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Case Study

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Nurse Practitioner-led Stroke Rehabilitation: A Case Study on Enhancing Awareness, Coping Skills, and Functional Independence

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Abstract

Aim and Background: Stroke remains a leading cause of disability and mortality worldwide. Effective rehabilitation is critical to optimizing recovery. Nurse practitioner-led rehabilitation programs, integrating multidisciplinary approaches, offer a promising, saleable model, especially in resource-limited settings.

Case Description: A 55-year-old male patient was admitted with an ischemic stroke affecting the right middle cerebral artery territory. He presented with left-sided weakness and impaired mobility. A structured, seven-day, nurse practitioner-led rehabilitation program was initiated, incorporating patient education, physical therapy, psychological support, medication adherence counseling, and regular clinical monitoring. Daily interventions focused on enhancing stroke awareness, promoting independence in activities of daily living (ADLs), and strengthening emotional resilience. The nurse practitioner coordinated care, delivered individualized interventions, and engaged family members in education sessions to support ongoing home rehabilitation.

Outcome: At the end of the program, the patient exhibited significant improvements in stroke awareness, partial independence in ADLs (e.g., dressing, toileting), increased muscle strength, and better coping strategies for managing anxiety and depression related to his condition.

Conclusion: This case underscores the pivotal role of nurse practitioners in stroke rehabilitation. Structured, patient-centered interventions led by nurse practitioners can drive substantial improvements in physical, cognitive, and emotional recovery within a short period.

Clinical Significance: Nurse practitioner-led stroke rehabilitation programs provide an effective, patient-centered, and cost-efficient model of care. They enhance functional outcomes and patient empowerment, making them particularly valuable in settings with limited access to specialized rehabilitation services.

key words: Stroke Rehabilitation, Nurse Practitioner, Activities of Daily Living, Coping Skills, Patient Awareness, Case Study

Introduction

Stroke is a significant global health concern and ranks as the second leading cause of death and a primary cause of disability worldwide. The World Health Organization estimates that one in four adults

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over the age of 25 will experience a stroke in their lifetime [1] . Among stroke survivors, the burden of physical, cognitive, and emotional disabilities is immense, requiring comprehensive rehabilitation to improve their quality of life [2 3].

In India, the stroke burden has been steadily increasing, driven by lifestyle changes, aging populations, and the prevalence of risk factors such as hypertension, diabetes, and dyslipidemia. India reports approximately 1.8 million new stroke cases annually, with a high proportion affecting individuals under 60 years and also world stroke organization report on stroke incidence “As shown in Figure 1” [4]. The lack of structured rehabilitation programs in resource-limited settings exacerbates the challenges of recovery for stroke survivors “As shown in Figure 2” [5 6].

Nurse-led stroke rehabilitation programs have emerged as an effective solution to bridge this gap. These programs focus on individualized, patient-centered care encompassing physical therapy, education, and emotional support [7]. In a study done at a tertiary care hospital in Chennai, India, it showed that nurse-led interventions greatly enhance stroke survivors’ knowledge of the disease, their ability to do activities of daily living (ADL) independently, and their ability to deal with stress [8]. Similarly, Dr. Devi D’s research highlights the effectiveness of structured educational programs in improving caregivers’ stroke awareness, leading to better patient outcomes and reduced caregiver stress [9].

Despite these promising outcomes, the integration of nurse-led rehabilitation in India remains limited.

Stroke continues to be a major public health concern, with ischemic strokes comprising approximately 87% of cases worldwide. The physical, cognitive, and emotional impairments that often follow strokes necessitate a multidisciplinary rehabilitation approach [10]. Nurse practitioners (NPs) play a pivotal role in bridging gaps in post-stroke care, combining clinical expertise, patient education, and psychological support. This case study illustrates the effectiveness of a structured, NP-led rehabilitation program implemented in a tertiary care hospital, focusing on improving awareness, ADL, and coping skills in stroke patients.

Ethical Considerations:

Informed consent for publication was obtained from the patient and his family after explaining the purpose and format of this case report. Institutional ethics approval was not required for this single-patient descriptive case study, as per the policies of the reporting institution. All efforts were made to maintain patient anonymity.

Case Presentation

The patient, a 58-year-old male farmer from a rural area near Chennai, India, was admitted to the neurology ward with a diagnosis of ischemic stroke. He presented with sudden onset of left-sided hemiplegia, slurred speech, and facial drooping. His Modified Rankin Scale (mRS) score was 3, indicating moderate disability, and he required assistance for basic activities of daily living (ADL).

The patient had a history of poorly managed diabetes mellitus and hypertension, both significant risk factors for stroke. He had not adhered to prescribed medications and had irregular follow-ups with healthcare providers. He lacked awareness of stroke warning signs, such as weakness, speech difficulties, and facial drooping, and his family had minimal understanding of preventive measures. Upon admission to the neurology ward, he reported dependency on caregivers for daily activities, low awareness of stroke-related risk factors, and emotional distress due to his condition.

- Patient Profile:

- Age : 55 years
- Gender : Male
- Comorbidities : Hypertension and diabetes mellitus
- Stroke Type : Ischemic
- Functional Status : Partial dependence in ADLs such as grooming, feeding, and mobility
- Psychological State : Moderate anxiety and frustration due to reduced autonomy
- Presenting Complaint: Left-sided hemiplegia, slurred speech, and difficulty swallowing.
- Past Medical History: Hypertension, type 2 diabetes mellitus, and obesity.
- Family History: Father had a stroke at age 62.

The patient's condition was further complicated by a lack of understanding of stroke prevention and rehabilitation, highlighting the need for structured educational and therapeutic interventions.

Clinical Details

1. **Biochemical Parameters**

1.1. Blood Sugar Levels:

- Random blood glucose: 215 mg/dL, indicating hyperglycemia.

- HbA1c: 9.2%, reflecting poor glycemic control over the preceding three months.

1.2. Lipid Profile:

- Total cholesterol: 280 mg/dL (elevated; normal <200 mg/dL).

- LDL cholesterol: 160 mg/dL (elevated; normal <100 mg/dL).

- HDL cholesterol: 35 mg/dL (low; normal >40 mg/dL).

- Triglycerides: 180 mg/dL (elevated; normal <150 mg/dL).

1.3. Coagulation Profile:

- Prothrombin time (PT): 12 seconds (normal range: 10–14 seconds).
- Activated partial thromboplastin time (aPTT): 28 seconds (normal range: 25–35 seconds).

-Fibrinogen: 400 mg/dL (normal range: 200–400 mg/dL), ruling out hypercoagulability.

1.4. Renal Function Tests (RFT):

- Serum creatinine: 1.4 mg/dL, indicating mild renal impairment likely due to diabetic nephropathy.

- Estimated glomerular filtration rate (eGFR): 58 mL/min/1.73 m², suggestive of stage 3 chronic kidney disease.

2. **Imaging:**

2.1. CT Scan of the Brain:

- Revealed an ischemic infarct in the right middle cerebral artery (MCA) territory. No hemorrhage or cerebral edema was observed "As shown in Figure 3".

2.2. Carotid Doppler Ultrasound:

- Detected >50% stenosis in the right internal carotid artery, suggestive of significant atherosclerosis, a primary cause of ischemic stroke "As shown in Figure 4".

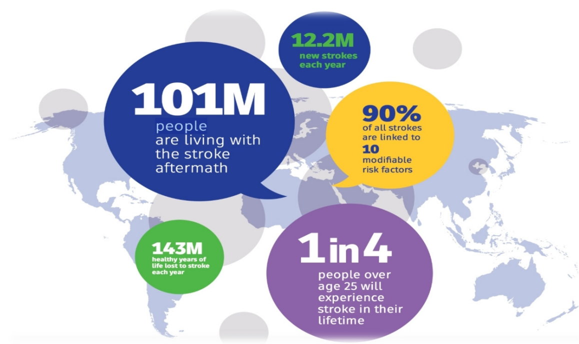

Figure 1: Stroke Incidence in India. Source: WHO Stroke Report, 2023.

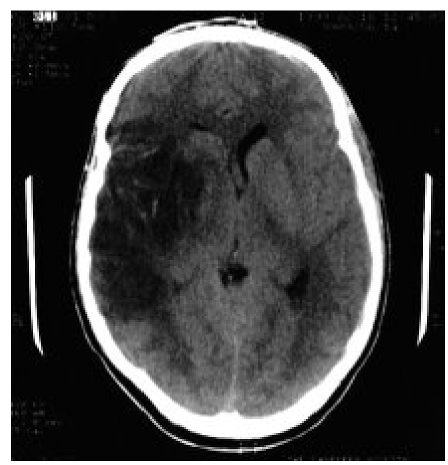

Figure 2: Access to Rehabilitation Services in India. Source: Indian Stroke Association, 2024.

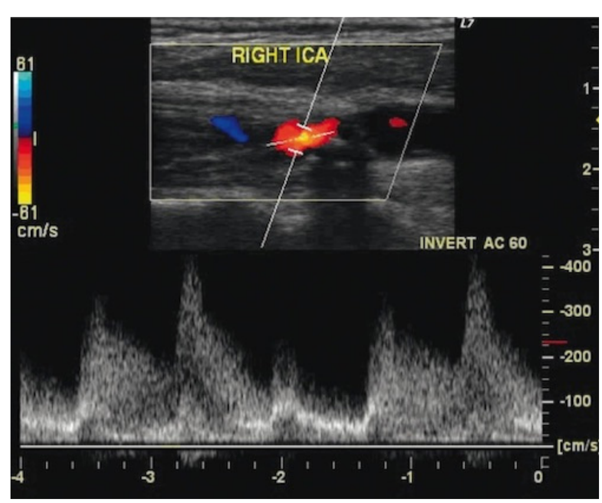

Figure 3: CT Scan Showing Right MCA Territory Infarct. Source: Patient Record (With Consent).

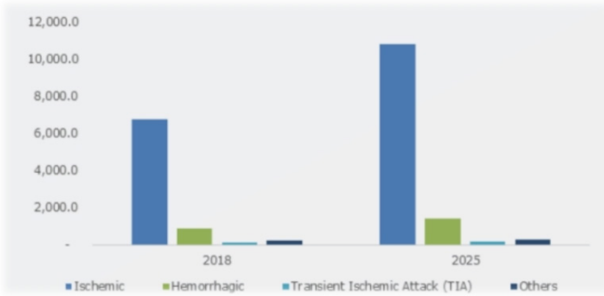

Figure 4: Carotid Doppler Indicating Right ICA Stenosis. Source: Patient Record (With Consent).

1. **Inflammatory Markers:**

- C-reactive protein (CRP): 12 mg/L (normal <5 mg/L), indicating ongoing vascular inflammation.

- Erythrocyte Sedimentation Rate (ESR): 30 mm/hour (elevated), supporting the inflammatory process.

2. **Cardiac Workup:**

- Electrocardiogram (ECG): Sinus rhythm with occasional premature atrial contractions.
- Echocardiogram: Mild left ventricular hypertrophy and normal ejection fraction of 55%, consistent with longstanding hypertension.

3. **Neurological Evaluation:**

- Modified Rankin Scale (mRS): 3, reflecting moderate disability.

- National Institutes of Health Stroke Scale (NIHSS): 8, indicating moderate stroke severity.

Family and Social Context

The patient's family, his primary caregivers, expressed significant emotional distress and uncertainty about managing his condition at home. They lacked prior knowledge of stroke prevention, early warning signs, and rehabilitation practices. This highlighted the critical need for a holistic, nurse-led rehabilitation program to address both patient and caregiver needs.

Intervention

The patient participated in a structured seven-day nurse-led stroke rehabilitation program. This program was designed to address three primary domains: stroke awareness, ADL, and coping mechanisms.

Role of Nurse Practitioner:

The NP played a key role in:

1. **Care Coordination**: Facilitating communication between the multidisciplinary team, including neurologists, physiotherapists, and dieticians.

2. **Personalized Care Planning**: Developing a tailored rehabilitation program based on the patient's clinical and functional status.

3. **Monitoring and Evaluation**: Conducting regular assessments, including neurological exams, ADL evaluations, and psychological assessments.

4. **Patient and Family Education**: Delivering detailed sessions on stroke prevention, medication adherence, and the importance of lifestyle changes.

Day 1: Stroke Awareness Education

- Delivered through a lecture using visual aids and interactive discussions.

- Covered stroke causes, symptoms, risk factors, medication adherence, and lifestyle modifications .

- Emphasized preventive strategies, blood sugar management, and physical activity.

Day 2: ADL Training

- Hands-on demonstrations of essential tasks, including grooming, feeding, bathing, and toileting.

- Focused on adapting techniques to the patient's physical limitations to encourage gradual independence .

Day 3: Range of Motion (ROM) Exercises

- Active and passive ROM exercises to improve muscle strength and joint flexibility .

- Exercises were tailored to the patient's capabilities, emphasizing techniques to avoid injury.

Days 4-7: Supervised Practice and Counseling

- Combined sessions of ADL training and ROM exercises, conducted for 40 minutes daily.

- The nurse provided continuous feedback, monitored progress, and offered psychological support.

- Family members were included in some sessions to ensure continuity of care at home.

Outcomes : Tools such as the Stroke Knowledge Assessment Tool, the Barthel Index, and the Brief-COPE scale evaluated the program's effectiveness.

1. **Awareness**

Pre-Test : The patient scored 10.4, indicating poor awareness of stroke causes, symptoms, and preventive strategies.

Post-Test : The score improved to 13.6, reflecting moderate to good awareness

Impact : The patient demonstrated a better understanding of risk factors, medication adherence, and lifestyle changes necessary to prevent recurrent strokes.

2. **Activities of Daily Living (ADL)**

Pre-Test : The patient was partially dependent on caregivers for basic tasks, with a Barthel Index score of 10.2.

Post-Test : The score increased to 13.23, indicating significant improvement and partial independence

Specific Improvements :

- Grooming: Fully independent by Day 7.

- Feeding: Independent with minimal supervision.

- Mobility: Achieved moderate independence with assistive devices.

3. **Coping Mechanisms**

Pre-Test : A Brief-COPE scale score of 21.8 indicated poor to moderate coping abilities.

Post-Test : The score rose to 35.03, showing highly significant improvement

Impact : The patient exhibited reduced frustration, increased emotional resilience, and a positive outlook toward recovery.

Patient and Family Feedback

Patient's Perspective:

Before this program, I didn't know much about my condition. The nurses helped me understand my illness and regain confidence in doing daily tasks. I feel stronger and more capable now.

Family's Perspective:

The patient's wife commented, the nurse practitioner was incredibly supportive, answering all our questions and teaching us how to assist my husband at home. We feel empowered to manage his recovery better.

Feedback on Nurse Practitioner's Role:

The patient and family praised the NP's expertise and compassionate approach, highlighting their pivotal role in facilitating recovery.

Discussion

This case study highlights the effectiveness of nurse-led stroke rehabilitation in improving functional and emotional outcomes. The structured approach addressed key challenges faced by stroke survivors, including limited awareness, dependency in ADLs, and poor coping mechanisms.

1. Stroke Awareness: Structured education significantly improved the patient's knowledge of symptoms, risk factors, and prevention strategies.

2. Functional Independence: Tailored ADL training and physical therapy, supervised by the NP, enhanced the patient's ability to perform daily tasks independently.

3. Psychological Resilience: Regular counseling and mindfulness techniques strengthened coping mechanisms, reducing emotional distress.

Key Insights from Literature

- Similar programs have demonstrated significant improvements in ADL and coping scores globally.
- Nurse-led interventions are particularly beneficial in LMICs, where disciplinary rehabilitation teams are limited.

Challenges

- **Initial Patient Reluctance**: The patient showed frustration and hesitation to actively participate in rehabilitation exercises in the early days.
- **Limited Stroke Awareness**: Both patient and caregivers had minimal knowledge about

stroke prevention and recovery, requiring intensive education.

- **Emotional Distress**: Anxiety, low motivation, and emotional fatigue impacted the patient's engagement and coping mechanisms initially.
- **Caregiver Burden**: Family members experienced high stress and lacked confidence in supporting the patient's rehabilitation at home.
- **Resource Limitations**: Limited access to multidisciplinary rehabilitation teams and equipment constrained the full scope of care delivery.

Strengths of the Program

Patient-Centric and Structured Approach: The program was tailored to the patient's specific clinical needs, enhancing functional and psychological recovery.

Effective Multidisciplinary Coordination: Seamless communication between nurses, physiotherapists, neurologists, and dieticians improved overall outcomes.

Empowerment through Education: Focused education sessions significantly improved stroke awareness and promoted medication adherence.

Family Involvement and Support: Training and counseling for family members ensured better continuity of care at home.

Significant Improvement in ADLs and Coping: Measurable gains in activities of daily living (Barthel Index) and coping mechanisms (Brief-COPE scores) were achieved in a short timeframe.

Emerging Trends and Recommendations:

Telehealth Integration: Incorporating tele-rehabilitation and virtual follow-ups can expand the reach of nurse practitioner-led stroke programs, especially in rural and underserved areas.

Utilization of Advanced Biomarkers: Routine monitoring of inflammatory markers (e.g., C-reactive protein, ESR) and neuroimaging techniques can enhance early detection of complications and personalize rehabilitation plans.

Technology-Enhanced Rehabilitation: Use of mobile applications, wearable devices, and home-based monitoring tools can promote patient engagement, track progress, and reinforce adherence to exercise and therapy protocols.

Strengthening Caregiver Training: Formal caregiver education programs can reduce caregiver burden, improve patient outcomes, and ensure sustained support after hospital discharge.

Development of Standardized urse-Led Rehabilitation Protocols: Creating evidence-based, structured rehabilitation guidelines tailored for nurse practitioners can standardize care delivery and improve outcome consistency across diverse healthcare settings.

Conclusion

While this single case highlights the potential of nurse practitioner-led stroke rehabilitation in improving functional and emotional outcomes, further studies with larger sample sizes are needed to validate and generalize these findings.

Source of Funding:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Consideration: Informed consent was obtained from the patient and his family. As per institutional policy, ethical approval was not required for a single-patient descriptive case study. Patient anonymity has been maintained.

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Systematic Review

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Effect of Physiotherapeutic intervention in the Rehabilitation of Bell's Palsy: A Systematic Review

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Abstract

Background: Acute idiopathic peripheral facial nerve paralysis, also known as Bell's palsy, can result in permanent weakness, asymmetry, and psychosocial sequelae. Physiotherapy is known to play an important role in optimizing recovery. However, there is considerable variation in physiotherapeutic management, and little is known about what is best. This systematic review aims to gather the best available evidence regarding physiotherapeutic management of Bell's palsy.

Methodology: An systematic search of the literature was done on the PubMed database, Google Scholar, and the Cochrane Library according to the PRISMA protocol for randomized controlled trials on the effectiveness of physiotherapy for Bell's palsy. A total of 14 trials were included from 1,156 records. The PEDro scale was used for assessing the methodological quality of the trials; only trials with a PEDro score of 7 and above were included.

Conclusion: Physiotherapy has a significant impact on the recovery of facial muscle function and symmetry in patients with Bell's palsy. Multifaceted physiotherapeutic interventions such as mirror therapy, motor imagery, neuromuscular retraining, and Kabat techniques have proven to have better outcomes than conventional exercises alone. The use of electrical stimulation has shown mixed results; however, it should be employed cautiously. Physiotherapy should be initiated early for better outcomes in the recovery of patients with Bell's palsy.

Keywords: Facial nerve paralysis; Kabat technique; electrical stimulation; physiotherapy rehabilitation; Facial disability index; Sunnybrook facial grading system.

Introduction

Bell's palsy is an acute idiopathic peripheral nerve disorder that causes sudden unilateral lower motor neuron paralysis. While some people make a complete recovery, a considerable number of individuals experience residual symptoms of weakness, asymmetry, synkinesis, and psychosocial

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problems, which affect facial expression, speech, mastication, and social interactions.[1][2][3][4]

Although pharmacotherapy, such as steroids, is usually used in the initial stages of the condition, its usefulness is compromised by delayed presentation and the inability of steroids to reverse established neuromuscular injury. As a result, physiotherapy has become an integral part of the treatment process, which aims to improve facial motor functions, prevent complications, and improve functional outcomes.[2][5]

Modern physiotherapy practices focus on active and patient-centered approaches, including neuromuscular training, mirror therapy, motor imagery, Kabat and proprioceptive neuromuscular facilitation methods, biofeedback training, and specific electrical stimulation. However, the diversity of the intervention methods, outcome measures, sample sizes, and follow-up periods limit the conclusive evidence on the best approach for the management of Bell's palsy. This systematic review therefore aims to provide high-quality evidence on the physiotherapeutic approaches for the management of Bell's palsy to improve functional and psychosocial outcomes. [6][7][8][9][10][11][12][13][14]

Material and methods

Systematic literature search was undertaken to find the randomized controlled trials that assessed the efficacy of physiotherapeutic interventions for the treatment of Bell's palsy. The search was conducted on the online research platforms, namely, PubMed, Google Scholar, and Cochrane Library, to cover the literature on the subject of interest.

Study selection was undertaken as per the PRISMA protocol, where the retrieved literature was screened for duplicates and irrelevant literature, followed by the full-text selection of the literature as per the inclusion and exclusion criteria (mentioned below). The selection of the literature was also presented as a PRISMA diagram (Figure no.1).

Out of 1,156 identified records, 14 studies were found to fulfill the inclusion criteria and were included in this review. The quality of these included studies was assessed by using the PEDro scale. Only those studies with a PEDro scale of 7 and above were included (Table 2). The included studies were reviewed and summarized under various headings: interventions, outcome measures, results, and conclusions. This information was presented in a structured table as mentioned in the review (Table 3). The synthesis of included studies was done by grouping them according to their intervention types. The risk of bias was assessed with special attention to blinding.

Inclusion criteria:

Studies involving participants who are diagnosed with Bell's palsy, regardless of age, gender, or the degree of the illness.

Studies involving Acute, sub-acute, and chronic cases of Bell's palsy.

Studies that involve the evaluation of physiotherapeutic interventions, which include but are not limited to: Facial exercises, Electrical stimulation, Biofeedback, Massage therapy, Neuromuscular re-education, Manual therapy, Mirror therapy, Laser therapy, TENS, Neural mobilization, etc.

Studies that compare physiotherapy interventions with: No treatment, Placebo or sham therapy.

Studies that involve the evaluation of functional recovery, which include but are not limited to: Facial muscle strength, Symmetry, Degree of paralysis, Facial movement/function, Quality of life, Patient satisfaction.

Study Design including Randomized Controlled Trials (RCTs).

Studies published in the last 10 years.

Studies published in the English language.

Studies published in peer reviewed journals.

RCT's with PEDRO score of 7 and above.

Exclusion criteria:

Studies involving facial palsy due to non-idiopathic causes (e.g., stroke, tumor, congenital facial palsy, Ramsay Hunt syndrome).

Studies that do not clearly distinguish Bell's palsy from other facial paralysis.

Studies that do not involve physiotherapy-based interventions.

Studies that involve only pharmacological interventions (e.g., steroids, antivirals) and do not include physiotherapy-based interventions.

Studies that include clinical trials, Case reports, case series with small sample size, Narrative reviews, expert opinions, conference abstracts without full data, Animal and in vitro studies.

Studies that are not written in the English language.

Studies that do not provide full text or insufficient data to be analyzed.

Data synthesis: Data synthesis was conducted by categorizing the literature according to similarities in physiotherapeutic interventions used. The literature on the use of the Kabat technique (Kanwal Khanzada et al. and Hamed et al.) demonstrated statistically significant improvements in facial functions, with greater improvements in facial functions post-treatment in the study conducted by Kanwal Khanzada et al. ($p < 0.05$) and significant improvements in Sunnybrook scores and electrophysiological parameters compared with standard therapy in the study conducted by Hamed et al. ($p < 0.001$) [15][16]. The literature on the use of electrical stimulation (Marotta et al., Jaseel M. Javath et al., Antonio Di Pietro et al., Santiago et al., and Ray et al.) demonstrated varied results, with significant improvements in facial functions with the use of electrical stimulation in some studies (Marotta et al., $p < 0.05$; Antonio Di Pietro et al., $p < 0.05$) and no significant difference in facial functions with the use of electrical stimulation in other studies (Jaseel M. Javath et al., $p > 0.16$; Ray et al., $p > 0.05$) [17][18][19][20][21].

Studies on the use of mirror therapy and motor imagery (Teresa Paolucci et al., Jodi Maron Barth et al., Martineau et al., and Happy Patel et al.) have shown statistically significant improvements in facial symmetry, quality of life, and psychosocial outcomes compared with controls (all studies showing a p-value of < 0.05) [22][23][24][25]. The studies on neuromuscular re-education (Samraiz Mughal et al.) have shown statistically significant improvements in FDI and House-Brackmann scores at follow-up compared with neuromuscular retraining alone ($p = 0.00$) [26]. The study in which neural mobilization was applied reported significant differences in Sunnybrook scores and muscle activation for both groups, i.e., $p = 0.001$[27]. The studies in which mime therapy was applied reported statistically significant improvement when compared to PNF with electrical stimulation, i.e., $p < 0.05$[28]. It was observed that all intervention groups showed statistically significant improvement, but when it comes to electrical stimulation, it showed variable results.

Risk of bias : Blinding was not consistently reported in the studies included, which generated a moderate risk of performance and detection bias. Some studies used assessor blinding for objective outcomes, but the majority did not report blinding for the participants or therapist, which could have an impact on the subjective outcomes of disability and quality of life scores.

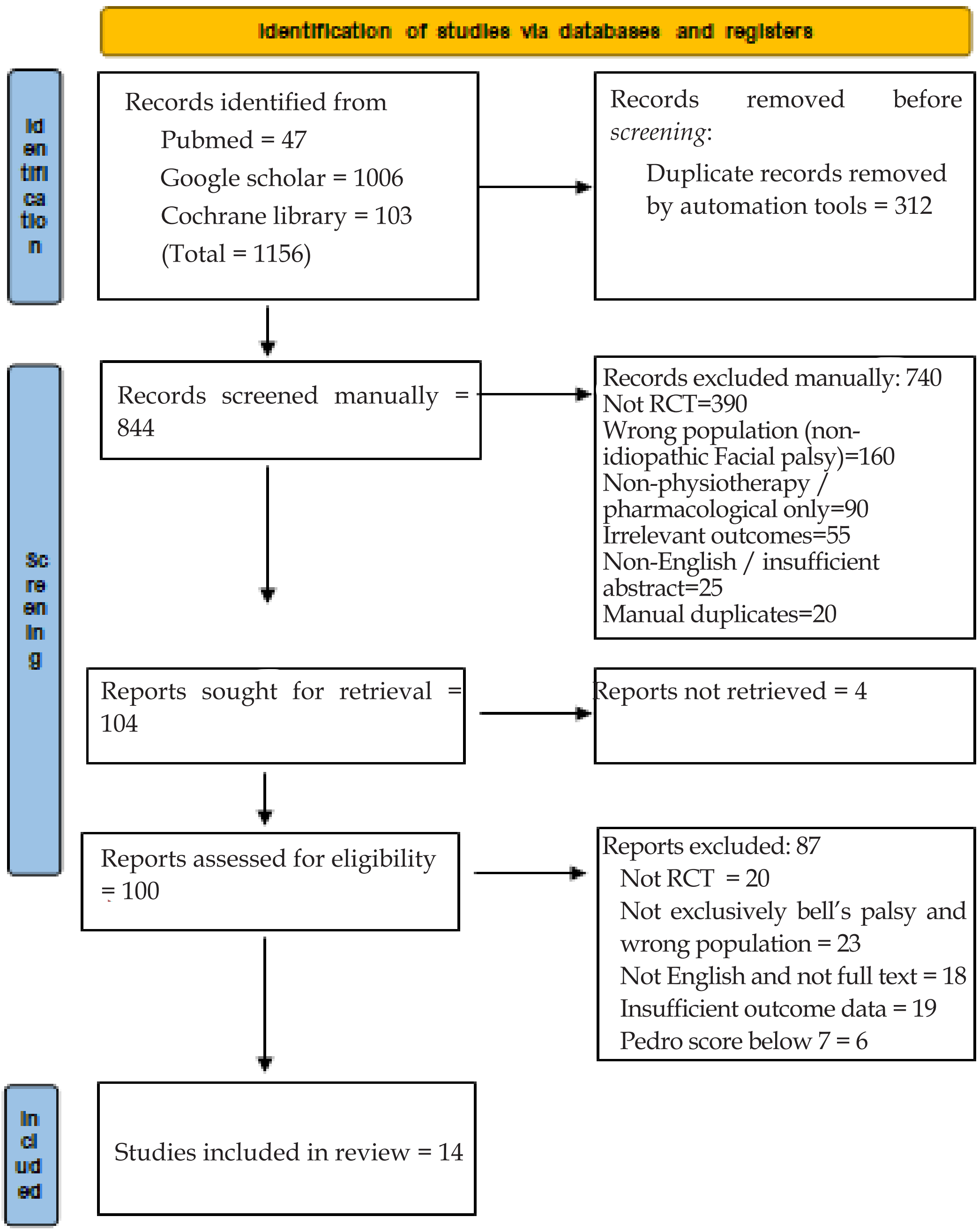

Figure no. 1: Prisma chart:

Table no. 3, Study characteristics:

Author & Year	Interventions	Outcomes	Results	Conclusions
Kanwal Khanzada (2018)[15]	52 patients divided equally, Group A receiving Kabat rehabilitation technique with nerve stimulation, and Group B receiving facial exercises with nerve stimulation.	Sunnybrook Facial Grading Scale (SFGS) Facial Disability Index (FDI)	More improvement was observed in SFGS and FDI in Group A compared to Group B after the end of 3 weeks.	Kabat technique is more effective than the facial exercises technique

Marotta et.al (2020)[17]	NMES + SWD versus sham NMES.	Sunnybrook Facial Grading System, Kinovea software analysis.	The NMES + SWD group showed a significant improvement compared to the control group.	The addition of NMES and SWD to conventional exercises enhanced voluntary movement in chronic Bell's palsy.
Teresa paolucci (2020) [22]	The experimental group was given mirror therapy and motor imagery, along with traditional rehabilitation. The control group was given traditional rehabilitation alone.	House-Brackmann Scale, Sunnybrook Facial Grading System, Facial Clinimetric Evaluation Scale, Beck Depression Inventory.	The experimental group showed better results in House-Brackmann Scale scores and quality of life and emotional depression.	The combined mirror therapy and motor imagery are effective in facial nerve palsy rehabilitation.
Jodi Maron Barth (2020)[23]	Mirror Book Group (n=15): Mirror book therapy + Standard facial rehabilitation Control Group (n=10): Standard facial rehabilitation	Facial Grading System (FGS) Facial Disability Index - Physical (FDIP) Facial Disability Index - Social (FDIS)	Mirror book therapy group results were significantly higher in FDIS scores compared with FGS and FDIP scores	Mirror book therapy added to standard facial rehabilitation does significantly improve results.
Jaseel M Javath (2021) [18]	LLLT vs Electrical Stimulation. Both groups also did facial exercises.	Sunnybrook Facial Grading System (SFGS), Facial Disability Index (FDI)	No significant difference between LLLT and ES.	LLLT and ES are equally effective .
Samraiz Mughal (2021) [26]	64 patients were randomly divided into two equal groups. Group 1 was treated using Mirror Visual Feedback in combination with Neuromuscular Retraining, while Group 2 was treated using Neuromuscular Retraining alone.	Facial Disability Index (FDI) - Physical and Social. House Brackmann Scale (HBS)	Significant difference observed in FDI-P, FDI-S and HBS scores.	The combination of Mirror Visual Feedback and neuromuscular retraining was more effective.
Martineau S et al., (2022)[24]	MEPP therapy, facial manipulations, motor imagery, and principles of neuromotor retraining vs. control	House–Brackmann 2.0, Sunnybrook), quality-of-life (FaCE-F),perceived speech intelligibility	No between-group difference was found for perceived speech intelligibility. Benefits were found up to 1 year post-treatment.	Promising long-term outcomes for early MEPP facial retraining compared with counselling alone.

Happy Patel (2022)[25]	30 patients were equally distributed, Group A receiving Motor Imagery and Mirror Book Therapy, Group B receiving Mime therapy, and Group C receiving mirror biofeedback exercises at home. All 3 groups received conventional exercises.	Sunnybrook Facial Grading System (SFGS) Facial Disability Index (FDI)	There was statistically greater improvement in Group A and Group B compared with Group C using SFGS scores and FDI scores.	Motor Imagery and Mirror Book Therapy, Mime therapy have shown greater improvement in facial functions, facial symmetry, quality of life, and psychosocial functions
Alharbi R et al., 2023)[27]	Neural mobilisation of the facial nerve was added as a treatment, in addition to conventional treatment (both groups received meds + conventional physio).	Sunnybrook Facial Grading System (SFGS); Kinovea Movement Analysis Software.	A significantly higher post-test Sunnybrook scores and kinivea for the mobilisation group.	Facial neural mobilisation is an effective adjunct to conventional rehabilitation..
Antonio Di Pietro (2023)[19]	Group 1 Usual PT Group 2 Usual PT + selective transcutaneous electrical muscle stimulation	eFACE and SFGS.	eFACE at discharge and 6-month follow-up; time to maximal recovery from flaccid paralysis.	The addition of selective muscle stimulation to usual PT hastens recovery.
Ganni Ramya (2023)[28]	Group A receiving Mime therapy plus electrical stimulation and Group B receiving (PNF) plus electrical stimulation.	(SFGS) (FDI)	(Group A) improved better than (Group B)	Mime therapy with electrical stimulation resulted in better recovery.
Hamed et al. (2023)[16]	The participants were treated either with Kabat Motor Control Re-education or physiotherapy	Electrophysiologic-al measures , Sunnybrook score.	The results showed that the Kabat group showed significant improvement in electrophysiological parameters and Sunnybrook scores	Kabat Motor Control Re-education significantly accelerates functional and electrophysiological recovery in Bell's palsy

Santiago S et al., (2024)[20]	Experimental: passive stretching of unaffected side + exercises for affected side + one faradic stimulation; Comparator: conventional facial exercises	Sunnybrook Facial Grading System (SFGS) scores were used for baseline, day 10, day 20.	Significant improvement in experimental group compared with comparator group in SFGS change scores.	.Adding stretching and exercises improved on conventional exercises in acute bell's palsy.
Ray et al. (2025)[21]	Both groups were given standard meds + facial exercises; ES group also received interrupted galvanic stimulation.	House–Brackmann score; Facial Disability Index	No statistically significant difference was found between groups on HB or FDI	Both groups improved significantly over time ($p<0.001$)

Discussion

This systematic review included high-quality randomized controlled trials (PEDro ≥7) to determine the effectiveness of physiotherapeutic interventions for individuals with Bell's palsy. Physiotherapeutic interventions have been found to have a beneficial effect on muscle function and symmetry for individuals with Bell's palsy.

Multimodal physiotherapeutic interventions have shown better outcomes than conventional physiotherapeutic interventions for individuals with Bell's palsy. Mirror therapy, motor imagery, and neuromuscular retraining have shown better outcomes for individuals with Bell's palsy in terms of voluntary movement, symmetry, and quality of life through facilitation of cortical reorganization.[23][24][25][26][27][42][43][44][45][46] Kabat method of rehabilitation and PNF techniques indicated further improvement in functional and electrophysiological outcomes by increasing neural recruitment.[15][16][29][30][31][32] Neural mobilization of the facial nerve also indicated promising outcomes; however, the need for addressing the restrictions along the course of the nerve was emphasized, especially during the acute stage.[28][47][48][49]

Intensive and structured facial retraining was seen to be effective in controlling synkinesis, preventing maladaptive recovery patterns, and improving quality of life.[16] Electrical stimulation was seen to be of varied efficacy. Its selective or therapist-directed use was seen to be beneficial in chronic or flaccid paralysis, but its routine use was not seen to offer any additional benefits over exercises alone, thus showing its efficacy depending on the proper timing and dosage of its use. [17][18][20][21][22][33][34][35][36][37][38][39][40][41]

The evidence supports a paradigm shift towards active, patient-centered, and multimodal physiotherapy, focusing on motor control, symmetry, and psychosocial engagement. However, the diversity of the applied interventions, outcome measures, treatment sessions, and follow-up periods prevents direct comparison between studies. Other limitations include the low sample size, absence of blinding, short follow-up, and publication bias. These studies highlight the need for standardization of the applied protocols, along with long-term, high-quality, well-designed RCTs, to identify the best physiotherapeutic approaches for the treatment of Bell's Palsy.

Conclusion

This systematic review has reaffirmed the importance of physiotherapy in the rehabilitation of individuals who suffer from Bell's palsy, where the most effective interventions are those that are multimodal and patient-centered, as these have the most significant effect on the improvement of the symptoms of the illness, as well as the reduction of the long-term complications of the illness, including synkinesis and disability.

In spite of substantial supportive research, differences in approaches, outcome measures, and follow-ups make it difficult to compare different research findings and develop standardized guidelines. Future research should focus on long-term randomized trials using standardized outcome measures to determine the best combination, dosage, and time of administration of physiotherapeutic management for Bell's palsy.

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Scoping Review

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Effects of Neuromuscular Joint Facilitation on Scapular Stability and Upper Limb Function in Stroke: A PRISMA-ScR Guided Scoping Review

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Abstract

Background: Neuromuscular Joint Facilitation is an emerging rehabilitation approach that integrates elements of PNF with joint mobilization techniques to enhance joint alignment, neuromuscular control, and functional movement. It has recently been explored as a therapeutic strategy to address scapular dyskinesia, shoulder subluxation, and upper-limb dysfunction following stroke.

Objective: To map the existing evidence regarding the effects of NJF on upper-limb function in individuals with stroke.

Methods: The scoping review was conducted in accordance with PRISMA-ScR guidelines. Electronic databases including PubMed, Google Scholar were searched to identify studies investigating NJF interventions in post-stroke populations. Studies were included if they evaluated NJF therapy and reported outcomes related to scapular alignment, shoulder stability, or upper-limb function. Five relevant studies met the eligibility criteria, comprising Randomized controlled trials (RCTs) and clinical intervention studies assessing NJF alone or in combination with other treatment.

Results: The included studies examined the impact of NJF on conditions such as scapular dyskinesia, shoulder subluxation and upper-limb motor impairment following stroke. Overall, NJF interventions were associated with improvements in scapular alignment, reduction in shoulder subluxation distance, increased supraspinatus muscle thickness, decreased muscle tone, and enhanced upper-limb functional performance. Additionally, one study reported improved outcomes when NJF was given for managing hemiplegic shoulder pain and movement dysfunction**.Conclusion:** The available evidence suggests that NJF therapy may positively influence scapular biomechanics and upper-limb functional recovery in individuals with sub-acute stroke. However, the limited number of studies and variability in study designs highlight the need for further well-designed RCTsto establish standardized NJF protocols and confirm its clinical effectiveness.

Keywords: Stroke, neuromuscular joint facilitation, upper limb motor, motor function, Scapular dyskinesia, Hand function

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Introduction

Stroke remains among the most common neurological conditions globally and is a major contributor to disability, placing a significant strain on patients, their families, and healthcare systems[1,3]. It arises when cerebral blood circulation is disrupted or reduced, leading to an inadequate supply of oxygen and nutrients to brain tissues, which ultimately causes neuronal injury[2]. The extent and nature of resulting deficits depend on the site and severity of the brain lesion, often resulting in considerable functional impairments and a diminished quality of life[4,5].

Among the range of deficits following stroke, motor impairment is considered one of the most debilitating outcomes. Dysfunction of the upper limb is especially prevalent, with approximately 80% of individuals affected during the early phase of recovery[4,6]. The upper extremity is essential for carrying out activities of daily living (ADLs), such as eating, dressing, and handling objects. However, regaining functional use of the upper limb remains challenging due to the complexity of coordinated arm and hand movements, which depend on accurate neuromuscular control[4,7]. As a result, a large proportion of stroke survivors continue to exhibit persistent upper limb limitations even after undergoing rehabilitation[7].

Restoring upper limb function is a central objective in stroke rehabilitation, as it significantly impacts an individual's independence, level of participation, and overall quality of life[5]. Rehabilitation strategies are primarily directed toward enhancing muscle strength, joint range of motion, coordination, and neuromuscular control to promote effective motor relearning[8]. Traditional physiotherapy methods, including range-of-motion exercises, strengthening programs, and task-specific training, continue to be commonly applied[9,10]. More recently, advanced rehabilitation techniques that focus on neuromuscular facilitation and sensorimotor integration have attracted growing interest[11,14].

Neuromuscular Joint Facilitation (NJF) is a relatively new therapeutic technique that combines elements of proprioceptive neuromuscular facilitation (PNF) with joint-oriented movement patterns[15]. This approach utilizes resistance, traction, and coordinated movements to improve joint performance and neuromuscular coordination[15,16]. NJF is designed to enhance muscle strength, joint stability, and motor control by activating proprioceptors within muscles and joint structures, thereby facilitating more effective functional movement patterns[13,15]. Research indicates that NJF may increase muscle activation, optimize joint alignment, and support functional recovery in individuals with neurological conditions, including stroke[16,17].

In individuals affected by stroke, motor deficits often involve both distal and proximal segments of the upper limb, with the shoulder complex being particularly impacted[18,19]. The scapula is essential for establishing a stable foundation for upper extremity movements and supports efficient arm function through its coordinated relationship with the humerus, referred to as the scapulohumeral rhythm[20]. After a stroke, disruptions in normal muscle activation patterns and deficits in neuromuscular control can impair this coordination, ultimately affecting upper limb performance[21,22].

Scapular dysfunction—characterized by altered positioning and abnormal movement patterns, commonly referred to as scapular dyskinesia—is frequently seen in individuals following stroke[23,24]. These abnormalities may arise due to muscle weakness, changes in muscle tone, and impaired neuromuscular coordination[24]. A loss of scapular stability can adversely influence shoulder biomechanics, limit range of motion, and increase the risk of complications such as shoulder pain and subluxation[25,26]. In addition, poor coordination among key scapular muscles, including the trapezius, serratus anterior, rhomboids, and levator scapulae, may result in inefficient movement patterns and reduced functional ability[22,27,28]

Given the importance of scapular stability in upper limb function, rehabilitation strategies targeting neuromuscular control of the shoulder complex are essential for improving functional outcomes after stroke [23,27]. NJF techniques are particularly relevant in this context, as they emphasize coordinated joint movement and neuromuscular activation, potentially addressing deficits in scapular control and upper limb function [15].

Previous research has highlighted the beneficial effects of NJF in enhancing functional outcomes among individuals with stroke. Clinical evidence indicates that NJF interventions can lead to improvements in muscle activation, joint stability, and upper limb function, particularly in patients experiencing shoulder subluxation[29]. Furthermore, NJF has been reported to positively influence muscle tone, hand function, and overall motor performance in individuals with hemiplegia following cerebral infarction[17]. Collectively, these findings indicate that NJF may serve as an effective therapeutic strategy for facilitating upper limb recovery and enhancing functional independence in stroke rehabilitation.

Materials and Methods

Study Design

This scoping review was conducted to systematically identify and synthesize existing literature evaluating the effectiveness of Neuromuscular Joint Facilitation (NJF) on scapular stability and upper limb function in individuals with stroke. The review methodology was guided by the framework of thePRISMA-ScR[30], which offers standardized recommendations for the conduct and transparent reporting of scoping reviews. The purpose of this review was primarily exploratory and descriptive, aiming to map and summarize the current body of evidence related to the role of NJF in enhancing neuromuscular control, scapular stability, and upper limb functional recovery in stroke rehabilitation, rather than undertaking a quantitative meta-analysis of outcomes.

