT) has gained increasing attention as a rehabilitation approach that specifically targets sensorimotor dysfunction.[14] SMT focuses on enhancing proprioception, neuromuscular coordination, and dynamic joint stability through balance-challenging and task-specific exercises.[14] Such training typically incorporates unstable surfaces, controlled joint movements, postural control activities, and functional tasks that stimulate joint and muscle mechanoreceptors.[15] By enhancing afferent sensory input and improving central sensorimotor integration, SMT aims to optimize motor output and functional movement patterns.[14]

Improved proprioceptive input achieved through SMT may reduce abnormal joint loading and improve movement efficiency during functional activities.[5] Enhanced neuromuscular control allows individuals to respond more effectively to postural perturbations, thereby improving balance and gait stability.[15] These adaptations are particularly relevant for individuals with knee osteoarthritis, in whom impaired sensorimotor control contributes significantly to functional disability and fall risk.[6] Emerging evidence suggests that proprioceptive and sensorimotor-based interventions may offer additional benefits over conventional exercise programs alone.[13] Studies have reported improvements in pain, joint position sense, balance performance, and functional mobility following SMT in individuals with knee osteoarthritis.[13] Balance-focused interventions are particularly important, as improvements in balance and gait are closely associated with reduced fall risk, increased confidence in mobility, and greater independence.[6]

Despite growing interest in SMT , limited studies have directly compared its effectiveness with conventional physiotherapy using standardized and validated outcome measures.[12]There remains a need for well-designed clinical studies to determine whether SMT provides superior benefits in pain reduction, functional improvement, and balance enhancement when compared to conventional approaches.[11] Understanding the relative effectiveness of these interventions is essential for optimizing rehabilitation strategies and improving clinical outcomes in individuals with knee osteoarthritis.[1]

Given the multifactorial nature of knee osteoarthritis, rehabilitation approaches that address both mechanical impairments and sensorimotor dysfunction may provide more comprehensive and sustained benefits.[4]

Therefore, the present study aimed to compare the effectiveness of SMT and Conventional Physiotherapy on pain intensity, functional disability, and balance and gait performance in individuals with knee osteoarthritis using validated outcome measures such as the Numerical Pain Rating Scale, WOMAC, and POMA.[1]

Materials and Methods

The present study was designed as an experimental study and was conducted in the Out-Patient Department of Physiotherapy of a tertiary care hospital after obtaining approval from the Institutional Ethics Committee.

Individuals of both genders aged between 50 and 70 years diagnosed with knee osteoarthritis were screened based on predefined inclusion and exclusion criteria. A total sample size of 46 was calculated using OpenEpi software, and participants were equally allocated into two groups (n = 23 each) using a simple random sampling method. Participants were included if they were cooperative and motivated, willing to participate voluntarily, diagnosed with grade II or grade III knee osteoarthritis according to the Kellgren–Lawrence classification confirmed by X-ray investigation, presented with functional limitations in activities of daily living, and had genu varum. Individuals with grade I or grade IV knee osteoarthritis, history of knee surgery, cognitive impairment, associated neurological conditions, cardiovascular or respiratory system complications, or those who were uncooperative during the study period were excluded.

Procedure

The purpose and procedure of the study were explained to all eligible participants in a language best understood by them, and written informed consent was obtained prior to enrollment. Baseline demographic details were recorded, and pre-intervention assessment of pain, deformity, balance, and gait was performed. Participants were then randomly allocated into two groups: the Sensory-Specific Motor Training (SSMT) group and the Conventional Physiotherapy group. The SSMT group received a structured sensory-motor training program aimed at improving proprioception, balance, and neuromuscular control of the knee joint, while the Conventional Physiotherapy group received standard physiotherapy management for knee osteoarthritis. The intervention was administered for six weeks, with sessions conducted five days per week, each session lasting 45 minutes. Exercise progression was carried out gradually based on patient tolerance and clinical response, and all sessions were conducted offline under supervision.