Eligibility Criteria

Eligibility criteria were established prior to the commencement of the literature search. Studies were included if they met the following requirements: participants were adults aged 18 years or above with a confirmed diagnosis of stroke, including cerebral infarction or hemiplegic stroke, and exhibited upper limb impairments such as scapular dyskinesia, shoulder subluxation, hemiplegic shoulder pain, or diminished upper extremity motor function.

The intervention of interest included the application of NJF to the shoulder complex or upper limb, delivered either as an independent therapy or in combination with other rehabilitation modalities, such as Transcranial Direct Current Stimulation. Additionally, studies investigating scapular facilitation methods closely aligned with the principles of NJF were also deemed eligible.

The outcomes of interest encompassed assessments of shoulder pain, scapular alignment or dyskinesia, degree of shoulder subluxation, range of motion, and functional performance of the upper limb. Eligible study designs included randomized controlled trials as well as clinical intervention studies that evaluated NJF-based rehabilitation in individuals with stroke.

Studies were excluded if they met any of the following conditions:

(i) involved neurological disorders other than stroke without providing separate analyses specific to stroke populations

(ii) assessed interventions that did not incorporate NJF

(iii) focused solely on rehabilitation outcomes of the lower limb

(iv) consisted of conference abstracts or reports lacking accessible full-text versions.

These exclusion criteria were established to ensure the selection of relevant clinical studies investigating NJF-based rehabilitation for upper limb dysfunction following stroke, including research conducted by Xiaofeng et al., Hiroshi et al., Yongmei et al., Ahmed et al., Liang et al.

Information Sources and Search Strategy:

A systematic search across the PubMed/ MEDLINE, Web of Science, Google Scholar, Cochrane library, PEDro, databases were performed to identify relevant studies published from 2015 to its inception up to January 2026. The search approach incorporated both controlled vocabulary terms and free-text keywords associated with Neuromuscular Joint Facilitation and stroke rehabilitation.

The primary search string used was: ("neuromuscular joint facilitation" OR "NJF") AND ("stroke" OR "cerebral infarction" OR "hemiplegia") AND ("upper limb" OR "shoulder" OR "scapular dyskinesia" OR "shoulder subluxation")

To enhance the completeness of the search, the reference lists of all included studies were manually examined to identify any additional relevant articles that were not captured during the initial database search.

Study Selection and PRISMA-ScR Flow

The study selection procedure was carried out in line with the recommendations of the PRISMA-ScR. All records identified through the database search were first screened by reviewing their titles and abstracts against the predefined eligibility criteria. Articles considered potentially relevant were then evaluated through full-text review.

The initial search yielded a total of 46 records from database searching and manual reference screening. Following the removal of 8 duplicate entries, 38 unique studies remained for title and abstract screening. At this stage, 26 articles were excluded due to lack of relevance to the review objectives. The primary reasons for exclusion included studies that did not involve Neuromuscular Joint Facilitation, those conducted on non-stroke populations, research focusing exclusively on lower-limb rehabilitation, and non-clinical experimental designs.

A total of 12 articles were obtained for full-text review. Among these, 7 studies were excluded based on the following criteria: lack of upper limb or shoulder-related outcomes (n = 2), interventions not incorporating NJF or related scapular facilitation techniques (n = 2), and conference abstracts or reports without accessible full-text versions (n = 3).

In the end, 5 studies satisfied all eligibility criteria and were included in the final synthesis. These studies consisted of randomized controlled trials and clinical intervention designs that examined NJF-based rehabilitation strategies aimed at enhancing shoulder mechanics, improving scapular alignment, and facilitating upper limb functional recovery in individuals with stroke.

Data Charting Process

Data extraction was performed using a structured charting form specifically designed for this scoping review. The following variables were systematically collected from each included study:

- Study design
- Sample size
- Stage of stroke (acute, subacute, or chronic)
- Target joint or muscle group addressed in the intervention
- Parameters of the Neuromuscular Joint Facilitation (NJF) intervention, including movement patterns, resistance techniques, number of sessions, and duration of each session
- Comparator or control intervention, where applicable
- Outcome measures related to scapular stability and upper limb function (e.g., muscle activation, motor control, range of motion, and functional performance)
- Main findings and study conclusions

Data Synthesis

Due to the heterogeneity in study designs, intervention protocols, and outcome measures among the included studies, a quantitative meta-analysis was not undertaken. Instead, the results were synthesized narratively in line with the recommendations for scoping reviews outlined in the PRISMA-ScR.

The extracted data were systematically organized and summarized to enable comparison of study characteristics, intervention strategies, and reported outcomes related to Neuromuscular Joint Facilitation in individuals with stroke. The synthesis primarily aimed to identify trends in intervention approaches and their reported effects on shoulder function and upper limb rehabilitation

To facilitate clear interpretation and organization, the study findings were grouped into the following thematic categories:

1. Scapular alignment and dyskinesia
2. Shoulder stability and reduction of subluxation
3. Upper limb motor function and overall functional performance

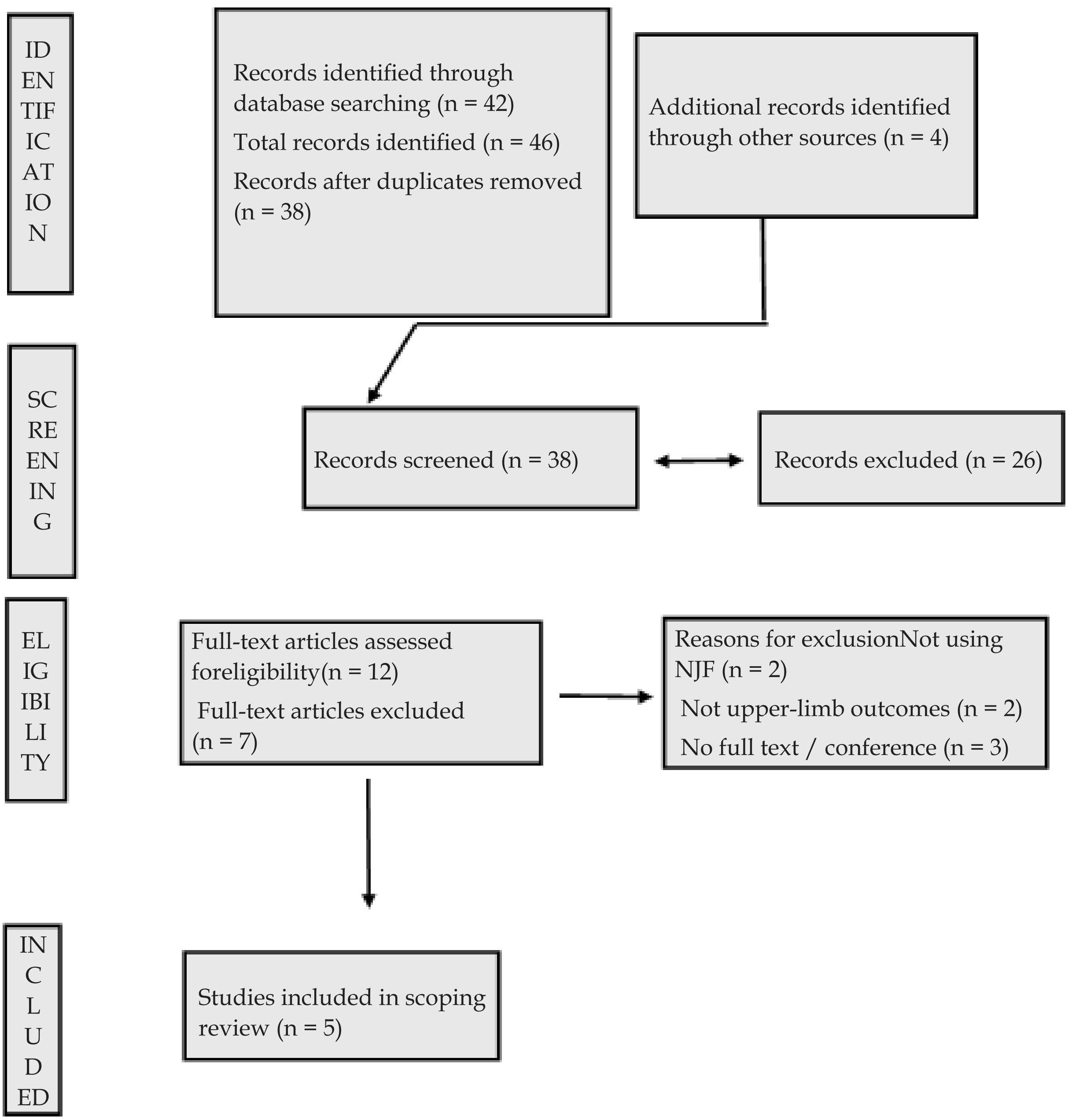
Within each category, key aspects such as intervention characteristics, study design, outcome measures, and reported therapeutic effects were examined and compared to identify consistent patterns across the included studies. This method allowed for the recognition of emerging evidence supporting NJF-based interventions, while also highlighting methodological limitations and existing gaps within the current body of literature.

Critical Appraisal

In line with the recommendations of the PRISMA-ScR. The primary objective of this scoping review was to map and summarize the available evidence rather than to perform a quantitative evaluation of intervention effectiveness. Nevertheless, important methodological features of the included studies were considered during data synthesis. These included relatively small sample sizes, open-label study designs, and inconsistencies in intervention protocols. Such factors were documented to aid in the interpretation of findings and align with limitations commonly reported in prior evidence syntheses, including those of the Cochrane Collaboration.

Ethical Considerations

As this included analysis of already published data ethical approval was not required.



*Flowchart 1: PRISMA-SCR flow chart.

Result

The electronic search identified a total of 46 citations. Following the removal of 8 duplicate records, 38 unique articles were retained for title and abstract screening. During this initial stage, 26 studies were excluded as they did not satisfy the predefined eligibility criteria. The main reasons for exclusion included studies that did not involve Neuromuscular Joint Facilitation, those conducted on non-stroke populations, research focused exclusively on lower limb rehabilitation, and non-clinical experimental designs.

A total of 12 articles were selected for full-text evaluation. Among these, 7 studies were excluded for the following reasons: lack of upper limb or shoulder-related outcomes (n = 2), interventions that did not incorporate NJF or related scapular facilitation techniques (n = 2), and conference abstracts or reports without available full-text versions (n = 3).

Consequently, 5 studies fulfilled all eligibility criteria and were included in the final synthesis. These consisted of randomized controlled trials and clinical intervention studies that examined NJF-based rehabilitation strategies aimed at improving shoulder mechanics, enhancing scapular alignment, and promoting upper limb functional recovery in individuals with stroke.

Characteristics of Included Studies

A total of five studies satisfied the inclusion criteria and were incorporated into the final synthesis. These studies, published between 2017 and 2022, indicate a growing interest in Neuromuscular Joint Facilitation (NJF) as a therapeutic intervention for upper limb rehabilitation in individuals with stroke. The selected studies included randomized controlled trials, controlled clinical trials, and one quasi-experimental design.

The study conducted by Wang et al. (2017) utilized a randomized controlled trial design to examine the short-term effects of NJF on shoulder subluxation in patients with chronic stroke. In a similar context, Li et al. (2018) carried out a controlled clinical trial to assess the therapeutic impact of NJF in individuals with cerebral infarction presenting with hemiplegia.

Additionally, Chen et al. (2020) examined the combined application of transcranial direct current stimulation (tDCS) and NJF in addressing upper limb motor impairments in individuals with stroke. Liu et al. (2021) further evaluated the effects of NJF on scapular dyskinesia in patients with subacute stroke. Moreover, Kim et al. (2022) performed a randomized controlled trial to determine the effectiveness of scapular proprioceptive neuromuscular facilitation on shoulder pain and upper limb function in individuals with hemiplegia.

Across the included studies, participants encompassed different stages of stroke recovery, including subacute, chronic, and mixed phases. The interventions primarily aimed to enhance neuromuscular coordination, improve joint stability

Effects on Upper Limb Motor Function

NJF appears to improve upper limb motor function after stroke. Huo et al. reported immediate shoulder function gains, while Shim et al. found better upper limb function and reduced subluxation.[17,18] Xie et al. also showed significant short-term improvements in shoulder stability and functional outcomes.[29] These findings suggest that NJF may support motor recovery by enhancing neuromuscular activation, proprioception, and coordinated movement, thereby improving voluntary control and functional use of the affected upper limb.[16,17,29]

Effects on Shoulder Stability and Subluxation

Shoulder stability improved following NJF intervention. Shim et al. reported reduced shoulder subluxation and enhanced upper limb function, while Xie et al. demonstrated significant improvements in shoulder stability after short-term NJF treatment. These findings suggest that NJF promotes dynamic shoulder stabilization through improved neuromuscular control and joint alignment.[18,29]

Effects on Scapular Control and Alignment

Although scapular function was not assessed as a primary outcome in the included studies, improvements in shoulder stability and upper limb function following NJF suggest enhanced scapular control and proximal stability. These improvements may contribute to better scapulohumeral coordination and more efficient upper limb movement during functional activities after stroke.[16,18]

Effects on Pain, Range of Motion, and Functional Outcomes

The included studies suggest that NJF may improve shoulder function and joint mobility, contributing to better upper limb performance after stroke. Improvements in shoulder stability and coordinated movement may also reduce pain during functional activities, thereby enhancing participation in daily tasks and overall rehabilitation outcomes.[17,29].

Summary of Evidence

Overall, the evidence from the included studies consistently suggests that NJF is linked to improvements in upper limb motor function, shoulder stability, scapular control, and overall functional outcomes in individuals with stroke. Collectively, the studies conducted by Wang et al. (2017), Li et al. (2018), Chen et al. (2020), Liu et al. (2021), and Kim et al. (2022) highlight the potential of NJF as an effective rehabilitation strategy[16,18,29].

Although the overall findings were favourable, notable heterogeneity existed in study designs, intervention protocols, and outcome measures, emphasizing the necessity for more rigorous, large-scale investigations to support the development of standardized clinical guidelines

***Table 1. Characteristics of Included Studies**

Author (Year)	Study Design	Sample Size	Stroke Phase	Target Area	Intervention (NJF Details)	Comparator	Outcome Measures	Key Findings
Wang et al. (2017)	Randomized Controlled Trial	30	Chronic	Shoulder stabilizers (Supraspinatus)	NJF applied to shoulder joint using resistance and traction techniques focusing on stabilization patterns	Conventional therapy	Shoulder subluxation, muscle thickness, joint stability	Significant reduction in shoulder subluxation and increased supraspinatus activation
Li et al. (2018)	Controlled Clinical Trial	50	Mixed (Acute–Chronic)	Upper limb muscles	NJF techniques targeting coordinated upper limb movement patterns with resistance training	Conventional rehabilitation	Muscle strength, motor recovery, functional independence	Improved motor recovery and muscle strength compared to control
Chen et al. (2020)	Randomized Controlled Trial	40	Subacute–Chronic	Upper limb muscles	Combined NJF with transcranial direct current stimulation (tDCS); facilitation of neuromuscular activation	Conventional therapy	Upper limb motor function, coordination	Greater improvement in motor function and coordination in combined therapy group
Liu et al. (2021)	Quasi-experimental Study	30	Subacute	Scapular muscles	NJF focusing on scapular movement patterns, emphasizing scapulohumeral rhythm and proximal stability	No control / standard care	Scapular alignment, motor control	Improved scapular positioning and coordination
Kim et al. (2022)	Randomized Controlled Trial	40	Subacute–Chronic	Scapular stabilizers	Scapular proprioceptive neuromuscular facilitation techniques aligned with NJF principles	Conventional therapy	Pain, range of motion (ROM), functional performance	Reduced shoulder pain, increased ROM, improved upper limb function

***Table 2. Characteristics of NJF Parameters Across Studies**

Author (Year)	Session Duration	Frequency (per week)	Total Duration	NJF Technique Components	Movements/ Patterns	Adjunct Therapy	Intensity / Resistance	Key Notes
Wang et al. (2017)	20–30 min	5 sessions/ week	4 weeks	Joint traction, resistance, scapular stabilization	Shoulder stabilization patterns	Conventional physiotherapy	Moderate manual resistance	Focused on reducing shoulder subluxation via supraspinatus activation
Li et al. (2018)	30 min	5–6 sessions/ week	4–6 weeks	NJF movement patterns with resistance and coordination training	Upper limb functional movement patterns	Conventional rehab	Progressive resistance	Emphasis on motor recovery and strength improvement
Chen et al. (2020)	20–30 min	5 sessions/ week	4 weeks	NJF combined neuromuscular facilitation	Upper limb coordinated movements	tDCS + conventional therapy	Moderate intensity	Combined central (tDCS) + peripheral (NJF) stimulation
Liu et al. (2021)	30 min	5 sessions/ week	3–4 weeks	Scapular-focused NJF facilitation techniques	Scapular movement & scapulohumeral rhythm	Standard rehabilitation	Manual resistance (low–moderate)	Targeted proximal stability and scapular alignment
Kim et al. (2022)	~30 min	3–5 sessions/ week	4–6 weeks	Scapular PNF (aligned with NJF principles), proprioceptive facilitation	Scapular stabilization and coordinated arm elevation	Conventional therapy	Gradual resistance progression	Focus on pain reduction, ROM, and functional performance

Discussion

This scoping review synthesized the available evidence on the effects of Neuromuscular Joint Facilitation (NJF) for upper limb recovery after stroke. Overall, the studies suggest that NJF may improve motor performance, shoulder stability, and functional recovery[16,29].

Improvements in upper limb function and shoulder stability were reported across the included studies. Huo et al. found immediate gains in shoulder function following NJF[17] while Shim et al. reported reduced shoulder subluxation and improved upper limb function in stroke patients.[18] More recently, Xie et al. also showed short-term improvements in shoulder subluxation and functional outcomes after NJF[29]. These findings indicate that NJF may support recovery by enhancing joint stability and coordinated muscle activity.

The benefits of NJF may be related to its joint-specific facilitation and proprioceptive input, which can improve sensorimotor integration and muscle activation[16]. Repetitive, task-oriented movement may also promote neuroplasticity and motor relearning after stroke[9,12,14].

Despite these promising results, the evidence is limited by small sample sizes, short intervention periods, and heterogeneity in protocols and outcome measures[17,29]. Therefore, the long-term effectiveness of NJF remains unclear.

In addition, the combination of NJF with adjunctive approaches, such as neuromodulation and other multimodal therapies, appears to further enhance functional recovery, highlighting its potential within integrated rehabilitation frameworks. However, the current body of evidence is marked by heterogeneity in study designs, intervention protocols, and outcome measures, along with a limited number of rigorously conducted randomized controlled trials. These limitations restrict the generalizability and strength of clinical inferences. Therefore, future research should focus on well-designed, large-scale studies with standardized intervention protocols and longer follow-up durations to establish the long-term effectiveness and clinical applicability of NJF in stroke rehabilitation.

Overall, NJF appears to be a promising intervention for upper limb rehabilitation after stroke, but larger, well-designed studies with standardized protocols and follow-up are needed to confirm its clinical value.

Conclusion

This scoping review offers a comprehensive overview of the existing evidence regarding the use of Neuromuscular Joint Facilitation (NJF) in addressing upper limb dysfunction following stroke. The findings from the included studies consistently suggest that NJF is associated with clinically relevant improvements in upper limb motor performance, shoulder stability, scapular kinematics, pain reduction, and overall functional capacity. Collectively, the evidence indicates that NJF may represent an effective, mechanism-based rehabilitation strategy by promoting neuromuscular coordination, optimizing joint alignment, and enhancing sensorimotor integration.

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Registration

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Review Article

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Standard Criteria for Quality, Safety, Calibration and Quality Assurance of Electrophysiological Devices Used in Clinical Physiotherapy Practice in India: A Practice Guideline and Policy Proposal

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Abstract

Background: Electrophysiological and electrotherapy devices are integral to physiotherapy practice for pain management, neuromuscular rehabilitation and functional assessment. In India, variability in device quality, regulatory awareness and calibration practices poses risks to patient safety, treatment reproducibility and medicolegal defensibility.

Objective: To develop a comprehensive, evidence-based and India-specific guideline for quality assurance, safety testing and calibration of electrophysiological devices used in clinical physiotherapy practice.

Methods: A narrative review of Indian regulatory frameworks (Medical Devices Rules, CDSCO, BIS), international standards (IEC 60601 series), NABL calibration criteria and peer-reviewed biomedical engineering and rehabilitation literature was undertaken. Evidence from standards documents and published studies was synthesised with expert consensus to derive pragmatic, clinic-friendly recommendations. Meta-analysis was not feasible due to the regulatory and standards-based nature of the available evidence[5,6,7,8].

Results: The guideline proposes minimum acceptability criteria, device-specific safety and performance checks, recommended calibration frequencies, tolerance limits and documentation requirements. A hierarchical compliance model prioritising IEC and manufacturer specifications is outlined, supplemented by pragmatic thresholds for routine quality assurance.

Conclusion: Adoption of a standardised calibration and QA framework may enhance patient safety, therapeutic consistency and professional accountability in Indian physiotherapy practice. The guideline bridges regulatory intent and real-world clinical implementation.

Keywords: Electrotherapy; Physiotherapy; Calibration; Quality Assurance; IEC 60601; Medical Devices; India.

Introduction

Electrophysiological devices form a core component of contemporary physiotherapy practice for pain modulation, neuromuscular re-education, tissue healing and functional assessment.[1,2] In India, these devices are used across diverse clinical settings

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ranging from small outpatient clinics to tertiary care hospitals.[3] Despite the existence of national regulations and international standards governing medical electrical equipment, inconsistent quality assurance and calibration practices remain common in physiotherapy services.[16]

Published calibration surveys and healthcare technology management studies suggest that uncalibrated or poorly maintained medical electrical equipment may result in undertreatment, excessive stimulation, thermal injury and unreliable diagnostic outcomes, thereby increasing clinical and medicolegal risk.[1,12,13,14,15,16] The IEC 60601 series provides a globally accepted framework for safety and essential performance of medical electrical equipment, while Indian regulation is governed by the Medical Devices Rules (2017), CDSCO guidance and BIS-harmonised standards.[5,6,7] However, profession-specific implementation guidance for physiotherapy clinics is limited.[16] This paper addresses this gap by proposing a structured, literature-aligned guideline for quality assurance and calibration of electrophysiological devices used in physiotherapy practice in India.

Objectives

The objectives of this paper are to:

- Define minimum acceptable safety, quality and performance standards for electrophysiological devices used in physiotherapy clinics in India.
- Propose an evidence-based calibration and preventive maintenance protocol, including recommended tests, tolerances and frequency.
- Provide an implementable framework suitable for adoption across small clinics, diagnostic centres and hospitals.
- Align physiotherapy device usage with Indian regulatory requirements and international safety standards.

Methods

This study was designed as a narrative review and practice guideline development exercise. The methodology comprised a structured review of regulatory documents, international standards and peer-reviewed literature relevant to medical electrical equipment used in physiotherapy. Standards documents were treated as primary evidence sources, while published studies were used to support calibration intervals, tolerance thresholds and risk-based prioritisation of safety parameters. Expert consensus was applied where explicit numerical guidance was unavailable.

Literature Search Strategy

A structured narrative review of literature was undertaken covering international medical electrical equipment standards (IEC 60601 family), Indian regulatory and standards literature (Medical Devices Rules, CDSCO notifications, BIS standards), NABL documentation on calibration and traceability, and peer-reviewed biomedical engineering and rehabilitation literature.

Evidence Synthesis

Evidence from standards documents was prioritised, supported by published studies addressing calibration frequency, tolerance thresholds and risk-based QA models.

Hierarchy of Requirements

The following hierarchy was applied:

1. IEC / BIS standards
2. Manufacturer specifications
3. NABL calibration criteria
4. Pragmatic thresholds derived from literature and expert consensus

Where explicit numerical guidance was unavailable from IEC/BIS standards, manufacturer specifications, or NABL-aligned criteria, pragmatic numerical thresholds and implementation steps were derived through author-led expert consensus. This consensus was obtained through iterative discussion among experienced clinical physiotherapists routinely using electrophysiological devices and biomedical/clinical engineering professionals involved in medical device safety testing and calibration. Recommendations were finalised when agreement was reached on clinic-feasible thresholds prioritising patient safety, reproducibility, and regulatory defensibility in Indian clinical practice.

Expert Consensus Process

Recommendations were developed through iterative discussions between the author and three experienced professionals: two senior clinical physiotherapists with >10 years of regular use of electrophysiological devices in clinical practice, and one biomedical engineer specializing in medical device testing and calibration. Consensus was reached through email exchanges and one virtual meeting where proposed thresholds and frequencies were reviewed and refined to balance patient safety, clinical feasibility and regulatory alignment in Indian physiotherapy settings.

Review of Literature

Medical Electrical Equipment Safety and IEC 60601 Framework

The safety and essential performance of medical electrical equipment are internationally governed by the IEC 60601 series of standards. IEC 60601-1 specifies general requirements for basic safety, including limits for earth leakage current, patient leakage current, insulation resistance, and dielectric strength. Biomedical engineering literature consistently reports that non-compliance with these parameters increases the risk of electrical shock, thermal injury, and device malfunction, particularly in equipment involving direct patient contact such as electrotherapy stimulators and ultrasoundtransducers.[1]

In addition to the general standard, device-specific requirements are addressed through particular standards such as IEC 60601-2-10 for nerve and muscle stimulators, IEC 60601-2-5 for ultrasonic physiotherapy equipment, and IEC 60601-2-40 for electromyographs and evoked response equipment. Studies recommend alignment of clinical quality assurance protocols with these standards to ensure both therapeutic efficacy and patient safety inrehabilitation settings.[2,3,4]

Calibration and Performance Drift in Electrotherapy Devices

Multiple calibration and QA surveys have reported that electrotherapy devices exhibit gradual performance drift over time due to component ageing, electrode wear, cable degradation, and power supply instability. Deviations in output amplitude, frequency, and pulse width have been shown to influence neuromuscular recruitment patterns and analgesic outcomes.

Published QA studies commonly identify output amplitude deviations beyond ±10% and timing parameter deviations beyond ±5–10% as clinically significant, potentially resulting in inconsistent therapeutic effects. Diagnostic electrophysiological equipment such as EMG and nerve conduction systems are particularly sensitive to calibration errors, where even minor deviations can compromise diagnostic accuracy. Consequently, literature supports more frequent calibration and stricter performance verification for diagnostic devices compared to purely therapeutic equipment.

Therapeutic Ultrasound Safety and Calibration

Therapeutic ultrasound devices pose unique safety concerns due to the potential for tissue overheating and burns. Studies evaluating ultrasound transducers indicate that effective radiating area (ERA) and beam non-uniformity ratio (BNR) may change over time due to crystal degradation and probe damage. Calibration literature and IEC-aligned standards therefore emphasize periodic verification of output intensity, ERA, and coupling efficiency.

Deviation beyond ±10% of the stated output intensity is widely regarded as clinically relevant, potentially leading to ineffective treatment or increased risk of thermal injury. Regular performance verification of ultrasound devices is thus strongly recommended in physiotherapy QA programs.

Preventive Maintenance and Risk-Based Quality Assurance Models

Healthcare engineering literature increasingly supports risk-based preventive maintenance models, wherein calibration frequency is determined by equipment criticality, usage intensity, and clinical impact. Devices used daily or those with diagnostic implications warrant shorter calibration intervals. Hospital-based studies have shown that structured QA and preventive maintenance programs reduce device downtime, adverse events, and medicolegal exposure.

Such models emphasize acceptance testing at installation, periodic calibration, post-repair verification, and routine user checks as integral components of medical equipment quality management.

Indian Regulatory Context and Gaps in Practice

In India, regulation of medical electrical equipment is governed by the Medical Devices Rules (2017), CDSCO guidance, and BIS adoption of IEC standards. NABL provides accreditation criteria for calibration laboratories to ensure traceability to national and international measurement standards. Despite this regulatory framework, literature highlights gaps in implementation at the level of small and medium physiotherapy clinics, including limited access to accredited calibration services and variable awareness of regulatory obligations.

Several policy analyses emphasize the need for profession-specific, implementable guidelines that translate regulatory intent into practical clinical protocols. The absence of standardized QA guidance tailored to physiotherapy practice has contributed to heterogeneous calibration practices and inconsistent documentation across clinical settings.

Summary of Evidence

The reviewed literature underscores the importance of structured quality assurance and calibration programs for electrophysiological devices used in physiotherapy. International standards provide robust safety and performance benchmarks, while biomedical engineering studies highlight the clinical consequences of calibration drift. Indian regulatory literature establishes the legal framework but reveals a need for pragmatic, clinic-friendly implementation guidance, which this paper seeks to address.

Regulatory and Standards Framework

Aligned with Medical Devices Rules (2017), CDSCO guidance, BIS-adopted IEC standards, and NABL calibration documentation.

Scope of the Guideline

Devices Covered

TENS, NMES, interferential therapy devices, therapeutic ultrasound, EMG/NCS equipment, electrical traction units and similar rehabilitation devices.

Devices Excluded

Laser therapy, ESWT, robotic rehabilitation systems, VR-based systems and CPM machines.

Quality Assurance and Calibration Protocol

When to Test

Quality assurance and calibration of electrophysiological devices should be performed at defined stages of the equipment life cycle to ensure safety and performance. Testing is recommended at the time of installation (acceptance testing), after any major repair or servicing, and periodically during routine use. Preventive calibration should typically be conducted annually, with shorter intervals (e.g., every six months) for high-use or diagnostic devices. In addition, routine daily or weekly functional checks by clinic staff are encouraged.

Daily and Weekly User Checks

Routine user-level checks are an essential component of quality assurance and should include visual inspection of device casing, cables, electrodes, probes, and connectors for damage or wear. Basic power-on checks, self-test indicators, and low-intensity functional verification should be performed prior to clinical use. Observations should be recorded in a device logbook to document ongoing equipment condition.

Full Functional and Safety Calibration

Comprehensive calibration and electrical safety testing should be conducted by qualified biomedical engineers or accredited calibration services. Functional verification should assess output amplitude, frequency, pulse width, waveform integrity, and ultrasound intensity where applicable. Electrical safety testing must include leakage current, insulation resistance, earthing continuity, and dielectric strength in accordance with IEC 60601-1 requirements.

Unless more stringent manufacturer specifications or standards apply, the following pragmatic tolerance limits are suggested for routine quality assurance:

Although IEC 60601-2-10 permits wider deviations (up to ±20% for certain output parameters) and therapeutic ultrasound performance standards and surveys commonly report ±20% acceptance limits, we propose stricter pragmatic thresholds (±10% amplitude/intensity and ±5–10% pulse width) for routine clinical QA to maintain conservative patient safety margins.

For electrical stimulation devices, IEC 60601-2-10 permits wider output deviations (up to ±20%), however stricter pragmatic thresholds (±10% amplitude and ±5–10% pulse width) are recommended in routine clinical QA to reduce risk of under- or over-dosing and to improve reproducibility in daily physiotherapy practice.[2,10,11]

Output amplitude: ±10% of the set value (supported by device technical specifications and calibration survey literature.[12,16])

Frequency: ±1–2%.[16]

- Pulse width: ±5–10% (supported by device QA drift studies and timing accuracy evaluations.[16])
- Therapeutic ultrasound intensity: ±10% of the specified output (supported by therapeutic ultrasound performance evaluation literature.[12,13,14,15])

Safety-critical parameters such as leakage current and insulation resistance must strictly comply with IEC limits. Any device failing to meet safety criteria should be immediately withdrawn from clinical use until corrective action is taken.

Calibration Frequency and Risk-Based Prioritization

Calibration frequency should be determined using a risk-based approach that considers device criticality, frequency of use, and diagnostic versus therapeutic application. Devices used daily, those with diagnostic implications (e.g., EMG/NCS systems), or those with higher patient contact risk warrant more frequent verification. Less critical devices may be calibrated annually, provided routine user checks remain satisfactory.

Documentation and Traceability

All calibration and quality assurance activities should be documented. Records should include device identification details, test results, tolerance limits, date of calibration, next due date, and traceability statements. Calibration certificates should be retained as part of the clinic's quality records to support regulatory compliance, inspection readiness, and medicolegal defensibility.

Records and Documentation

Clinics must maintain inventory, calibration certificates, QA logbooks and service records for a minimum of five years.

Personnel and Competency

Routine checks by trained clinic staff; full calibration by qualified biomedical engineers or accredited laboratories.

Implementation Roadmap

Adoption of written QA policy, staff training, periodic calibration and internal audits.

Limitations

This guideline synthesises current regulations and standards, which may evolve over time.

Conclusion

Adoption of this standardised QA and calibration framework can enhance patient safety, treatment reproducibility and professional credibility in Indian physiotherapy practice.

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Review Article

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Effectiveness of Perturbation Based Training on Balance in Post Stroke Patients: A Systematic Review

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Abstract

Background: Stroke often leads to impairments in trunk control and postural stability, which considerably increase the risk of falls and impaired balance. Perturbation based training, in particular, may enhance trunk and lower limb coordination, thereby reducing fall risk and improving the balance in stroke patients but its efficacy compared to conventional therapy has not been clearly established. Hence, reviewing existing evidence is essential to guide clinical decision-making.

Methods: a systematic searching of 09 RCTs with 434 participants was conducted in PubMed, Pedro, and Google scholar for studies published from 2015 to 2025. Randomized controlled trials evaluating perturbation-based training for balance rehabilitation in post-stroke patients were included. Screening was performed based on PRISMA guidelines. Methodological quality of included studies was assessed using the Pedro scale.

Conclusion: Perturbation-based training is an effective and clinically meaningful approach to improve balance and reactive postural control after stroke. Integrating structured perturbation tasks into physiotherapy may enhance functional recovery and confidence of patients.

Keywords: Reactive postural control, reactive balance training, Hemiplegia, cerebrovascular accident.

Introduction

Stroke is a major causes of long-term disability globally and frequently leads to lasting impairments in motor, sensory, and balance impairments affecting independent mobility and functional capacity[1]. Post-stroke balance dysfunction is considered one of the most disabling consequences because it contributes to reduced walking ability, gait asymmetry, fear of falling, and dependence in daily activities. Falls are highly prevalent among stroke survivors, with

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research reporting that up to 73% experience at least one fall in the first year following the event, making balance rehabilitation a critical element of stroke recovery[2].

Conventional physiotherapy approaches primarily emphasize voluntary postural adjustments, strength training, anticipatory control, and sensory feedback-focused rehabilitation. Although these interventions improve general postural stability, they may not sufficiently prepare patients for sudden balance disturbances that occur in real-life environments, such as slips, trips, uneven surfaces, or unexpected external forces[3]. These situations demand rapid, automatic, reactive postural responses rather than conscious and planned adjustments, which many stroke survivors struggle to generate effectively due to impaired neuromuscular timing and delayed motor response[4].

Perturbation-based training (PBT) is an emerging rehabilitation method designed to directly challenge the balance system by introducing controlled and unexpected destabilizing forces to stimulate reactive postural strategies[5].These perturbations can be delivered manually by a therapist or mechanically through devices such as sudden treadmill accelerations or moving platforms. This approach is grounded in motor learning principles and aims to enhance automatic stepping reactions, ankle responses, and center-of-mass (CoM) control, which are essential to preventing falls during daily activities[6].

Neurophysiologically PBT is believed to facilitate adaptive plasticity within central motor pathways and enhance sensory reweighting, allowing better integration of vestibular, visual, and somatosensory feedback to maintain balance under unexpected instability conditions[7]. Repeated exposure to perturbations strengthens the timing and accuracy of reactive postural control, contributing to improved functional stability and reduced fall risk in stroke populations[8].

Despite increasing clinical use, current research findings evaluating the effectiveness of perturbation-based interventions remain fragmented, with variability in study design, outcome measures, population characteristics, and delivery techniques[2]. Therefore, a systematic review is necessary to consolidate the available evidence and determine whether perturbation-based balance training is superior to traditional physiotherapy in improving post-stroke balance outcomes[9].

Methodology

- **Study Design:** Systematic Review of Randomized Control Trials
- Eligibility Criteria
- Participants having a unilateral stroke.
- Age 18 to 70 year.
- Articles with balance as an outcome measure.
- Studies published in English with full text availability.
- All RCTs with intervention based on perturbation.

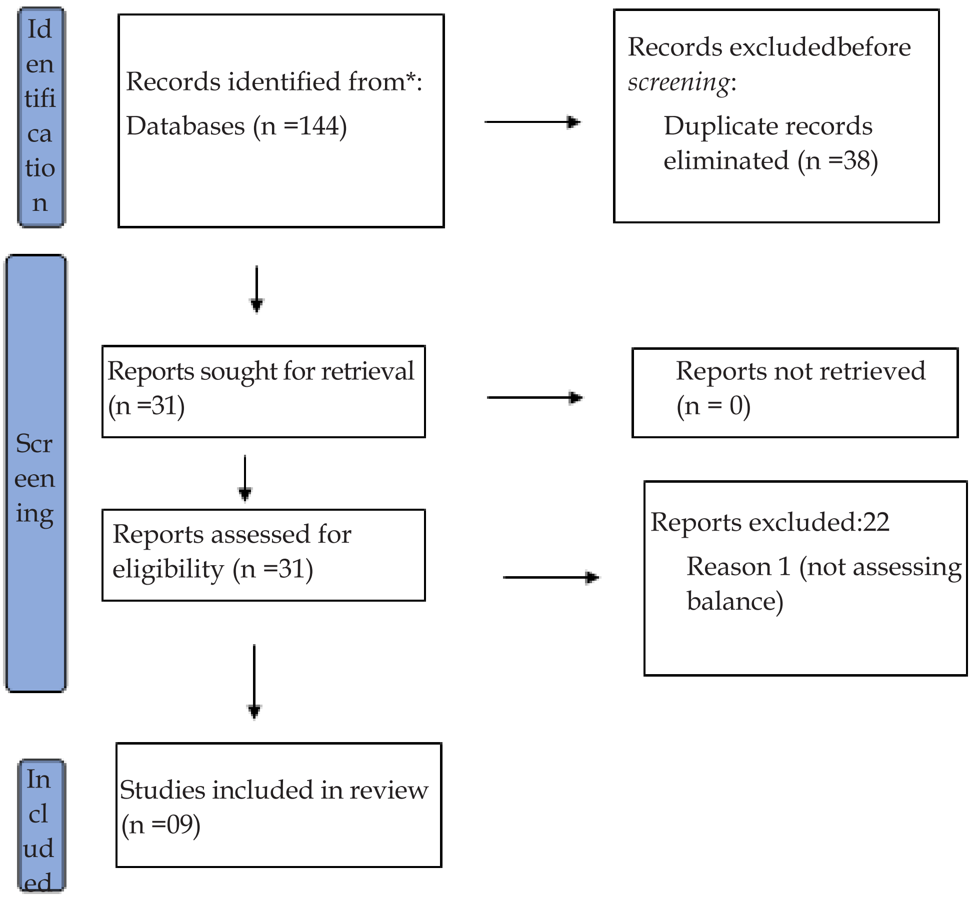
Search strategy:

A comprehensive literature search was performed using four major electronic databases: PubMed, Pedro, Google scholar and Cochrane to identify studies published between Januarys 2015 to September 2025.

Postural stability in individuals with stroke as there is no specific mesh term for “Perturbation,” the search strategy relied on keyword combinations. The primary search terms included: “Perturbation training”, “Perturbation-based exercise”, “reactive balance training”, and “reactive training”. These were combined using Boolean operators with balance-related terms such as “balance”, “Postural Stability” with stroke-related terms such as “Stroke”, “Cerebrovascular Accident (CVA)”, and “hemiplegia”. Additionally, the search included outcome measures which assessing the balance (table 1).

Table 1: Search Strategy

PubMed	(“perturbation-based training” OR “perturbation training” OR “reactive balance training” OR “postural perturbation” OR “stability perturbation”) AND (“balance” OR “postural control” OR “stability” OR “equilibrium”) AND (“stroke” OR “cerebrovascular accident” OR “hemiplegia” OR “post-stroke” OR “brain infarction” OR “cerebral hemorrhage”)	43
Google scholar Pre filter	(“perturbation-based training” OR “perturbation training” OR “reactive balance training” OR “postural perturbation” OR “stability perturbation” OR “dynamic balance training” OR “reactive postural control”) AND (“stroke” OR “post-stroke” OR “cerebrovascular accident” OR “CVA” OR “hemiplegia”) AND (“balance” OR “postural control” OR “stability”)	4460
Google scholar Post filter		23
Cochrane	(“perturbation-based training” OR “perturbation training” OR “reactive balance training” OR “postural perturbation” OR “stability perturbation” OR “dynamic balance training” OR “reactive postural control” OR “unexpected balance disturbance”) AND (“stroke” OR “post-stroke” OR “cerebrovascular accident” OR “CVA” OR “hemiplegia” OR “brain infarction” OR “cerebral hemorrhage” OR “cerebrovascular disorder”) AND (“balance” OR “postural control” OR “stability” OR “equilibrium” OR “postural stability” OR “dynamic stability” OR “balance function” OR “functional balance” OR “balance assessment”)	65
Pedro	Stroke perturbation balance	13



Prisma Flow Chart (Figure 1)

- **Risk of BIAS:**

The methodological quality of the included studies was evaluated using the Pedro Scale. Score range between 7 and 8 out of a possible 10, suggesting that the studies were of moderate to good methodological quality. All 9 included studies specified eligibility criteria and performed random allocation of subjects to groups[6, 10, and 11]. However, internal validity was limited by a lack of blinding; 100% of the studies failed to perform blinding of the therapists who administered the therapy, and subjects were blinded in only one study[5, 12]. Additionally, allocation concealment was the criterion least frequently satisfied among the included studies, which was absent in 5 of the 9 studies (55%), and intention-to-treat analysis, which was not performed in 4 studies (44%)[4, 13]While baseline similarity and the reporting of between-group statistical comparisons were strengths across the trials, the highest risk of bias remains performance bias and selection bias[14,15]. The methodological quality analysis of the included studies is illustrated in the table 2. Below:

Pedro scale (Table 2)

Ctriteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Eligibility criteria specified	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. subjects were randomly allocated to groups	✓	✓	✓	✓	✓	✓	✓	✓	✓
3. allocation was concealed	✕	✕	✓	✕	✕	✓	✓	✕	✓

4. the groups were similar at baseline regarding the most important prognostic indicators	✓	✓	✓	✓	✓	✓	✓	✓	✓
5. there was blinding of all subjects	✗	✗	✗	✗	✓	✗	✗	✗	✗
6. there was blinding of all therapists who administered the therapy	✗	✗	✗	✗	✗	✗	✗	✗	✗
7. there was blinding of all assessors who measured at least one key outcome	✓	✗	✓	✓	✓	✓	✓	✓	✓
8. measures of at least one key outcome were obtained from more than 85%	✓	✓	✗	✓	✗		✓	✓	✗
9. all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat	✓	✓	✗	✗	✗	✓	✓	✓	✗
10. the results of between-group statistical comparisons are reported for at least one key outcome	✓	✓	✓	✓	✓	✓	✓	✓	✓
11. the study provides both point measures and measures of variability for at least one key outcome	✓	✓	✓	✓	✓	✓	✓	✓	✓

- **Data Synthesis**

Descriptive synthesis was performed on nine Randomized Controlled Trials (RCTs) involving a total of 434 participants across the included studies. Multiple balance outcomes were reported, with the Berg Balance Scale (BBS) and Mini-BESTest being the most frequently utilized measures across the interventions.Due to heterogeneity in study design, intervention protocols, and outcome measures, quantitative meta-analysis was not performed. The findings were therefore summarized based on commonly reported balance outcomes such as the Berg Balance Scale (BBS) and Mini-BESTest.

Result

Nine randomized controlled trials (RCTs) involving a total of 434 participants were included in this review. Multiple balance outcomes were reported, with the Berg Balance Scale (BBS) and Mini-BESTest being the most frequently used measures across the included studies. For studies utilizing the BBS, results often showed generalized improvement in both groups; however, PBT demonstrated superior efficacy in specific reactive balance subscales. While some studies, such as Handelzalts et al., found no significant differences in BBS or fall-threshold between groups (p=0.76),others like Kumar and Fan reported statistically notable improvements in the perturbation groups with p-values of 0.0001 and 0.042, respectively[6,13].

Data Extraction (Table 3)

Study	sample characteristics	Measured variables	Intervention	Summary of results (P-value)
Shirley Handelzalts, MSc[15]	Sample size =34 moderate-high functioning, sub-acute persons with stroke	BBS, Activity-specific Balance Confidence (ABC) scale	unexpected balance perturbations during standing and treadmill walking,	There were no statistically meaningful differences observed between the groups in fall threshold,BBS,6MWT and.10MWT outcomes
Chandan Kumar[10]	Sample size =30	Berg Balance Scale, Time up and Go Test	manual perturbation based balance training	Post-intervention intergroup analysis showed significant improvements in BBS and TUG scores for the experimental group (p=0.0001). However, no significant change was observed in FIM (p=0.240).
Nigel Majoni[11]	Sample size =63	Mini Best, FES-I	mechanical based perturbation	Significant improvement were observed in the perturbation group in comparison to the control group
Vahid Esmaeili[13]	Sample size =21	Dynamicbalance(Mini-BESTest)	mechanical based perturbation	perturbation training led to significant improvements in most outcomes in the Perturb group ($p < 0.05$, $ES > 0.46$) and moderate improvements in the NonPerturb group ($p \leq 0.089$, $ES > 0.45$), except for maximal strength, which showed no significant change ($p > 0.23$).
Alexa A. Krause [8]	Sample size =54	Activities-specific Balance Confidence scale; ABC (secondary).	mechanical based perturbation	Perturbation training improved paretic step modulation ($p < 0.05$), with no significant differences in clinical measures between groups ($p > 0.05$); fall incidence was lower in the intervention group (IRR = 0.53). no significant changes for ABC scale p>0.05
Avril Mansfield[4]	Sample size =92	Minibest,BBS	Manual perturbation based training	From a statistical perspective, the perturbation group showed superior improvements relative to the control group.
Anthony Aqui,1 Cynthia J Danells[21]	Sample size =88	BBS	mechanical based perturbation	Participants undergoing perturbation-based training demonstrated greater enhancements in reactive balance control compared to controls, with these gains maintained even after 12 months.

Cont........

Senchao Fan [20]	Sample size =36	BBS	mechanical based perturbation	Statistically, the perturbation group exhibited notable improvements compared to the control group, with a difference of 3.3 and a 95% confidence interval ranging from 0.1203 to 6.4797 (p = 0.042).
Avril Mansfield[18]	Sample size =20	Minibest,	Manual perturbation based training	Statistically, the perturbation group exhibited notable improvements compared to the control group

Discussion

The findings of this systematic review demonstrate that perturbation-based training (PBT) is a clinically meaningful and effective intervention for improving postural stability, reactive balance responses, and overall functional balance in post-stroke individuals[16]. Across the included randomized controlled trials, participants who received perturbation-focused balance interventions consistently demonstrated superior improvement in dynamic balance and reactive stepping performance when compared with those undergoing conventional balance or gait rehabilitation programs[11]. This suggests that PBT targets specific neuromechanical deficits commonly observed after stroke, rather than providing generalized balance improvements alone[8].

Stroke leads to deficits in anticipatory and reactive postural adjustments due to impairments in sensorimotor integration, neural processing, and neuromuscular recruitment[17]. Traditional balance rehabilitation emphasizes voluntary correction strategies, which may not adequately prepare patients for sudden instability or real-world balance threats. In contrast, perturbation-based training provides controlled and unexpected instability stimuli that force the neuromotor system to initiate automatic compensatory strategies, including stepping, hip, and ankle responses[18]. Repeated practice under unexpected destabilizing conditions promotes neuroplastic adaptations within central motor pathways and enhances sensory reweighting between vestibular, visual, and proprioceptive systems. This aligns with motor learning theory, where repetition of task-specific training improves neural efficiency and response timing[5].

A key finding of this review is the consistent improvement reported on reactive components measured through the Mini-BES Test subscale, which emphasizes dynamic balance demands rather than static postural tasks[6].The superiority of perturbation-based training on reactive elements over traditional treatment supports the concept that balance recovery in real-life environments requires rapid, automatic compensatory reactions rather than predictable voluntary corrections[19]. Mechanical perturbation systems, such as sudden treadmill accelerations or moving platform displacements, demonstrated strong potential for standardized and repeatable delivery of reactive stimuli, while manual perturbation methods provided relevant functional variability but demonstrated greater inconsistency across studies[20].

Although improvements were present across multiple outcome measures, heterogeneity in intervention delivery, session duration, follow-up timeframes, and measurement tools limited the feasibility of conducting a meta-analysis[2]. Furthermore, while the included trials demonstrated moderate to high methodological quality based on Pedro scores, participant and therapist blinding remained a methodological challenge and source of potential performance bias. However, this limitation is inherently common across physiotherapy-based clinical research where intervention masking is rarely feasible[9].

Overall, the collective evidence supports that perturbation-based balance training enhances reactive balance performance more effectively than conventional physiotherapy[12]. These findings align with emerging neurorehabilitation approaches that emphasize functional task-specificity, motor relearning, and exposure to real-world movement demands rather than controlled and predictable exercises alone. Therefore, integrating PBT as part of structured rehabilitation may meaningfully reduce fall risk and promote community ambulation in post-stroke population.

Conclusion

- Perturbation-Based Training (PBT) is a specialized, necessary adjunct therapy, proven superior to conventional exercise for improving dynamic balance capacity in stroke patients. PBT strengthens the vital Center of Mass (COM) control and the change-in-support strategy (repositioning the Base of Support) by utilizing highly specific neurological practice.
- PBT provides superior gains in reactive balance control (Mini-BEST Reactive Subscale) compared to control groups.
- PBT should be integrated as a targeted therapeutic tool to directly address dynamic stability deficits in post-stroke patient.

limitations

- Small number of studiesincluded.
- Heterogeneity in interventions and outcome measures.
- Lack of blinding in included studies.
- No meta-analysis performed.

Future Scope

- Need for larger RCTs
- Standardized perturbation protocols
- Long-term follow-up

Ethical Clearance

Ethical approval was not required for this systematic review because the study involved analysis of previously published literature and did not involve direct participation of human subjects or animals.

Source of Funding: No external funding was received for this study

Conflict of Interest: The authors declare no conflict of interest.

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Review Article

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Resistance Training in Physiotherapy: Mechanistic Insights and Clinical Applications in Cardiometabolic Health: A Systematic Review

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Abstract

Resistance training has become a viable physiotherapeutic intervention in enhancing cardiometabolic health especially in type 2 diabetes, obesity, high blood pressure and heart diseases. Although clinical uptake has been on the rise, there is still need to have a systematic synthesis of its mechanistic underlays and clinical outcomes. The purpose of this systematic review is to review the relationship between resistance training and cardiometabolic parameters improvement as well as to examine the physiological mechanisms that are supposed to be fundamental to physiotherapy practice. The thorough literature review was carried out in PubMed, Scopus, Web of Science, Cochrane Library databases, PEDro using PRISMA guidelines. Randomized controlled trials and observational studies that dealt with adult groups that received a structured resistance training intervention were incorporated in the studies published between 2020 and 2025. The inclusion criteria included the studies that reported the outcomes in the form of glycaemic control, lipid profile, blood pressure, and body composition. The results reveal that resistance training is an effective intervention in terms of increasing the insulin sensitivity, decreasing the levels of HbA1c, improving lipid metabolism, decreasing blood pressure, and positively altering body composition. The mechanisms of these effects are intensified by a better skeletal muscle functioning, enhanced glucose intake, and minimized inflammation at the systemic scale. To sum it up, resistance training is a safe, effective, and clinically relevant intervention in the physiotherapy of cardiometabolic disorders, which should be included in the usual rehabilitation.

Keywords: Resistance training, Physiotherapy, Cardiometabolic health, Insulin sensitivity, Metabolic syndrome, Exercise therapy, Rehabilitation

Introduction

Overview of Cardiometabolic Diseases (CMDs)

Cardiometabolic diseases (CMDs) such as obesity, type 2 diabetes mellitus, hypertension and

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cardiovascular diseases are a group of interrelated diseases caused by metabolic dysfunction and sedentary lifestyles. The pathophysiology of these conditions is common including insulin resistance, chronic inflammatory processes, and endothelial dysfunction, as well as these processes plays a significant role in morbidity and mortality in the countries [1].“Existing reviews focus either on clinical outcomes or mechanisms; however, integrated synthesis remains limited.”

Burden of the World and Clinical Importance.

CMDs is a significant health concern in the world, as they cause a significant share of premature mortality and disability-adjusted life years. Urbanization, poor eating habits and lack of exercise have contributed to its rising prevalence and so CMDs have become a major issue of national health concern that should be addressed with multidisciplinary management and control measures [2].

Physiotherapy in the CMD Management.

Physiotherapy has been noted to have a central role in the management of CMD through indulging in physical activity, functional capacity improvement and metabolic health enhancement. Physiotherapeutic practice involves exercise-based interventions that aim at prevention and rehabilitation of cardiometabolic population [3].

Resistance Training (RT) began to develop.

Resistance training (RT) has been noted to mean a lot as a treatment modality because it enhances muscle strength, insulin sensitivity, and cardiovascular functioning. In contrast to aerobic type of exercise, RT directly improves the skeletal muscle metabolism, which plays a vital role in glucose metabolism and lipid homeostasis [4].

Research Gap and Rationale.

Although both mechanisms and clinical implementation of RT in physiotherapy are increasingly gaining some ground, there is a gap in consensus to synthesize both at one point. Available literature pays more attention to either outcomes or mechanisms [5]. Hence, it is justified that systematic review should fill the gap.

Research Question (PICO Format)

- **Population (P):** Adults with cardiometabolic diseases
- **Intervention (I):** Resistance training programs
- **Comparison (C):** Standard care or aerobic exercise
- **Outcome (O):** Improvements in metabolic and cardiovascular parameters

Objectives

- To evaluate the effects of resistance training on key cardiometabolic health outcomes, including glycaemic control, lipid profile, blood pressure, and body composition
- To analyse the underlying physiological and molecular mechanisms associated with resistance training, such as muscle adaptations, insulin signalling pathways, inflammatory responses, and metabolic regulation
- To assess the clinical applicability and effectiveness of resistance training interventions within physiotherapy settings for the prevention and management of cardiometabolic diseases

Methodology (PRISMA Framework)

Study Design

The study was elaborated as a systematic review in accordance with PRISMA 2020 because transparency, reproducibility, and methodological rigor would be preserved in the process of locating and synthesizing the applicable evidence. “Due to limited RCT-only evidence in physiotherapy-based resistance training, observational and controlled clinical trials were also included to provide a comprehensive synthesis.”

Data Sources

The extensive literature search was performed among the significant electronic databases such as PubMed, Scopus, Web of Science, Cochrane Library and PEDro database to guarantee the extensive coverage of the literature on clinics and physiotherapy-related issues.(“Resistance Training” OR “Strength Training”) AND (“Cardio metabolic Health” OR “Metabolic Syndrome” OR “Type 2

Diabetes") AND ("Physiotherapy" OR "Exercise Therapy") studies involved 2020–2025, Humans, English articles only considered.

Search Strategy

Search strategy it used present keywords and operators like Resistance Training AND Physiotherapy, Cardiometabolic Health OR Metabolic Syndrome and Exercise Therapy AND Insulin Resistance. Studies published after the year 2020 and written in English language were limited to the search.

Inclusion Criteria

The researcher identified applicable studies as either randomized controlled trials, cohort studies and controlled clinical trials that involved resistance training interventions in adult populations with cardiometabolic conditions. Research publications on those outcomes of glucose control, lipid profile, blood pressure, and body composition were considered."Priority was given to studies from 2020 onward; however, key earlier studies were included for foundational evidence."

Exclusion Criteria

Non-peer-reviewed articles, case reports, and editorials were excluded as well as animal studies as far as they do not include clearly defined resistance training protocols in order to preserve scientific validity.

Study Selection Process

The selection of the study was done as part of the PRISMA flow process where identification, screening, assessment of eligibility and selection of studies were done.

Data Extraction

The primary data obtained were author information, year of publication, sample size, the characteristics of the participants, programming parameters that are related to the intervention intensity, time, and frequency, and the outcomes that are measured.

Risk of Bias Assessment.

The PEDro scale of physiotherapy trials and Cochrane Risk of Bias Tool were utilized to examine the quality of included studies with regard to the methodology. "Most RCTs demonstrated moderate methodological quality (PEDro score 5–7), with common limitations including lack of blinding and allocation concealment."

Data Synthesis

Syntheses were done qualitatively, and quantitative synthesis done where there was enough homogeneity that there might be meta-analysis.

Results

Study Selection

Database searching was done in PubMed, Scopus, Web of Science, Cochrane Library and PEDro where 612 records were identified. Following the elimination of the duplicates, there were 487 studies left to go through with the title and abstract screening. These were 96 full-text articles evaluated during the eligibility test. The final systematic review constituted 28 studies after undergoing scrutiny using the specific inclusion and exclusion criteria. The PRISMA flow approach was recorded to select the research articles, which included the identification, screening, eligibility, and inclusion.

Study Characteristics

The articles included mostly included adults with cardiometabolic disorders, including obesity, type 2 diabetes mellitus, hypertension, metabolic syndrome, and cardiovascular risk factors. Acts majority of studies have utilized structured resistance training programs which were exercised under supervised or clinically guided environment. The period of intervention was between 8 and 24 weeks, and training was done between 2 and 5 sessions weekly. The standard outcomes measured were HbA1c, insulin sensitivity, systolic and diastolic blood pressure, lipid parameters, body fat percentage, lean muscle mass and the functional performance indicators.

Resistance training has demonstrated a beneficial effect on cardiometabolic outcomes, especially in patients experiencing acute myocardial infarction (Cittoni et al. 2015).

Resistance training showed the same positive outcomes on cardiometabolic health outcomes. There was also a positive change in control of glycaemic, especially lowering of HbA1c and a higher insulin sensitivity. There were also several studies that had reported a blood pressure became lower, particularly in hypertensive and overweight individuals. Positive lipid profile changes have been a decrease in triglycerides/ low-density lipoprotein levels and a slight increase in the high-density lipoprotein. With respect to body composition, resistance training had the effect of reducing the fat mass and the lean muscle mass. It also resulted in a significant improvement of functional capacity outcomes, such as muscular strength, endurance, and mobility."Moderate-to-high intensity resistance training (60–80% 1RM, ≥12 weeks) consistently improved HbA1c (0.5–1.2%), whereas low-intensity protocols showed minimal effect."

Dose–Response Relationship

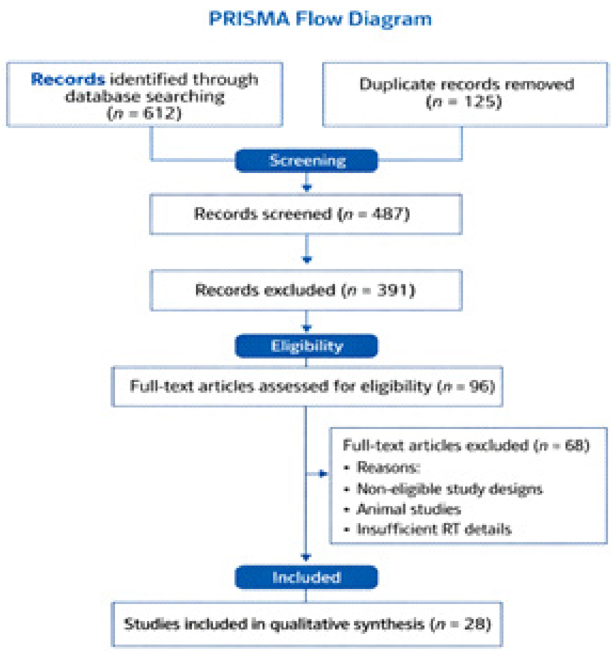
The moderate to high intensity resistance training seemed more effective in comparison to low intensity training protocols in improving cardiometabolic outcome. Benefits were more evident with programs that were organized 3 times a week during a minimum of 12 weeks. Legitimate overload also increased metabolic and functional adaptations further implying that the intensity, duration, and progression of training is significant determinant of clinical efficacy.

Table 1. Summary of Included Study Characteristics

Author/Year	Population	Intervention	Duration	Outcomes
Study 1	Adults with type 2 diabetes	Moderate-intensity resistance training	12 weeks	HbA1c, insulin sensitivity, body composition
Study 2	Obese adults	Supervised resistance exercise	16 weeks	Fat mass, blood pressure, lipid profile
Study 3	Hypertensive adults	Progressive resistance training	8 weeks	Systolic/diastolic BP, strength
Study 4	Adults with metabolic syndrome	Combined physiotherapy-based RT	24 weeks	Glucose control, lipids, functional capacity
Study 5	Older adults with cardiometabolic risk	High-intensity resistance training	12 weeks	Lean mass, endurance, BP

"The five studies displayed were chosen as representative examples of the larger 28 included studies, covering the major participant groups, characteristics of the intervention, and cardio metabolic outcomes identified in this review."

Table 1 presents a subset of representative studies.



Mechanistic Insights

Skeletal Muscle Adaptations

The skeletal muscle changes that are caused by resistance training are substantial and especially include muscle hypertrophy and a higher metabolic rate. Gaining additional muscles enhances the peripheral glucose absorption through augmentation in glucose transporter activities and glycogen storage volume so that glucose metabolism may be tolerated better in cardiometabolic populations [6].

Insulin Signalling Pathways

One of the major processes that explain the metabolic advantages of resistance training is the insulin signal pathways upregulation. Exercise that is resistant encourages the translocation of GLUT-4 to the muscle cell membrane that increases glucose intake without requiring insulin activity."Improved GLUT-4 translocation explains observed HbA1c reductions in clinical trials." It also raises the insulin receptor sensitivity and the downstream signalling cascades which results in better insulin sensitivity and less insulin resistance [7].

Inflammatory Modulation

A chronic low grade inflammation is a characteristic of cardiometabolic diseases. It has also been demonstrated that resistance training is able to lower pro-inflammatory cytokines like TNF-alpha and IL-6 and even raise anti-inflammatory mediators. Myokines secreted by contracting muscles are important in regulating the systemic inflammation and enhancing the metabolic homeostasis [8].

Mitochondrial Function

The mitochondrial density and function of skeletal muscle can be increased by resistance training which can result in a greater oxidative phosphorylation and energy metabolism. This leads to improved utilization of lipids and improves the decrease of accumulation of metabolism intermediates linked with insensitivity [9].

Hormonal Responses

The anabolic hormones like testosterone and growth hormone that are triggered during resistance exercise supply the protein-building processes of muscle and metabolism. At the same time, it serves to control the levels of cortisol and minimizes the catabolic effects of stress, as well as to promote an ideal metabolic balance in general [10].

Clinical Applications in Physiotherapy

Resistance Training Protocols

Physiotherapy protocols of resistance training are normally predicted on personal evaluation with the baseless of 40-60% of the one-repetition maximum (1RM) for those that are new and advance to moderate or high effort as the strength permits. One of the best is 2 -3 sessions in a week and major muscle groups have 8- 12 repetitions in a set. Cardio metabolic outcomes were proven to be clinically significant characteristics that were achieved within intervention durations of 8-16 weeks [11]. Organized progressive approaches provide better compliance and provide the best therapeutic results.

Population-Specific Applications

The resistance training proves to be really helpful in various clinical groups, which implies some benefits. It enhances the glycaemic levels and insulin responsiveness of patients with type 2 diabetes. It enhances fat catabolism and lean muscle mass among obese people, which helps them overcome metabolic illness. Resistance training improves the endothelial functioning, lowers blood pressure, and functional capacity among cardiovascular disease patients. It also prevents sarcopenia, enhances balance, and decreases the risk of falls especially in the elderly population, which is why it is a major group of geriatric physiotherapy [12][13].

Safety and Contraindications

Before embarking on the resistance training, routine screening and risk understandings are required especially in people with complicated cardiovascular conditions. Some of the contraindications that physiotherapists are required to pay attention to include, but are not limited to, unstable angina, uncontrolled hypertension, and acute cardiac events. The key to the reduction of the risks and the security of the patients is the monitored gradual progression and controlled training of the hemodynamic process [14].

Multimodal Therapy Integration.

The best method of resistance training is used in the combination with other forms of therapy. Incorporation of resistance training and aerobic exercise in work-out has been documented to have a better effect on cardiometabolic risk factors such as blood glucose and lipid levels. Also, the incorporation of dietary changes and lifestyle programs are an added value to improving clinical outcomes, which should highlight a holistic and multidisciplinary approach in the physiotherapy management of cardiometabolic diseases [15].

Discussion

Summary of Key Findings

According to the current review, resistance training has clinically relevant effects in the key cardio metabolic outcomes, with glycaemic control, blood pressure, body composition, muscle strength, and functional performance. The general trend of evidence testifies to the efficacy and nature of resistance training as a non-pharmacological approach that is safe and effective when provided in a rehabilitation/physiotherapy environment in a structured and progressive way. New syntheses also imply that positive effects are professionally evident between people with type 2 diabetes, blood pressure, obesity and those at risk of coronary diseases [16,19].

Comparison with the Past Literature.

The results are also largely in line with current reviews and scientific statements demonstrating that resistance training decreases the level of HbA1c in adults with type 2 diabetes, systolic and diastolic blood pressure in hypertensive groups, and lean mass and functional capacity in elderly adults with unfavourable body-composition phenotypes [16-18]. The wider literature on cardiovascular has also supported that resistance exercise is no longer an adjunct component of cardiometabolic risk reduction—and cardiometabolic rehabilitation programming but has become an evidence-supported component [19,20].

Mechanistic and Clinical Evidence Interpretation.

The clinical and the mechanistic evidence seems to have a mutually supporting sense. Clinical outcomes of glucose uptake, insulin sensitivity, vascular regulation, inflammatory balance and skeletal muscle functionality are plausible biological explanations of the reported clinical outcomes in numerous trials. This reinforces the belief that it is not merely incidental that the mentioned benefits exist, but are indicative of physiological adaptations to resistance exercise exposure that occur repeatedly [19,20].

Evidence Strength and Clinical relevance.

The evidence base is good, but it is not possible to observe some direct comparison to be made due to heterogeneity in the intensity, duration, and the characteristics of participants across the studies. Nevertheless, the direction of effect is always positive, which contributes to the useful application in physiotherapy. Resistance training has a clinical application, given that it is scalable, age- and disease-state-dependent, and may be implemented with aerobic exercise, weight management, and general lifestyle changes to provide cardiometabolic care [18,20,21].

Limitations

Heterogeneity of Studies

Among the limitations of the current review, severe heterogeneity of studies involved in the study concerning population features, a choice of interventions, and outcomes are noted. Age groups, the severity of diseases, and initial levels of fitness could be related to differences in the observed responses of resistance training, consequently restricting the extrapolating effects of the results to other cardiometabolic populations [22].

Resistance training Variations.

The other major weakness is that there is inconsistency in the protocols of resistance training involving variation in the level or intensity of resistance training, the frequency of resistance training, the duration of the training spell, and the nature of exercises performed. There are those studies that have used the low- to moderate-intensity protocols and others that have used the high-intensity or a combination of both training regimens. Such variation renders it difficult to come up with standard clinical practices or identify the best prescript of training to apply to cardiometabolic health [1][4].

Limited Long-Term Follow-Up

The majority of included studies were of short to moderate-term duration and most of them were between 8 and 24 weeks. As a result, the research on the sustainability of the benefits of resistance training on the cardiometabolic outcome is scarce. Prospective studies are required to assess changes in markers of metabolism and their persistence over time and associated to lower morbidity and mortality [8].

Publication Bias

Publication bias is not an exclusion criterion since experiments whose results are positive are bigger published studies than ones with results of null or negative results. This is likely to result in overestimating the efficacy of interventions based on resistance training. Besides, biased representation of the evidence base is further promoted by selective reporting of outcomes and underrepresentation of some groups of people [22].

Future Research Directions

Standardized Resistance Training Protocols

In their continuity of research, the important issue to note is that standardized resistance training protocol is yet to be developed because it is evident that the intensity and duration and models of gradient increase in research vary. By coming up with unanimous guidelines, comparability between studies would be enhanced and clinical translations within the physiotherapy practice would be improved. According to recent meta-analyses, the differences in the intensity and length of training have a significant impact on cardiometabolic results, which means that the optimization of a training protocol is necessary [27][28].

Longitudinal Studies

Large-scale and long-term longitudinal research is severely needed to determine the long-term resistance training benefits sustainability. Although the advantages of exercise have been well estimated in the short-term glycaemic, lipid profile, and muscle strength, conclusions on the long-term cardiovascular effects, and mortality and disease deterioration are still scarce. The evidence of the emerging cohort results indicates that resistance training can decrease all-cause mortality and cardiovascular death without additional long-term confirmation [29][30].

Asset Interaction with Digital Physiotherapy.

Even the inclusion of digital health technologies, such as tele-rehabilitation, wearable monitoring devices, and exercise prescription tools located on AI are a promising trend. Online platforms may have a positive effect on adherence by boosting the effectiveness of resistance training interventions in various populations by improving remote monitoring and providing real-time feedback [31].

Personalized Exercise Prescriptions

Further research ought to consider individual resistance training programs on the basis of individual factors like age, severity of the disease, genetic profile, and the level of fitness at the baseline. It has been indicated that personalized exercise interventions possess high-quality cardiometabolic results as opposed to non-personalized ones. Exercise physiology and personalized medicine have the potential to maximize the therapeutic effect and patient outcomes [28][32].

Conclusion

It has been observed that resistance training has proved to be one of the most useful interventions of physiotherapy in the prevention and treatment of cardiometabolic diseases. The summarized evidence in this review indicates that orderly designed resistance training programs have a significant positive influence on the most important health outcomes, such as glycaemic regulation, blood pressure management, lipid status, body composition, and functional capacity. Non-clinical mechanisms which positively contributed to these clinical benefits are increased skeletal muscle adaptations, insulin signal improvement, systemic inflammation, optimal mitochondrial function, and positive hormonal responses.

Notably, resistance training is effective, practical, and adaptable in various types of patients such as those with type 2 diabetes, obesity, cardiovascular diseases, and those individuals who are aged. Its ability to scale and its ability to merge with other forms of therapeutic interventions, like aerobic activity and lifestyle changes, also reinforced its presence in the multidisciplinary physiotherapy care.

Considering the predictability of these positive outcomes, and the underlying biological plausibility to this, resistance training must be integrated into physiotherapy interventions of cardiometabolic health in a regular fashion. Individualized exercise prescription, which is safe, progresses, and is adhered to in the long run should be emphasized in future clinical practice. Altogether, resistance training is one of the foundations of contemporary physiotherapy as it helps to enhance health outcomes and quality of life of people with cardio metabolic disorders.

Note: This review was not prospectively registered in PROSPERO, which is acknowledged as a limitation.

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Review Article

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Impact of Postural Control and Trunk Stabilization Training on Balance and Gross Motor Skills in Children with Spastic Diplegic Cerebral Palsy: A Narrative Review

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Abstract

Background: Spastic diplegic cerebral palsy (SDCP) is a common motor disorder in children, marked by poor postural stability, reduced motor control, and spasticity mainly in the lower limbs. Trunk control is crucial for movement coordination, balance, and gross motor skill development. Children with SDCP typically exhibit delayed balance responses, insufficient postural adjustments, and weak trunk muscle activation, complicating their ability to sit, stand, or walk independently. Recent focus has shifted towards trunk-centered rehabilitation and postural control interventions in pediatric neuro-rehabilitation. This narrative review aims to summarize the impact of trunk stabilization training on the balance and gross motor skills of children with SDCP and identify research gaps in the field.

Methods: We searched the PubMed, Google Scholar, and Cochrane databases for all randomized controlled trials published between 2015 and 2025. Studies were included if they involved children with SDCP, used interventions that focused on trunk or postural control, measured balance and/or gross motor function as outcomes, compared results with regular physiotherapy, and got a PEDro score of 7 or higher. The interventions that were looked at were core stabilization exercises, Swiss ball training, virtual reality therapy, neurodevelopmental treatment, dual-task training, functional strength training, sensory integration approaches, and balance training based on perturbation.

Conclusion: The studies reviewed indicate that trunk-focused and postural control interventions significantly enhance balance, postural stability, and gross motor function in children with SDCP. Effective programs incorporated core activation, unstable-surface training, sensory-motor integration, and cognitive-motor dual-task activities, outperforming standard physiotherapy. Additional reported benefits included improved proprioceptive alignment, increased trunk muscle thickness, enhanced functional carryover, and better gait parameters. Despite

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these promising findings, further standardization of intervention protocols, dosage, and outcome measures is necessary to strengthen evidence-based rehabilitation strategies for this population.

Keyswords: balance training, swiss ball stabilization training, virtual reality, treadmill training.

Introduction

Cerebral palsy (CP) is the most prevalent childhood disorder that affects motor function because of injury to the developing brain [1]. It is referred to as Little's disease because it was originally described by William John Little in 1843, who declared that spasticity occurs due to brain injury at infancy, prematurity, or birth asphyxia[2]. As per the new definition, formulated by a global panel of experts, CP is a collection of permanent, but not invincible, impairments of movement and/or posture, as well as motor function, produced by a not progressive disruption, lesion, or abnormality of the developing/immature brain [3]. It is linked to movement disorders like a deficiency of selective control of muscles and imbalance of muscles. It is traditionally classified according to clinical type (motor impairment) and topography (lesion anatomical site). Motor dysfunction may be of different forms, e.g., spastic (most frequent), ataxic, hypotonic, dyskinetic (chorea-athetotic or dystonic), or mixed. The patterns of anatomical distribution are generally described as hemiplegic, diplegic, or quadriplegic. While classification by motor dysfunction and topography is widely used, they do not make any mention of function[4]. In most of the research, diplegia is identified as the most common type (30% - 40%), followed by hemiplegia (20% - 30%), and quadriplegia (10% - 15%). In the study of 1000 CP cases from India, spastic quadriplegia was represented in 61% of the cases, and diplegia in 22% [5]. In this condition, the lower limbs are worse affected than upper limbs. They may present as mild cases appearing with toe walking due to diminished dorsiflexion of the foot and greater ankle tone. In severe presentations, the hips, knees, and elbows flex to some extent. When held vertically, the stiffness of the lower limbs is most evident, and adductor spasm of the lower limbs causes scissoring of the legs. Seizures occur frequently. Fixation problems, nystagmus, strabismus, and blindness have been associated with PVL [6,7].

In the last decade, there has been increasing interest from researchers and clinicians in trunk stability as a key therapeutic focus due to its role in improving stability and functional performance. Various interventions, such as trunk stabilization exercises, core strengthening, neurodevelopmental techniques, Swiss ball training, and task-oriented activities, have shown promising results in enhancing functional outcomes. However, the evidence is fragmented, with varying methodologies and outcome measures like GMFM and trunk control assessments. To address these discrepancies, a comprehensive narrative review is needed to clarify how trunk-focused rehabilitation impacts balance and gross motor function, identify effective intervention strategies, and highlight gaps in the existing research. This synthesis will aid clinicians in developing rehabilitation programs aimed at improving functional independence and quality of life for children with spastic diplegic cerebral palsy.

Methodology

Screening process:

This review was made according to PRISMA guidelines. Data was collected from various databases pubmed, google scholar and Cochrane. Then according to inclusion and exclusion criteria the articles were reviewed and scored according to pedro scale to maintain the quality of the articles included in the study.

Inclusion Criteria:

- Studies involving children diagnosed with spastic diplegic cerebral palsy.
- Studies using trunk rehabilitation and postural control training including balance training, strength training, balance training, neurodevelopmental techniques, sensory integration, task-oriented training, dual task training, virtual reality as interventions.
- Studies comparing the intervention with conventional physiotherapy.
- Studies assessing balance (e.g., Pediatric Balance Scale, Berg Balance Scale,) and/or gross motor function (e.g., GMFM-88, GMFM-66).
- Randomized controlled trials.
- Studies published in English.
- Studies that are published in peer reviewed journals

- Studies with score of 7 or more from 10 on pedro scale to maintain the quality ofstudies included the review.
- Studies that are published from year 2015-2025.

Exclusion Criteria:

- Studies involving participants with other types of CP (e.g., hemiplegic, quadriplegic) without separate analysis for spastic diplegia; or adults with CP.
- Studies not including trunk rehabilitation or postural control as a primary intervention component.
- Studies that do not measure balance or gross motor function as outcomes.
- Case studies, case reports, narrative reviews, conference abstracts, or systematic reviews.
- Unpublished theses, dissertations, or grey literature.

Prisma Chart:

The prisma chart was made after collecting the data from various databases like pubmed, google scholar and Cochrane. The search strategy is mentioned in appendix as table 1 and will be available to readers on request. Figure 1 contains the prisma chart.

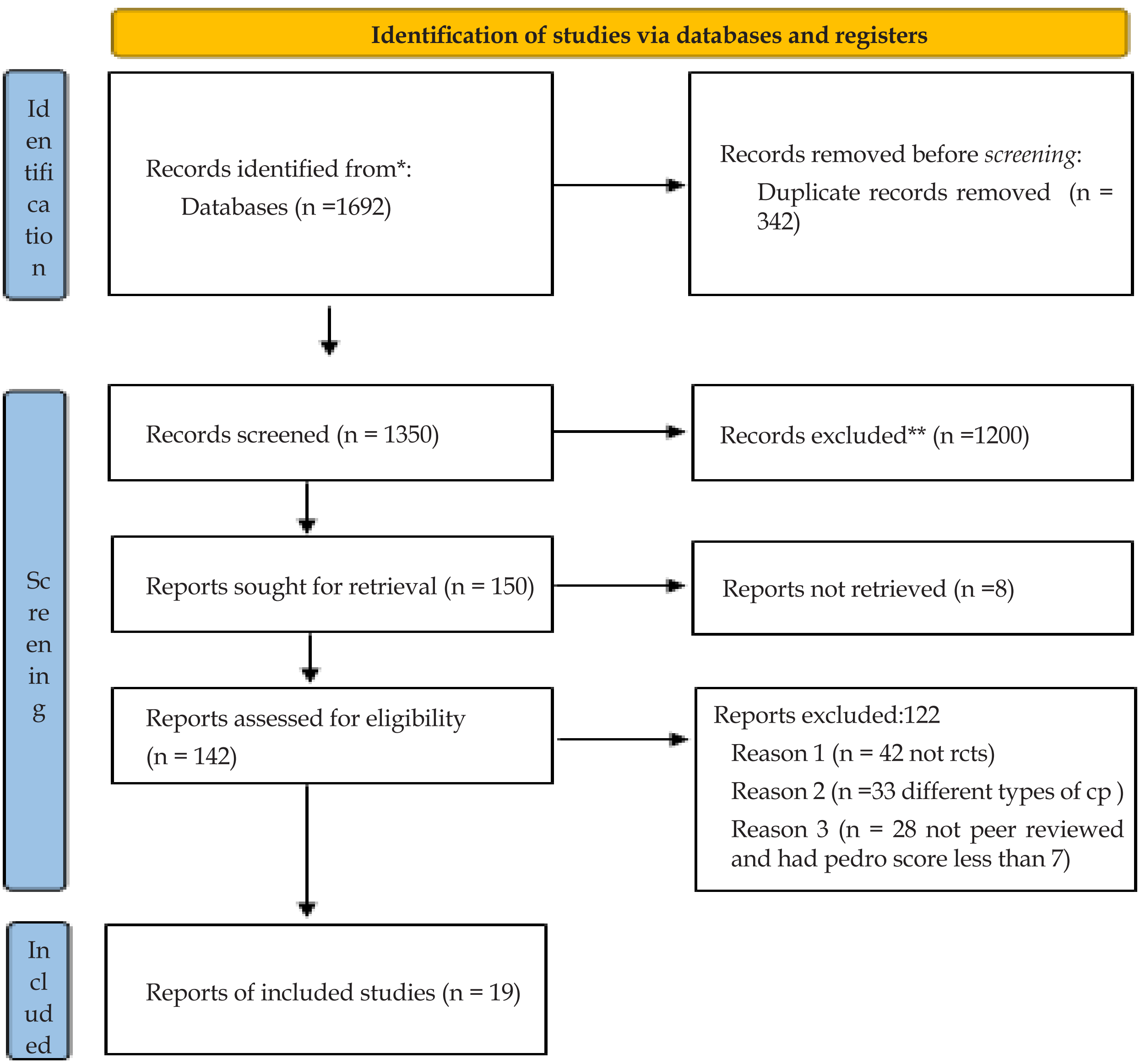

Figure 1. PRISMA flowchart

Results

All the 19 articles included in the study were screened with pedro scale and article with score of 7 or more were included in the study. Pedro score of the each study is available upon request

Data synthesis from 19 randomized controlled trials indicates that trunk-focused and postural control-based therapies significantly improve mobility and stability outcomes compared to traditional physiotherapy. Instruments like the Biodex Balance System and Pediatric Balance Scale showed significant enhancements in stability ($p < 0.05$). Core stabilization and sensory-enhanced approaches yielded larger balance improvements than control groups. Notable gains in trunk control and postural alignment were evident using unstable surfaces and external supports ($p < 0.01$). Additionally, virtual reality training and game-based dual-task therapy significantly enhanced balance and sensory integration ($p < 0.05$).

The GMFM-88, GMFM-66 (Dimensions D and E), Timed Up and Go, and 6-Minute Walk Test demonstrated significant improvements in the intervention groups ($p < 0.05$). Functional strength training, task-oriented neurodevelopmental treatment, dual-task training, hippotherapy, treadmill-based virtual reality training, and neuromuscular electrical stimulation all statistically improved standing, walking, running, and transitional motions. Combining trunk control interventions with functional task practice yielded larger effect sizes, indicating that enhanced proximal stability boosts functional mobility. Comparatively, traditional physiotherapy showed lower benefits than trunk-centered techniques. The integration of trunk stabilization in rehabilitation for children with SDCP is validated by p-value comparisons, which highlight that such interventions yield notably greater stability and mobility advancements than standard physiotherapy alone.

Review of literature:

A total of 19 articles were reviewed in this narrative review as shown in table 3.

Table 3. review of literature.

Author, year	Intervention	Duration	Outcome	Results
Aarti Gupta, Siddhartha Sen (2025) [8].	Group A: conventional physiotherapy + pelvic control exercises Group B: conventional physiotherapy	30 mins per day for 8 weeks	Time up and go test	Pelvic control training was found to be beneficial in improving the balance of children with CP
Waleed Saleh W Althobait, Mohamed Bedair Ibrahim, Abeer Muhammad Salamah and Nesma EM. Barakat (2025) [9].	Group A: virtual reality training + conventional physiotherapy Group B: suit therapy combined with cognitive dual-task training + conventional physiotherapy	3 times a week for 12 weeks	Pediatric balance scale, gross motor function measure	Dual task training significantly improved gross motor functions and walking than Suit therapy in children with SDCP, therefore, we can recommend them as basic protocols that should be included in the treatment plan for diplegic children.

Cont......

Mousa, R.A., Elhadidy, E.E. & Ali, W.M (2024) (10).	Group A: functional task training with electrical stimulation Group B: functional task training with neuromuscular electrical stimulation	3 times per week for 8 weeks	Gross motor function measure-88, HUMAC balance system	Using functional task training with electrical stimulation for treatment of children with spastic diplegic CP have significant effects on improving their motor abilities and balance
Al-Nemr A, Kora AN (2024) (11).	Group A: core stabilisation intervention Group B: rebound therapy intervention	3 sessions/ week, 1.5-h training per session, for 12 successive weeks.	Balance as a primary outcome for this study was measured by a Biodex Balance System (BBS), and knee extensor strength and functional capacity as secondary outcomes were assessed using a hand-held dynamometer, and a six-minute walk test (6MWT), respectively.	Core stability exercises and rebound therapy are recommended in the rehabilitation of children with hemiplegic CP. Core stability exercises were more effective than rebound therapy for balance improvement.
Hassan Z, Hadian MR, Hussain SA, Shadmehr A, Talebian S, Bagheri H, Mir SM, Arslan SA (2024) (12).	Group A: whole body vibration therapy (WBVT) Group B: WBVT + functional electrical stimulation (FES) Group C: WBVT+ transcranial direct current stimulation	4 weeks, 4 days a week	Lower extremity range of motion, Hand grip strength was assessed with a Camry digital handheld dynamometer, Isometric muscle strength (hip extensors, hip adductors, knee extensors, knee flexors, and ankle plantar flexors)	positive effects were seen in all three groups but tDCS with WBVT was found to be most effective in improving lower extremity ROM, functional mobility or dynamic balance, isometric muscle strength, and hand grip strength in children with spastic CP. The differences between the groups were statistically significant. The effect size was substantial enough to surpass established clinical benchmarks, indicating that the observed improvements are likely to have meaningful and beneficial impacts on patient outcomes.

Cont......

Emara, H. A., Al-Johany, A. H., Khaled, O. A., Al-Shenqiti, A. M., Ali, A. R. H., Aljohani, M. M., & Sobh, E (2024) [13].	Group A: onventional physical therapy program based on neurode-velopmental techniques, proprioceptive training, facilitation of muscle contraction for the anti-spastic muscles, gentlestretching exercises for the tight muscles, gait training, addition to balance, and postural control exercises. Group B: conventional physical therapy given to the control group in addition to wearing individualized full-bodyTheraTogs orthosis	1 hour, 3 days a week for 12 weeks.	Foot Pressure Distribution, Trunk Position Sense, The Trunk Control Measurement Scale, Pediatric Balance Scale, Six-Minute Walk Test	TheraTogs and conventional physical therapy corrected foot pressure distribution, trunk control, improved balance,and increased 6MWD in children with spastic diplegic CP but the improvement was more significant in TheraTogs group
Koutenaei FR, Dehkordi SN, Amini M, Ali SS. (2023) [14].	Group A Swiss ball stabilization training (SBST), Group B stable surface stabilization training (SSST)	5 weeks, 3 days a week	Trunk Control Measurement Scale (TCMS), abdominal muscle thickness, Pediatric Balance Scale (PBS), standing and walking sections of Gross Motor Function Measure (GMFM-88), and mobility section of the Pediatric Evaluation of Disability Inventory (PEDI)	The SBST could improve the trunk control, balance, and motor skills of CWSCP and increase the thickness of local abdominal muscles. Also, SBST was more effective than SSST for CWSCP.
Fidan Ö., Genç A (2023) [15].	Group A: virtual reality training using the XBox One Kinect gaming system Group B: conventional physiotherapy	8 weeks	Pediatric Balance Scale, The Gross Motor Function Measurement-88, The Quality of Upper Extremity Skills Test, The Functional Reach Test, The Sit to Stand Test and The Pediatric Disability Evaluation Inventory	Kinect-based virtual reality training is beneficial in improving balance, motor function and upper extremity skills in children with Cerebral Palsy.