Outcome Measures

Outcome measures were recorded at baseline and after completion of the six-week intervention period. Pain intensity was assessed using the Numerical Pain Rating Scale (NPRS), functional status was evaluated using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and balance and gait were evaluated using the Performance-Oriented Mobility Assessment (POMA). Post-intervention assessments were conducted using the same outcome measures, and pre- and post-treatment data were recorded and analyzed for further evaluation.

Intervention

Group A (experimental group)

Goals	Intervention	Dosage
Reduce Pain	• Interferential Therapy (IFT)	15 min / 80–100 Hz
Improve Proprioception and joint awareness	• Active Joint Repositioning Training – 5–7 min • Exercise: Ankle circles / Alphabet drawing (in a pain-free range). • progression with Mirror feedback & Resistance Band	2sets x 10 reps 3sets of 10-12 reps (each direction)
Balance Training	• Static Balance- Tandem stance (with eyes open) • Dynamic balance - Weight Shift on balance board and reach outs • progression with Heel-to-Toe Walking & Tandem Walking	30 sec hold x 5 reps 5 reps each direction (ant -post & medial-lateral), 3 sets. 10–15 steps forward and backward, 3 sets.
Strength training	• Heel and Toe Raises • progression to Lateral Step-Up • Resisted Terminal Knee Extension (TKE) with TheraBand ○ progression to • Single-Leg Standing on BOSU Ball • Single-Leg Standing Reach-Out • Standing Perturbation Training	3 sets of 10 reps (pain-free range). 3 sets of 8–12 reps (each leg) on a low step. 3 sets of 10–12 reps with a light to moderate resistance band. Hold for 10–20 sec, 3-5 reps per leg. 3 sets of 10 reach-outs 10 random perturbations per session, 3 sets
Surface training	• Stepping on foam	3 setsX10 reps
Improve Functional reach and postural control	• Seated Perturbation Training	Therapist provides gentle pushes (random directions), 10–15 reps per set, 3 sets.

Gait training	• Hurdle Walking on Different Surfaces
	• Dual-Task Training While Walking
	  • Task Examples:
	  • Walk while counting backward or naming objects.
	  • Walk while carrying a tray with a cup
		Walk 5m on different surfaces (foam, uneven mats, grass), 3 rounds.

Endurance & Joint Mobility	• Static cycling	10 min at moderate resistance

Group B (control group)

The conventional physiotherapy intervention was provided for six weeks and included patient education, pain management, mobility, strengthening, balance, and functional training. Pain was managed using cryotherapy (10–15 minutes/day) and burst-mode TENS (10 minutes). Knee mobility exercises included heel slides, dynamic quadriceps exercises, patellar mobilization, and stretching of the hamstrings, quadriceps, and tendo-Achilles. Strengthening progressed from isometric exercises and straight leg raises to open and closed kinetic chain exercises such as mini-squats, step-ups, lunges, wall squats, and resisted quadriceps and hamstring exercises.

Balance and proprioceptive training involved weight shifts, single-leg stance, tandem standing, side-stepping, and figure-of-eight walking. Functional and endurance training included treadmill walking, stair climbing, and gait retraining, with progression based on patient tolerance.

Statistical analysis and Result

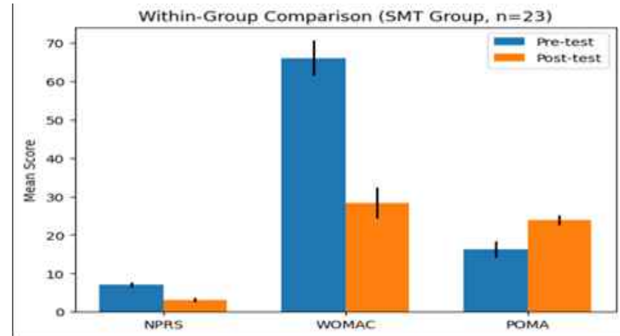
Statistical analysis was performed using the (SPSS), version 26.0. Descriptive statistics were used to summarize the data, and all values were expressed as mean ± standard deviation (SD). A total of 46 participants were included in the study, of which 26 were female and 20 were male. Participants were randomly allocated into two groups, with 23 participants in each group. In the SMT group, there were 13 females and 10 males, while the Conventional Physiotherapy group comprised 13 females and 10 males, ensuring comparable gender distribution between the groups. The mean age of participants in the SMT group was 58.4 ± 6.2 years, while the mean age of participants in the CPT group was 57.9 ± 5.8 years, indicating that both groups were age-matched at baseline.Outcome measures assessed included pain intensity using the Numerical Pain Rating Scale (NPRS), functional disability using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and balance and gait performance using the Performance-Oriented Mobility Assessment (POMA).