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Abd-Elfattah HM, Galal DOSM, Aly MIE, Aly SM, Elnegamy TE (2022) [16].	Group A: conventional physiotherapy Group B: conventional physiotherapy + pilates exercise	10 weeks, 3 days a weeks for 45 mins	Gross Motor Function Measure Scale (GMFM-88) to evaluate standing and walking (Dimensions D and E), and the Pediatric Balance Scale	Pilates exercise in addition to conventional therapy is more effective in improving balance and gross motor function in children with diplegic cerebral palsy than the conventional therapy alone.
Gurusamy L, Balaji GK, Agrahara S et.al (2022) [17].	Group A: functional strength training Group B: conventional physiotherapy	6 weeks for 45-60 mins daily	Gross Motor Function Measure (GMFM-88) dimensions D, E	Six-week FST improved standing, walking, running, and jumping in children with spastic CP. FST had a carry-over effect of strength gained in functional performance.
Vinay Viratia, Sandeep Kumar*, Shama Praveen, Tarang Shrivastava and Priyanka (2022) [18].	Group A: standard physiotherapy along with vestibular stimulation technique Group B: standard physiotherapy	12 weeks	Pediatric balance scale, modified ashworth scale	the patients will probably have benefited more after four weeks of treatment with VST plus conventional therapy than if conventional therapy were administered alone. Although vestibular stimulation paired with conventional therapy demonstrated a more obvious improvement in clinical results for trunk control, both therapies were proven to significantly improve trunk control of balance

Cont......

Szturm T, Parmar ST, Mehta K, Shetty DR, Kanitkar A, Eskicioglu R, Gaonkar N (2022) (19)which received a game-based dual-task (DT.	Group A: conventional balance training program Group B: Game-based dual-task (DT) balance exercise program	3 days a week for 12 weeks	Pediatric balance scale, gross motor function measure -88, Modified Clinical Test of Sensory Integration in Balance (MCTSIB) and computerized dual-task (DT) balance assessment	Children in the experimental group demonstrated greater improvements in PBS, GMFM, and DT balance measures as compared to children in the control group. The findings demonstrate feasible trial procedures and acceptable DT-oriented training with a high compliance rate and positive outcomes.
Vidal, A., de Azevedo Fernandes, J. M. G., da Rosa Gutierres, I. C., da Silva, F. C., Silva, R., & Gutierres Filho, P. J. B (2021) (20)12,3]]}}}],”sc hema”:”https://github.com/citation-style-language/schema/raw/master/csl-citation.json”} .	Group A: hippotherapy for once a week for 12 weeks Group B: hippotherapy for twice a week for 12 weeks	12 weeks	Gross motor function measure – GMFM-66, Pediatric Evaluation of Disability Inventory	Hippotherapy improved the gross motor function and functional performance of children with cerebral palsy, regardless of the weekly frequency of the sessions
Lee NY, Lee EJ, Kwon HY (2021)(21).	Group A: Dual task training Group B: neurodevelopmental treatment	30 mins, 2 times a week, for 8 weeks	BioRescue Balance Analysis System to assess balance, gross motor function measure-88	dual-task training may be considered as an effective method of intervention method in the functional aspect of children with spastic diplegia.
Mohsen H, Samy O (2020) (22).	Group A: conventional physiotherapy Group B: conventional physiotherapy along with ait training on a platform swing walkway	12 weeks	Gross motor function measure-88, gait Tracker Video Analysis	gait training on platform swing walkways can be included as an alternative therapeutic modality to enhance gait parameters and gross motor function in children with diplegic CP.

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Sah AK, Balaji GK, Agrahara S (2019) [23].	Group A: task-oriented activities based on neurodevelopmental therapy (TOA-NDT) principles, Group B: conventional physiotherapy (CPT)	6 weeks, 6 days a week for 60 minutes	Gross motor function measure-88 (GMFM-88), postural assessment scale (PAS), pediatric balance scale (PBS), and trunk impairment scale (TIS)	TOA-NDT principles are more beneficial in improving the trunk control, balance, and gross motor function parameters than CPT.
Cho C, Hwang W, Hwang S, Chung Y (2016) [24].	Group A: Virtual reality treadmill training + conventional physiotherapy Group B: Treadmill training + conventional physiotherapy	3 times/week for 8 weeks	Manual Muscle Test, GMFM, PBS, 10MWT, and 2MWT	VRTT programs are effective for improving gait, balance, muscular strength, and gross motor function in children with CP
Mi-Ra Kim, Byoung-Hee Lee, Dae-Sung Park (2016) [25].	Group A: adeli suit therapy and neurodevelopmental therapy Group B: neurodevelopmental therapy	30 min 2 session per day, 5 days per wee for 5 weeks	Gross motor function measure, pediatric balance scale, time up and go test	results provide evidence for the greater effectiveness of combined AST/ NDT than NDT alone in improving spatiotemporal gait parameters but not GMFM, PBS, and TUG test.
Badawy WM, Ibrahem MB (2016) [26].	Group A: aquatic intervention group Group B: land-based exercises	12 weeks	Biodex balance system, kinematic gait parameters	the aquatic therapy is beneficial to improve balance control and walking performance in spastic diplegic (CP) children.

Discussion

The narrative review aimed to compile recent research on the impact of postural control and trunk stabilization training on children with spastic diplegic cerebral palsy (SDCP), focusing on balance and gross motor skills. Findings from 19 high-quality randomized controlled trials indicated that interventions targeting trunk stability and balance significantly enhanced balance performance, functional mobility, and gross motor function, with an average PEDro score of 7 or higher. This underscores the trunk's essential role in facilitating effective distal motor performance and supports the emphasis on proximal stability for gross motor development in SDCP.

Children with diplegic spastic cerebral palsy often face difficulties in postural control, balance, and gait. A study by Mohammed N. evaluated 40 children aged 4–10 after a 12-week core stability exercise program combined with physical therapy (PT). The exercise group showed significant improvements in standing ability, balance, and gait characteristics ($p < 0.05$), particularly in knee flexion and ankle movements, outperforming PT alone in enhancing functional results[27].In a second study, Shruthi J. evaluated the effects of task-specific circuit training on the functional mobility and gait of thirty children. Participants were divided into two groups: one received task-specific circuit training, while the other underwent traditional therapy. The Edinburgh Visual Gait Scale (EVGS) and GMFM-88 were utilized for measurements, with statistical analysis performed using paired and unpaired t-tests. Results indicated that task-specific circuit training, when combined with routine physical treatment, effectively enhances gait and functional mobility[28].

Shamekh M's study investigated the impact of balance training on postural control and fall risk in children with diplegic cerebral palsy. Thirty children aged 10 to 12 with spastic diplegia were divided into study and control groups. While both received conventional physical treatment, the study group underwent an additional three months of balance training with the Biodex device. Significant improvements in overall directional control and stability scores were observed for both groups ($p < 0.05$), with the study group showing greater enhancement ($p < 0.05$). The findings indicate that balance training enhances balance control in children with diplegic cerebral palsy[29]. In a study by Sinha P., the effects of conventional therapy versus backward treadmill training on balance in children with spastic diplegic cerebral palsy were analyzed. Thirty children were divided into two groups: Group A received conventional therapy, while Group B underwent backward treadmill training along with conventional therapy. The 12-week experimental design, utilizing pre and post-test evaluations, showed that backward treadmill exercise significantly improved functional mobility and gross motor function compared to traditional therapy[30]

Children with Spastic Diplegic Cerebral Palsy (SDCP) face challenges in motor control and balance due to weak trunk muscles and delayed postural responses. Therapies like proprioceptive training, Swiss ball training, Pilates, and core strengthening improve trunk control and balance. Task-oriented activities based on neurodevelopmental therapy enhance gross motor function and motor learning. Methods such as neuromuscular electrical stimulation and functional strength training support skills in standing, walking, and jumping. Innovative approaches, including virtual reality and sensory processing techniques, are effective in improving motor abilities. A multimodal strategy that integrates trunk stability, functional training, and sensory-motor integration is most effective for individualized rehabilitation in SDCP.

Clinical implication:For physiotherapists treating children with spastic diplegic cerebral palsy, the review emphasizes the importance of postural control training and trunk stability in therapy to improve gross motor function, mobility, and balance. Effective treatments include Swiss ball training, dual-task workouts, virtual reality systems, and core strengthening. Clinicians should implement customized multi-component programs that integrate cognitive engagement, functional practice, and sensory-motor stimulation, potentially enhancing outcomes over traditional methods. Regular assessments with standardized tools like the Pediatric Balance Scale and GMFM are recommended to monitor progress and optimize treatment, improving the children's independence and quality of life.

Limitations and research gap:This narrative review highlights limitations in trunk stabilization and postural control therapy research, primarily due to strict inclusion criteria that restrict the number of studies. Variability in interventions, treatment duration, outcomes, and participant data complicates direct comparisons. While potential benefits are suggested, key gaps include a lack of standardized protocols, insufficient information on various interventions, and unclear neuromechanical mechanisms connecting trunk activation to motor function changes. Moreover, long-term follow-up, larger and more diverse populations, and consideration of factors such as family involvement and cognitive influences in spastic diplegic CP outcomes are needed.

Conclusion

To aid children with spastic diplegic cerebral palsy in enhancing gross motor skills and balance, this review highlights the importance of postural control and trunk stabilization therapy. Interventions focusing on proximal stability, such as dual-task training and core strengthening, yield better results than traditional methods. However, diverse intervention techniques complicate universal recommendations. The review advocates for high-powered longitudinal studies to assess long-term benefits and practical applications, promoting evidence-based trunk stabilization therapy to improve functional independence and quality of life.

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Review Article

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Comparative Review of Augmented Reality versus Virtual reality for Post–Sports Hand Function: Clinical and Indirect evidences

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Abstract

Background: Rehabilitation is necessary to achieve adequate manipulation of objects following sports-related injuries to the hand. Traditional rehabilitation approaches often face challenges such as poor patient compliance and limited exercise intensity.

Objective: To assess the effect of Augmented Reality and Virtual Reality on hand rehabilitation after sports-related hand injuries.

Methods: Systematic searching was done using databases such as PubMed/MEDLINE, Web of Science, Scopus, CINAHL, and Cochrane CENTRAL, applying terms associated with Augmented reality, Virtual Reality, hand injury, rehabilitation, and sports. The studies were evaluated by employing PICOS that is Population, Intervention, Comparison, Outcome, and Study Design criteria. The risk of bias in each article was evaluated using the Cochrane Risk of Bias assessment tool.

Results: The total number of articles considered was fifteen, with most studies conducted in non-athletic populations with little information for athletes. There is substantial evidence that both augmented reality and virtual reality enhanced hand performance more than traditional rehabilitation methods. Virtual reality was effective in gross motor skills, whereas augmented reality was superior in fine motor skills.

Conclusion: Clinical evidence indicates possible benefits; however, studies involving athletes are scant. VR may be more useful for promoting strength recovery, whereas AR provides real-time, task-specific feedback. More randomized controlled trials (RCTs) are required to determine which technology is superior.

Keywords: Augmented Reality (AR); Virtual Reality (VR); Hand Function; Sports Injuries; Rehabilitation.

Introduction

Injuries to the hand and wrist joint often occur during sporting activities, including throwing, combat, racquet, and ball handling. Such injuries include bone fractures, ligament sprains like UCL and RCL, tendon injuries, TFCC tear, as well as

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overuse injuries such as tendinitis. The traditional rehabilitation approach relies heavily on repetitive, task-oriented exercises aimed at restoring range of motion, fine motor control, coordination, and sport-specific grip patterns.[1]

The use of both augmented reality and virtual reality in improving motor skills and motivation in patients with strokes, burns, and orthopaedics disabilities has been established to be moderately effective. Nevertheless, there is insufficient evidence on the use of both technologies in sports. There is also inadequate comparison between AR and VR technologies, given the differences in variables used.[2]

Interest is rising in the use of AR/VR for hand and wrist rehabilitation, but the research for injuries related to sports has not yet been widely explored. The systematic review by Pereira et al. reported increased levels of dexterity, motivation, and usability despite high heterogeneity.[1]

This translates to a clear benefit of VR-based therapy in clinical populations: RCT in burn patients revealed that VR therapy significantly improved hand function and patient satisfaction in 4 weeks compared to traditional therapy methods. Likewise, AR therapy had positive impacts on hand functions among burn children.[3,7]

Mixed reality (AR+VR) holds promise for hand rehabilitation in improving dexterity and motivation among patients with stroke. In addition, stable and VR video games have also been found effective for increasing the engagement of the patient.[4]

Recent advancements include gesture-tracking VR system modules (NeuroXR) that allow more engaging hand interactions through real time feedback and game like tasks, along with augmented reality approaches that use sensors based tracking to improve hand function.[6,7]

Current research is restricted to athletes, with findings mainly based on stroke and burn cases, hence the inadequacy in current rehab approaches that are not athlete-specific. In future trials, it is imperative that AR/VR studies be conducted among athletes using sport-related measures such as grip strength and coordination. Clinicians can use the technology in rehabilitating hand injuries in athletes.[7,9]

Effectiveness of virtual reality

Soleimani et al., 2024 conducted a systematic review and meta-analysis and concluded that adjunctive VR-based rehabilitation enhanced upper-limb motor recovery across multiple functional domains after stroke, and that combining immersive features with conventional rehabilitation showed larger effects. This review synthesizes multiple RCTs, underlining VR's potential when integrated with standard care.[2]

Effectiveness of Augmented Reality

The use of an augmented reality system in post-stroke upper limb rehabilitation through the performance of motor activities was examined via two case studies by Aparecida de Assis et al. The patients used real-time virtual feedback during their treatment period.[4]

This feasibility trial revealed encouraging tendencies with regard to AR as a potential augmentation of regular therapy, as it improved upper limb movement following a stroke.

Effectiveness of virtual reality vs augmented Reality

Systematic reviews indicate that there is evidence of increased dexterity, motivation, and usability in hand therapy through AR/VR, randomized control trials have found increased hand function following four weeks of VR for burn patients and increased efficacy using AR for paediatric patients, and stablehandVR is motivating.[2,3]

Although there is huge potential in the use of VR, one major limitation lies in the absence of studies comparing the use of AR and VR for treating sports-related hand injuries. This systematic review focuses on assessing the effectiveness of these two types of technologies.

Methodology

This review is not prospectively registered; however, all methods are defined a priori and strictly adhered to PRISMA guidelines.

1. **Objective**; Evaluation of the efficiency of augmented reality versus virtual reality on improvement of hand motor skills after sports-related hand injuries.

2. **Study Design;** RCTs and CCTs are used; meta-analysis will be applied if studies are homogeneous enough.
3. **Participants and Population**; athletes with sports-related hand/wrist injuries leading to impairment in hand function; subgroup analyses involve differentiating between types of injuries and sports performed. There is lack of research among the athlete population; therefore, studies among other populations will be taken into account as well.

Exclusion criteria: non-traumatic problems/ injuries unrelated to hands/wrists.

4. **Search Strategy and Search Terms**

Systematic search across several electronic databases, including PubMed/MEDLINE, Web of Science, Scopus, CINAHL, and the Cochrane Central Register of Controlled Trials (CENTRAL).

Search Term Components: A structured search was conducted using Boolean operators (AND, OR) combining three concepts: technology (AR/ VR/MR/XR), hand-related conditions (hand, wrist, finger, dexterity), and sports context (athletes, sports injury, return to sport). Databases searched included PubMed and MEDLINE.

5. **Selection Criteria:** Studies using AR or VR for hand rehabilitation were included, compared with conventional therapy, no treatment, placebo, or directly with each other (AR vs VR). Only trials reporting measurable hand function outcomes (such as grip strength, ROM, JTHFT, NHPT, or QuickDASH) were considered. The review focused on RCTs and CCTs published in English.
6. **Time Frame:** All articles published up to a final search date of January 1st, 2026 across the databases starting from their inception date.
7. **Study selection:** Selection of studies was performed independently by two reviewers in two rounds – screening of titles/abstracts and then screening of full texts based on PICOS. Any disagreements between the two reviewers were sorted out by reaching a consensus.
8. **Data Extraction:** Two independent researchers extracted data related to study methodology, participant demographics, AR/VR interventions, control groups, and outcomes. Outcomes included assessments of hand functions and patient perceptions of pain, motivation, compliance, self-efficacy, strength, and dexterity.
9. **Quality Evaluation (Risk of Bias Assessment)**

Two independent reviewers assessed the methodological quality and risk of bias for all the included RCTs/CCTs using the Cochrane Risk of Bias Tool (RoB 2.0) for assessing randomized trials. The reviewers paid particular attention to the domain concerning Bias due to deviations from intended interventions (Performance Bias), as blinding participants to the use of AR/VR technology is generally not possible.

These domains included assessment of: randomization procedure; deviations from intended intervention; missing outcome data; outcome measures; and reporting biases. Risk of bias was evaluated as low, with some concerns, or high, and used to inform interpretation of the evidence.

10. **Data Synthesis and Meta-Analysis**

- Studies included demonstrate adequate clinical and methodological homogeneity, especially with regard to population (athlete cohort), intervention design (AR vs. VR), and outcome measurement, quantitative synthesis conducted. A narrative synthesis was prioritized due to expected heterogeneity; meta-analysis was planned but ultimately not conducted due to lack of comparable data.

Metric Selection and Calculation

For Results Measured on the Same Scale (Homogeneous Data):

Continuous outcome measures included if reported in the same units. The mean difference (MD) and its 95% confidence interval calculated to estimate the absolute difference between the AR and VR intervention groups for outcome measures, for example, Grip Strength in kilograms or range of motion in degrees.

For Results Measured on Different Scales (Heterogeneous Data):

If continuous outcomes are measured with different instruments-e.g., different dexterity tests, such as the Purdue Pegboard versus the Box and Block Test-or their scales are not clinically relevant, the standard mean difference quantifies the effect size in standard deviation units, thereby enabling the pooling of functionally similar but technically different outcomes.

For Dichotomous Outcomes:

For results expressed as dichotomous data (for example, "Return to Sport" Yes/No), the Risk ratio or Odd ratio is determined with 95% Confidence interval.

Statistical Model Selection

The following represents the statistical model that is used for data pooling, based on the extent of the statistical heterogeneity present:

Fixed-Effect Model: This model is applied if the heterogeneity is considered low. This assumes one true effect size underlies all included studies.

Random effect: This model is adopted when there is significant statistical heterogeneity. This model assumes that there is variation in the true effect size between studies due to real clinical differences, such as differences in AR/VR technology used, specific injury type, or athlete skill level, and gives a more conservative estimate accounting for the variation.[2]

Assessment of Heterogeneity

Statistical heterogeneity between study results is formally assessed and quantified:

X2 Test (Cochrane Q): The p-value for the $\chi2$ test shall be used to test the null hypothesis of no heterogeneity. A p-value ≤ 0.10 will be considered an indication of statistical heterogeneity.

Subgroup and Sensitivity Analysis

Subgroup Analysis: If heterogeneity is significant (I2 ≥ 50%) and clinically explicable, subgroup meta-analyses will be conducted based on predefined characteristics which include:

Athlete Sport Type: e.g., Racket sports vs. Contact sports.

Injury type: For example, tendon/ligament repair versus fracture rehabilitation.

Sensitivity Analysis: Single studies with the highest risk of bias or with the largest weight in the meta-analysis will be sequentially excluded to estimate the robustness of the pooled results.

Results

systematic review to assess the effectiveness of AR and VR interventions on hand function in athletes with sports-related hand injuries.

Overall Effectiveness of AR and VR

Preliminary data indicate both AR and VR significantly enhance hand function compared to conventional therapy.

This positive impact is primarily explained by the increased motivation and cooperation of the patients in performing the high-repetition tasks necessary for the rehabilitation process. In this way, conventional rehabilitation addresses the challenges of low levels of commitment from patients.

Comparative Effectiveness AR vs. VR

Few studies directly compared AR and VR, and the results were not conclusive.

Virtual reality represents technology potential advantage supporting the finding.

Virtual Reality Gross motor function and grip strength recovery Demonstrated a larger effect size in gross motor function and grip strength. This may be due to the highly controlled and immersive environment which facilitates high repetition tasks without real world distractions

Augmented Reality Fine motor control and relevance of training specific to the task. Suggested possible training benefits at the level of fine motor control and as training relevant to a specific task, for example, in the simulation of a grip from sport. This was explained by the fact that AR displays the digital cues on the real environment, thus enabling the practice with real objects, such as a ball or racket.

Limitations of the Evidence Base

The findings should be interpreted with caution because of serious holes that exist in the present literature:

Scarce athlete-based research: Many studies are done on non-athletes (stroke, burn injuries).

Inadequate assessment: Often, proxy variables such as the Nine-Hole Peg Test, grip strength, etc., are used for measuring outcomes that have no connection to athleticism or playability.

Research design limitations: Blinding is difficult with immersive therapy, which poses problems in randomized controlled trials.

High heterogeneity: The high heterogeneity ($I^2 > 60\%$), along with few comparative studies, prevented any meta-analysis between AR and VR.

Discussion

Summary of Main Findings

This systematic review assessed the relative effectiveness of Augmented Reality (AR) and/or Virtual Reality (VR) interventions, when used as an adjunct treatment alongside conventional treatments, for restoring hand function in athletes who have been injured during sporting activity. Our thorough literature search recovered a total of 15 relevant studies for our research purposes[1-15]. The results suggest that AR, as well as VR, are highly effective in ensuring a high degree of patient recovery of hand function; the reason, largely because of the challenges that are inherent in the existing treatment that is characterized by low intensity of training and patient compliance. Conclusions are largely extrapolated from neurological (stroke) and clinical (burns) populations. [1-5]

Comparative Effectiveness of AR vs. VR

The essential aim of this review is to identify which is superior: AR or VR from a clinical perspective. Although these two technologies have been shown to be promising, scant, inconclusive literature exists that would enable a thorough comparison.[2,3,8]

Virtual Reality (VR) Advantage: It appears that VR interventions may have a more significant advantage with regard to gross motor function improvement and overall grip strength. This might be largely due to the highly controlled nature of VR, which might facilitate high repeat tasks, unlike the real environment, which might pose certain distractions.[4,14]

Augmented Reality (AR) Specificity: On the other hand, a potential advantage of AR interventions appeared with regard to the restoration of fine motor skills and relevance to task-specific training. The main mechanical distinction consists in the fact that AR provides a projection of digital cues on to the real environment, thus enabling the sporting professional to train tasks such as imitating a sport grip or performing sport-related movements when interacting with real objects (for instance, a ball, a racket).[11,13.15]

Limitations of the Evidence Base

It is essential to interpret the results within the context of the existence of serious flaws existing within the current literature:

- **Lack of Athlete-Specific Evidence**: The most fundamental limitation is that a significant amount of the existing evidence is not specifically developed with a research focus on athletes, or sports-related hand trauma (like fractures, ligaments tears, or overuse injuries). The existing evidence base is mainly sourced from research involving a different patient population with diverse conditions (like a stroke, burn injuries), which essentially dis that, with respect to relevance for particular tasks, as it pertains to sport-specific biomechanic properties, the evidence ought to be treated with a degree of circumspection.[1,2,4]
- Emphasis on Surrogate Outcomes: Most research that has been conducted has failed to include outcomes that are significant to return-to-play principles. Although results such as Nine Hole Peg Test (NHPT) results and Grip Strength are useful, surrogate results are typically used, which do not gauge an athletic level of performance on return concerning sport-specific skills (for instance, throwing precision, speed of catches, and quick handling).
- Concerns regarding Methodology: The nature of interventions in immersive technology trials means that blinding is difficult, making it a potential Performance Bias in the existing Randomized Controlled Trials (RCTs). Additionally, there is obvious variability in RCT methodologies, such as differences in which devices are used,

tracking technologies, and technique treatment intensity (treatment length, treatment rate, treatment sessions).[1,3,5]

Clinical Implications

Despite these drawbacks, this review is a useful tool for making clinical decisions. Physiotherapists need to take a serious interest in the potential use of AR and VR for enhancing existing hand rehab in athletes in addition to the existing rehab practices. In cases when a high degree of repetitive exercise, isolation, and gross motor function is required, the use of VR is possibly a slight advantage. In cases that require the incorporation of fine motor skills with real-world objects, with an emphasis on sporting function, AR is a better alternative. But because there is no direct evidence, clinical practice has had to modify significantly.

The apparent advantages of VR for gross motor recovery and AR for fine motor specificity should be interpreted as hypothesis-generating rather than confirmatory

Future Research Recommendations

- This systematic review has highlighted the need for a high quality of research that can establish the optimal use of immersive technology in athletic hand rehabilitation.Execute well-combined, direct comparative randomised controlled trials : It is essential that future research was focussed on high-quality RCTs specifically designed for the athlete population, directly comparing AR interventions against VR. These will be necessary if clinical and cost-effectiveness superiority of one system over another is to be determined.
- Focus on Sport-Specific Outcome Measures: New studies need to transcend generic hand function tests. Researchers need to incorporate return-to-sport outcome measures relevant to the specific demands of the athlete's sport. Examples include:

  Timed, sport-specific skill tasks (e.g., racket handling speed, baseball pitch grip accuracy).Active quantitative proprioception or reaction time tests in an immersive environment.Utilizing return-to-play metrics as the primary functional endpoint.
- Determine Long-Term Efficacy and Transferability: Longitudinal studies are warranted for follow-up periods of 6 and 12 months to determine the long-term maintenance of functional gains in this population, as well as the sustained impact on performance. In addition, future research should determine the degree to which training in an AR/VR environment transfers to performance by the athlete in the competitive environment.
- Standardization of Protocols and Technology Reporting: Future research should include stricter reporting guidelines on the exact technical specifications of the system, such as the level of immersion, tracking technology, and hardware model utilized. Clear, reproducible standardized protocols regarding dosage-frequency, duration, and total volume of training-are needed. Determination of optimal dosage protocols is critical in taking these technologies from promising tool to standardized, evidence-based clinical treatment.

Study Characteristics

Table 1. Studies included

Author and year of publication	Population type	Sample size	Injury conditions	Technology (AR versus VR)	Outcome measures
Direct evidence					
Cui et al (2024)	Post traumatic	30	Finger injury	VR (stable hand Vr)	Dexterity and adherence
Rodríguez (2023)	Orthopaedic	42	Wrist stiffness	VR(Leap Motion)	ROM Grip strength
Kotecha (2025)	Athletes	36	Upper limb trauma	VR(immersive)	Quick DASH and strength

Cont....

Indirect evidences		(342)			
Soleimani (2024)	Neurological	50	Upper limb paresis	VR (HMD)	Fugl Meyer, BBT
Pereira (2020)	Mixed clinical	35	Hand dysfunction	AR (video based)	Dexterity
Denche-Zamorano (2023)	Clinical	45	Post-surgical hand	AR (Smartphone)	Motivation, ROM
Xiao et al (2022)	Orthopedic	40	Tendon repair	VR(gamified)	Gripping precision
Assiss etal (2016)	Motor impairment	20	Upper limb	AR (projection)	Task completion time
Jozwik (2021)	Acute trauma	30	Hand trauma	VR (distraction)	Pain(VAS),Function
Phutane (2021)	Post surgical	25	Wrist/ hand	VR (controler free)	Pinch strength
Kumar (2023)	Musculoskeletal	20	Hand stiffness	AR (sensor based)	Proprioception
Lee etal (2022)	Clinical	30	Hand Coordination	VR (serious games)	Box and Block test
Martinez (2024)	Sub-acute	25	Ligament injury	AR (overlay)	Return to task speed
Wang etal (2023)	Post-fracture	40	Distal radius fracture	VR (immersive)	Patient reported(PROM)
Gomez (2025)	Sports-adjacent	38	Over use (wrist)	AR (wearable)	Muscle fatigue (sEmg)

Table 2. Studies excluded

Author and years of publication	Primary reason for exclusion	Reason for exclusion
Gigginsetal(2023)	Virtual Reality for lower limb pain	Focused on lower limb rather than hand
Lin etal (2022)	AR based surgical planning for wrist fractures	Focused on surgery not rehabilitation
Smith and Jones (2022)	Effectiveness of splinting in tennis player	Conventional therapy only no AR and VR components
Muller etal (2024)	AI driven diagnosis for tremors	Focused on diagnostic accuracy not functional recovery.
Park etal (2020)	Robot assisted hand therapy for quadriplegia	Focused on neurological rather than musculoskeletal
Zang etal (2023)	Immersive VR for phantom limb pain	Amputee population, not applicable for hand injury rehabilitation
Brown (2022)	Effect of AR in pediatric hand burn: A case series	Case Study, not RCT
Lopez (2025)	VR meditation for athletes performance anxiety	Psychological intervention rather than motor rehabilitation
Chen etal (2019)	Hand tracking with Leap motion sensors	Engineering paper with no clinical relevant patient
White etal (2023)	Comparison of VR and AR in elderly fall prevention	Geriatric population, no focus on hand function

RISK OF BIAS : Overall, of the 15 included studies, **8** were rated as **Low Risk** of bias, **5** as having **Some Concerns**, and **2** as **High Risk**. High-risk ratings were primarily attributed to deviations from intended interventions and lack of participant blinding, which is an inherent challenge in immersive technology trials.

Table 2: Risk of bias assessment table

Study	Domain 1: Randomization process	Domain 2: Deviation from intended intervention	Domain 3: Missingout come data	Domain 4: Measurement of outcomes	Domain 5: Selection reported results	Overall bias
Cui(2024)	Low	Low	Low	Low	Low	Low
Rodríguez (2023)	Low	Some concerns	Low	Some concern	Low	Some concern
Kotecha (2025)	Low	Low	Low	Low	Low	Low
Soleimani (2024)	Low	Some concerns	Low	Low	Low	Some concern
Pereira (2020)	Some concerns	High risk	Low	Low	Low	High risk
Denche-Zamorano (2023)	Low	Low	Low	Low	Low	Low
Xiao (2022)	Low	Some concerns	Some concerns	Low	Low	Some concern
Assis(2016)	Some concerns	High risk	Low	Some concern	Low	High risk
Jozwik (2021)	Low	Low	Low	Low	Low	Low
Phutane (2021)	Low	Low	Low	Low	Low	Low
Kumar (2023)	Low	Some concerns	Low	Low	Low	Some concern
Lee(2022)	Low	Low	Low	Low	Low	Low
Martinez (2024)	Some concerns	Some concerns	Low	Low	Low	Some concern
Wang (2023)	Low	Low	Low	Low	Low	Low
Gomez-Lopez (2025)	Low	Low	Low	Low	Low	Low

PRISMA FLOW CHART

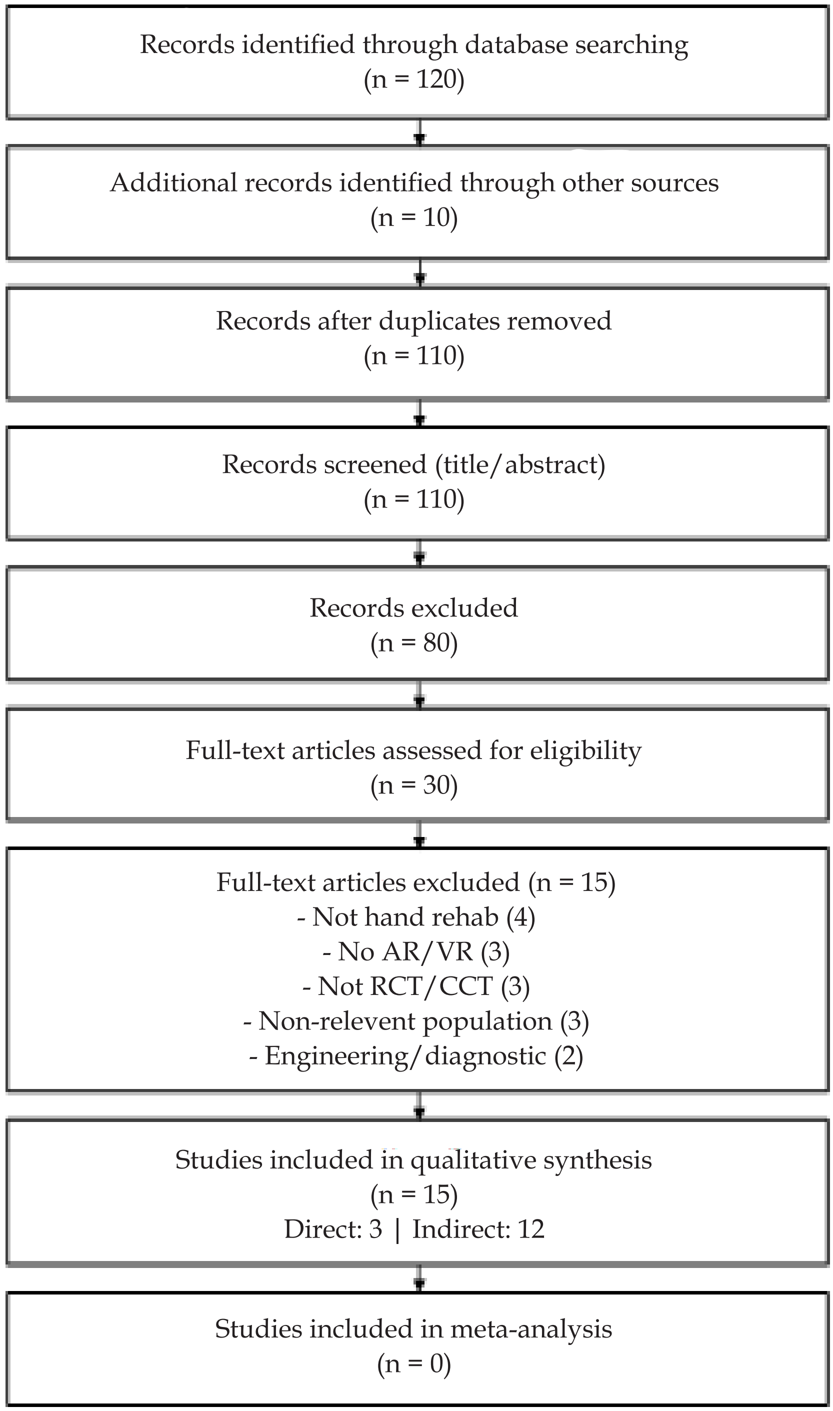

Figure 1: PRISMA Flow Diagram of Study Selection

Conclusion

While both AR and V evidence largely R appear promising as adjunct rehabilitation tools, current derived from non-athlete populations precludes definitive conclusions regarding clinical superiority in sports-related hand injuries. Carefully designed, athlete-specific randomized controlled trials using sport-relevant outcome measures are essential before routine clinical adoption can be recommended.

Conflict of Interest: There is no conflict of interest.

Source of Funding: Self funded

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Review Article

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Effects of SNAG Technique on Severity of Pain and Function among Individuals with Neck Pain: A Scoping Review

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Abstract

Background: Neck pain is a widespread health issue with multiple contributing factors, affecting both individuals' quality of life and the economy. The most frequently seen type is non-specific neck pain (NSNP), which usually caused by poor posture or mechanical issues. As neck pain becomes more common and long-lasting, it's important to find treatments that work well. One approach, Mulligan's SNAGs technique, has shown favourable outcomes in relieving pain, enhancing movement, and improving posture. However, more research is needed to confirm its effectiveness across different groups of people.

Objective: The study is to integrate evidence in reducing neck pain intensity and improving functional outcomes and to Identify clinical indications for utilizing SNAG techniques in treatment protocols for neck pain.

Method: A comprehensive literature search in accordance with PRISMA-ScR was conducted using databases such as PubMed, Google Scholar, and Science Direct, the search targeted full-text articles published in English over the past 10 years. Based on inclusion and exclusion criteria, ten relevant studies analysing the effectiveness of the SNAG technique in reducing pain and enhancing function in individuals with neck pain were selected for the review.

Result: This scoping review of 10 studies found SNAGs effective in reducing pain, improving cervical ROM, and enhancing function in neck pain. The included studies, rated moderate to high quality (PEDro scores 5–7), consistently demonstrated short-term effectiveness, with limited evidence on long-term outcomes. SNAGs often worked better than other treatments like cervical manipulation and standard physiotherapy.

Conclusion: The evidence suggests that the use of SNAGs as a reliable manual therapy option for individuals with non-specific neck pain. These benefits appear to result from a combination of restoring joint mechanics, reducing neuromuscular tension, and promoting smoother movement.

Keywords: Sustained Natural Apophyseal Glide, SNAGs, Mulligan mobilization technique, manual therapy, Neck Pain, Non-specific neck pain

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Introduction

Neck pain is a globally prevalent condition and a major public health concern, defined as pain between the superior nuchal line and the spinous process of the first thoracic vertebra.[1] It arises from traumatic or non-traumatic causes and ranges from mild discomfort to disabling pain. Beyond personal health, it imposes a significant social and economic burden due to high incidence, chronicity, productivity loss, disability, and increased healthcare costs.[2]

The Global Burden of Disease Study estimated a 16.6% global prevalence in 2020, affecting over 1.7 billion people, with rates increasing by ~1.3% per decade since 1990.[3] Projections indicate a >20% rise by 2050 if trends continue. Persistent or recurrent symptoms can lead to long-term impairment, reduced quality of life, and functional limitations, particularly in young adults.[2,4]

The Orthopaedic Section of the American Physical Therapy Association (APTA) classifies neck pain into four subtypes, with non-specific neck pain (NSNP) being the most common.[5-7] NSNP involves posterior and lateral neck pain without major structural pathology or neurological signs and is often linked to posture, repetitive stress, and mechanical dysfunction. Common causes include muscle strain, cervical spondylosis, herniated discs, whiplash injuries, and sustained poor posture, especially from prolonged device use. Symptoms include pain, stiffness, muscle spasm, and occasionally neurological signs; severe cases may present dizziness, headaches, or impaired coordination.[6,7]

Manual therapy is central to physiotherapy for NSNP. The Mulligan Concept's Sustained Natural Apophyseal Glide (SNAG), introduced in 1999, applies a sustained facet joint glide during active patient movement to correct positional faults and improve motion.[8] Evidence shows SNAGs reduce pain (Numerical Pain Rating Scale), improve function (Neck Disability Index), enhance cervical range of motion, and correct forward head posture.[9,10] While promising, responses vary, and high-quality evidence remains limited.

The review will identify the extent, range, and nature of research activity in this area, examine how SNAG has been used as a treatment modality, and highlight the areas where further research is needed. This will help clinicians, researchers, and policymakers in understanding the potential of SNAG as a therapeutic intervention for non-specific neck pain and contribute to evidence-based clinical decision-making.

A scoping review was selected since the current evidence on SNAGs is still developing and varies widely in study design and quality. This approach makes it possible to explore the available research in depth, map out key findings, and highlight gaps that future studies need to address, rather than narrowly focusing on pooled data as in a systematic review or meta-analysis.

Methods

Literature Search Strategy:

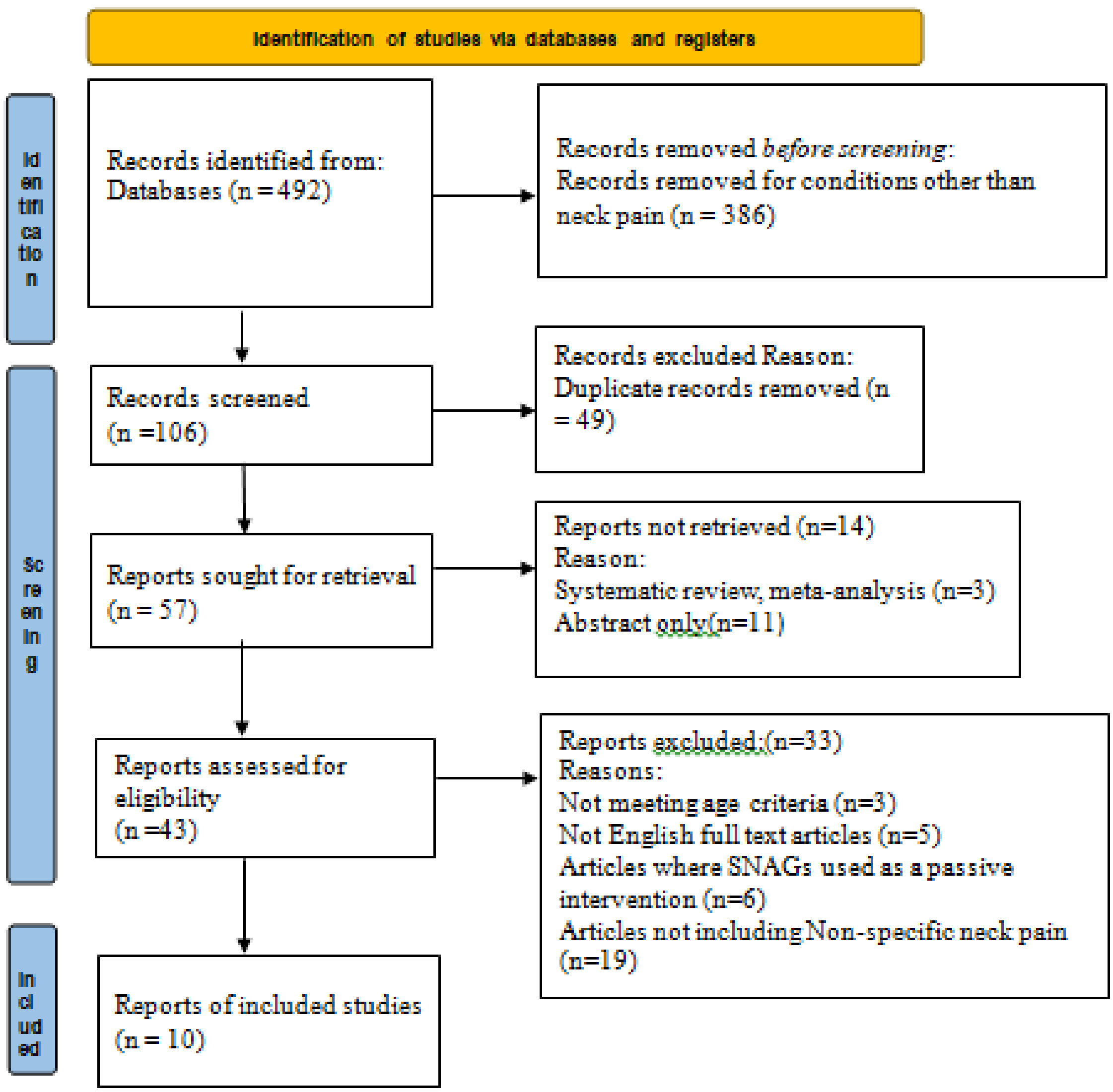
A comprehensive literature search was conducted using electronic databases in PubMed, Google Scholar, and ScienceDirect. The search focused on full-text articles published in English within the last 10 years. Relevant keywords used in the search included: "Sustained Natural Apophyseal Glide", "SNAGs", "Mulligan mobilization technique", "manual therapy", "neck pain", and "non-specific neck pain."

Eligibility criteria

A total of 492 articles were retrieved, and 386 articles are removed as they had articles for conditions other than Neck pain. Then 106 articles were screened, and 49 duplicates were removed from each PubMed and ScienceDirect. 57 articles were sought for retrieval, from which 14 were not retrieved, and later 43 articles were assessed for eligibility, from which 33 articles were excluded. Articles were included if they met the following inclusion criteria: a) studies involving adult human subjects (aged ≥ 18 years); b) randomized controlled trials (RCTs), cross-sectional studies, case studies, or quasi-experimental studies; c) studies focusing on determinants for the onset of non-specific neck pain, where non-specific neck pain is defined as pain without a specific systemic disease being identified as the underlying cause; d) articles in which SNAG technique was used as an active intervention; and e) only English-language, full-text studies.

Exclusion criteria were: a) studies involving other conditions such as tumours, fractures, infections, inflammatory disorders, or osteoporosis; and b) articles in which SNAG technique was used solely as a passive intervention.

The records retrieved from the search strategy were screened for eligibility by following the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews) flowchart. This was used to identify relevant studies through databases during initial phase. Finally, 10 articles met the study criteria and were included in the scoping review. These are presented in Table 1, and their PEDro scores are summarized in Table 2.



Result and Discussion

This scoping review of 10 experimental studies indicates that the Sustained Natural Apophyseal Glide (SNAG) technique is a beneficial approach for managing both mechanical and non-specific neck pain, leading to notable reductions in pain, improvements in cervical range of motion, and better functional outcomes. Comparisons with other manual therapy methods, including NAGs, cervical manipulation, thoracic manipulation, also favored SNAGs, with even greater benefits observed when combined with conventional treatment. The included studies, which were of moderate to high quality (PEDro scores 5–7), reported no adverse effects.

Ten randomized controlled trials were analysed and found consistent evidences supporting the use of SNAGs as an effective intervention. The reviewed studies found that SNAGs were associated with improvements in reducing pain, increasing cervical ROM, and enhancing overall functional ability.

Several physiological mechanisms explain the benefits of SNAGs; a primary factor is the correction of joint dysfunction. The glide applied during SNAGs mobilization releases locked facet joints and stretch the surrounding soft tissues, especially on the side where movement is restricted. Additionally, this technique helps reposition any displaced meniscoid structures trapped within the facet joints.[8] Restoring normal joint mechanics through this process contributes significantly to improved mobility and pain reduction.

Moreover, SNAGs stimulate large-diameter sensory fibres (A-beta), which interact with spinal inhibitory neurons. This interaction potentially “closes the gate” to pain signals at the spinal level, a concept consistent with the widely recognized Gate Control Theory.[7,12] As a result, patients often experience immediate relief from discomfort.

Enhanced blood circulation at the mobilization site is another important benefit. The technique facilitates better delivery of nutrients and removal of waste products from the affected tissues.[12] This localized improvement in circulation supports the healing of minor soft tissue damage and helps reduce inflammation and stiffness.

Additionally, research suggests SNAGs activate descending pain-inhibitory pathways in the central nervous system. The release of neurotransmitters such as serotonin and noradrenaline can help suppress pain perception and relax muscle tension, further contributing to functional recovery (Elkeblawy et al. 2021).[13]

Combining SNAGs with exercise was found better treatment outcomes. This combined approach not only promotes joint mobility but also supports muscle re-education and tissue repair, leading to better pain management and a greater increase in cervical ROM.[8,16]

The overall findings of this review align with the proposed mechanisms. All ten studies reported positive outcomes following SNAG intervention, with most demonstrating greater effectiveness compared to other manual therapies like cervical manipulation, Maitland mobilization, and conventional physiotherapy. When SNAGs were used alongside standard physiotherapy treatments, the therapeutic results were consistently superior, the included studies varied in terms of treatment duration, frequency, and control interventions, the short-term effectiveness of SNAGs was consistently evident.

Although the findings of this review are encouraging, some limitations within the included studies should be considered. Many of the trials involved only a small number of participants, which makes it harder to draw strong conclusions or apply the results to a wider population. In addition, several studies did not use proper blinding, which raises the risk of bias and may have influenced the reported outcomes. Another concern is that most of the research focused only on short-term effects, leaving uncertainty about how effective SNAGs remain over the long term. Differences in treatment protocols, follow-up periods, and outcome measures across studies also make it challenging to compare results directly. These issues highlight the need for larger, well-designed trials with longer follow-up to better establish the effectiveness and durability of SNAGs.

Summary of Included articles:

Title	**Type of Study**	**Methods**	**Outcome measures**	**Conclusion**	**Pedro score**
Effects of Sustained natural Apophyseal Glides versus cervical manipulation on pain and Disability in Non-specific Neck pain among Wrestlers[11]	Randomized clinical trial	56 Participants were randomly allocated into 2 main groups: A participant’s received snags while and B received cervical manipulation; 6 weeks treatment were provided 9 (2 sessions each week)	Numeric pain rating scale (NPRS) and neck pain disability index (NDI) tools were used	The study concludes that both SNAGs and cervical manipulation techniques were beneficial in reduction of neck pain. But on comparison Snag were more effective than cervical manipulation.	6

Cont........

Efficacy of mulligan on electromyography activation of cervical muscles in mechanical neck pain: randomized experimental trial[12]	Randomised experimental trial	90 subjects were randomly assigned to 2 groups: Group A received SNAGs with conventional therapy, while Group B received only conventional therapy (treatment given for 3 times a week for 4 weeks)	Muscle activity, pain and function were assessed before and after12 treatment sessions using EMG, VAS and the Arabic neck disability index.	The study concludes that both groups showed improvement in neck pain, function, and range of motion, with greater benefits in the SNAGs group.	7
Short-term Effects of Mulligan SNAGs on Pain intensity, Cervical range of motion and Craniovertebral Angle in patients with Non-specific neck pain: A Quasi-experimental Study[8]	Quasi-experimental Study	20 patients were randomly allotted into 2 groups. Group A received Interferential therapy and Static neck Exercises. Group B received Mulligan SNAGs in addition to interferential therapy and static neck exercises.	Pain intensity using Numerical Pain Rating Scale (NPRS), Active Range of motion by Goniometer, CV angle was measured by Electronic Head Posture Instrument (EHPI)	Study concluded that, short-term Mulligan SNAGs with conventional physiotherapy is more effective in reducing pain, improving cervical range of motion, and correcting CV angle in non-specific neck pain patients.	5
Mulligan Sustained Natural Apophyseal Glides Versus Thoracic Manipulation on Mechanical Neck Pain: A Randomized Controlled Study[13]	Randomized Controlled Study	60 MNP patients were randomly divided into 3 groups: Group I received SNAGs with conventional therapy (CPT), Group II received thoracic manipulation with CPT, and Group III received only CPT. All participants received 3 sessions per week for four weeks.	Visual analogue scale (VAS), pressure algometer, Cervical ROM, and Neck disability index (NDI) were measured	The study concluded that Adding SNAGs or thoracic manipulation to CPT significantly improved pain, pressure pain threshold, disability, and cervical ROM in MNP patients, with SNAGs showing greater benefits.	7
Comparative study on the effectiveness of mulligan sustained natural apophyseal glides (SNAGs) VS Mulligan Natural Apophyseal glides (NAGs) in patients with Mechanical Neck Pain[14]	Randomized clinical trial	50 subjects are randomly divided 2 equal groups: Group A will receive Mulligan SNAGs while Group B will receive Mulligan NAGs (Treatment given for 3 times per week for two weeks)	Wong-Baker faces pain scale (WBFPS) to measure pain and Neck disability index (NDI) to assess change in pain	The study concluded that the Mulligan's techniques are effective but Mulligan's SNAGs is more effective in case of Mechanical Neck pain then in comparison to Mulligan's NAGs	6

Cont........

Efficacy of Sustained Natural Apophyseal Glides in the Management of Mechanical Neck Pain: A Randomized clinical Trial[15]	Randomized Clinical Trial	100 patients were randomly assigned to to 2 groups: Group A received SNAGs with CPT, and Group B received ultrasound with CPT. Each group were treated 3 times a week (for 2 weeks)	Pain, ROM, and neck disability were assessed on Visual Analog Scale (VAS), Goniometer, and Neck Disability index (NDI) respectively.	The study concluded that SNAG mobilization illustrated better improvement in neck ROM, pain, and neck disability in patient with mechanical neck pain	6
Effectiveness of Snag Mobilization on computer professionals with Mechanical Neck pain and Mobility deficit[16]	Experimental Study	100 subjects were equally divided into 2 groups: 50 received SNAGs manual therapy (experimental group) and 50 received conventional therapy (control group), with treatment over six weeks.	Neck Disability Index (NDI), and active range of motion (AROM)	The Study Concludes that SNAGs led to great improvement in cervical ROM, pain and disability than conventional physiotherapy alone in patients with mechanical neck pain.	5
Comparison between sustained natural apophyseal glides (SNAG's) and myofascial release techniques combined with exercises in non-specific neck pain[7]	Randomized controlled trial	70 participants with NS-NP were randomly assigned to 3 groups: the SNAG's group, MFR group, and controlled group. Each group received a total of 12 treatment sessions, 3 sessions per week over 4 weeks.	Neck range of motion was assessed using the Myrin OB goniometer, functional activity using the Neck disability index (NDI), and Neck pain using VAS	The study found that combining SNAGs or MFR with exercise provides short-term benefits for pain relief, improved ROM and function in NS-NP.	7
To Study effectiveness of cervical mobilization (SNAGs) compared with isometric exercises on increasing ROM, reducing pain and disability in patients with Mechanical Neck pain[17]	Experimental study	40 patients with mechanical neck pain were divided into 2 groups: 20 in the experimental group received SNAGs, and 20 in the control group performed isometric exercises.	Neck Disability index (NDI), Visual Analogue Scale (VAS) and Goniometry were measured	The study found that SNAGs treatment led to reduced pain and disability, along with improved range of motion in patients with mechanical neck pain.	5

Cont........

Comparison of Sustained Natural Apophyseal Glides and Maitland Manual Therapy in Non-specific Neck Pain on Numeric pain Rating Scale and Neck Disability Index[18]	Quasi-experimental study	75 subjects with non-specific neck pain were randomly assigned to three groups: Group 1 received SNAGs, Group 2 received Maitland mobilization, and Group 3 received conventional treatment.	Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), functional status with the Neck Disability Index (NDI), ROM with a goniometer, and neck muscle strength through MMT.	The study concluded that SNAGs is more effective in the management of non-specific neck pain.	5

Pedro Score:

Author	Eligibility criteria	Random allocation	Concealed allocation	Baseline similarity	Blinding of subjects	Blinding of therapists	Blinding of assessor	>85% Follow-up	ITT-Analysis	Between group comparison	Point estimates and variability provided	Quality
Zakaullah S (2023)	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓	✓	Moderate
Abd El-Azeim AS (2023)	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	High
Vijayan K (2022)	✓	✓	✗	✓	✗	✗	✗	✓	✗	✓	✓	Moderate
Elkeblawy MA (2021)	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	High
Raza SM (2021)	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓	✓	Moderate
Shamsi S (2021)	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓	✓	Moderate
Pal A (2019)	✓	✓	✗	✓	✗	✗	✗	✓	✗	✓	✓	Moderate
Rezkallah S (2018)	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	High
Banu SB (2018)	✓	✓	✗	✓	✗	✗	✗	✓	✗	✓	✓	Moderate
Tanveer F (2017)	✓	✓	✗	✓	✗	✗	✗	✓	✗	✓	✓	Moderate

Conclusion

This scoping review provides strong evidence supporting the effectiveness and safety of the Sustained Natural Apophyseal Glide (SNAG) technique for managing mechanical and non-specific neck pain. Across ten randomized controlled trials, SNAGs consistently reduced pain, improved cervical mobility, and enhanced functional performance. These benefits were observed both as a standalone treatment and when combined with conventional physiotherapy, often surpassing other manual therapy approaches. The combined mechanical and neurophysiological effects of SNAGs likely contribute to these significant improvements.

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Declaration of conflicts of interest: The authors declare no conflicts of interest.

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Original Article

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Effect of Therapeutic Electrical Stimulation on Agonist Versus Antagonist Muscle on Spasticity in Patients with Cerebral Palsy: A Randomized Controlled Trial

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Abstract

Background: Cerebral palsy is one of the most common neurological disorders leading to disability. A hallmark of CP is spasticity. Spasticity leads to movement limitations and thus, largely contributes to the disruption of motor performance. To decrease the spasticity various physiotherapy techniques are used.

Objective: To compare the effect of therapeutic electrical stimulation on agonist versus antagonist muscle on plantar flexors' spasticity in patient with spastic diplegic cerebral palsy.

Methods: In the present comparative interventional study, total 33 patients were participated. Out of which 17 patients were randomly allocated in group A and 16 patients to group B. Group A received Therapeutic electrical stimulation of agonist muscle + conventional physiotherapy and Group B received Therapeutic electrical stimulation of antagonist muscle + conventional physiotherapy. As per inclusion and exclusion criteria and treatment was given for the duration of 20 minute, 5 days per week for 4 weeks. Pre and post intervention assessment were carried out by using Modified Tardieu scale and Hmax / Mmax ratio. Data was collected and analyzed.

Results: Agonist muscle group shows significant difference in Hmax / Mmax ratio (p=0.032), and antagonist muscle group shows significant improvement in Dynamic component of MTS and Hmax / Mmax ratio (p=0.000), whereas no difference found in quality of muscle reaction. Antagonist muscle shows significant difference in Dynamic component of MTS and Hmax / Mmax ratio (p=0.001).

Conclusion: This study concludes that therapeutic electrical stimulation of the antagonist muscle is more effective for reduction of spasticity.

Key words: cerebral palsy, spasticity, therapeutic electrical stimulation.

Introduction

Cerebral Palsy (CP) is defined as a group of permanent, non-progressive disorders affecting the development of movement and posture, causing

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activity limitation [1]. These disorders are attributed to disturbances occurring in the developing fetal or infant brain. While the initial cerebral lesion is static, the clinical manifestations evolve over time as the child grows and matures, often creating the illusion of a progressive condition. As the most common cause of severe physical disability in childhood, CP represents a significant challenge to global public health systems, with profound implications for the individual, their family, and society[2-4].

In developed countries, the prevalence of CP is reported to be 1-2 per 1000 live births, a figure that rises dramatically with decreasing gestational age. In the context of a developing nation like India, the estimated incidence is around 3 per 1000 live births, with an estimated population of 2.5 million children living with CP, though the actual figure is likely higher due to underreporting and limited access to diagnostic services[5].

CP is classified based on the nature of the movement disorder (spastic, dyskinetic, ataxic, or mixed) and its topographic distribution (hemiplegia, diplegia, quadriplegia). Among these, spastic CP is the most prevalent, accounting for approximately 80% of all cases. Spastic diplegia, a subtype where the lower limbs are significantly more affected than the upper limbs, is particularly common, especially among children born prematurely [6, 7].The functional consequences of spasticity are multifaceted and often debilitating. It can lead to functional problems with activities of daily living (ADLs) such as gait, feeding, and dressing. Over time, persistent spasticity can cause muscle contractures, joint deformities, bony malformations, pain, spasms, and impaired seating posture, ultimately diminishing functional independence and quality of life[8, 9, 10].

Accurately assessing the degree of spasticity remains a challenge in clinical practice. Several tools are employed, ranging from clinical scales like the Modified Ashworth Scale (MAS) and the Modified Tardieu Scale (MTS) to more objective electrophysiological tests like the Wartenberg pendulum test. The prognosis for individuals with CP is strongly associated with the type and severity of motor impairment, as well as the presence of associated non-motor disabilities. [9, 11].

Given the complexity of CP, management necessitates an interdisciplinary approach, drawing on the expertise of physiatrists, neurologists, physical and occupational therapists, orthotists, and surgeons. The management of spastic hypertonia is a cornerstone of treatment and involves a tiered approach. This includes physical therapy (muscle stretching, strengthening, and functional training), oral medications (e.g., baclofen, diazepam), chemical neurolysis (intramuscular Botulinum Toxin A injections, phenol nerve blocks), intrathecal baclofen therapy, and orthopaedic surgeries. Physical therapy, specifically regular muscle stretching and joint mobilization, is considered fundamental for preventing contractures and temporarily reducing spastic tone[11, 12].

Within the realm of physical therapy modalities, Therapeutic Electrical Stimulation (TES) has emerged as a promising intervention for managing spasticity and improving motor function in children with CP. Neuromuscular Electrical Stimulation (NMES), a form of TES, involves the application of electrical current to peripheral nerves to elicit muscle contractions. Research evidence suggests that NMES can have positive effects on gait parameters, range of motion, muscle strength, and gross motor function[13, 14].

However, the application of TES is not monolithic, and a critical methodological variation exists in its application. Some studies and clinical protocols advocate for the stimulation of the spastic muscle itself (the agonist), with the rationale of improving its strength, endurance, and voluntary control, thereby normalizing muscle function and reducing hypertonia through reciprocal inhibition[15, 16]. Conversely, other approaches propose stimulating the antagonist muscle to the spastic agonist.

This dichotomy in application creates a significant gap in the clinical literature. While numerous studies have investigated the effects of TES, there is a lack of direct, comparative evidence evaluating the relative efficacy of agonist versus antagonist stimulation in reducing spasticity and improving function in children with cerebral palsy. The existing body of research is fragmented, with studies often focusing on one approach or the other without a head-to-head comparison, making it difficult for clinicians to make evidence-based decisions regarding the most effective stimulation paradigm[16-18].

Therefore, a clear need exists for a structured study to systematically compare these two distinct approaches to TES. Determining which method—stimulation of the spastic agonist or its antagonist—yields superior outcomes in terms of spasticity reduction, improvement in range of motion, and enhancement of functional abilities is of paramount clinical importance. Such evidence would directly inform and optimize physical therapy practice, leading to more targeted and effective interventions for children with spastic CP.

This study aims to bridge this knowledge gap by investigating and comparing the effectiveness of Therapeutic Electrical Stimulation applied to the agonist muscle versus the antagonist muscle on spasticity, passive range of motion, and functional status in children with spastic cerebral palsy. The findings of this research will provide valuable, evidence-based guidance for clinicians, ultimately contributing to improved rehabilitation strategies and quality of life for this patient population.

Materials and methods

This study was a comparative interventional trial conducted over a one-year period. The required sample size was calculated a priori using G*Power software (version 3.1.9.2). With an effect size of 1.421 and an alpha (α) level set at 0.05, the analysis indicated a minimum sample size of 28 participants. To account for a potential dropout rate of 10%, the final sample size was increased to 34. However, total of 33 children diagnosed with spastic diplegic cerebral palsy were enrolled through purposive sampling method from SPB Physiotherapy College, various physiotherapy clinics, and special schools in Surat. Participants were selected based on inclusion criteria, children of both genders, aged between 5 and 11 years[19], with a confirmed diagnosis of spastic diplegic CP and demonstrable spasticity in the plantar flexor muscles of the lower limb, graded between 1 and 3 on the Modified Ashworth Scale (MAS)[20]. Children were excluded from the study if they had a diagnosis of mental retardation, unstable seizures, or behavioural disorders. Additional exclusion criteria included any musculoskeletal or neurological surgery on the lower limb within the past year, Botox treatment in the preceding six months, current use of any antispastic, anticonvulsant, or other stimulant/relaxant medications, and the presence of any sensory disturbances. Ethical clearance for the study was obtained from the institutional ethical committee prior to commencement, and informed consent was secured from the parents of all participating children.

Participants were enrolled and randomized into two groups of 17 (Group A) and 16 (Group B) participants each. Randomization was achieved using a simple coin toss method. Group A (16) received therapeutic electrical stimulation on agonist group of muscle (stimulation of plantar-flexors muscle) and conventional physiotherapy treatment. 1 participant from group A discontinued the intervention due to unavailability in the city. Group B (16) received therapeutic electrical stimulation on antagonist group of muscle (stimulation of dorsi-flexors muscle) and conventional physiotherapy treatment. Duration of treatment was set as 20 minof TES+45-minute conventional physiotherapy 5 times per week for 4 weeks.

Conventional treatment[21,22] included was passive stretching exercises for the hip flexors, hip adductors, hamstring, calf muscle with 30 seconds hold and rest duration of 30 seconds (3 repetitions = 3 times for each muscle group within pain limit), resistive exercises, weight bearing exercises (bridging, kneeling, kneel sit to stand, sit to stand, single leg standing and stepping), reaching exercises in sitting, kneeling and standing, and gait training. 10 repetitions were kept for each exercise.

Therapeutic electrical stimulation of agonist muscles [Plantar flex or muscles] and antagonist muscles were given for 20 min, 5 times per week for 4 weeks. Stimulus intensity was adjust edaccording to individual subject's toleranceata level which produces a visible muscle contraction without discomfort. Electrical stimulation wasgiven byusing, LCD diagnostic stimulator (Medipulse) Serial no. = MS066/1/16. Both the group shadthe same stimulation parameters [23] with frequency 20 Hz, Pulse-width 0.25 mses, and intensity according to tolerance level of patient.

Measurement of spasticity was done by Hmax/Mmax and MTS. Spasticity of ankle joint was measure through modifiedtardieu scale and H-reflex and the M-wave measures were determined with Neurophysiology software machine[24,25]. Parameters of instrument was SweepSpeed=5ms/div, Sensitivity=1.0mV/div and filter Setting=5Hz-10

KHz. According to child's tolerance level rest was given when required and total of 45 minutes session was given. Spasticity was used as an outcome measure at first day and at 4th week of the treatment.

Statisticalanalysis and Results

The statistical analysis was conducted using SPSS version 15.0 for Windows. All calculations were performed with an alpha level set at 0.05 and confidence interval at 95%. The normality of the data was assessed using the Shapiro-Wilk test. Mean and standard deviation were computed to represent central tendency and dispersion, respectively. The impact of the interventions over time on the Hmax/Mmax ratio and the dynamic angle component of the Modified Tardieu Scale (MTS) was analyzed using a paired t-test for intra-group comparisons and an unpaired t-test for inter-group comparisons. Additionally, the effects of the interventions on the quality of muscle reaction component of the MTS were evaluated using the Wilcoxon Signed Rank test for intra-group analysis and the Wilcoxon Sum Rank Test (Mann-Whitney U Test) for inter-group analysis.

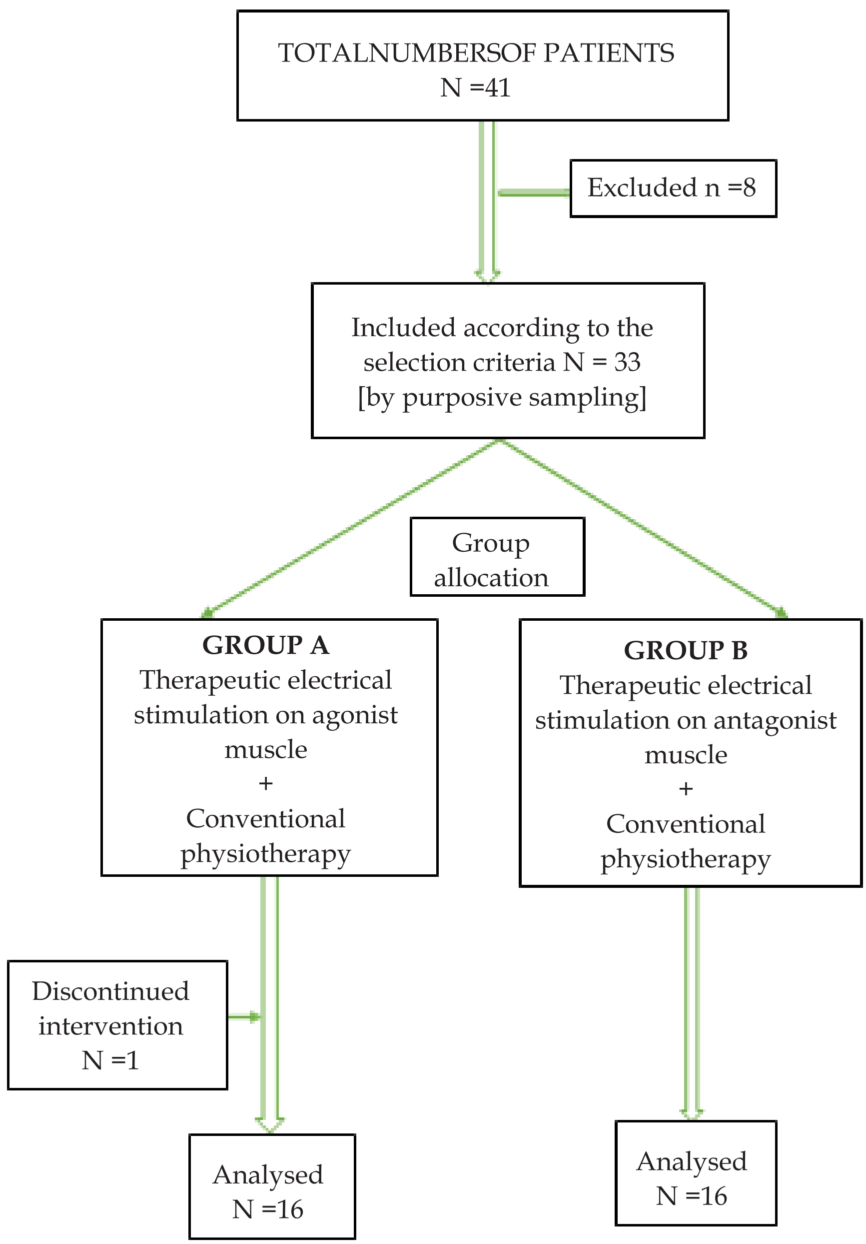

Figure 1: Provides a flow diagram of participant recruitment and retention through the study.

Table 1: Baseline characteristics and evaluation

VARIABLE	GROUP A TES on agonist muscle + conventional physiotherapy MEAN ± SD	GROUP B TES on antagonist muscle+conventional physiotherapy MEAN± SD	p value
Age[inyears]	8.071 ± 0.633	7.5 ± 0.447	0.009
Gender	Boys= 68.75% Girls =31.25%	Boys= 62.5% Girls =37.5%	–
Pre-angle	5.06 ± 1.769	5.44 ± 2.421	0.039
Pre-QMR	1.875 ± 0.806	1.875 ± 0.718	<0.001
Pre-H/Mratio	0.512 ± 0.212	0.449±0.232	0.265

The table displays the statistics of age distribution of the 32 subjects that participated in the study. Among the 32 subjects, the mean + SD of age of 16 subjects in GroupAwas8.07±0.633years and the mean + SD of age of 16 subjects in Group B was 7.50± 0.447 years. Out of 32 patients, 21 (65.62%) were boys and 11(34.38%) were girls.

Intragroup analysis

Table 2: Intra group analysis of Group A

Outcome measures	Intervention	Mean	± SD	tvalue	p value
Dynamic component of MTS	Pre	5.06	1.769	0.269	0.791
	Post	5.00	2.129		
Quality of muscle reaction of MTS	Pre	1.88	0.806	1.732	0.083
	Post	1.69	0.704		
Hmax/Mmax ratio	Pre	0.512	0.212	2.361	0.032
	Post	0.476	0.243		

The above table shows the mean+SD of pre and post intervention dynamic component and quality of muscle reaction. Results prove therapeutic electrical stimulation on agonist group of muscle (stimulation of plantar-flexors muscle) and conventional physiotherapy treatment improves H_{max}/M_{max}ratio for spasticity. No significant effect was found in Dynamic component and quality of muscle reaction of MTS.

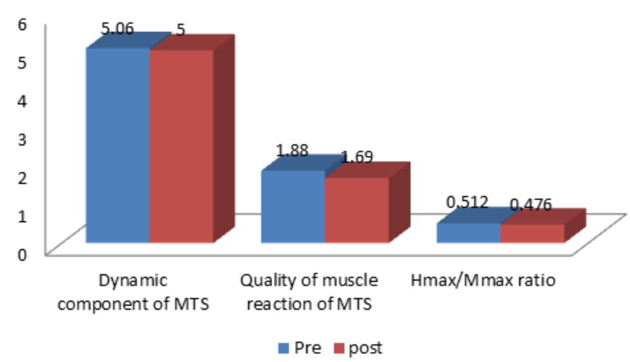

Figure 2: Intra group analysis of Group A

Table 3: Intra group analysis of Group B

Outcome measures	Intervention	Mean	± SD	tvalue	p value
Dynamic component of MTS	Pre	5.44	2.421	4.478	<0.001
	Post	3.50	1.633		
Quality of muscle reaction of MTS	Pre	1.88	0.719	-1.00	0.317
	Post	1.81	0.655		
Hmax/Mmax ratio	Pre	0.449	0.232	5.323	<0.001
	Post	0.288	0.203		

The above table shows the mean±SD of pre and post intervention dynamic component, quality of muscle reaction, and H_{max}/M_{max} ratio. Result shows therapeutic electrical stimulation on antagonist group of muscle and conventional physiotherapy treatment improves H_{max}/M_{max}ratio for spasticity and quality of muscle reaction.

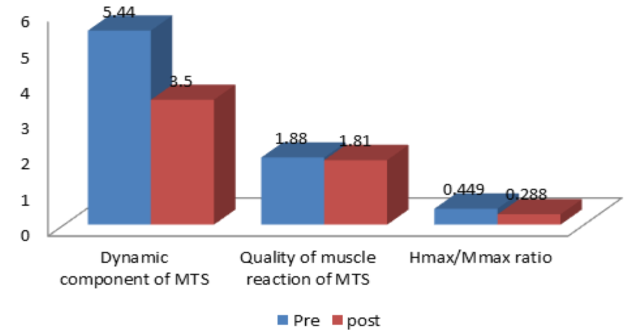

Figure 3: Intra group analysis of Group B

Table 3: Inter group comparison of Group A and B

Outcome measures	Group	Mean	tvalue	p value
Dynamic component of MTS	Group A	-0.06	3.818	0.001
	Group B	-1.94		
Quality of muscle reaction of MTS	Group A	0.13	112.0	0.293
	Group B	1.50		
Hmax/Mmax ratio	Group A	-0.036	0.686	0.001
	Group B	-0.161		

The above table shows post intervention dynamic component, quality of muscle reaction, and H_{max}/M_{max} ratio for Group A and Group B. It proves therapeutic electrical stimulation on antagonist muscle improves H_{max}/M_{max}ratio for spasticity and quality of muscle reaction in electricalstimulation. It says antagonist muscle is more effective compare to agonist for reduction of spasticity in patients with spastic diplegic cerebral palsy.

Discussion

This study aimed to compare the effects of therapeutic stimulation on agonist versus antagonist muscles in reducing spasticity of the plantar flexor muscles in patients with cerebral palsy. All participants received conventional physiotherapy alongside therapeutic electrical stimulation: Group A received stimulation on agonist muscles, while Group B received it on antagonist muscles, for 20 minutes, five days a week over four weeks. The Modified Tardieu Scale and the Hmax/Mmax ratio were utilized to assess pre- and post-intervention effects on spasticity.

Before any intervention, an increase in the Hmax/Mmax ratio was observed in the spastic muscles of the participants, indicating stretch reflex hyperexcit ability associated with spasticity. This condition arises from upper motor neuron (UMN) lesions that disrupt spinal inhibitory mechanisms, leading to diminished reciprocal inhibition. To address spasticity, therapeutic electrical stimulation was employed. Spasticity is believed to stem from an imbalance between excitatory and inhibitory inputs to alpha motor neurons, resulting in heightened excitability. The therapeutic effects of electrical stimulation in central nervous system (CNS) lesions are thought to facilitate neuroplasticity by enhancing afferent input, activating previously unused neuronal connections, or suspending their inhibition[26-27].

In Group A, a significant improvement in the Hmax/Mmax ratio was noted post-intervention, although no significant change was observed in the Modified Tardieu Scale. Previous studies by Lee et al., Chen SC et al., and Robinson et al. have similarly reported reductions in spasticity following surface electrical stimulation of spastic muscles. The physiological rationale for this is that stimulation of agonist muscles antidromically activates motor neurons, which then trigger inhibitory interneurons (Renshaw cells) that inhibit alpha motor neurons in the spastic muscles[28, 29].

Group B demonstrated significant improvements in the dynamic component of the Modified Tardieu Scale and the Hmax/Mmax ratio, but no notable change in the quality of muscle reaction. Research by Levin and colleagues has shown decreased hamstring spasticity with surface electrical stimulation of the quadriceps and iliopsoas, while Seib et al. reported reduced spasticity in the gastrocnemius following stimulation of the tibialis anterior[30]. This effect is attributed to reciprocal inhibition, where stimulation of the antagonist muscle excites large-diameter Ia muscle spindle afferents, activating spinal inhibitory interneurons that inhibit alpha motor neurons, leading to muscle relaxation through Golgi tendon organ activation.

Statistical analysis revealed significant differences in the dynamic component of the Modified Tardieu Scale and the Hmax/Mmax ratio between the two groups, but no significant difference in the quality of muscle reaction. So electrical stimulation to antagonist muscle group showed improvement in spasticity. Previous studies by Nielsen (1989) and Crone (1993) indicated that the inhibition of antagonistic motoneurons during agonist muscle activation involves multiple physiological mechanisms beyond disynaptic reciprocal Ia inhibition, including propriospinal-mediated inhibition and presynaptic inhibition directed at Ia fibers projecting to soleus motor neurons[31, 32].

The study supports that there is a significant difference between therapeutic electrical stimulation of antagonist muscles in reducing spasticity of the plantar flexors in spastic diplegic cerebral palsy. The results are easily applicable in clinical practice due to the cost-effective nature of the interventions, equipment, and settings involved. Therefore, incorporating therapeutic electrical stimulation of antagonist muscles into the rehabilitation phase for cerebral palsy patients mayeffectively reduce spasticity. Several limitations of the present study should be considered when interpreting its findings. Firstly, the study was conducted with a relatively small sample size, which may limit the generalizability of the results. Furthermore, there was a notable gender imbalance, with significantly fewer female participants than males. The study design also lacked a follow-up period, preventing any assessment of the long-term effects of the interventions. Additionally, the potential for bias exists as the study was not blinded; both the therapists administering the treatment and the participating subjects were aware of the group allocations. Finally, the narrow age range of 5 to 11 years, while controlling for developmental variability, restricts the applicability of the findings to other pediatric age groups.

Several avenues for future research are recommended. Subsequent investigations should prioritize a larger sample size to enhance the statistical power and validity of the results. The promising protocol used here could also be applied to other populations with spasticity, such as stroke or spinal cord injury patients, and could be extended to study spastic muscle groups in the upper limb. To strengthen the research design, future studies should incorporate a control group, aim for balanced gender distribution, and implement blinding procedures. Further exploration is needed to determine the optimal treatment duration for Therapeutic Electrical Stimulation and to utilize a wider array of outcome measures. Finally, conducting studies with long-term follow-up would be invaluable for understanding the carryover effect and sustained benefits of the intervention.

Conclusion

The study concludes that therapeutic electrical stimulation of theagonist and antagonistmuscleis improving dynamic component and Hmax/Mmax ratio for spasticity, however electrical stimulation of antagonist muscle is more effective compare to agonist for reduction of spasticity in patients with spastic diplegic cerebral palsy.

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Original Article

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Effectiveness of Myofascial Release with Tennis Ball versus Static Stretching in IT Professionals with Trapezitis Pain

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Abstract

Background: Neck pain affects 13% of people, with 50% experiencing it at least once in their lifetime. Trapezitis is caused due to trapezius muscle strain. Treatment includes acupuncture, dry needling, Myofascial and Static Stretching. These methods relieve pain, reduce muscle tension and improve range of motion, benefiting individuals, especially IT professionals with prolonged sitting. This study aims to compare the effect soft tennis ball MFR and static stretching on pain and functional outcomes in IT professionals.

Methodology: The study was conducted on 52 participants aged 30-40 years, both male and female with Trapezitis recruited through convenience sampling. The 52 samples were equally divided into two groups, Group A and B containing 26 participants each.

Group A received Myofascial release with a tennis ball. Group B received static stretching of trapezius muscle. VAS score, NDIscale were used as an outcome measure to assess pre and post exercise, samples underwent exercise accordingly under supervision of physiotherapists. The pre and post values were analyzed and was managed by word 2013, and analyzed by SPSS 17.

Results: Both groups showed statistically significant improvements in VAS and NDI scores from pre- to post-intervention ($p < 0.05$). Group A (MFR with tennis ball) showed a greater reduction in pain and improvement in neck function compared to Group B (static stretching).

Conclusion: Both interventions resulted in significant improvement in pain and functional outcomes. However, the data from the study reveals that Myofascial Release with tennis ball has a much more significant effect on the IT professionals who suffer from trapezitis pain.

Keywords: Myofascial Release, Static Stretching, Trapezitis Pain, Neck Pain, IT Professionals, Tennis Ball

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Introduction

Neck pain is one of the most prevalent musculoskeletal disorders worldwide, with a point prevalence of approximately 13% and a lifetime prevalence nearing 50%.[1] Its prevalence increases with age and is more common in women.[1] Although serious causes such as tumours or neurogenic disorders are rare, most cases are nonspecific. Without appropriate physiotherapy intervention, acute neck pain progresses to chronic pain in 10–30% of individuals.[2]

The major contributor of neck pain is Muscle strain, with the trapezius muscle being highly affected due to sustained postural stress causing trapezitis[3] or trapezius myalgia leading to discomfort, muscle spasms in the back of neck caused by inflammation of the trapezius muscle. Around 42-59% of people experience trapezius pain atleast once in their lifetime[4] and 38% of female IT professionals report similar pain[5].The upper trapezius innervated by cranial nerve 11 and plays an important role in maintaining the posture, shoulder elevation and shrugging. Tightness in this muscle restricts the cervical mobility causing reduced neck range of motion and potentially damaging other soft tissue structures. Clinical assessment involves shoulder shrugging with slight abduction[6].

Myofascial release is an effective way of treating trapezius pain as it increases the pressure pain threshold[7]. The pulling of fascia, a connective tissue running throughout the body, from one side causes pain and tension in the other side similar to pulling a plastic sheet. This is treated by Myofascial release[9]. Myofascial release known for its efficacy in reducing skeletal immobility and pain. It aims to reduce pain by releasing fascial restrictions caused by collagen densification and nociceptor activation[10]. Myofascial release relaxes contracted muscles by applying sustained pressure over myofascial trigger points, improving vascular and lymphatic circulation and reducing pain. Trigger points form due to unidirectional fascial strain and are effectively released using manual pressure or tools such as a tennis ball.

Stretching, a mechanical maneuver used to improve flexibility of the muscles and mobility of the joint[11], performed by performing the action opposite to the primary action of the muscle leads to relaxation of a particular muscle and is most commonly performed after workouts. Static stretching is a method involving the stretch of the muscle for 30 seconds and then relaxing it. It is considered to be effective in increasing range of motion and exercise performance reducing the risk of injuries[12], reducing the muscle strength temporarily during the stretching[13] and reducing muscle soreness after exercise[14]. In the trapezius muscle, static stretching has been shown to reduce muscle tension[15] and neck pain while improving cervical mobility[16], without significantly affecting muscle[17]. Occupational factors contribute significantly to neck pain, with approximately 60.3% of computer users reporting symptoms[18]. IT professionals often maintain prolonged static postures for 7–8 hours daily, increasing the risk of trapezius muscle overuse and chronic neck pain.

Aim of the Study

1. To measure the effect of MFR with tennis ball in terms of pain and functional outcome.
2. To compare the effect of MFR and Static stretching in improving pain and physical function in IT professionals

Need of the Study

IT professionals form a major part of the population and due to their prolonged sitting hours and static posture, major strain is applied on the trapezius muscle leading to trapezitis. It leads to functional limitations and has the possibility of turning into a prolonged chronic neck condition.

Myofascial release and static stretching are the common approaches used for Trapezitis and the comparision of the has not been studied as of now. Additionally, the use of a cost effective instruement such as tennis ball makes that can be used at the clinic as well as workplace makes it feasible and easy to apply. To summarise, the needs of the study are

1. To determine and compare the most common interventions for Trapezitis such as Myofascial release with tennis ball and static stretching
2. To evaluate the feasibility of a tennis ball in managing neck pain in IT professionals

3. To provide a feasible evidence based intervention to manage trapezitis pain in IT professionals

Methodology

Study Design

This was an experimental comparative study using a convenience sampling technique.

Participants

A total of 52 participants aged 30–40 years (both male and female) with unilateral trapezitis were recruited from an IT company in Bangalore over a 12-week study period. Participants were equally divided into two groups of 26: Group A (MFR with tennis ball) and Group B (static stretching). Both groups additionally received a conventional physiotherapy protocol throughout the study duration.

Inclusion Criteria

- IT workers working 6–8 hours per day
- Age group: 30–40 years
- Both male and female with unilateral trapezitis
- Trapezitis pain persisting for more than 4 weeks

Exclusion Criteria

- Psychological problems
- Recent surgery in the cervical region
- Currently under any medications
- Cervical instability
- Cervical radiculopathy
- Vertigo
- Thoracic outlet syndrome
- Herniated disc
- Osteoarthritis or rheumatoid arthritis
- Any other degenerative disorder

Outcome Measures

1. Visual Analogue Scale (VAS) – for pain intensity
2. Neck Disability Index (NDI) – for functional disability

Ethical Considerations

Informed consent was obtained from all participants prior to enrolment. Participants were free to withdraw at any time without penalty. The study was conducted in accordance with ethical guidelines for research involving human participants.Approval obtained from Vydehi Institute of ethical committee on 9th March 2024,VIEC/2024/APP/012 DCGIE EC Reg No.BCR/747/Inst/KA/2015/RR21 DHR EC Reg No. EC/NEW/INST/2023/KA/0322

Procedure

Conventional Physiotherapy Protocol (Both Groups)

All participants in both groups received standard physiotherapy comprising moist heat application (15 minutes) prior to the intervention, to reduce baseline pain and prepare the musculature. Both groups were also instructed to perform self-stretching exercises 5 times per week as a home exercise programme.

Group A: Myofascial Release with Tennis Ball

Group A: Patient position was sitting on the stool, hand resting on thigh. Therapist was standing behind the patient closer to the treating area. Tennis ball is used to apply pressure and glide along the neck with sustained pressure. The pressure was applied for 30-90 seconds over the trigger point. As the session began, patient was instructed to perform contralateral cervical side flexion. This session was repeated for 4 times, twice a week for 9 weeks.

Group B: Static Stretching

Patient position was sitting on the stool, hand resting on thigh. Therapist was standing behind the patient stabilizing the shoulder with one hand. A deep stretch pressure was applied by the therapist thumb on trapezius muscles. The patient was then instructed to perform lateral cervical flexion. This position was held for 30 seconds. The session was repeated for 3-5 times, twice a week for 9 weeks. Both groups were advised to perform self stretching exercises 5 times a week as a home exercise. Both the groups received the conventional physiotherapy protocol. Patient follow up and post value was recorded on 10th week.

Pre-intervention outcome measures (VAS, NDI, and goniometry) were recorded at baseline (Week 0). Post-intervention measurements were recorded at Week 10 (one week after the final treatment session).