Within-Group Comparison (Paired t-test)

Within-group comparisons were performed using the paired t-test to evaluate pre- and post-intervention changes in groups.

SMT Group (n=23)

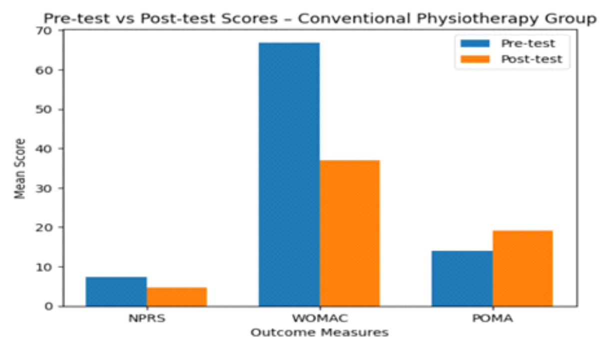
Outcome	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
NPRS	7.00 ± 0.74	3.09 ± 0.67	65.13	<0.001
WOMAC	65.91 ± 4.63	28.26 ± 3.98	29.13	<0.001
POMA	16.22 ± 2.11	23.83 ± 1.30	-17.56	<0.001



The SMT group demonstrated statistically significant improvement across all outcome measures, with a marked reduction in NPRS and WOMAC scores and a significant increase in POMA scores following the intervention period ($p < 0.001$).

Conventional Physiotherapy Group (n=23)

Outcome	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
NPRS	7.43 ± 0.99	4.61 ± 0.84	15.78	<0.001
WOMAC	66.87 ± 6.35	36.91 ± 2.57	18.94	<0.001
POMA	14.04 ± 1.49	19.17 ± 1.34	-15.62	<0.001

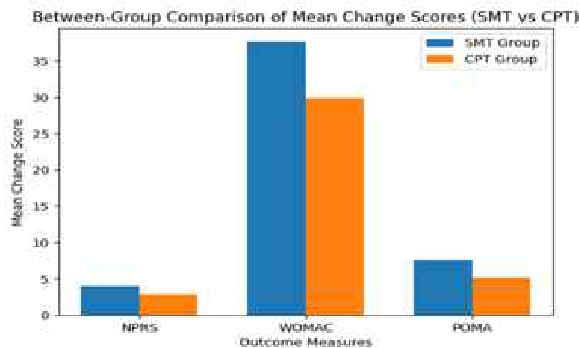


Similarly, the CPT group also showed statistically significant improvements in pain, functional disability, and balance outcomes from baseline to post-treatment ($p < 0.001$).

Between-Group Comparison (Independent t-test)

Between-group comparisons were conducted using the independent t-test on mean change scores to assess differences in the magnitude of improvement between the two groups

Outcome	SMT Mean Change	CPT Mean Change	t-value	p-value
NPRS	3.91	2.83	6.75	<0.001
WOMAC	37.65	29.96	3.69	0.001
POMA	7.61	5.13	5.94	<0.001



The analysis revealed a statistically significant difference favouring the SMT group across all outcome measures. The SMT group demonstrated significantly greater reduction in pain intensity and functional disability and superior improvement in balance and gait compared to the CPT group. The between-group differences were statistically significant for NPRS ($p < 0.001$), WOMAC ($p = 0.001$), and POMA ($p < 0.001$).