Results

Data were collected and managed using MS Word 2013 and analysed by SPSS version 17.Within-group comparisons were performed using the Paired Samples t-test (NDI, which was normally distributed) and the Wilcoxon Signed Ranks Test (VAS, which was non-normally distributed). Between-group comparisons used the Independent Samples t-test or Mann-Whitney U test as appropriate.

Demographic Data

Table 1 presents descriptive statistics for both groups. The mean age of participants in Group A was 35.6 years and in Group B was 34.7 years. Table 2 shows the gender distribution across groups; both groups were comparable in terms of age and gender ($p > 0.05$).

Table 1: Descriptive statistics for Group A and Group B

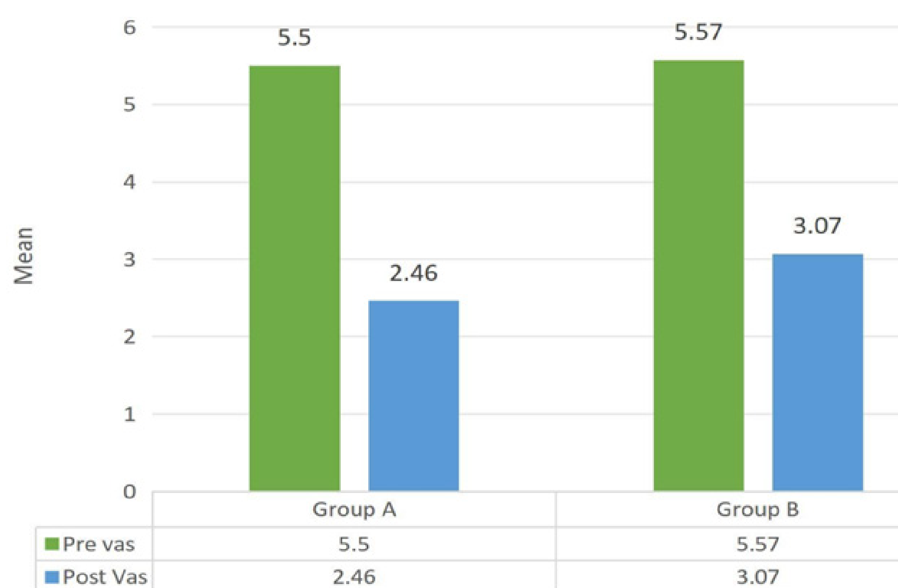
	N	Mean		Std. Deviation	
Age	52	Group A	35.6	Group A	3.09
Valid N (list wise)	52	Group B	34.7	Group B	3.29

Table 2: Gender frequency table for Group A and Group B

	Frequency		Percent		Valid Percent		Cumulative percent	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
Female	14	13	53.8%	50%	54.0	50.0		
Male	12	13	46.1%	50%	46.0	50.0	54	50
Total	26	26	100%	100%	100.00	100.00	100	100

VAS Score (Pain)

Graph 1 illustrates the comparison of pre- and post-intervention VAS scores for both groups. As shown in Table 3 (Wilcoxon Signed Ranks Test), both Group A and Group B demonstrated statistically significant reductions in VAS scores following intervention ($p < 0.05$). Group A showed a greater mean reduction in VAS score compared to Group B. Table 4 (Test Statistics) confirms a statistically significant between-group difference in VAS improvement in favour of Group A ($p < 0.05$).



Graph 1: Comparison between pre- and post-intervention VAS scores for Group A and Group B

Table 3: Wilcoxon Signed Ranks Test for VAS

VAS Post - VAS Pre	Negative Ranks	26[a]	13.50	351.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	26		
VAS Post - VAS Pre	Negative Ranks	26[d]	13.50	351.00
	Positive Ranks	0[e]	.00	.00
	Ties	0[f]		
	Total	26		

a. VAS Post < VAS Pre
b. VAS Post > VAS Pre
c. VAS Post = VAS Pre
d. VAS Post < VAS Pre
e. VAS Post > VAS Pre
f. VAS Post = VAS Pre

Table 4: Test statistics for between-group VAS comparison

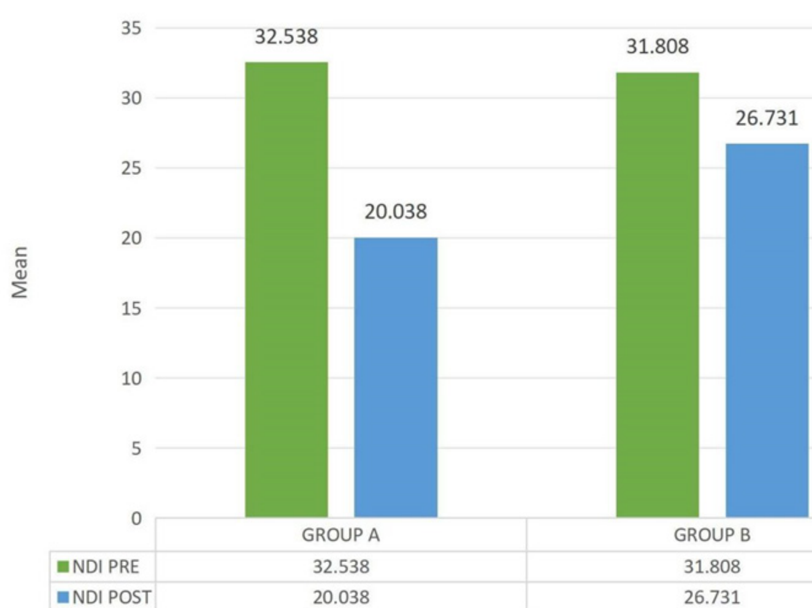
Test Statistics[a]		
	VAS Post - VAS Pre	**VAS Post - VAS Pre**
Z	-4.485	-4.506
P value	.000*	.000*

*P<α is considered as significant

Conclusion: There is a statistically significant difference between pre and post values

NDI Score (Functional Disability)

Graph 2 displays the pre- and post-intervention NDI scores. Table 5(Paired Sample Statistics) shows mean NDI scores at baseline and at Week 10 for both groups. Table 6 (Paired Samples t-test) confirms a statistically significant improvement in NDI scores within both Group A and Group B ($p < 0.05$), indicating both interventions effectively reduced neck disability. Group A recorded a significantly greater improvement in NDI score than Group B ($p < 0.05$), suggesting superior functional outcomes with MFR.



Graph 2: Comparison between pre- and post-intervention NDI scores for Group A and Group B

Table 5: Paired sample statistics for NDI and VAS

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Group A	NDI Pre	32.538	26	5.5298	1.0845
	NDI Post	20.038	26	6.0958	1.1955
Group B	NDI Pre	31.808	26	6.8762	1.3485
	NDI Post	26.731	26	7.9022	1.5497
Group A	VAS Pre	5.5	26	1.83847763	0.360555128
	Vas Post	2.46	26	1.272	0.249496534
Group B	Vas Pre	5.57	26	1.747	0.342717991
	VAS Post	3.07	26	1.622	0.318279398

*p < α is considered significant

Table 6: Paired Samples t-test for NDI

Paired Samples Test									
		Paired Differences					t	df	P value
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Group A	NDI Pre - NDI Post	12.5000	4.4294	.8687	10.7109	14.2891	14.390	25	.000*
Group B	NDI Pre - NDI Post	5.0769	2.6065	.5112	4.0241	6.1297	9.932	25	.000*

Summary of Mean Values

Graph 3 summarises the mean values of age, pre- and post-intervention VAS and NDI for both groups, providing a visual overview of the magnitude of improvement achieved by each intervention.

Graph 3: Mean values of age, Pre-VAS, Post-VAS, Pre-NDI, Post-NDI for Group A and Group B

Discussion

This study compared the effectiveness of myofascial release with a tennis ball versus static stretching on pain and functional outcomes in IT professionals with trapezitis. The major finding was that both interventions produced statistically significant improvements in VAS and NDI scores; however, MFR with a tennis ball showed significantly greater reductions in pain and neck disability compared to static stretching.

The systematic review of Ajimsha et al. (2015) of randomised controlled trials concluded that MFR is effective in managing a variety of musculoskeletal conditions and is better than passive interventions over short and medium-term follow-up.[9] Similarly, a meta-analysis by Overmann et al. found that MFR produced significant reductions in pain intensity in adults with chronic neck pain.[10] A systematic review by McKenney K, Elder AS, Elder C, Hutchins A stated that the sustained compressive pressure applied by the tennis ball is thought to act on fascial mechanoreceptors and Ruffini endings, resulting in reduced myofascial tone, improved fluid dynamics, and lowered nociceptive sensitivity.[8] The contralateral cervical lateral flexion performed simultaneously is believed to further elongate the fascial chain and augment the release, enhancing outcomes beyond what static pressure alone would achieve.

Static stretching also produced significant within-group improvements, as stated by Bandy et al. (1997), who demonstrated that sustained stretching improves muscular flexibility.[11] Klee et al. (2016) demonstrated that static stretching of the upper trapezius reduces muscle tension and improves cervical range of motion, which aligns with our Group B outcomes.[16] However, the magnitude of improvement was lower than that observed in Group A.

The findings from these studies have important implications for occupational physiotherapy. IT professionals due to their prolonged static postures are at a higher risk of developing neck pain and various other neck related disorders. This study demonstrates the effectiveness of a low cost and easy to administer method with an easily available instrument(tennis ball) under supervision in reducing pain and improving functional capacity. Further more, self administration of MFR using a tennis ball offers a promising home care strategy for the same.

Limitations

This study has several limitations that should be considered when interpreting the results.

1. The samples taken for the study were taken from several IT companies in Bangalore with almost similar working hours, which makes it difficult to analyse the effect of intervention on varying working hours.
2. The study lacked a control group receiving no treatment, making it difficult to determine and compare how much of the improvement was due to natural recovery.
3. Long-term follow-up beyond 10 weeks was not conducted, proving the durability of the treatment unknown.
4. The absence of objective muscle activity data (e.g., electromyography) limits the mechanistic interpretation of results.

Future Research

Future studies should use randomised controlled designs with larger samples and longer follow-up periods (e.g., 6 months) to establish the long term efficacy of these interventions. . Comparative studies involving other MFR tools (e.g., foam rollers) or combined intervention protocols (MFR + stretching) would also be valuable.

Conclusion

Both myofascial release with a tennis ball and static stretching resulted in statistically significant improvements in pain (VAS) and functional disability (NDI) in IT professionals with trapezitis. However, myofascial release with a tennis ball was superior in producing greater reductions in pain and improvement in neck function. Given its simplicity, low cost, and effectiveness, MFR with a tennis ball is recommended as a preferred intervention in the physiotherapeutic management of trapezitis among IT professionals. Future research should validate these findings through randomised controlled trials with longer follow-up and objective outcome measures.

Conflict of Interest: The authors declare no conflict of interest.No financial or personal relationships with any organisation or individual have influenced the design, conduct, reporting, or interpretation of this research.

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Original Article

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Efficacy of Cold Compress Versus Kinesiotape in Managing Pain Associated with Primary Dysmenorrhea among Young Women

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Abstract

Background: Primary Dysmeorrhea, characterized by lower abdominal pain during menstruation in the absence of pelvic pathology, significantly affects the quality of life among young women. Non-pharmacological approaches such as Kinesiotape (KT) and cold compress (CC) have gained attention due to their safety and effectiveness in pain management.

Objective: To compare the effectiveness of cold compress versus kinesiotape in reducing menstrual pain among women with primary dysmenorrhea.

Methods: A total of 48 women aged 18-30 years experiencing primary dysmenorrhea were randomly assigned to two groups. Group A (n=24) received kinesiotape, and group B (n=24) received cold compress for three consecutive days during menstruation. Pain intensity was measured using the Numerical Pain Rating Scale (NPRS) before and after intervention.

Results: Both interventions resulted in a statistically significant reduction in pain. However, the reduction was more pronounced in the cold compress group (mean difference=4.174, $p<0.0001$). A significant difference was observed between the post-intervention scores of both groups ($p<0.0001$), favoring cold compress.

Conclusions: Both kinesiotape and cold compress are effective in reducing primary dysmenorrhea pain, but cold compress demonstrated greater effectiveness. It offers a simple, cost effective, non-invasive alternative for menstrual pain.

Keyword: Kinesiotape, cold compress, menstruation pain, physiotherapy, dysmenorrhea.

Introduction

Normal menstruation is formally characterized as periodic uterine bleeding occurring from the uterine body between the onset of menarche and cessation at menopause[1]. Dysmenorrhea refers to cramping or pelvic pain experienced during or just

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before menstruation[2]. This condition often negatively impacts the quality of life, leading to missed work to school (absenteeism), and is also linked to heightened levels of stress, anxiety and depressive symptoms[3]. Dysmenorrhea is broadly classified into two types: Primary and secondary. Primary dysmenorrhea occurs in the absence of any detectable pelvic disease and may be associated with other symptoms like fatigue, nausea, vomiting, lower back pain, insomnia, and diarrhea. In contrast secondary dysmenorrhea is related to identifiable medical or pelvic abnormalities[3,4].

At present, primary dysmenorrhea (PD) is the most common gynaecological condition experienced during menarche[4]. This condition is linked to the increased secretions of prostaglandins following the decline of progesterone levels at the end of the luteal phase of the menstrual cycle, which in turn induces uterine contractions and results in pain that typically begins a few hours before or immediately after the onset of menstruation[5,1]. Dysmenorrhea symptoms usually begin during adolescence and can substantially impact daily functioning and academic performance, frequently resulting in school and work absenteeism and reduced participation in social and sports activities[6]. Pharmacological interventions, such as analgesics and oral contraceptives, are effective for pain relief but are frequently associated with adverse effects, including nausea, vomiting, dizziness, breast tenderness, menstrual irregularities and potential organ complications[7]. In contrast, non-pharmacological strategies such as transcutaneous electrical nerve stimulation (TENS), acupuncture, massage, vertebral mobilization, stretching, exercise, thermotherapy, relaxation and breathing techniques, biofeedback, music therapy, compresses and kinesiotaping provide safer alternative, as they act through physiological mechanism and minimize the risk of side effects[7,6]. Kinesio tape (KT) is a physiotherapy technique that stimulates muscle activity, supports weak muscles, reduces pain, enhances proprioception, improves lymphatic and blood flow and helps relieve aces, spasms, stiff bands, sore patches and abnormal contractions[7,5,4]. Designed as a thin, elastic, water-resistant, and permeable band, it can remain on the skin for up to three days[7].Kinesiotaping continues to provide therapeutic benefits as long as the tape remains adhered to the skin[8]. The adhesion of kinesiotape stimulates the skin's mechanoceptors. These proprioceptive signals travel to the dorsal horn, where they inhibit the transmission of nociceptive information, thereby reducing pain. Application of kinesiotape lifts the skin, creating convulation that increase interstitial space and reduce interstitial pressure. This change is thought to support tissue repair. Additionally, the decrease in pressure relieves subcutaneous nociceptors, further alleviating pain[9]. Kinesiotape provides continuous cutaneous stimulation and proprioceptive feedback to the skin and this stimulation reduces pain. Kinesiotape is often left for 2-5 days on the skin, because its proposed neurosensory and circulatory effects require prolonged exposure to influence sustained pain modulation and proprioceptive input[10].

Another study by Jooyoung Kim et al. found that keeping kinesiotape for longer duration on skin lead to greater reduction in markers realated to muscle damage and soreness[11]. Cold compresses help relieve pain by slowing nerve conduction and blocking nerve signals. The cold draws heat from the body leading to vasoconstriction, reduced metabolism and pain. Local cooling reduces microcirculation by over 60% minimizing blood leakage into tissues and easing pain[12]. Additionally, cold compresses alleviate pain by stimulating endorphin release, reducing heart rate, constriction blood vessels, and decreasing local blood flow, thereby alleviating discomfort[13]. It also reduces inflammation by lowering prostaglandin levels that amplify pain at the injury site[14]. Cold compress is generally applied to the skin for 20 minutes per session to avoid adverse effect like excessive vasoconstriction or tissue damage[15].

Methodology

The experimental study was conducted over a period of six months at The Assam Royal Global University, Guwahati, with the objective of evaluating the effectiveness of cold compress versus kinesiotape in reducing pain associated with primary dysmenorrhea. Ethical clearance was obtained from the Institutional Ethical Committee. A total of 48 female participants both clinically diagnosed and and undiagnosed between the age 18-30 years, experiencing lower abdominal pain during menstruation (dysmenorrhea) for at least the past six cycles and scoring 5 or above on the Numeric Pain Rating Scale (NPRS) were selected through restricted randomization using chit method. The participants were randomly allocated to Group A (kinesiotaping) and Group B (Cold compress) by using chit method. 48 identical chits were prepared. On 24 chits Group A is written and on the remaining 24 chits, Group B is written. Each participant was asked to pick one slip blindly. The group written on the slip becomes the participant's allocation.The sample size of 48 was calculated using the formula for comparing two independent proportions with equal group sizes. Atwo-sided significance level (α) of 0.05 and a power of 80% (β=0.20) were assumed. The expected proportion of utcome in the control group (P_0) was taken as 0.30 and in the intervention group (P_1) as 0.70, with equal allocation in both the groups (q1=q0=0.5). Using thestandard normal deviate values corresponding to a (Zα=1.96) and (Zβ=0.84), the total sample was collected using the pooled proportion method: $N=(A+B)2/\ (P_1-P_0)2$, where $A=Z\sqrt{[P(1-P)(1/q_1+1/q_0)]}$ and $B=Z\beta\sqrt{[P_1(1-P_1)/q_1+P_0(1-P_0/q_0]}$, where P is the pool proportion. Participants with underlying gynaecological conditions, musculoskeletal disorders, irregular menstrual cycles, a history of pelvic or abdominal surgery, severe mental illness, cancer, or those who were pregnant or lactating were excluded from the study. Written informed consent was taken from each participant prior to the commencement of the study. Baseline demographic data including age, height, weight, BMI, age of menarche, and menstrual cycle history were recorded. The participants were randomly assigned into two groups. Group A received kinesiotape intervention, and group B received cold compress therapy. In Group A, kinesiotape was applied on the first day of menstruation using the copula technique, placing one tape horizontally and one vertically on the lower abdominal region, and another tape horizontally on the sacral region. The tape remained on the skin for three consecutive days. In Group B, a cold compress was applied to the lower abdomen and lower back for 20 minutes daily over three consecutive days. Pain intensity was measured between and after the intervention using the NPRS. Each intervention is dosed according to its own validated clinical protocol. Both the interventions are aimed at modifying symptoms like pain and swelling associated with primary dysmenorrhea[16]. Although, these interventions address pain via different but clinically relevant pathway, sensory modulation for kinesiotaping and thermal analgesia for cold therapy, yet both are commonly used in musculoskeletal rehabilitation[15].

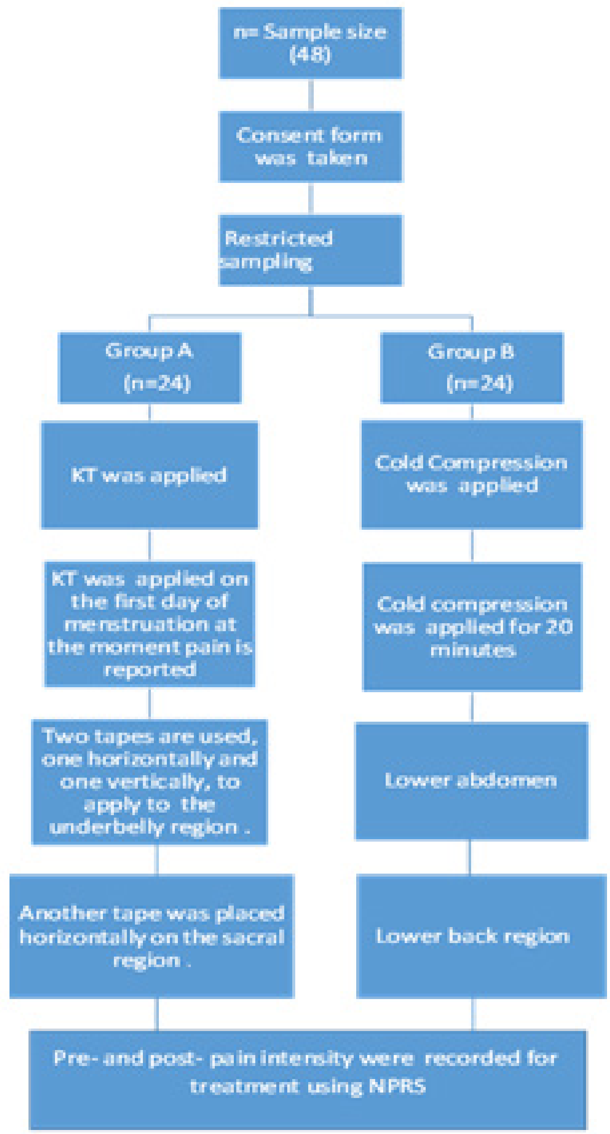

Figure 1: Flowchart showing participant recruitment into Group A (KT application) and Group B (cold compression) and intervention allocation.

Result

Table 1: Pre- and post- intervention of Group A (Kinesiotape) Subjects

	Mean	Standard Deviation	p-value	t-value	Mean Difference
Pre-intervention	6.478	1.163	<0.0001	7.342	1.217
Post-intervention	5.261	1.287			

Table 1 shows for Group A the pre-intervention means score 6.478, post means score is 5.261. The standard deviation was found to be 1.163 in pre- intervention, whereas the post- intervention standard deviation is 1.287. The p-value is <0.0001, with a mean difference of 1.217. The t- value of 7.342 suggests a strong effect and a significant difference between the pre and post-intervention means. Therefore, there was a significant difference between the pre- and post-intervention.

Table 2: Pre and post intervention of Group B (Cold compress)

	Mean	Standard Deviation	p-value	t-value	Mean Difference
Pre-intervention	6.957	1.224	<0.0001	19.449	4.174
Post-intervention	2.783	1.85			

Table 2 shows for Group A the pre-intervention means score 6.957, post means score is 2.783. The standard deviation was found to be 1.224 in pre-intervention, whereas the post- intervention standard deviation is 1.85. The p-value is <0.0001 with a mean difference of 4.174. The t-value of 19.449 is very high, indicating that the difference in means is statistically significant. Therefore, there was significant difference between the pre- and post-intervention.

	Mean	Standard Deviation	p-value	t-value	Mean Difference
Group A	5.261	1.287	<0.0001	5.273	2.478
Group B	2.783	1.85			

Table 3: Post –intervention of Group A and Group B

Table 3 shows that for Group A (kinesiotape), the post- intervention mean score is 5.261, and for Group B (cold compress), the post-intervention mean score is 2.783. The standard deviation was found to be 1.163 in Group A. Whereas the Group B post-intervention standard deviation is1.85. The p-value is <0.0001, with mean difference of 2.478 and the t-value is 5.273. Therefore, there is a significant difference between the post- intervention groups of Group A and Group B.

Discussion

Dysmenorrhea is a significant issue affecting women during their monthly menstrual cycle[17]. The underlying cause of menstrual pain is thought to be the excessive production of prostaglandins and leukotriene[18].

This study aimed to find out if there is any effect of kinesiotape and cold compress on pain in primary dysmenorrhea. Numeric pain rating scale (NPRS) was used to evaluate the pain. The NPRS is an 11-point scale rating from 0 to 10, where 0 represents no pain and 10 indicates the worst imaginable pain[19]. The participants in group A received KT regularly for three consecutive days, and the participants in group B received CC for 20 minutes in the abdomen and lower back for three consecutive days.

In the present study, the demographic characteristics of participants across both groups were found to be largely comparable, with 52.2% of subjects in both group A and group B being 23 years old. However, slight differences were noted in anthropometric parameters. The weight range for subjects in group A was between 50-53 kg, while the majority of the subjects in group B weighed between 49-50kg. Height distribution also showed minimal variation, with most group A participants measuring approximately 155 cm, whereas participants in group B ranged between 154-155 cm. Despite the close similarity in age, weight, and height, a notable difference was observed in body mass index (BMI). Group A participants had a lower average BMI of around 18,indicating a leaner body composition, while group B participants presented a higher BMI ranging between 21-22, falling within the normal category.

Menstrual cycle patterns were found to be within the normal range for both groups. In group A, 34.8% of the participants reported a 28-day cycle, while 26.1% reported a 30-day cycle. Similarly, in group B, 30.4% reported a 28-day menstrual cycle, and an equal proportion (30.4%) reported a 30-day cycle. Regarding medical diagnosis of dysmenorrhea, 56.5% subjects in group A had not been clinically diagnosed, while the remaining were diagnosed by a healthcare professional. A comparable distribution was observed in the clinical diagnosis of dysmenorrhea in group B, where 56.5% of the participants were not medically diagnosed, and 43.55 had received a formal diagnosis.

The statistical analysis of Group A demonstrated a significant reduction in pain levels following the intervention. The pre-intervention mean pair score was 6.478 with a standard deviation of 1.163 indicating a moderate level of pain experienced by participants prior to the intervention. Post-intervention, the mean pain score decreased to 5.261 with a slightly increased standard deviation of 1.287, reflecting an overall reduction in pain intensity. The calculated mean difference was 1.217 and t-value was found to be 7.234, indicating a highly significant change. The p-value was <0.0001, confirming that the observed reduction in pain score was statistically significant and not due to chance. These findings suggest that the intervention applied in Group A was effective in providing immediate pain relief and may serve as a viable non-pharmacological approach for managing symptoms in individuals experiencing dysmenorrhea. In a study conducted by

In Group B Cold Compress, a more pronounced reduction in pain intensity was observed following the intervention. The pre-intervention mean pain score was 6.957 with a standard deviation of 1.224, indicating a relatively higher baseline pain level compared to Group A. After the intervention, the mean pain score significantly dropped to 2.783 with a standard deviation of 1.880. The mean difference was 4.174, identical to Group A, and the t-value was 19.449, reflecting a strong statistical effect. The p-value of <0.0001 confirms that the reduction in pain was statistically highly significant. These results indicate that the intervention administered in Group B was highly effective in alleviating menstrual pain, with a larger magnitude of pain reduction compared to Group A. The greater drop in post-intervention pain scores suggests that the treatment used in Group B may offer more immediate or impactful relief for dysmenorrhea and warrants further investigation for clinical application.

A comparison of the post-intervention outcomes between Group A and Group B revealed a statistically significant difference in pain reduction between the two interventions. Group A had a post-intervention mean pain score of 5.261 with a standard deviation of 1.287, whereas Group B demonstrated a lower post-intervention mean of 2.783 with a standard deviation of 1.850. The mean difference between the two groups was 2.478, with a t-value of 5.273 and a p-value of <0.0001, indicating a highly significant difference in treatment effectiveness. This suggests that while both interventions were effective in reducing menstrual pain, the intervention administered to Group B was considerably more effective in lowering pain intensity when compared to Group A. The greater reduction in pain in Group B highlights its potential as a more impactful and clinically beneficial method for managing dysmenorrhea, supporting its consideration for wider implementation in physiotherapeutic practice.

Stella Iacovides et al., found no significant effect for menstrual cycle phase and dysmenorrhea despite notable variation in progesterone and estradiol levels across phases. This indicates that changes in reproductive hormone levels may not significantly affect pain sensitivity in women regardless of the presence of dysmenorrhea[20]. Despite the high prevalence, dysmenorrhea remains frequently underdiagnosed, insufficiently treated and often normalized even by those experiencing it who may perceive the symptoms as natural and unavoidable part of menstruation. As a result, many assume that medical treatment is either unnecessary or unavailable[21]. Darius Boguszewski et al., also observed that the use of kinesio tape seems to alleviate the intensity of pain in women experiencing menstrual comfort[22], However the magnitude of improvement observed in the current study was smaller compared with other prior studies.A study conducted by Alka Pawalia et al. also indicated the kinesiotaping is an effective method for relieving dysmenorrhea related pain in both short and long term [23].Celenay et al. demonstrated that kinesiotaping significantly reduced pain and anxiety compared to sham taping in women with primary dysmenorrhea suggesting a neurosensory and proprioceptive modulation mechanism[4]. A study involving 40 students at the Abdurrahman Palembang Academy reported that cold compress was more efficient than warm compress in alleviating the severity of dysmenorrhea[24]. Applying a cold compress helps stimulate endorphin release, the cold sensation from a compress at 10°C–15°C for 15 minutes and can significantly block pain signals and trigger vasoconstriction of blood vessels[25].

The comparative smaller pain reduction observed with kinesiotaping may be explained by the nature of its analgesic mechanism. A recent systematic review and meta-analysis reported that kinesiotaping produces moderate reduction in dysmenorrhea pain, with differences in outcomes likely related to variations in taping technique and application durations. This suggests that kinesiotaping may exert gradual neurosurgery modulation rather than immediate analgesia., whereas cold compress provides rapid pain inhibition through thermal and neurophysiological mechanism. These differences may explain the greater short-term reduction in the cold compress group [26]. In addition, cold compress reduces nerve conduction velocity and increases pain threshold, thus, producing rapid analgesia[27]. Cold compress also decreases tissue metabolism and inflammatory mediator activity which contributes to reduction in prostaglandin mediated dysmenorrhea[28,29].

Conclusion

The present study concludes that both kinesiotaping and cold compress may be effective in reducing pain in young women with primary dysmenorrhea. A statistically significant reduction was observed in both the groups following the intervention. The findings indicate that cold compress appears to provide greater short-term pain relief compared to kinesiotaping. However, these results should be considered preliminary due to the limited sample size and lack of binding and control. Further large scale, well designed randomized controlled and blinded trials are required to confirm these findings.

Limitation:

The sample size of the present study was small and drawn from a single instituition, which may limit the generalizability of the findings and increase the risk of type II error. The absence of a control or sham group makes it difficult to rule out the influence of natural fluctuations in menstrual pain across cycles. The short duration of intervention and lack of follow up did not follow-up did not allow long term assessment of long term or sustained effect of kinesiotaping and cold compress. Potential confounding factors such as stress, level, physical activity, dietary habits which may influence dysmenorrhea, were not evaluated. Pain intensity was assessed using the NPRS, a subjective measure that may be affected by individual pain perception and psychological factors. In addition, the functional and psychological outcome related to dysmenorrhea were not assessed.

Recommendation:

Further studies should include a larger and more diverse sample with appropriate control or sham groups. Blinded assessment is recommended to strengthen internal validity. Long-term follow up across multiple menstrual cycle is recommended to evaluate sustained effects of kinesiotaping and cold compress. Further research should also assess functional limitations, absenteeism and quality of life to provide a more comprehensive evaluation of the clinical impact of these interventions.

Ethical Clearances*:* Reference no of ethical clearence RGU/IECHR/BPT/2024/21

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Original Article

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Quality of Life and Determinants among Persons with Disabilities Attending a Rural Physical Rehabilitation Centre in Southern India

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Abstract

Introduction: Disability can significantly affect physical, psychological, social, and environmental aspects of health, thereby influencing the quality of life (QOL) of persons with disabilities (PwDs). Limited evidence is available regarding the determinants of QOL among PwDs attending rural rehabilitation centres in Southern India. The present study aimed to assess the QOL and its determinants among PwDs attending a rural physical rehabilitation centre in Southern India.

Methodology: A cross-sectional study was conducted among 75 PwDs attending a government rural physical rehabilitation centre attached to Community Health Centre Mankada from January to June 2025. Data were collected using a semi-structured questionnaire and the validated WHOQOL-BREF tool. Domain scores were transformed to a 0–100 scale and analyzed using SPSS version 26.

Results: The mean QOL scores were 30.69 ± 11.25 in the physical health domain, 29.56 ± 11.44 in the psychological domain, 38.25 ± 19.56 in social relationships, and 38.38 ± 13.94 in the environmental domain. Younger age, higher educational status, upper socioeconomic status, and shorter duration of disability showed significant association with better physical and psychological health scores ($p<0.05$). Environmental health scores were also significantly associated with distance from the rehabilitation centre ($p=0.019$). Participants with stroke-related disability demonstrated comparatively lower QOL scores across multiple domains.

Conclusion: Persons with disabilities demonstrated a comparatively lower quality of life, particularly in physical and psychological domains. Sociodemographic, clinical, and rehabilitation-related factors significantly influenced QOL, highlighting the need for targeted rehabilitation strategies and supportive community-based interventions.

Keywords: Persons with disabilities; Disability; Quality of life; Rehabilitation centers; WHOQOL-BREF; Physical disability; Rural health services

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Introduction

Disability is a complex condition that affects not only physical functioning but also an individual's interaction with society and the surrounding environment. It includes impairments, limitations in daily activities, and restrictions in social participation that can influence overall well-being.[1-3] Globally, nearly 1.3 billion people, accounting for around 16% of the world's population, live with significant disabilities, with approximately 1 in 6 individuals affected worldwide. The burden of disability continues to increase due to population aging and the growing prevalence of noncommunicable diseases. In India, National Family Health Survey data indicate that nearly 4.52% of the population, corresponding to about 63 million people, experience some form of disability. Furthermore, the World Bank estimates that nearly 20% of the world's poorest population are persons with disabilities.[3-7]

Persons with disabilities (PwDs) often face difficulties in accessing education, employment, health care services, mobility, and social opportunities, which may adversely affect their quality of life. In addition, social stigma, dependence on others, and reduced participation in community activities can contribute to psychological distress and poor social well-being. Quality of life (QOL) is a multidimensional concept comprising physical, psychological, and social aspects of health. Since it is influenced by several personal and environmental factors, identifying determinants such as physical activity, self-efficacy, anxiety, and depression is important for improving rehabilitation outcomes and supportive care among PwDs.[8-10]Previous studies have reported several factors influencing quality of life among PwDs. A study by Kunal Kuvalekar et al. in Udupi, Karnataka, found that 36.2% had congenital disabilities, 26.2% had post-polio residual paralysis, and 11.5% required assistance in ADL, with disability negatively affecting social participation and marriage.[11] Similarly, Fatemeh Rajati et al. reported that demographic and clinical factors, anxiety, depression, physical activity, and self-efficacy predicted 20% of PCS and 43% of MCS variations in QoL scores.[12] Furthermore, Hira Kanwal and Nazia Mustafa observed significantly lower psychological well-being ($t=5.90$, $p<0.05$) and quality of life ($t=8.40$, $p<0.05$) among physically disabled individuals compared to normal employees.[13] These findings highlighted the influence of physical, psychological, and social factors on QoL among PwDs.

The scientific rationale of the present study was based on the growing recognition that PwDs often experience physical, psychological, and social challenges that can significantly influence their quality of life. Despite the increasing burden of disability, limited rural Indian studies have comprehensively evaluated the determinants affecting quality of life among individuals attending rehabilitation centres. [10-13]The novelty of the study lies in its institution-based assessment of QOL and its determinants among PwDs in Southern India, an area that remains inadequately explored in existing literature. Understanding the factors associated with QOL may help in developing targeted rehabilitation measures, supportive care, and community-based interventions to improve overall well-being. [12-15]Against this backdrop, our study aimed to assess the QOL and its determinants among PwDs attending a rural physical rehabilitation centre in Southern India.

Methods

Study Design, Setting, Duration

This cross-sectional study was conducted among persons with disabilities attending a government rural physical rehabilitation centre attached to the Community Health Centre, located in Mankada village, Malappuram district, Kerala, India. The study was carried out over a period of six months from January 2025 to June 2025.

Study population, Sample size, and Sampling

Persons with disabilities aged above 18 years attending the physical rehabilitation centre at Community Health Centre Mankada who provided consent were included in the study, while individuals who were mentally unstable or unable to comprehend were excluded.

The sample size was calculated using the formula $n = 4pq/d^2$, considering a prevalence of 36.2% from a previous study by Kuvalekar et al. [11]and a relative precision of 30% of the estimated prevalence. A wider relative precision of 30% was adopted, considering the limited source population available at the study setting. This level of precision was considered appropriate for an institution-based exploratory study involving a limited and accessible population of persons with disabilities attending a rehabilitation centre. A total of 75 participants were included in the study.

A comprehensive list of PwDs attending the rehabilitation centre attached to CHC Mankada was obtained from the rehabilitation centre records. After taking permission from the authorities, eligible participants fulfilling the inclusion criteria were identified, assigned unique identification numbers, and selected using a simple random sampling technique with the help of a computer-generated random number table to ensure unbiased participant selection.

Method of data collection

Data were collected through face-to-face interviews using a semi-structured, pre-designed questionnaire among PwDs attending the physical rehabilitation centre. According to WHO, persons with disabilities are individuals with impairments, activity limitations, or participation restrictions that affect their involvement in society. Quality of life was assessed using the validated WHOQOL-BREF questionnaire, consisting of 27 items distributed across physical, psychological, social, and environmental domains. Domain scores were calculated according to WHOQOL-BREF scoring guidelines, and additional information regarding socio-demographic and clinical determinants of quality of life was also collected. WHOQOL-BREF domain scores were transformed to a 0–100 scale and categorized as poor (<40), moderate (40–60), and good (>60) quality of life for interpretation.

Data collected were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were expressed as frequencies and percentages, and cross-tabulation was performed for relevant variables. Independent t-test and one-way ANOVA were used to assess the association between sociodemographic variables and WHOQOL-BREF domain scores. A p-value ≤0.05 was considered statistically significant.

All participants were assured of confidentiality and anonymity, participation was voluntary, and written informed consent was obtained prior to data collection. Ethical approval was obtained from the Institutional Ethics Committee of the MES Medical College, Perinthalmanna, Kerala, India, with reference number IEC/MES/INT13/2024 dated 26th June 2024.

Results

Sociodemographic characteristics (n=75)

Among the study participants, 57.3% were aged more than 50 years, and 54.7% were males. The overall mean age of the study participants was 54.28 ± 13.46 years. Most participants had lower educational status (62.7%), belonged to the lower socioeconomic class (72.0%), and lived in nuclear families (61.3%). Trauma due to RTA/fall (40.0%) and stroke (38.7%) were the major causes of disability, while 54.7% had disability duration of more than 5 years. The majority of participants (60.0%) had been undergoing physiotherapy for ≤5 years, and family members were the primary caregivers for 84.0% of the study population.**(Table 1)**

Table 1: Sociodemographic characteristics of the study population (n=75)

Variable	Frequency (n)	Percentage (%)
Age		
≤50 years	32	42.7
>50 years	43	57.3
Sex		
Male	41	54.7
Female	34	45.3
Education		
Lower	47	62.7
Higher	28	37.3
Marital status		
Married	49	65.3
Others (Widowed/ Separated)	26	34.7
Socioeconomic status		
Lower	54	72.0
Upper	21	28.0
Type of family		
Nuclear	46	61.3
Joint	29	38.7

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Cause of disability		
Stroke	29	38.7
Trauma	30	40.0
Others (Congenital, infections..)	16	21.3
Duration of disability		
≤5 years	34	45.3
>5 years	41	54.7
Duration of physiotherapy		
≤5 years	45	60.0
>5 years	30	40.0
Caregiver		
Family members	63	84.0
Others	12	16.0
Distance from centre		
≤10 km	58	77.3
>10 km	17	22.7

Quality of life scores among persons with disabilities (n=75)

The mean quality of life scores among persons with disabilities were 30.69 ± 11.25 in the physical health domain, 29.56 ± 11.44 in the psychological health domain, 38.25 ± 19.56 in the social relationships domain, and 38.38 ± 13.94 in the environmental health domain. The findings indicated comparatively lower quality of life scores across all domains, particularly in the physical and psychological aspects of health. **(Table 2)**

Table 2: Domain-wise quality of life scores among study participants (n-75)

Domains	Mean ± SD	95% CI
Physical health	30.69 ± 11.25	28.13–33.25
Psychological health	29.56 ± 11.44	26.95–32.17
Social relationships	38.25 ± 19.56	33.79–42.71
Environment health	38.38 ± 13.94	35.20–41.56

QOL and its determinants among persons with disabilities (n=75)

Physical and psychological health scores were significantly higher among participants aged ≤50 years (p=0.004 and p=0.006, respectively). Participants with higher education and upper socioeconomic status also demonstrated significantly better physical and psychological domain scores (p<0.01). Furthermore, individuals with disability duration ≤5 years had significantly higher physical (p=0.007) and psychological health scores (p=0.011) compared to those with longer duration of disability. Social relationship scores were significantly better among younger and higher educated participants (p=0.041 and p=0.039, respectively). Environment health scores showed significant association with younger age (p=0.012), higher education (p=0.008), upper socioeconomic status (p=0.002), shorter duration of disability (p=0.029), and residence within 10 km from the rehabilitation centre (p=0.019). Participants with stroke-related disability had comparatively lower quality of life scores across multiple domains. **(Table 3)**

Table 3. Association of sociodemographic and clinical variables with domain-wise quality of life scores among study participants (n-75)

Variable	n	Physical health Mean ± SD	Psychological health Mean ± SD	Social relationships Mean ± SD	Environment health Mean ± SD
Age: ≤50 years	32	34.82 ± 10.46	33.14 ± 10.58	42.91 ± 18.84	42.73 ± 12.96
>50 years	43	27.62 ± 10.98	26.89 ± 11.34	34.78 ± 19.62	35.21 ± 13.88
p value		*0.004**	*0.006**	*0.041**	*0.012**
Sex: Male	41	32.47 ± 11.06	30.82 ± 11.63	39.96 ± 18.77	39.87 ± 13.22
Female	34	28.54 ± 11.31	28.03 ± 11.18	36.18 ± 20.41	36.58 ± 14.77
p value		*0.184*	*0.326*	*0.421*	*0.298*
Education: Lower	47	27.83 ± 10.92	26.74 ± 10.88	35.16 ± 18.72	35.89 ± 13.41
Higher	28	35.48 ± 10.12	34.29 ± 11.24	43.42 ± 19.96	42.58 ± 13.87
p value		*0.001***	*0.002***	*0.039**	*0.008***

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Marital status: Married	49	31.84 ± 10.96	30.12 ± 11.27	39.81 ± 18.63	39.24 ± 13.66
Others	26	28.53 ± 11.74	28.51 ± 11.86	35.31 ± 20.48	36.74 ± 14.11
p value		*0.213*	*0.441*	*0.298*	*0.382*
SES: Lower	54	28.14 ± 10.82	27.49 ± 11.02	35.82 ± 18.89	35.73 ± 13.08
Upper	21	37.26 ± 10.14	34.88 ± 11.23	44.49 ± 20.16	45.21 ± 13.56
p value		*0.001***	*0.001***	*0.048**	*0.002***
Family: Nuclear	46	29.42 ± 11.54	28.71 ± 11.82	37.62 ± 20.03	37.11 ± 14.18
Joint	29	32.70 ± 10.63	30.91 ± 10.98	39.24 ± 18.88	40.39 ± 13.57
p value		*0.327*	*0.441*	*0.718*	*0.452*
Cause: Stroke	29	26.74 ± 10.96	25.93 ± 11.04	34.11 ± 18.87	33.89 ± 13.66
Trauma	30	32.88 ± 11.21	31.26 ± 11.53	40.86 ± 19.54	40.92 ± 13.84
Others	16	35.41 ± 10.43	34.12 ± 10.78	41.73 ± 20.41	42.11 ± 14.02
p value		*0.018**	*0.011**	*0.092*	*0.024**
Disability duration: ≤5 years	34	34.36 ± 10.88	32.82 ± 11.06	41.76 ± 19.08	41.88 ± 13.41
>5 years	41	27.65 ± 10.96	26.86 ± 11.31	35.34 ± 19.74	35.48 ± 14.06
p value		*0.007***	*0.011**	*0.154*	*0.029**
PT duration: ≤5 years	45	32.18 ± 10.94	30.91 ± 11.26	39.84 ± 19.11	39.71 ± 13.66
>5 years	30	28.46 ± 11.48	27.54 ± 11.63	35.88 ± 20.18	36.39 ± 14.21
p value		*0.148*	*0.239*	*0.372*	*0.281*
Caregiver: Family members	63	31.12 ± 11.08	29.93 ± 11.27	38.74 ± 19.28	38.94 ± 13.71
Others	12	28.41 ± 12.03	27.64 ± 12.14	35.68 ± 21.14	35.46 ± 14.86
p value		*0.418*	*0.506*	*0.622*	*0.534*
Distance: ≤10 km	58	31.86 ± 10.97	30.48 ± 11.24	39.82 ± 19.12	40.21 ± 13.58
>10 km	17	26.68 ± 11.83	26.42 ± 11.91	32.88 ± 20.84	32.14 ± 14.26
p value		*0.041**	*0.048**	*0.127*	*0.019**

Discussion

The comparatively lower physical and psychological quality of life scores observed in our study were consistent with the findings reported by Lena Ashok et al.[11], who identified lower psychological domain scores among physically disabled individuals and noted that 11.5% required assistance in ADL. Reduced independence in daily activities may adversely affect self-esteem, social participation, and psychological well-being, thereby contributing to a poorer quality of life. Similarly, Hosein Hosseini et al.[12] demonstrated that anxiety, depression, physical activity, and self-efficacy significantly predicted QoL, accounting for 20% of PCS and 43% of MCS variations. These findings suggest that psychological resilience and functional ability play an important role in shaping quality of life among PwDs. Furthermore, Hira Kanwal et al.[13] reported significantly lower psychological well-being ($t=5.90$, $p<0.05$) and quality of life ($t=8.40$, $p<0.05$) among physically disabled individuals, possibly reflecting the influence of disability-related restrictions on social engagement and emotional health. The comparatively lower quality of life observed among participants with stroke-related disability in our study may be related to persistent functional impairment, dependency in daily activities, and prolonged rehabilitation needs. Likewise, Darabi et al.[16] found that higher education was significantly associated with better QoL across all domains ($p<0.001$), while increasing age negatively affected environmental QoL ($p=0.02$). Higher education may improve health awareness, utilization of rehabilitation services, and social participation, whereas advancing age may be associated with greater dependency and functional limitations. Nandini et al.[17] also reported that age, income, and social support significantly influenced environmental health. Better socioeconomic conditions may facilitate access to healthcare, rehabilitation, assistive devices, and supportive environments. Similarly, Murthy et al.[18] reported poorer psychological and environmental QoL among older individuals, which may be attributable to age-related decline in physical function and reduced community participation. The overall similarity across studies may reflect the common influence of physical limitations, psychosocial challenges, and socioeconomic barriers experienced by PwDs across different settings.

The lower quality of life scores observed in our study were also comparable to the findings of Ramadass et al.[19], who reported higher disability prevalence among older and economically dependent individuals. Economic dependence may limit access to healthcare and rehabilitation services, thereby affecting quality of life. Similarly, Choi et al.[20] identified significant positive effects of social relationships (β=.535, p<0.0001), income (β=.146, p<0.0001), and housing environment (β=.132, p<0.0001) on QoL, highlighting the importance of social and environmental support systems in maintaining well-being. Participants residing farther from the rehabilitation centre may experience reduced access to rehabilitation services and follow-up care, which could adversely affect environmental and overall quality of life.Likewise, Abebe et al.[21] reported that only 41% participants had good HRQOL, while younger age groups and educated individuals demonstrated significantly better QoL. Younger individuals may possess better functional capacity and adaptability, while education may enhance awareness regarding available health and rehabilitation resources. Comparable observations were reported by Gnanaselvan et al.[22], where 37.5% participants had poor QoL, and lower socioeconomic status adversely affected social and environmental domains. Limited financial resources may restrict access to assistive devices, transportation, and rehabilitation opportunities. Similarly, Chaudary et al.[23] found socioeconomic status significantly associated with the psychological domain (p=0.000), while Sutham et al.[24] identified age as a significant predictor of QoL (p<0.05), emphasizing the role of economic and demographic factors in influencing well-being. Furthermore, the meta-analysis by Syifa et al.[25] highlighted age, severity of disability, family support, and environmental accessibility as important determinants of QoL. These factors may influence independence, social integration, and access to supportive services, ultimately affecting quality of life. Minor differences between studies could be attributed to variations in study settings, sample characteristics, severity of disability, rehabilitation accessibility, and sociocultural contexts.

Limitations

The cross-sectional design of the study limited the ability to establish causal relationships between quality of life and its associated factors. Since the study was conducted in a single rural rehabilitation centre with a relatively small sample size, the findings may have limited generalizability to other settings and populations. Also, the use of a wider relative precision may have limited the precision of estimates and the ability to detect smaller associations. Furthermore, the use of self-reported responses in the WHOQOL-BREF questionnaire could have introduced recall and response bias.

Conclusion

The present study found comparatively lower quality of life scores among PwDs, particularly in the physical and psychological domains. Better quality of life scores were observed among younger participants, those with higher educational status, upper socioeconomic status, shorter duration of disability, and better accessibility to rehabilitation services. Participants with stroke-related disability had comparatively lower quality of life scores across multiple domains. These findings suggest that demographic, socioeconomic, and rehabilitation-related factors may influence quality of life among PwDs and should be considered while planning rehabilitation and supportive services. Future multicentric studies with larger sample sizes are warranted to further explore the determinants of quality of life among PwDs and improve the generalizability of the findings.

Declarations

Conflict of Interest: No

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Original Article

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Assessing the Burden of Low Back Pain-Induced Disability Among Operation Theatre Technicians in Guwahati

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Abstract

Background: Operation theater technicians are especially susceptible to low back pain, a common musculoskeletal condition that affects people in a variety of occupations. This is because of their uncomfortable postures, repetitive motions, and extended standing. Their job's physical demands and ergonomic difficulties lead to a high rate of low back pain, which impairs functional ability and increases disability. Designing successful prevention and intervention methods requires an understanding of the burden of disability caused by low back pain in this population.

Methods: A cross-sectional study of OT technicians working in different Guwahati hospitals was carried out. Purposive sampling was employed to choose participants, and a validated questionnaire measuring the frequency, severity, and functional limits of LBP was utilized to gather data. The degree of disability was measured using the Oswestry Disability Index (ODI). Demographic variables were also assessed for correlation with disability.

Conclusion: The study found that OT technicians had considerably higher disability ratings and a high prevalence of LBP-induced disability. In order to lessen the impact of LBP and enhance the functional outcomes of OT technicians, the results emphasize the necessity of focused ergonomic interventions, posture teaching, and workplace adjustments. Preventive interventions can improve their general quality of life and productivity at work.

Keywords: Oswestry disability index, Oswestry disability index, low back pain musculoakeletal problem.

Introduction

Low back pain (LBP) is a common musculo skeletal illness that affects people in a variety of occupations, with healthcare providers being particularly vulnerable due to the tough physical demands of their jobs[1,2]. Operation theatre (OT) workers have particular occupational problems, including awkward postures, prolonged standing, and repetitive physical duties, which raise their risk

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of getting LBP considerably[3,4]. Operational theatre technicians frequently have to endure prolonged static stress on their spines, which can eventually result in degenerative changes, spinal strain, and muscular weariness[5-7]. In addition to having an impact on personal health, the incidence of LBP in this population has ramifications for the effectiveness and security of healthcare delivery.

The development of musculoskeletal diseases, particularly LBP, has been closely linked to prolonged standing, a major occupational danger for OT personnel[8,9]. According to studies, standing for long periods without taking enough rest can cause muscle exhaustion, reduced circulation, and spinal compression, all of which increase the chance of developing chronic pain[10,11]. Psychosocial stressors, such as a heavy workload and the demands of precise tasks in operation theatre, can also exacerbate physical strain and make people more prone to LBP[12,13]. Finding the precise environmental and occupational factors causing LBP in this population is essential to creating efficient preventative strategies[14,15].

Guwahati, a major city in northeastern India, hosts several prominent healthcare institutions where OT staff play a critical role in surgical procedures. Despite the vital role of their employment, there is little study evaluating the prevalence and contributing causes of LBP among OT staff in this area. Developing focused interventions to prevent and manage LBP is crucial for improving healthcare workers' quality of life and guaranteeing the best possible patient care.

This study aims to determine the impact of low back pain on the lives of Guwahati's operation theatretechnicians in terms of disabilities. To seek ways to lessen the burden of LBP among OT staff, this study aims to establish the scope and kind of the issue to guide evidence-based methods for ergonomic training, workplace improvements, and health promotion initiatives. These initiatives are essential for increasing staff productivity, protecting their health, and optimizing surgical units' general operation.

Methodology

Participants in this observational study were chosen from five Guwahati City facilities: GNRC Hospital, Marwari Maternity Hospital, Pratiksha Hospital, Prarthona Orthopedic and Super Speciality Hospital, and Metro Hospital.

Inclusion criteria:

1. Staff working in the study hospitals' operation theatres for atleast 6 months.
2. Staffs having backache.
3. Staff with an agebetween20-40years
4. Staff who are willing to participate in the study.

Exclusion criteria:

1. Staffwith other musculoskeletal conditions, e.g., osteoporosis, arthritis.
2. Staff having psychological issues

The degree of disability is measured using the Oswestry low back pain disability questionnaire, which is considered a standardised low back pain functional outcome tool. In 1976, John O'Brien created the Oswestry questionnaire. The Oswestry uses a questionnaire to assess low back pain patients' pain-related impairment.

After completing the consent form, the subjects received instructions regarding the questionnaire, and data were collected according to those instructions. Figure 1 outlines the study's procedure.

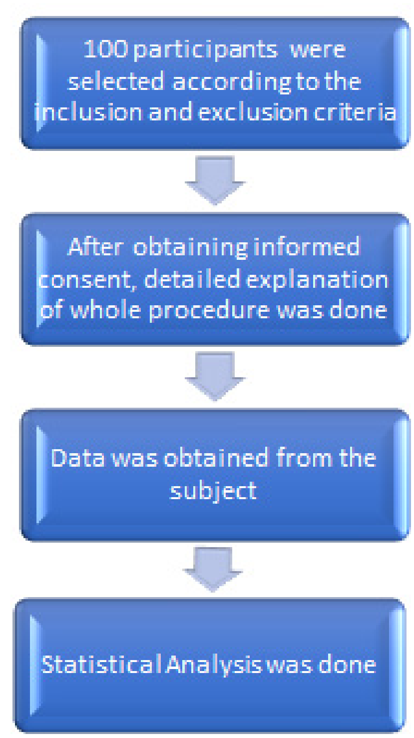

Figure 1: Flowchart for the procedure of the study

Results

The distribution of genders is shown in Table 1and Figure 2.There were 55 male and 45 female participants in this study.

Table 1: Gender Distribution

	Frequency	Percentage
Female	45	45.00
Male	55	55.00
Total	100	100.00

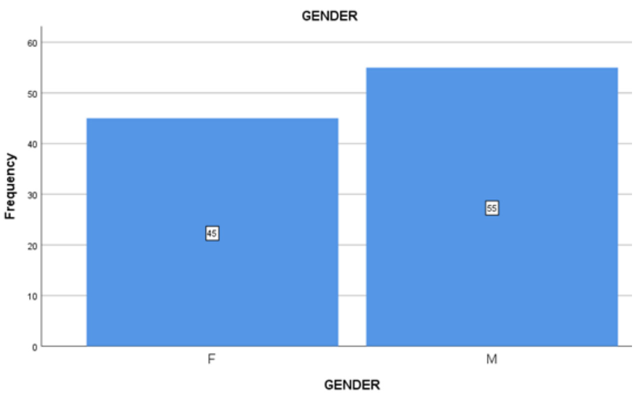

Figure 2: Gender distribution

Table 2: Oswestry score

Oswestry Score			
		Frequency	Percent
Levels	Minimaldis ability	66	66.0
	Moderatedis ability	11	11.0
	Severedis ability	6	6.0
	Completely disabled	17	17.0
	Total	100	100.0

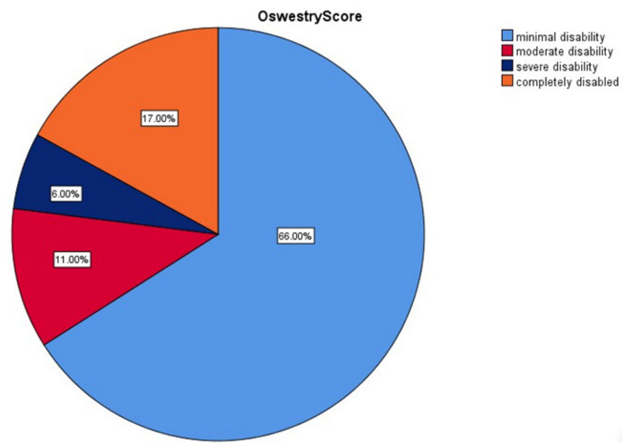

Figure 3: Oswestry score

Table 3: Oswestry level according to age group

Age Group*Oswestry Score Cross tabulation						
Count						
		Oswestry Score				**Total**
		minimal disability	**moderate disability**	**severe disability**	**completely disabled**	
Age Group	20-24	8	0	0	0	8
	25-29	37	2	0	0	39
	30-34	21	6	0	0	27
	35-39	0	3	6	15	24
	40	0	0	0	2	2
Total		66	11	6	17	100

The frequency of different levels of disability according to age groups is displayed in the above table (Table 3). As we can see, the age group of 25 to 29 has the greatest row total, 39, indicating the greatest number of disabled people in this age range. However, there are only 15 persons under the age of 35–39 who are completely incapacitated, and there are only 2 people under the age of 40 who fall into this category. There are no individuals in other age groups with that degree of disability.

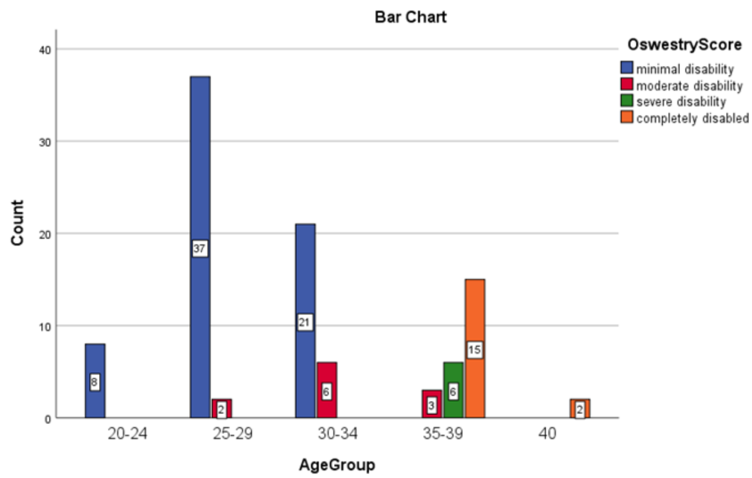

Figure 4: Bar chart for Oswestry score (cross distribution)

Table 3: Table for the association of disability with sex

Descriptive Statistics						
	GENDER	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
AGE	FEMALE	22	22	35	27.00	2.992
	MALE	25	26	39	32.40	3.342
Disability	FEMALE	22	17.78	77.78	24.7475	13.33854
	MALE	25	20.00	108.89	50.3111	31.03748

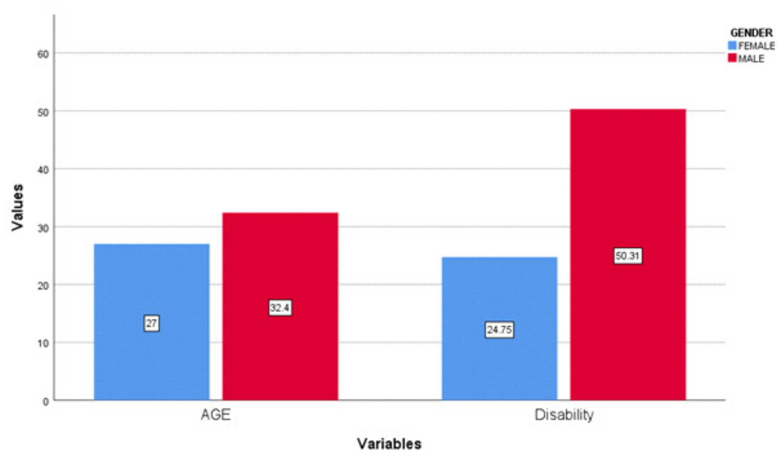

Figure 5: Association of disability with sex

Table 4: Test of normality

Tests of Normality					
	GENDER	**Shapiro-Wilk**			
		Statistic	**df**	**p value**	**Remark**
AGE	FEMALE	.921	22	.080	NS
	MALE	.949	25	.236	NS
Disability	FEMALE	.451	22	.000	***
	MALE	.807	25	.000	***

NS-Not Significant ***Significant at $p<0.001$

Here, the Shapiro-Wilk test was performed to check the normality of the data. We can see that the p-values for both genders in Age are greater than 0.05, which suggests that the age data follow the normality assumption at the 5% level of significance. But the p-values for both genders in Disability are less than 0.05, which suggests that the Disability data do not follow the normality assumption at the 5% level of significance.

Table 5: Independent Sample t-Test

Independent Sample t-Test							
	t-test for Equality of Means						
	t	df	p value	Mean Difference	95% Confidence Interval of the Difference		Remark
					Lower	Upper	
AGE	-5.803	45	.000	-5.400	-7.274	-3.526	***

***Significant at p<0.001

Table 6: Mann-Whitney U test

Mann-Whitney U test					
	Mann-Whitney U	Wilcoxon W	Z	p value	Remark
Disability	82.500	335.500	-4.278	.000	***

***Significant at p<0.001

For both comparisons, p-values are much smaller than 0.05, indicating results are significant at the 5% significance level. Thus, there is a statistically significant difference between males and females in Age and Disability.

Discussion

LBP is a common occupational health issue, especially for medical workers like operation theatre technicians who must stand for extended periods, do repetitive motions, and move large objects when performing surgery[16-19]. The results of this study, which was carried out among OT technicians in Guwahati, highlight the high incidence of disability associated with LBP and its negative effects on functional capacity and quality of life.

Numerous studies show that OT technicians have an elevated risk of LBP, which is consistent with international data that shows healthcare workers are particularly vulnerable because of their physically demanding jobs[20-22]. The lumbar spine is severely strained by prolonged static postures and frequent bending, twisting, and lifting during surgical operations, which raises the risk of musculoskeletal diseases[23,24]. LBP is the most prevalent work-related musculoskeletal problem, frequently resulting in disability and absenteeism, according to similar research done among OT staff and nurses in various areas[25,26].

A sizable fraction of research participants reported moderate to severe functional restrictions brought on by LBP, which impacted their capacity to carry out daily and professional tasks efficiently. The degree of disability suffered was clearly understood through the use of standardised evaluation instruments, such as the Oswestry Disability Index[27,28]. In line with findings from related occupational research, participants reported difficulties performing duties like lifting, standing for extended periods, walking, and bending. These restrictions affected not just the effectiveness of work but also the general quality of life, which resulted in lower production and higher healthcare use.

OT technicians experienced mental discomfort, worry, and decreased job satisfaction as a result of chronic pain and functional restrictions. Long-term impairment frequently leads to feelings of powerlessness, dissatisfaction, and an elevated risk of burnout, which eventually impacts general well-being and productivity at work. According to related research, chronic LBP among medical personnel is linked to increased stress and a drop in morale, which may have an indirect impact on the standard of patient care[29,30].

According to this study, older OT technicians had higher degrees of disability associated with LBP, which was indicative of years of cumulative occupational exposure.According to these findings, healthcare workers who are older and male are more likely to experience LBP (significant at $p<0.001$).

The study emphasises the necessity of preventative measures and proactive ergonomic treatments to lower the incidence of LBP-related disability among OT technicians. By putting ergonomic changes into place, such as supportive footwear, anti-fatigue mats, and adjustable workstations, spinal load during extended standing duties can be greatly decreased. Regular training regimens that include core strengthening exercises, good body mechanics, and posture correction can also help reduce the chance of getting LBP. Incorporating stretching exercises, encouraging brief pauses, and raising knowledge of musculoskeletal health can all help to lessen disability in this susceptible group.

Limitations:

This study has some limitations, even if it provides insightful information about LBP-related impairment among Guwahati's OT technicians. The study's cross-sectional design makes it impossible to establish a causal link between LBP and occupational characteristics. Furthermore, recollection bias may affect self-reported information on functional limits and pain severity. The findings may not be as applicable to a wider group of OT technicians due to the very limited sample size.

Scope for further studies:

To evaluate the long-term effects of LBP and the efficacy of ergonomic therapies among OT technicians, future research should concentrate on longitudinal studies. Evidence-based interventions to reduce LBP-related disability in this occupational category may be provided by interventional studies that assess the effectiveness of workplace adjustments, structured exercise programs, and mindfulness-based stress reduction techniques.

Conclusion

This study concludes by highlighting the significant impact and high frequency of LBP-related disability among Guwahati's OT technicians. The results highlight the critical need for focused treatments to lower LBP and the handicap it causes, such as ergonomic changes, educational initiatives, and preventative measures. Healthcare organisations may enhance the well-being, productivity, and general quality of life of OT technicians by supporting musculoskeletal health and improving the working environment. This will ultimately improve patient outcomes.

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Ethical Clearance: Institutional Ethical Committee for Human Research,

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Original Article

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Effect of Autogenic Drainage Technique on Dyspnoea, Sputum Clearance and Functional Capacity in Adults with Stage III Esophageal Cancer; a Pilot Feasibility Trial

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Abstract

Background/Objectives: Stage III esophageal cancer (EC) is often associated with respiratory impairment, including dyspnea and reduced functional capacity, negatively affecting quality of life. Autogenic drainage (AD), a self-administered airway clearance technique using controlled breathing at varying lung volumes, has shown effectiveness in improving mucociliary clearance and reducing dyspnea in chronic respiratory conditions. However, its feasibility and therapeutic role in advanced EC remain unexplored.

Methods: This prospective pilot study evaluated the effects of autogenic drainage technique (ADT) on dyspnea, sputum clearance, and functional exercise capacity in 20 patients with stage III EC. Participants were randomly allocated into two groups: an intervention group receiving standard physiotherapy plus ADT, and a control group receiving standard physiotherapy alone. The primary outcome was dyspnea severity measured using the Modified Borg Scale. Secondary outcomes included functional capacity assessed by the six-minute walk test (6MWT) and sputum volume. Pre- and post-intervention data over a 4-week period were analyzed using appropriate statistical tests.

Results: The ADT group showed improvements in dyspnea and 6MWT, though not statistically significant. Sputum volume increased significantly in the intervention group ($p < 0.05$), indicating enhanced airway clearance. An inverse correlation was observed between baseline dyspnea and functional improvement, suggesting greater benefit in more symptomatic patients. Feasibility outcomes demonstrated a recruitment rate of 67.3%, retention of 50–66.7%, and no adverse events.

Conclusions: ADT appears to be a feasible and potentially beneficial adjunct for managing respiratory dysfunction in stage III EC. Larger randomized trials are needed to confirm these findings.

Keywords: autogenic drainage, dyspnea, esophageal cancer, quality of life, respiratory function tests, sputum clearance, treatment outcome.

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Introduction

Esophageal carcinoma (EC) represents the eighth most frequently diagnosed malignancy worldwide and the sixth leading cause of cancer-related mortality[1,2]. Studies estimated 604,100 new cases and 544,076 deaths documented in 2020 globally[3]. EC is a significant global health problem with 79.7% of new diagnoses occurring in Asia and approximately 80% of cases arising in less-developed regions[4]. while AC, is more commonly observed in Western populations and exhibits a stronger correlation with obesity and gastroesophageal reflux disease[5]. Notably, although EC is uncommon in pediatric patients, its presentation mirrors that of adults, featuring symptoms such as dysphagia and weight reduction but without discernible predisposing elements[6,7]. This underscores the necessity for tailored management strategies in treating this age group.

Autogenic drainage technique, (ADT), is a therapeutic technique that involves controlled breathing to expel respiratory airway secretions. This method promotes the elimination of secretions[8]. Research indicates that AD may be as effective as alternative airway clearance methods, such as the active cycle of breathing technique (ACBT), in patients with cystic fibrosis (CF) and chronic obstructive pulmonary disease (COPD)[9]. The effectiveness of ADT in clearing mucus and improving ventilation has been demonstrated, but its impact on pulmonary function tests, such as FEV1, remains unclear[10]. Some studies have suggested that the FEV1 may not be the best measure of airway clearance in peripheral lung regions. Despite this, patients prefer AD over other techniques, such as postural drainage with percussion (PD), which may improve treatment adherence[10–12].The literature suggests that there is limited scientific evidence to support the superiority of one manual airway clearance technique over another. However, ADT is one of the few techniques with moderate evidence supporting its use[13]. Research has demonstrated that ADT can improve the clearance of sputum in individuals who have cystic fibrosis or non-CF bronchiectasis.[14,15] Various studies have suggested that ADT sessions lead to improvements in lung function tests and a reduction in airway resistance. However, other studies do not report any considerable changes in lung function parameters, such as forced expiratory volume in 1 second (FEV1)[8,16–19].

Research suggests that AD can enhance the perception of dyspnea during physical activity in individuals with COPD[8,20,21]. While none of the previous studies have specifically evaluated the effectiveness of AD and functional capacity or dyspnea in patients with EC. Furthermore, sputum burden and severe dyspnea are worsened by radiation-induced pneumonitis, mucosal edema, and impaired mucociliary transport which are often sequelae of chemoradiation used in stage III disease[22]. Cancer-related cachexia causes muscle weakening in the respiratory tract and the spontaneous cough is less effective, impairing the ability for air expulsion even further[23]. These physiological mechanisms allow a plausible case for the use of autogenic drainage (ADT) in advanced (stage III) esophageal cancer patients with dyspnea and productive cough, despite the tumor not being thoracic. So, this study aimed to assess ADT's efficacy in stage IIIEC.

Materials and Methods

Study design and sample population

Ethical approval was obtained from DRC, Galgotias University under ref no; (DRC/PT/84/23). The study was conducted between January and April 2024 at Narayana Super Specialty Hospital, Gurugram, India after obtaining permission for data collection. A total of 20 participants meeting the eligibility criteria were enrolled in the study. The research protocol adhered to (SPIRIT) and (TIDieR) guidelines and Declaration of Helsinki[24,2526]. Written informed consent was obtained from all participants.

Eligibility criteria

Inclusion criteria were adults with stage III EC presenting with dyspnea and productive cough, able to provide consent, follow the protocol, and complete assessments. Exclusion criteria included severe COPD, pregnancy, significant psychiatric disorders and contraindications to breathing exercises or 6MWT.

Sample size calculation

The study proposed was a pilot feasibility study; hence no formal statistical calculation of the sample size was necessary. Rather, pilot studies suggest an acceptable sample size of 12 to 30 participants which is widely accepted as an appropriate pilot studies sample size[27]not only for the main trial but also for any preliminary pilot trial. When the outcome is a continuous variable, the sample size calculation requires an accurate estimate of the standard deviation of the outcome measure. A pilot trial can be used to get an estimate of the standard deviation, which could then be used to anticipate what may be observed in the main trial. However, an important consideration is that pilot trials often estimate the standard deviation parameter imprecisely. This paper looks at how we can choose an external pilot trial sample size in order to minimise the sample size of the overall clinical trial programme, that is, the pilot and the main trial together. We produce a method of calculating the optimal solution to the required pilot trial sample size when the standardised effect size for the main trial is known. However, as it may not be possible to know the standardised effect size to be used prior to the pilot trial, approximate rules are also presented. For a main trial designed with 90% power and two-sided 5% significance, we recommend pilot trial sample sizes per treatment arm of 75, 25, 15 and 10 for standardised effect sizes that are extra small (≤0.1.

Outcome Measures

Primary and secondary outcomes

The primary outcome for this study was the severity of dyspnea, measured with the Modified Borg Dyspnea Scale. Other outcomes were exercise capacity, assessed with the six-minute walk test (6MWT) and sputum clearance, measured as sputum volume.

Data collection procedure

Data were collected through face-to-face assessments. Participants completed validated questionnaires using paper-based instruments (Figure 1).

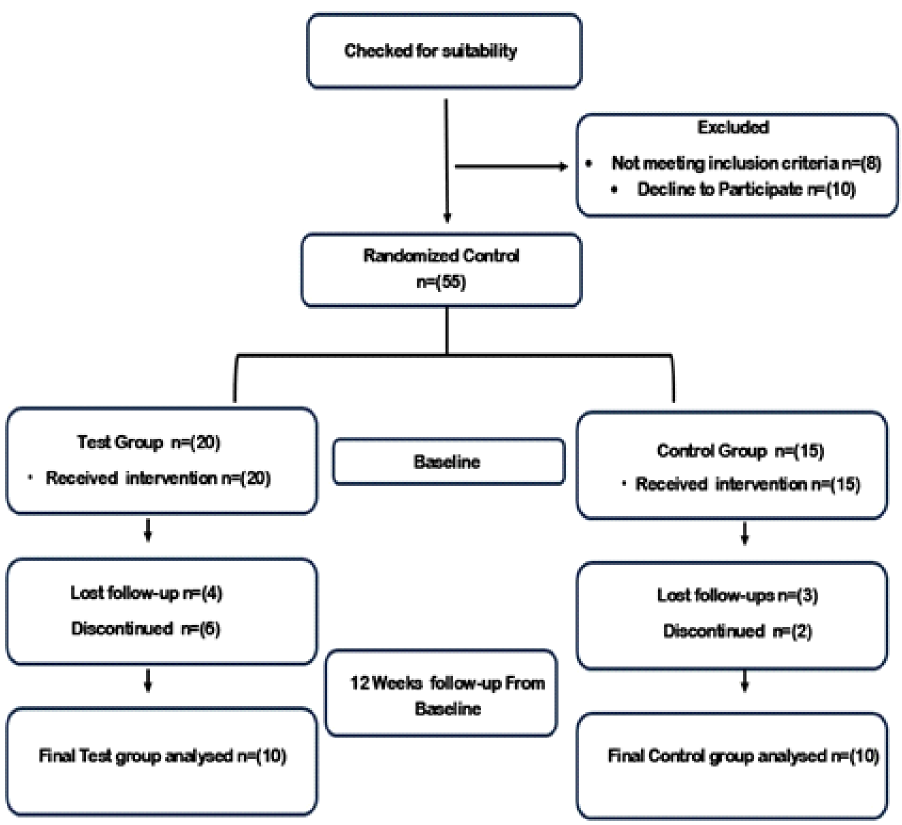


Figure 1. CONSORT flow diagram illustrating participant recruitment, allocation, and retention throughout the study.

Intervention procedure

Participants were randomized (1:1) using a computer-generated sequence by an independent researcher, with allocation concealed in sequentially numbered, opaque, sealed envelopes, which were opened after baseline assessments[28]. Due to the nature of the intervention, participants and therapist blinding was not feasible; however assessments followed standardized protocols and date were analyzed independently. The control group received standard physiotherapy (active control), while the intervention group received standard care plus ADT. Both groups underwent supervised physiotherapy three times weekly for four weeks (30-45 minutes/ session). Standard care included chest percussion (100 beats/ minute for 10-20 minutes), mechanical vibration (12-15 Hz), and diaphragmatic breathing with home practice twice daily. The (ADT) group additionally performed a standardized 3-phase protocol (unsticking, collecting, evacuating) under a certified therapist, consisting of deep inhalation, short breath holding, followed by full expiration, and huffing or coughing at the conclusion of every third treatment. All participants completed 12 sessions and were instructed not to perform ADT outside supervised sessions to maintain protocol fidelity.

Assessment of dyspnea scores

Dyspnea severity was assessed using the Modified Borg Dyspnea Scale (0-10), a validated measure in respiratory and oncological populations[29]. Ratings were recorded at baseline and post intervention.

Assessment of cardiopulmonary fitness level

The six-minute walk test (6MWT) was used to assess functional exercise capacity and cardiorespiratory fitness conducted per standardized guideline in a ≥30 m corridor with 5 m markers[30]. Participants walked as far as possible in 6 minutes, with rest permitted and standardized encouragement provided. Heart rate was recorded pre-post-test using a pulse oximeter. Total distance was the primary outcome measure

Assessment of sputum volume

Sputum production was quantified using a standardized expectoration protocol, with by volume (mL) after forced expiration and coughing into a graduated container at baseline and post-intervention[31].Feasibility outcomes included recruitment, retention and adherence rates, along participant-reported acceptability of the intervention.

Data analysis

Data were analyzed using JASP (V 0.18). Continuous variables were reported as means ± SD and categorical data as frequencies and percentages with $\alpha = 0.05$. Emphasis was placed on effect sizes and confidence intervals. Between-group comparisons used independent t-tests (Mann-Whitney U for non-normal data), and with-in-group changed used paired t-tests (or Wilcoxon signed-rank tests based on Shapiro-Wilk results. Correlations were assessed using Pearson or Spearman's coefficients as appropriate. Multivariate linear regression identified predictors of post-intervention outcomes, with model fit assessed by R^2; $p = 0.05$ was considered significant and 0.05 and 0.10 indicated trends.

Results

Participant Characteristics

Baseline demographic and clinical characteristics were comparable between groups, confirming successful randomization. No significant differences were observed in age, gender, sleep, duration or residential status. However, educational attainment differed significantly ($p= 0.03$), which more university graduates in the intervention group; this was considered in interpreting adherence and outcomes (Table 1]).

Table 1. Baseline demographic and clinical characteristics of participants by group allocation

Variable	Group	n	Mean (SD)	t test/Chi2	p-value
Age	CG	10	46.30 ±12.18	t = -0.76	0.45
	TG	10	51.10 ± 15.70		
Gender	CG	10	Female: 6, Male: 4	$X^2 = 0.80$	0.37
	TG	10	Female: 4, Male: 6		
Sleep	CG	10	6.40 ± 1.43	t = -0.16	0.87
	TG	10	6.50 ± 1.27		
Residency	CG	10	Urban: 6, Rural: 4	$X^2 = 0.80$	0.37
	TG	10	Urban: 4, Rural: 6		
Education	CG	10	SSC: 2, Inter: 5, Degree: 3	$X^2 = 6.66$	0.03*
	TG	10	SSC: 4, Inter: 0, Degree: 6		

Note: This table presents the mean and SD values for the main demographic variables of both groups and indicates no statistically significant differences among the groups, although education level was statistically significant (*p* = 0.036).

Feasibility outcomes

Feasibility outcomes indicated that recruitment was achievable but retention and adherence require improvement. Out of 55 screened participants, 37 were eligible (67.3%). 20 were allocated to the intervention group and 15 to control. Retention was 50% (10/20) in the intervention group and 66.7% (10/15) in controls, with a final analyzed sample of 20 completers. No adverse events were reported.

Baseline equivalence of outcome measures

Independent t-tests showed no baseline differences in primary outcomes, confirming successful randomization (Table 2). Pre-intervention dyspnea, 6MWT distance and sputum volumes were comparable between groups. Post-intervention, the treatment group showed trends toward improvement. Dyspnea reduction did not reach significance (p= 0.11) but demonstrated a moderate to large effect (d = 0.75). Similarly, 6MWT performance showed a large effect (d= 0.87); p=0.06) approaching significance. No meaningful between group difference was observed for sputum volume (Table 2).

Table 2: Comparison of pre-intervention score across groups

Variable	Test	Statistic	df	p-value	Cohen's d	SE Cohen's d
Pre-SOB	Student	-0.64	18	0.52	-0.28	0.45
	Welch	-0.64	17.9	0.52	-0.28	0.45
Pre-6MWT	Student	-0.45	18	0.65	-0.2	0.45
	Welch	-0.45	17.6	0.65	-0.2	0.45
Pre-SC	Student	0.11	18	0.91	0.05	0.44
	Welch	0.11	17.8	0.91	0.05	0.44
Post-SOB	Student	1.67	18	0.11	0.75	0.47
	Welch	1.67	17.9	0.11	0.75	0.47
Post-6MWT	Student	1.94	18	0.06	0.87	0.48
	Welch	1.94	17.9	0.06	0.87	0.48
Post-SC	Student	0.33	18	0.74	0.14	0.44
	Welch	0.33	17.5	0.74	0.14	0.44

The table depicts a summary of independent t-tests comparing pre-intervention scores between the CG and TGs on shortness of breath (Pre-SOB), the 6-minute walk test (pre-6MWT), and the sputum clearance test (Pre -SCT).

Baseline equivalence confirmed group comparability. Post-intervention comparisons (post-SOB, post-6MWT, post-SCT) showed no statistically significant differences; however, trends toward improvement were observed in the treatment group for dyspnea and 6MWT. Despite moderate to large effect sized, the lack of significance precludes definitive conclusions regarding intervention efficacy.

Abbreviations Used in the table: (ADT=Autogenic drainage technique, EC= Esophageal Cancer, TG = Treatment group, CG = Control group, SOB = Shortness of Breath, SC = Sputum Clearance, 6MWT = Six Minute Walk Test, SD = Standard deviation, df = Degree of Freedom, ES = Effect Size, CI = Confidence Interval

Within-group changes following intervention

Within-group analysis (paired t-tests and Wilcoxon tests) showed a non-significant reduction in dyspnea (p=0.11). However, sputum volume increased significantly with a moderate to large effect, supported by both parametric (p = 0.02, r= -0.62) (Table 3).

Within the TG, dyspnea reduction approached but did not reach significance (p=0.14), and 6WMT showed minimal change (p=0.93). While sputum clearance improved, large samples are needed to detect significant effect on dyspnea and functional capacity (Table 3).

Table 3: pre-and post-intervention comparisons within groups

Variable	Test	z	df	p	ES	SE ES	95% CI	
							Lower	Upper
Pre vs Post SOB	Student	-1.4	19	0.11	-0.37	0.37	-0.81	0.09
	Wilcoxon			0.14	-0.4	0.26	-0.74	0.11
Pre vs Post 6MWT	Student	0.11	19	0.93	0.018	0.35	-0.42	0.45
	Wilcoxon			0.92	0.029	0.25	-0.43	0.48
Pre vs Post SC	Student	-2.4	19	0.02*	-0.55	0.27	-1.01	-0.07
	Wilcoxon			0.01*	-0.62	0.25	-0.84	-0.21

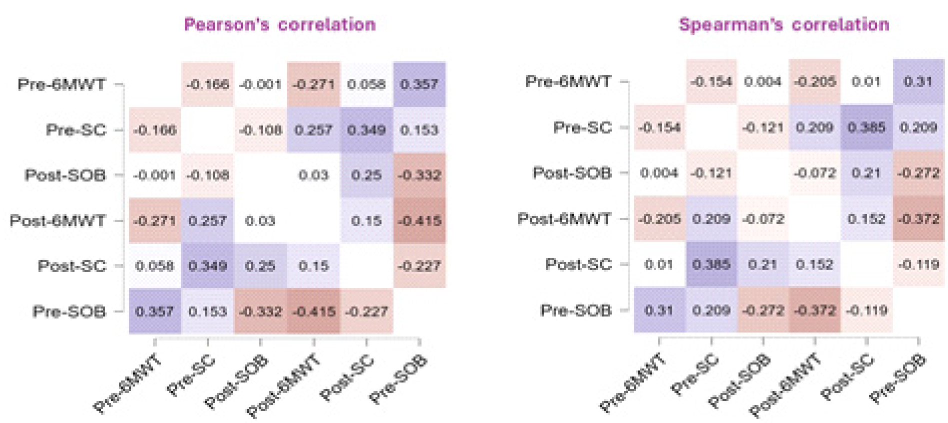
Note: This table presents the results of the paired sample t-tests comparing the pre-and post-intervention scores within each group. Significant improvements in sputum clearance (post-SC) were observed in the CG (*p = 0.05). No significant changes were noted in shortness of breath or 6-minute walk test scores.

Abbreviations: SOB = Shortness of Breath; 6MWT = Six-Minute Walk Test; SC = Sputum Clearance; ES = Effect Size; CI = Confidence Interval

Correlational analysis

Correlation analyses (Table 4, Figure 2) revealed a moderate negative association between baseline dyspnea and post-6MWT (r= -0.41, p= 0.06), approaching significance. This suggests that participants with greater initial dyspnea tended to achieve better post-intervention functional capacity. Possible explanations include greater physiological scope for improvement, higher adherence due to symptom burden and ceiling effects in those with milder baseline symptoms. These findings highlight baseline dyspnea as a potential predictor of response to ADT.

Variables		Pearson				Spearman			
		r	p	z	SE	rho	p	z	SE
Pre-6MWT	Pre-SC	-0.17	0.5	-0.17	0.2	-0.2	0.5	-0.2	0.2
	Post-SOB	-64.6	1	-64.6	0.2	0	1	0	0.2
	Post-6MWT	-0.27	0.3	-0.28	0.2	-0.2	0.4	-0.2	0.2
	Post-SC	0.06	0.8	0.06	0.2	0.01	1	0.01	0.2
	Pre-SOB	0.36	0.1	0.37	0.2	0.31	0.2	0.32	0.2
Pre-SC	Post-SOB	-0.11	0.7	-0.11	0.2	-0.1	0.6	-0.1	0.2
	Post-6MWT	0.26	0.3	0.26	0.2	0.21	0.4	0.21	0.2
	Post-SC	0.35	0.1	0.37	0.2	0.39	0.1	0.41	0.2
	Pre-SOB	0.15	0.5	0.16	0.2	0.21	0.4	0.21	0.2
Post-SOB	Post-6MWT	0.03	0.9	0.03	0.2	-0.1	0.8	-0.1	0.2
	Post-SC	0.25	0.3	0.26	0.2	0.21	0.4	0.21	0.2
	Pre-SOB	-0.33	0.2	-0.35	0.2	-0.3	0.3	-0.3	0.2
Post-6MWT	Post-SC	0.15	0.5	0.15	0.2	0.15	0.5	0.15	0.2
	Pre-SOB	-0.42	0.1	-0.44	0.2	-0.4	0.1	-0.4	0.2
Post-SC	Pre-SOB	-0.23	0.3	-0.23	0.2	-0.1	0.6	-0.1	0.2



Outcome Measures	Variable				95% CI	
Post-SOB	Model		t	p	Lower	Upper
	M_0	(Intercept)	17.6	< .001	6.3	8
	M_1	(Intercept)	-1.31	0.23	-25.05	6.87
		Age	0.5	0.63	-0.06	0.1
		BMI	2.29	0.05	0	0.67
		Sleep	2.08	0.07	-0.08	1.49
		Pre-SOB	-0.98	0.36	-1.15	0.47
		Pre-6MWT	0.38	0.72	-0.02	0.02
		Pre-SC	0.73	0.49	-0.06	0.11
		Gender (Female)	0.91	0.39	-1.42	3.27
		Economic (BPL)	1.68	0.13	-0.54	3.44
		Res (Rural)	2.18	0.06	-0.13	4.8
		EdU (Inter)	3.4	0.01	1.15	6
		EdU (Degree)	1.82	0.11	-0.46	3.9

Cont......