The level of statistical significance was set at $p < 0.05$, with values less than 0.01 considered highly significant and values less than 0.001 considered very highly significant. Overall, although both interventions were effective in improving pain, function, and balance, SMT demonstrated superior effectiveness compared to conventional physiotherapy.

Discussion

The present study compared the effectiveness of Sensory Motor Training (SMT) and Conventional Physiotherapy (CPT) on pain intensity, functional disability, and balance and gait performance in individuals with knee osteoarthritis. The main findings revealed that although both groups demonstrated statistically significant improvements across all outcome measures, the SMT group showed consistently greater improvements in pain reduction, functional ability, and balance and gait performance. These findings support and accept the proposed hypothesis that SMT is more effective than conventional physiotherapy in improving clinical outcomes in individuals with knee osteoarthritis.

The validity and accuracy of the results are strengthened by the use of standardized, reliable, and widely accepted outcome measures such as NPRS, WOMAC, and POMA, which are commonly employed in osteoarthritis research to assess pain, function, and mobility. The presence of statistically significant within-group and between-group differences further supports the internal validity of the study findings. The consistent superiority of SMT across multiple outcome domains highlights the robustness and clinical relevance of the observed effects.

The reduction in pain observed in both groups is in agreement with previous evidence indicating that exercise therapy is an effective non-pharmacological intervention for managing pain in knee osteoarthritis. Exercise is known to reduce pain through improved muscle strength, enhanced joint stability, and modulation of pain processing mechanisms. However, the greater pain reduction seen in the SMT group may be attributed to improved proprioceptive input and neuromuscular control, which can reduce abnormal joint loading and nociceptive input from periarticular tissues. Similar findings have been reported in earlier studies demonstrating enhanced pain outcomes following proprioceptive and neuromuscular training compared to conventional exercise programs.[12]

Functional disability, assessed using the WOMAC index, improved significantly in both intervention groups, indicating that both SMT and CPT were effective in improving functional performance. Conventional physiotherapy primarily improves function by enhancing muscle strength and joint mobility.

However, the significantly greater improvement in the SMT group suggests that addressing sensorimotor deficits provides additional functional benefits. Functional activities require coordinated movement, accurate joint position sense, and postural control, all of which are directly targeted through SMT. Previous literature supports the role of neuromuscular and proprioceptive training in improving functional outcomes in individuals with knee osteoarthritis.[4]

Balance and gait performance showed the most pronounced improvement in the SMT group, as reflected by higher POMA scores. Balance impairment is a common feature of knee osteoarthritis and is associated with increased fall risk and reduced independence. SMT emphasizes postural control, dynamic stability, and sensory integration, leading to improved balance and gait adaptability. Enhanced afferent feedback from joint and muscle mechanoreceptors improves central nervous system processing, allowing more effective postural responses during functional activities. These findings are consistent with earlier research highlighting the effectiveness of balance and sensorimotor training in improving mobility and reducing fall risk in older adults with knee osteoarthritis.[16]

The uniqueness of this study lies in its direct comparison of SMT and CPT using multiple clinically relevant outcome measures within a structured intervention framework. While previous studies have examined the effects of proprioceptive or conventional exercise programs independently, fewer studies have compared their relative effectiveness on pain, function, and balance simultaneously. The present findings contribute new evidence suggesting that SMT should not be viewed merely as an adjunct but as a central component of rehabilitation for knee osteoarthritis.

Despite the positive findings, certain limitations should be considered. The relatively small sample size may limit the generalizability of the results. The absence of long-term follow-up restricts conclusions regarding the sustainability of the observed improvements. Additionally, factors such as adherence to exercise protocols and variations in disease severity were not explored in detail and may have influenced outcomes. These factors represent potential weaknesses in interpretation and should be addressed in future research.

Future studies should include larger sample sizes, longer intervention durations, and follow-up assessments to evaluate long-term effects. Further research may also explore combined rehabilitation approaches incorporating both sensory motor and conventional physiotherapy techniques to optimize outcomes.

Clinical Implication SMT emerges as a next-generation rehab approach, offering superior outcomes compared to Conventional Physiotherapy. Demonstrates stronger neuroplastic adaptation, making it highly effective for patients with chronic pain and functional deficits. Optimizes proprioceptive re-education. Shows greater patient engagement, as task-oriented sensory inputs make therapy more interactive and motivating.

Conclusion

The findings of the present study demonstrate that while both Sensory Motor Training and conventional physiotherapy are effective in managing knee osteoarthritis, SMT results in superior improvements in pain, functional disability, and balance and gait performance. These results support the acceptance of the study hypothesis and reinforce the importance of incorporating sensorimotor-focused interventions into physiotherapy rehabilitation programs for knee osteoarthritis.

References

1. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. Lancet. 2019;393(10182):1745–1759.
2. Safiri S, Kolahi AA, Smith E, Hill C, Bettampadi D, Mansournia MA, et al. Global, regional and national burden of osteoarthritis 1990–2017: a systematic analysis of the Global Burden of Disease Study 2017. Ann Rheum Dis. 2020;79(6):819–828.
3. Katz JN, Arant KR, Loeser RF. Diagnosis and treatment of hip and knee osteoarthritis: a review. JAMA. 2021;325(6):568–578.
4. Hurley MV, Dickson K, Hallett R, Grant RL, Hauari H, Walsh N, et al. Exercise interventions and patient beliefs for people with knee osteoarthritis: a mixed methods review. Rheumatology (Oxford). 2019;58 (10):1715–1725.
5. Knoop J, Steultjens MP, van der Leeden M, van der Esch M, Thorstensson CA, Roorda LD, et al. Proprioception in knee osteoarthritis: a narrative review. Osteoarthritis Cartilage. 2020;28(2):174–182.
6. Stubbs B, Hurley M, Smith T. What are the factors associated with falls in people with knee osteoarthritis? Arch Phys Med Rehabil. 2020;101(10):1788–1796.
7. Neogi T. The epidemiology and impact of pain in osteoarthritis. Osteoarthritis Cartilage. 2020;28(2):159–168.
8. Rice DA, McNair PJ. Quadriceps arthrogenic muscle inhibition: neural mechanisms and treatment perspectives. Sports Med. 2019; 49(9): 1349–1360.
9. Collins NJ, Prinsen CA, Christensen R, Bartels EM, Terwee CB, Roos EM. Knee injury and Osteoarthritis Outcome Score (KOOS): systematic review of measurement properties. Osteoarthritis Cartilage. 2019;27(11): 1601–1613.
10. Shumway-Cook A, Woollacott M. Motor control: translating research into clinical practice. 5th ed. Philadelphia: Wolters Kluwer; 2020.
11. Bannuru RR, Osani MC, Vaysbrot EE, Arden NK, Bennell K, Bierma-Zeinstra SMA, et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. Osteoarthritis Cartilage. 2019;27 (11):1578–1589.
12. Fransen M, McConnell S, Harmer AR, van der Esch M, Simic M, Bennell KL. Exercise for osteoarthritis of the knee. Cochrane Database Syst Rev. 2020;1:CD004376.
13. Uthman OA, van der Windt DA, Jordan JL, Dziedzic KS, Healey EL, Peat GM, et al. Exercise for lower limb osteoarthritis: systematic review and network meta-analysis. Ann Rheum Dis. 2021;80(5):562–569.
14. Riemann BL, Lephart SM. The sensorimotor system, part I: the physiologic basis of functional joint stability. J Athl Train. 2020;55(6):589–600.
15. Ageberg E, Roos EM. Neuromuscular exercise as treatment of degenerative knee disease. Br J Sports Med. 2019;53(6): 386–392.
16. Stubbs B, Binnekade T, Soundy A, Schofield P, Huijnen IP, Eggermont L. Are older adults with chronic musculoskeletal pain less active than older adults without pain? A systematic review and meta-analysis. Pain Med. 2020;21(5):1–12.