Post 6MWT	M_0	(Intercept)	12.2	< .001	168.83	238.9
	M_1	(Intercept)	2.02	0.08	-86.97	1293
		Gender (Female)	-1.25	0.25	-156.5	46.46
		Economic (BPL)	-0.4	0.7	-101.1	70.97
		Res (Rural)	-1.35	0.21	-168.9	44.2
		EdU (Inter)	-0.39	0.7	-122.7	86.86
		EdU (Degree)	-2.55	0.03	-198.2	-9.77
		Age	0.5	0.63	-2.78	4.31
		BMI	-1.45	0.18	-23.72	5.39
		Sleep	1.08	0.31	-18.01	49.75
		Pre-SOB	-3.09	0.02	-81.75	-11.83
		Pre-6MWT	-0.32	0.76	-0.88	0.66
		Pre-SC	2	0.08	-0.48	6.79
Post-SC	M_0	(Intercept)	14.1	< .001	31.93	43.1
	M_1	(Intercept)	1.4	0.2	-34.59	141.3
		Gender (Female)	-1.43	0.19	-20.95	4.9
		Economic (BPL)	-0.55	0.6	-13.57	8.4
		Res (Rural)	1.99	0.08	-1.89	25.3
		EdU (Inter)	0.52	0.62	-10.37	16.3
		EdU (Degree)	-0.17	0.87	-12.88	11.1
		Age	-3.05	0.02	-1.05	-0.1
		BMI	2.18	0.06	-0.11	3.6
		Sleep	-3.06	0.02	-10.04	-1.4
		Pre-SOB	-0.12	0.91	-4.68	4.2
		Pre-6MWT	-0.15	0.89	-0.1	0.1
		Pre-SC	2.21	0.06	-0.02	0.9

Note. The table shows the Pearson and Spearman correlation coefficients between the various pre- and post-intervention measures. Negative correlations were observed between Pre-SOB and Post-SOB as well as between Pre-SOB and Post-6 MWT, although these associations did not reach statistical significance.

Linear Regression analysis

Multivariate regression identified post-intervention outcomes (Table 5). The dyspnea model explained 26.3% of variance ($R^2 = 0.26$); no predictors were significant, though sleep duration showed a trend ($p = 0.07$). The 6MWT model explained 33.6% of variance ($R^2 = 0.34$), with baseline dyspnea as a significant negative predictor ($p = 0.02$). Educational attainment was also significant predictor ($p = 0.03$), though interpretation is limited by given the small sample. Overall, sleep and baseline severity may influence response, but modest variance suggests additional factors; larger studies are needed. (Table 5).

Discussion

The present pilot randomized controlled trial investigated the efficacy of autogenic drainage technique as an adjunctive respiratory intervention in adults with stage III esophageal carcinoma. The findings yielded mixed results, with statistically significant improvements observed in sputum clearance but non-significant trends toward improvement in dyspnea severity and functional exercise capacity. The most robust finding of this investigation was the statistically significant increase in sputum volume in the treatment group ($p = 0.02$, Cohen's $d = -0.54$), demonstrating ADT's effectiveness in enhancing mucociliary clearance. This finding aligns with established evidence from cystic fibrosis and bronchiectasis populations, where ADT has consistently demonstrated superior sputum mobilization compared to conventional chest physiotherapy techniques. The physiological mechanism underlying this effect involves the controlled breathing pattern of ADT, which optimizes expiratory flow rates at varying lung volumes to mobilize secretions from peripheral to central airways without airway collapse[32,33]. In the context of esophageal carcinoma, enhanced sputum clearance may confer several clinical benefits. First, improved airway clearance reduces the risk of post obstructive pneumonia, a common complication in patients with malignancy-associated airway compromise[34]. Second, effective secretion management may attenuate dyspnea by reducing airway resistance and work of breathing. Third, enhanced mucociliary clearance may improve ventilation-perfusion matching, potentially improving oxygenation and exercise tolerance[35,36]. Although dyspnea scores and 6MWT performance demonstrated trends toward improvement in the treatment group, these changes did not achieve statistical significance (post-SOB: $p = 0.11$, Cohen's $d = 0.75$; post-6MWT: $p = 0.06$, Cohen's $d = 0.87$). However, while moderate-to-large effect sizes were found, the absence of statistical significance suggests that these results are not definitive and may reflect a lack of statistical power rather than intervention effect sizes. Several methodological considerations may explain the absence of statistical significance despite promising effect sizes. First, the Modified Borg Dyspnea Scale, while widely used and validated, may lack the sensitivity to detect subtle improvements in dyspnea in this heterogeneous population[37]. Dyspnea in esophageal cancer patients is multifactorial, influenced by tumor burden, treatment-related toxicity (chemotherapy, radiation), nutritional status, and psychological distress[38,39]. More comprehensive assessment tools, such as the Cancer Dyspnea Scale or the Multidimensional Dyspnea Profile, may provide more nuanced characterization of dyspnea dimensions (sensory-perceptual, affective distress, and impact[40]. Second, the relatively brief intervention duration (4 weeks) may have been insufficient to observe maximal treatment effects. Respiratory rehabilitation interventions typically require 8-12 weeks to demonstrate significant functional improvements, with additional time needed for consolidation of gains[41]. The chronic nature of dyspnea in advanced cancer suggests that sustained, long-term interventions may be necessary to achieve and maintain clinically significant improvements[42]. Third, disease progression during the study period may have attenuated observable treatment effects. Stage III esophageal carcinoma is characterized by progressive tumor growth and potential metastatic spread, which may independently worsen respiratory function despite effective airway clearance interventions[43,44]. Future studies should incorporate measures of disease progression (tumor size, staging changes) to account for this confounding variable. A particularly noteworthy finding was the moderate inverse correlation between baseline dyspnea severity and post-intervention functional capacity ($r = -0.41$, $p = 0.07$), suggesting that patients with more severe baseline respiratory impairment derived greater functional benefit from ADT. This finding has important clinical implications for patient selection and treatment individualization. Several mechanisms may explain this relationship. Physiologically, patients with more severe airway obstruction due to retained secretions may experience more dramatic improvements following effective secretion clearance, resulting in greater reductions in airway resistance and work of breathing[45]. Behaviorally, patients experiencing more distressing symptoms may demonstrate enhanced motivation and treatment adherence, leading to more consistent and effective ADT performance[46,47]. Statistically, ceiling effects may limit observable improvements in patients with milder baseline symptoms, whereas those with severe impairment have greater capacity for measurable change. These findings suggest that ADT may be particularly beneficial when targeted toward patients with moderate-to-severe dyspnea and evidence of impaired secretion clearance. Clinical implementation should consider baseline symptom severity in treatment planning, with more intensive ADT training and monitoring provided to patients presenting with significant respiratory compromise. The regression analysis revealed that sleep duration approached significance as a predictor of post-intervention dyspnea outcomes ($p = 0.07$), with longer sleep associated with reduced dyspnea.

This finding aligns with established evidence linking sleep quality to respiratory function and symptom perception in chronic illness populations. Sleep deprivation and fragmentation are common in advanced cancer patients due to pain, anxiety, medication side effects, and nocturnal dyspnea. Insufficient sleep impairs multiple physiological systems relevant to respiratory function, including respiratory muscle strength, autonomic nervous system regulation of breathing, immune function, and inflammatory processes[48]. Additionally, sleep deprivation enhances pain and symptom perception, potentially amplifying subjective dyspnea intensity independent of objective respiratory impairment. These findings suggest that comprehensive respiratory rehabilitation for cancer patients should incorporate sleep hygiene interventions alongside airway clearance techniques. Strategies may include optimizing pain management, treating nocturnal dyspnea, addressing anxiety and depression, and implementing behavioral sleep interventions[49,50]. The potential synergistic effects of improved sleep and enhanced airway clearance warrant investigation in future studies.

Limitations and clinical implications

Despite its limitations, this pilot study provides preliminary support for ADT as an adjunctive respiratory intervention in stage III esophageal carcinoma. Significant improvement in sputum clearance, along with trends toward better dyspnea and functional capacity (moderate-to-large effect sizes), supports further revaluation in adequately powered trials.

Clinically is non-invasive, cost-effective and self-administered promoting patient engagement and easy integration into standard physiotherapy minimal adverse effects. Its applicability may extend to other oncologic populations with respiratory compromise including lung cancer and post-thoracic treatment cases and could be incorporated into pulmonary rehabilitation programs to improve outcomes and quality of life. As an adjunct to standard care, findings reflect the added benefit of ADT particularly for patients with greater baseline severity. However, limited sample size and moderate retention constrain definitive conclusions. These findings primarily informfeasibility, effect size estimation and deign of well-powered RCTs with improved adherence strategies.

Conclusions

This pilot feasibility trial provides preliminary evidence supporting ADTas an adjunctive respiratory intervention in stage III esophageal carcinoma. Patients with greater baseline dyspnea showed promising functional improvements, indicating potential benefit in those with higher respiratory impairment. Overall, ADT appears feasible and may enhance sputum clearance; however, definitive efficacy requires larger, adequately powered RCTs.

Future recommendations

Future studies should include larger samples (50-60 per group), extended intervention(≥8-12 weeks), broader outcomes (pulmonaryfunction, quality of life, psychological measures), and long-term follow-up (3-12 months), with adherence monitoring. Evaluating ADT in patients with respiratory comorbidities and optimizing dosing and delivery will further enhance clinical applicability.

Data Availability Statement: Data is freely available in online repository; https://doi.org/10.6084/m9.figshare.30929405

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Original Article

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Effect of Tai Chi Versus Cawthorne Cooksey Exercises on Balance and Gait in Patients with Benign Paroxysmal Positional Vertigo

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Abstract

Background: Benign Paroxysmal Positional Vertigo (BPPV) is a leading cause of vertigo, affecting balance, gait, and mobility, particularly in older adults. While canalith repositioning maneuvers effectively treat BPPV, many patients experience residual dizziness (RD) and postural instability, increasing fall risk. Vestibular rehabilitation, including Cawthorne-Cooksey Exercises (CCE) and Tai Chi, has been explored to enhance post-BPPV recovery. However, limited research directly compares their effectiveness.

Method: A randomized controlled trial was conducted with 54 participants diagnosed with BPPV, divided into two groups: Group C (CCE, n=27) and Group T (Tai Chi, n=27). Both interventions were administered over 12 sessions across four weeks. Outcome measures included the Timed Up and Go (TUG) Test, Four Square Step Test (FSST), and Functional Gait Assessment (FGA). Statistical analysis was performed using SPSS version 29, with paired and independent t-tests applied for intra- and inter-group comparisons.

Conclusion: Both interventions significantly improved balance and gait ($p<0.001$). However, Tai Chi proved to be more effective in enhancing postural stability, dynamic balance, and overall functional mobility. Participants who practiced Tai Chi exhibited better movement adaptation, increased confidence in mobility, and a greater reduction in dizziness-related difficulties compared to those who performed CCE. Both CCE and Tai Chi are effective in improving balance and gait post BPPV. However, Tai Chi offers greater improvements in postural stability, dynamic balance, and functional mobility, possibly due to its focus on weight shifting, proprioceptive integration, and mind-body coordination. These findings suggest Tai Chi may serve as a viable, holistic alternative to conventional vestibular rehabilitation exercises.

Keywords: Vestibular Rehabilitation; Benign Paroxysmal Positional Vertigo (BPPV); Tai Chi; Cawthorne-Cooksey Exercises; Balance; Gait Performance

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Introduction

Benign Paroxysmal Positional Vertigo (BPPV) is the most common peripheral vestibular disorder, accounting for nearly one-third of vertigo cases globally.[25] It is characterized by brief, recurrent episodes of vertigo precipitated by changes in head position, such as rolling in bed, looking upward, or bending forward.[26] The pathophysiology involves dislodged otoconia from the utricle entering the semicircular canals (posterior canal most commonly affected with 10% recurrence rates)—most often the posterior canal—causing abnormal endolymphatic flow and deflection of the cupula, which triggers vertigo.[10, 11]

In India, BPPV is present in 25% of patients presenting with vertigo, with a mean age of 41 years and a predominance among females (59%)[17]. The high recurrence rate and persistence of postural imbalance highlight the need for sustained vestibular rehabilitation rather than relying solely on canalith repositioning manoeuvres.[17]

Although repositioning techniques like the Epley or Semontmaneuvers are highly effective in resolving positional vertigo, many patients continue to experience residual dizziness (RD). RD has been attributed to incomplete repositioning of otoconia, delayed central vestibular compensation, and dysfunction of the otolith organs.[15] Persistence of RD significantly impacts functional mobility and increases fall risk, especially in elderly populations.[15]

Vestibular rehabilitation plays a crucial role in restoring balance and gaze stabilization following BPPV. Among various techniques, the Cawthorne–Cooksey Exercises (CCE) remain one of the most widely adopted protocols for vestibular retraining, whichinvolves repetitive eye, head, and body movements that encourage vestibular habituation, sensory reweighting, and central compensation which helps improve postural stability and reduced fall risk in middle-aged adults.[18] The physiological mechanisms underlying CCE include habituation, adaptation (recalibration of vestibulo-ocular reflexes), and sensory reweighting (better integration of visual, vestibular, and proprioceptive cues), which collectively promote vestibular compensation, allowing the intact vestibular system to offset dysfunction on the affected side.[14]

Parallel to structured vestibular exercise programs, Tai Chi has emerged as a promising mind–body intervention for improving balance and postural control as it emphasizes slow, rhythmic, and continuous movements integrated with controlled breathing and mindfulness.[19] The movements involve gradual weight shifting, trunk rotation, and semi-squatting postures, which collectively enhance proprioceptive input, neuromuscular coordination, and lower-limb strength and contribute to stability and prevention of falls in older adults.[22]

Tai Chi training has led to significant improvements in postural stability, stride length, and functional mobility in individuals with Parkinson's disease.[8] Beyond physical benefits, Tai Chi reduces anxiety and fear of falling, enhancing self-efficacy and psychological well-being—factors closely associated with vestibular recovery.[19]

There is a significant research gap regarding their direct comparison in post-BPPV rehabilitation. Most existing studies[27, 28] have examined these approaches in isolation, without evaluating which method produces greater improvements in functional mobility, gait stability, and fall reduction. This gap highlights the need for systematic comparative research to determine the relative efficacy of CCE and Tai Chi in addressing residual dizziness and postural imbalance following BPPV.[29, 30] Through this study we hypothesize that Tai Chi will help reduce residual dizziness after BPPV by using slow, continuous head and body movements that support vestibular adaptation and sensory reweighting. Through gradual weight shifting and controlled postural transitions, Tai Chi is expected to improve balance, gait stability, and tolerance to movement. Its calm, rhythmic, and mindful practice may also reduce anxiety and fear of movement, thereby further decreasing the perception of dizziness and improving functional recovery. Establishing such evidence would enable physiotherapists to design targeted, evidence-based, and cost-effective rehabilitation protocols, integrating both traditional vestibular and holistic mind–body approaches to enhance recovery, promote long-term balance restoration, and improve overall quality of life in post-BPPV patients.

Material and Methods

Study Design and Setting - The present study was designed as a randomized controlled trial (parallel group design) and was conducted in the Department of Physiotherapy and Sports Medicine Rehabilitation, Nanavati Max Super Specialty Hospital, Mumbai, from January 2024 to December 2024.Ethical clearance was obtained from the Institutional Ethics Committee (Approval No: ECR/566/Inst/MH/2014/RR-20), and the study was prospectively registered in the Clinical Trials Registry of India (CTRI/2025/03/100753). All participants provided written informed consent prior to their inclusion in the study.

A total of 54 participants diagnosed with Benign Paroxysmal Positional Vertigo (BPPV) were recruited using a convenience sampling method. Sample size was determined using an a-priori power analysis for a t-test comparing two independent means (two groups). An assumed effect size of 0.5, alpha error of 0.05, and power of 95% (0.95) were used. Eligible participants were randomly allocated into two groups of 27 each using the odd–even randomization technique.

Inclusion criteria included adults clinically diagnosed with BPPV who had undergone canalith repositioning but continued to experience residual dizziness or light-headedness during movement, and who had intact cognition, assessed prior to admission using Mini Mental State Examination Scale >24 Exclusion criteria included individuals with neurological, musculoskeletal, or systemic conditions affecting balance, and those with injuries or comorbidities that could hinder participation in the exercise program.

Procedure-After screening and consent, baseline assessments were conducted using the following standardized outcome measures:

- Timed Up and Go Test (TUG) – to evaluate functional mobility and fall risk [31] In vestibular populations, the Timed Up and Go test shows excellent reliability, with test–retest ICC values around 0.97 and low measurement error (SEM ≈ 0.46 s; MDC ≈ 1.07 s), indicating stable and repeatable performance.[34]
- Four Square Step Test (FSST) – to assess dynamic balance and coordination[32] In individuals with vestibular disorders, the Four Square Step Test demonstrates excellent reliability (ICC ≈ 0.93) and good concurrent validity with other balance and mobility measures, supporting its use in vestibular rehabilitation.[35]
- Functional Gait Assessment (FGA) – to measure postural stability and gait performance [33]In patients with vestibular disorders, the Functional Gait Assessment shows high inter- and intra-rater reliability (ICC > 0.90) and good concurrent validity through strong correlations with other balance and mobility measures.[36]

Participants were then randomly assigned to one of two intervention groups:

- Group A (Conventional Group) received the Cawthorne–Cooksey Exercises (CCE), a structured vestibular rehabilitation protocol emphasizing progressive head, eye, and body movements from sitting to standing positions [37]
- Group B (Experimental Group) performed Tai Chi Shibashi exercises, derived from Yang Cheng Fu's movement principles emphasizing postural alignment, body control, and relaxation[38]

Both interventions were delivered under physiotherapist supervision for 45 minutes per session, three times a week, over a period of four weeks. Participants completed a total of 12 sessions. Post-intervention assessments were conducted using the same outcome measures as at baseline.

Materials Used - Minimal equipment was required for the intervention and assessment procedures, including:

- Cones
- Ball
- Stopwatch
- Measuring tape
- Standard chair

All sessions were conducted in a well-lit, quiet clinical environment with adequate safety precautions.

Data Analysis- The sample size was calculated using a two-tailed independent t-test for difference between means, assuming an effect size (d) of 0.5, $\alpha = 0.05$, and power $(1-\beta) = 0.95$, yielding a total sample size of 54 participants (27 per group).

Data were analyzed using SPSS version 30 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize demographic data, while paired t-tests and unpaired t-tests were employed to determine within-group and between-group differences. Statistical significance was set at $p < 0.05$.

Ethical Considerations - The study adhered to the ethical principles of the Declaration of Helsinki (2013). Participants were fully informed about the nature and purpose of the research, and confidentiality was maintained throughout the study. Written informed consent was obtained from all participants before data collection.

CAWTHORNE COOKSEY EXERCISE PROTOCOL-

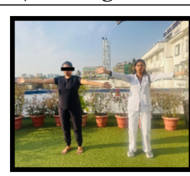
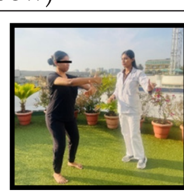
Table 1: Interventions received by participants

Exercise Set / Movement	**Illustrations**	**Stepwise Procedure**	**Clinical Explanation / Purpose**
Set A – Head Movements	 Figure 1: Head and Neck Movements (Flexion / Extension)	Eye movements: up–down, side–side, focus on thumb moving inwards.	Facilitates visual-vestibular coordination and gaze stability.
Set B – Head Movements	 Figure 2: Head and Neck Movements (Rotations)	Head movements: flexion-extension, rotation (eyes open → closed).	Stimulates vestibular input and habituation to head motion.
Set C – Shoulder Movements	–	Shoulder shrugs, circles, bend forward to pick an object.	Improves proprioception, cervical mobility, and upper limb coordination.
Set D – Standing Movements	 Figure 3: Throwing a small ball above eye level from one hand to the other hand	Sit-to-stand, throwing ball above eye level, passing behind knee, turning around.	Enhances postural stability and dynamic balance under visual perturbations.

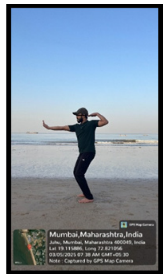
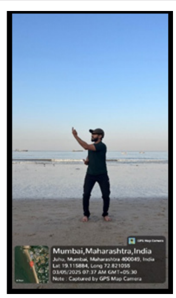
Cont.......

Set E – Moving About	 Figure 4: Walking	Walking around, catching ball, walking with eyes open → closed, slope walking.	Improves spatial orientation, gait stability, and vestibulo-ocular reflex adaptation.

TAI CHI (SHIBA SHI) EXERCISE PROTOCOL-

Exercise Movement	**Illustrations**	**Stepwise Procedure**	**Clinical Explanation / Purpose**
Commencing Form	 Figure 5: Commencing form (Raising the arms)	Raise arms to shoulder height, palms down, coordinated breathing in/out.	Promotes postural alignment, respiratory control, and movement initiation.
Chest Expansion	 Figure 6: Chest expansion (Broadening One's Chest)	Open chest, arms extended to sides, controlled inhalation/ exhalation.	Expands thoracic mobility, enhances balance through chest-lung coordination.
Dancing with Rainbow	 Figure 7: Dancing with rainbow (painting a rainbow)	Shift weight, alternate side arcs with smooth breathing.	Improves dynamic balance and proprioceptive awareness via smooth transitions.
Separate the Clouds	 Figure 8: Separate the clouds (circling arms)	Cross hands, circle arms overhead, synchronized breathing.	Facilitates bilateral coordination and trunk control with respiratory synchronization.

Cont.......

Repulse Monkey	 Figure 9: Repulse monkey (rolling the arms / Twisting Waist & Swing Arms)	Waist rotation with alternate arm movements simulating pulling/ pushing.	Trains weight shifting, coordination, and vestibular- cervical integration.
Rowing	 Figure 10: Rowing (rowing the boat in the lake)	Circular rowing motion engaging trunk and shoulders.	Strengthens shoulder girdle and trunk, promoting rhythmic motor control.
Lift the Ball	 Figure 11: Lift the ball in front of the shoulder.	Alternating side arm lifts coordinated with trunk rotation and breathing.	Improves balance, coordination, and lower limb weight transfer.
Carrying the Moon	 Figure 12: Carrying the moon (Turning the body to look at the moon)	Trunk rotation with arm elevation mimicking moon-gazing posture.	Enhances flexibility, rotation control, and visual tracking.
Pushing Palms	 Figure 13: Pushing palms (Turning waist and push palm)	Alternating palm pushes with waist rotation for balance and focus.	Promotes fluid motion, mindfulness, and functional stability.

Results and Discussion

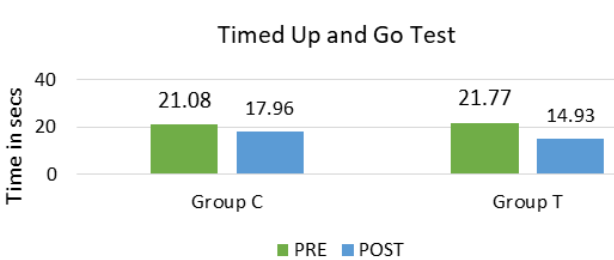
Demographic and Baseline Characteristics - A total of 54 participants (14 males and 40 females) diagnosed with residual dizziness following Benign Paroxysmal Positional Vertigo (BPPV) were enrolled and allocated into two groups: Group A (Cawthorne-Cooksey Exercises) and Group B (Tai Chi). The mean age of participants in Group C was 49.96 ± 14.37 years and in Group T, 53.85 ± 16.30 years. Females formed the majority in both groups, reflecting the higher prevalence of BPPV among women, particularly around menopausal age due to hormonal and otoconial changes.

Table 2: Demographic details of the participants

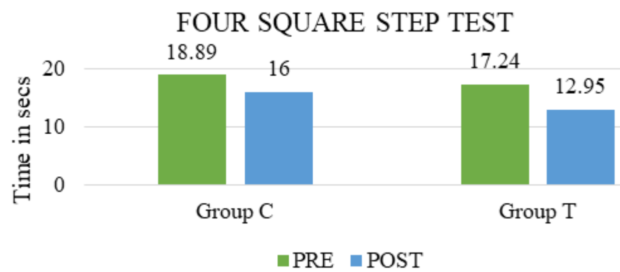
	Group A	Group B
Gender (M/F)	6/21	8/19
Age (mean in yrs)	49.96±14.37	53..85±16.30
Age – Females (mean in yrs)	46.10 years	48.68 years
Age – Males (mean in yrs)	63.50 years	66.13 years

Normality of the pre-intervention data was assessed using the Kolmogorov–Smirnov test, which showed no significant deviation from a normal distribution (p > 0.05), thereby justifying the use of parametric statistical tests. Intragroup analyses were performed using paired *t*-tests, while intergroup comparisons employed independent *t*-tests, with significance set at $p \leq 0.05$.

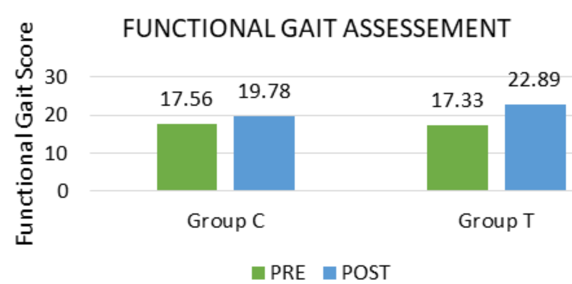
1. Timed Up and Go (TUG) Test - The TUG scores significantly improved in both groups (Group C: 21.08 ± 4.61 s to 17.96 ± 4.02 s, $p < 0.001$; Group T: 21.77 ± 5.52 s to 14.93 ± 4.52 s, $p < 0.001$). The intergroup difference was non-significant at baseline ($p = 0.62$) but became significant post-intervention ($p = 0.01$), indicating superior improvement in Group T.



2. Four-Square Step Test (FSST) - Both groups showed significant intragroup gains (Group C: 18.89 ± 4.46 s to 16.00 ± 3.99 s; Group T: 17.24 ± 5.01 s to 12.95 ± 4.37 s; $p < 0.001$). The mean improvement was greater in Group T (–4.29 s) than in Group C (–2.89 s), with a significant intergroup difference after intervention ($p = 0.01$).



3. Functional Gait Assessment (FGA) -Functional gait and postural stability improved markedly in both groups (Group C: 17.56 ± 2.63 to 19.78 ± 2.45; Group T: 17.33 ± 3.06 to 22.89 ± 3.43; $p < 0.001$). The intergroup comparison showed no difference at baseline ($p = 0.77$) but a highly significant difference post-intervention ($p < 0.001$), favouring Tai Chi.



Collectively, these results highlight that while both interventions enhanced balance and mobility, Tai Chi demonstrated greater efficacy across all outcome measures, emphasizing its role as a dynamic, functionally oriented rehabilitation method.

Discussion

This study compared the effects of Cawthorne-Cooksey Exercises (CCE) and Tai Chi in individuals experiencing residual dizziness post-BPPV. Both groups achieved significant within-group improvements in mobility and balance, yet Tai Chi produced superior post-intervention outcomes across all parameters—TUG, FSST, and FGA—suggesting its broader neuromechanical and psychosomatic benefits.

Interpretation of Findings - The greater efficacy of Tai Chi can be attributed to its integration of slow, rhythmic, multidirectional movements that continuously challenge dynamic postural control and enhance lower-limb strength. The exercise's reliance on mindful weight shifting and proprioceptive feedback enhances multisensory integration across vestibular, visual, and somatosensory systems, facilitating vestibular adaptation and central reweighting.

CCE, while effective for vestibular habituation and gaze stabilization, primarily targets static balance and controlled motion, lacking the dynamic complexity and functional transference characteristic of Tai Chi. This limitation may explain its relatively modest improvements in tasks involving multidirectional stepping and dynamic gait stability, as reflected in FSST and FGA outcomes.

Comparison with Previous Literature - The findings are consistent with previous reports by Whitney et al. (2004)[21]and Han et al. (2011)[5] , who demonstrated the efficacy of CCE in promoting vestibular compensation and postural adaptation. However, studies by Wayne and Kaptchuk (2008)[19] and Penn et al. (2019)[12] have highlighted Tai Chi's superior capacity to improve proprioception, neuromuscular control, and lower-limb strength, aligning with the current study's results.

Furthermore, the holistic benefits of Tai Chi extend beyond physical rehabilitation. Prior research (Abbott &Lavretsky, 2013; Kuang et al., 2024) has shown that Tai Chi reduces anxiety and cortisol levels, thereby addressing the psychological components of residual dizziness. By enhancing body awareness and relaxation, Tai Chi promotes a confident, fear-free approach to movement—a crucial factor in long-term vestibular rehabilitation success.

Physiological Mechanisms - Tai Chi facilitates vestibulo-ocular reflex recalibration, vestibulospinal adaptation, and proprioceptive refinement. It strengthens the ankle, knee, and hip joint moments, training the center of mass (COM) to remain within the base of support (BOS) and improving dynamic gait stability. Its emphasis on slow, mindful transitions between stances fosters cortical engagement and sensorimotor synchronization, further contributing to balance recovery.

Clinical Implications - The study underscores Tai Chi's viability as a clinical adjunct to standard vestibular rehabilitation. Its adaptability and minimal equipment requirements make it suitable for community-based and home programs, enhancing patient adherence. Incorporating Tai Chi into clinical protocols may also improve patients' psychosocial outcomes and reduce fall risk in populations with vestibular dysfunction.

Study Limitations - The study's short intervention period (four weeks) and modest sample size limit generalizability. Future studies should include larger cohorts, longer follow-up durations, and objective measures of cortical or vestibular adaptation. Stratified analyses by age and sex could further elucidate demographic influences on intervention outcomes.

Conclusion

This study demonstrates that both Cawthorne-Cooksey Exercises and Tai Chi effectively improve balance, gait, and functional mobility in patients experiencing residual dizziness following BPPV. However, Tai Chi produced significantly greater enhancements in dynamic balance, postural stability, and gait performance. Its integrative approach—blending physical training, proprioceptive control, and mindfulness—makes it a superior, holistic intervention for vestibular rehabilitation.Beyond physiological gains, Tai Chi fosters psychological resilience by reducing anxiety and fear of movement, thereby improving overall quality of life and should be considered a viable adjunct to conventional vestibular rehabilitation programs.

Future research should investigate the long-term retention of these improvements, explore Tai Chi's role in other vestibular disorders such as Meniere's disease and vestibular migraine, and evaluate its feasibility within structured clinical protocols.

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Conflict of Interest: The authors declare no conflict of interest.

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Original Article

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Association Between Ankle Joint Mobility and Dynamic Balance in Chronic Post-Stroke Survivors

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Abstract

Background: Balance impairment is a leading cause of fall and loss of independence in chronic stroke survivors. The ankle joint plays a critical role in maintaining balance. This study aimed to investigate the relationship between active dorsiflexion range of motion (AROM-DF) of both ankles and dynamic balance in chronic post-stroke survivors.

Methods: A descriptive cross-sectional study was conducted at the Neurology Physiotherapy Unit of the National Hospital of Sri Lanka. Eighty-seven chronic post- stroke survivors (≥3 months post onset) participated. Bilateral AROM- DF and dynamic balance were assessed with validated tools. Spearman's correlation was used to analyze the relationship between AROM-DF and Timed-Up-and- Go (TUG) performance. Mean AROM-DF was 6.62° (±5.74) in the paretic ankle and 17.57° (±5.27) in the non-paretic ankle. Mean TUG score was 37.35 seconds (±30.41). There was a significant negative correlation between paretic AROM-DF and TUG score ($r = -0.443$, $p < 0.001$), indicating poorer balance with reduced dorsiflexion. No significant correlation was observed between non-paretic AROM-DF and TUG scores.

Conclusions: Impaired active dorsiflexion of the paretic ankle is associated with reduced dynamic balance in chronic stroke. Rehabilitation programs should prioritize improving ankle mobility to enhance community ambulation and reduce fall risk.

Keywords: ankle mobility, dynamic balance, physiotherapy, rehabilitation, stroke

Introduction

Stroke is a leading cause of adult disability worldwide, with over 100 million people living with its long-term effects globally, including motor impairments and balance dysfunctions that severely compromise independence and mobility.[1] In Sri Lanka, the prevalence of stroke is estimated at 10.4 per 1,000 individuals, with over 90% of survivors developing hemiparesis.[2] These impairments often

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persist beyond the acute phase, with chronic stroke survivors facing challenges in gait, postural control, and community ambulation.[3]

Dynamic balance defined as the ability to maintain stability during weigh shifting, often while changing the base of support. Sound dynamic balance is required to safely ambulate in community.[4]It is a critical component of functional mobility and fall prevention. Individuals with stroke have a twofold higher risk of falling compared to age- and sex-matched peers.[5,6] Falls not only increase morbidity and healthcare costs but also lead to reduced activity levels, fear of falling, and social isolation.[6] Previous research has shown that limited dorsiflexion may alter gait kinematics and impair postural stability, particularly in tasks requiring dynamic balance.[7]However, these findings are mostly based on passive ROM measures or generalized from elderly populations without stroke.[8] Evidence specific to active ankle mobility and its association with functional balance in chronic stroke remains sparse.

Furthermore, while rehabilitation efforts often target the paretic limb, there is increasing recognition that the non-paretic limb may also contribute to compensatory balance strategies.[9] Evaluating bilateral ankle mobility offers a more comprehensive understanding of lower limb contributions to balance control in this population. Given these gaps, the present study aimed to assess the AROM-DF of both paretic and non-paretic ankle joints and explore their associations with dynamic balance, as measured by the Timed Up and Go (TUG) test, in chronic stroke survivors. We hypothesized that reduced AROM-DF of the paretic ankle of stroke survivors would be significantly associated with poorer dynamic balance performance.

Materials and Methods

Study Design

This descriptive cross-sectional study was designed to investigate the association between ankle joint mobility and dynamic balance in chronic stroke survivors. Ethical approval was granted by the Ethics Review Committee of the Faculty of Medicine, University of Colombo, Sri Lanka (Ref: UCP/AL/19/491). Approval to conduct the study was obtained from the Director of the National Hospital of Sri Lanka (NHSL).

Setting and Participants

The study was conducted at the Neurology Physiotherapy Unit of the National Hospital of Sri Lanka between September 18 and October 8, 2023. Participants were recruited through non-probability convenience sampling among outpatients receiving physiotherapy treatment. This sampling technique was chosen due to limited availability and accessibility to eligible chronic post-stroke survivors attending the physiotherapy clinic during the study period.

Individuals were eligible to participate if they were aged 18 years or older, had a confirmed diagnosis of ischemic or hemorrhagic stroke with a post stroke duration ≥ three months, presented with hemiparesis or hemiplegia who were able to ambulate independently with or without a walking aid, could stand unsupported for at least five minutes, and were able to understand and follow verbal instructions. Participants were excluded if they had a history of other neurological disorders, significant visual impairment, a recent fall within the past two weeks, ankle pain or impairments in the non- paretic limb, fixed contractures of the ankle, or any terminal illness. A total of 87 individuals were included in the final sample.

Outcome Measures

All measurements were performed by the primary investigator after receiving a training to ensure consistency and reduce inter-rater variability.

Active Dorsiflexion Range of Motion (AROM-DF)

Active dorsiflexion range of motion (AROM-DF) was assessed bilaterally using 360° universal plastic goniometer with 11.5cm movable arms. Participants were positioned in supine lying with the knee flexed to approximately 20° to 30° using a rolled towel under the knee. The goniometer's axis was aligned just inferior to the lateral malleolus, with the stationary arm along the fibula pointing toward the fibula head, and the movable arm aligned with the fifth metatarsal. Participants were instructed to actively dorsiflex the ankle as far as possible. Two trials were recorded for each ankle, and the average was used in the analysis. The AROM-DF was recorded in degrees as a continuous variable.

This method follows standardized procedures that have demonstrated strong inter- rater reliability and validity in measuring ankle joint mobility using a manual universal goniometer.[10]

Dynamic Balance

Dynamic balance was assessed using the Timed Up Go (TUG) test. Participants began seated in a chair with armrests and were instructed to stand up upon the verbal cue "Go", walk three meters, turn around at a marker, return to the chair, and sit down. The total time taken to complete the task was recorded in seconds using stopwatch, single practice trial was allowed, and the second attempt was used for data analysis. If a participant failed to complete the test after three valid attempts, they were terminated from the study. Walking aids were permitted if already in regular use by the participant to recreate their daily, functional balance performance.

The TUG test has been validated as a reliable measure of dynamic balance in stroke populations and is commonly used in clinical and research settings.[11] A TUG score equal to or greater than 14 seconds was considered indicative of increased fall risk.[12]

Results

A total of 87 participants (mean age = 58.8 ± 10.1 years; 78.2% male) met the inclusion criteria and completed all outcome measures. The majority of participants had ischemic stroke (69.0%, n = 60), and right-sided hemiparesis was slightly more prevalent (54.0%, n = 47). The demographic and clinical characteristics of the participants are presented in Table 1.

Table 1. Frequency distribution of the type of stroke, paretic side and gender of the participants

		Frequency, No.	Percentage, %
Type of stroke	Ischemic	60	69.0
	Hemorrhagic	27	31.0
Paretic side	Right side	47	54.0
	Left side	40	46.0
Gender	Male	68	78.2
	Female	19	21.8

n, Total number of participants.

Dynamic Balance Performance (TUG Scores)

The mean TUG score among participants was 37.35 seconds (± 30.41), with a median of 29.5 seconds. The wide variability is attributed to difference in stroke severity, duration post-stroke and mobility impairments within the sample. Based on the established threshold of ≥14 seconds as a marker of increased fall risk, 76 participants (87.4%) were identified as being at risk of falling. Most participants (83.9%) completed the TUG without a walking aid, while 11 used a cane and 3 used a walker. Descriptive statistics of AROM-DF of both ankles and the TUG scores of the participants are presented in Table 2.

Table 2. Descriptive statistics of participant variable

Variable	Minimum	Maximum	Mean	SD
Paretic ankle joint ROM (degrees°)	0.1	23.0	6.62	5.47
Non-paretic ankle joint ROM (degrees°)	5.0	32.0	17.57	5.27
Timed Up and Go test score (seconds)	2.10	163.00	36.93	30.42

SD, Standard Deviation

Association Between AROM-DF and Dynamic Balance

Spearman's rank correlation coefficient was employed to evaluate the relationship between AROM-DF (both paretic and non-paretic sides) and TUG test performance. A p- value of less than 0.05 was considered statistically significant.

A significant negative correlation was observed between paretic ankle AROM-DF and TUG score ($r = -0.443$, $p < 0.001$), indicating reduced active dorsiflexion in the paretic ankle was associated with longer TUG times and poorer dynamic balance performance. No significant association was found between non-paretic AROM-DF and TUG score ($r = -0.158$, $p = 0.144$)

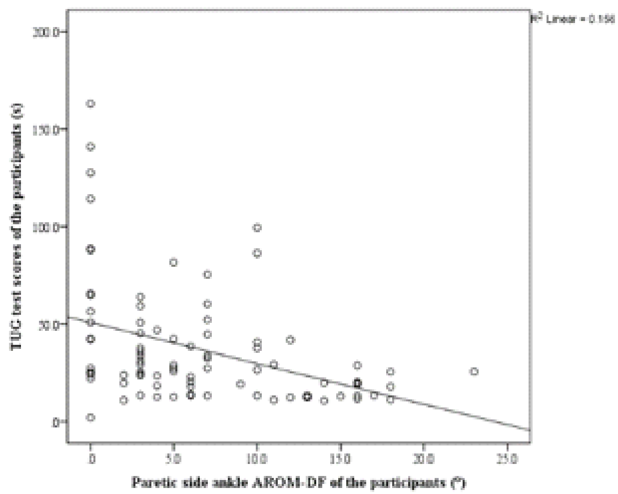

Figure 1: Association between paretic side AROM-DF and TUG score of the participants

Discussion

This study investigated the relationship between ankle joint active dorsiflexion range of motion (AROM-DF) and dynamic balance in chronic stroke survivors. The primary finding was a significant negative correlation between paretic side AROM-DF and Timed Up and Go (TUG) test performance, indicating reduced dorsiflexion mobility on the affected side is associated with poorer dynamic balance. No such association was found for the non-paretic ankle.

The mean AROM-DF of the paretic ankle in this study (6.62° ± 5.74) was substantially lower than normative values reported in healthy adults, where dorsiflexion averages approximately 30°.[13,14] This reduction is consistent with previous findings in post-stroke populations, where dorsiflexor muscle weakness, altered motor control, and tissue stiffness limit voluntary movement.[15] In contrast, the non-paretic ankle showed relatively preserved dorsiflexion (mean = 17.57° ± 5.27), although it too was below typical norms.

The significant association between paretic AROM-DF and dynamic balance aligns with earlier reports indicating that ankle dorsiflexion plays a crucial role in maintaining postural stability during walking and transitional movements.[16]A study by Hernández-Guillén et al.[17] demonstrated a similar inverse relationship between AROM-DF and TUG performance in older adults, and our findings extend this association to chronic stroke survivors. Limited dorsiflexion can impair the ability to control the tibia's forward progression during stance, increasing the risk of postural instability and falls.[17]Interestingly, no association was found between non-paretic AROM-DF and dynamic balance. This contrasts with some earlier assumptions that compensatory changes in the unaffected limb may support balance in stroke survivors.[9] Our results suggest that rehabilitation should prioritize recovery of mobility and function in the paretic limb, especially the ankle, rather than relying solely on compensatory strategies.

A substantial proportion of participants (87.4%) exceeded the 14-second threshold associated with fall risk, highlighting the clinical importance of addressing modifiable impairments such as limited ankle mobility.

This study has several strengths, including a relatively large sample size, use of standardized protocols for goniometric measurement, and focus on active (rather than passive) range of motion, which better reflects voluntary motor performance. However, limitations include the use of convenience sampling and the cross-sectional design. While convenience sampling is a common approach in clinical rehabilitation-based studies where population -wide sampling is not feasible, it may introduce selection bias and limit the generalizability of findings to broader stroke population. This is acknowledged as a limitation of this study. Additionally, only active dorsiflexion in sagittal plane, was measured, other ankle motions such as plantarflexion, inversion, and eversion, which may also influence balance, were not evaluated.

Importantly, several key confounding variables were not controlled in this study including stroke severity and use of assistive devices. These factors are known to influence both ankle mobility and balance performance in stroke survivors. For example, participants with greater stroke severity may present with more pronounced impairments, while those using walking aids may demonstrate different TUG performance. The wide variability in TUG scores observed in this study likely reflects, in part of heterogenicity in these stroke related characteristics within the sample. Furthermore, due to participant availability constraints, an upper limit of chronic post-stroke duration was not considered for eligibility criteria.

Other confounding factors such as muscle strength, spasticity, and proprioception are known to influence balance in stroke survivors, these variables were beyond the scope of the present study. The exclusion of these variables is also acknowledged as a limitation. Future studies should account for these variables through stratified sampling, covariate adjustment, or more homogenous recruitment criteria.

Conclusion

Active dorsiflexion mobility of the paretic ankle is significantly linked to dynamic balance in chronic post-stroke individuals. Targeted physiotherapy interventions to enhance ankle mobility may improve balance abilities and reduce fall risk in stroke survivors.

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Original Article

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Correlation of Modified Ashworth and Modified Tardieu Scales with H-Reflex in Post-Stroke Spasticity: A Pilot Study

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Abstract

Background: This pilot study examined correlations between clinical spasticity scales Modified Ashworth Scale (MAS) and Modified Tardieu Scale (MTS and H-reflex parameters in assessing wrist flexor and plantar flexor spasticity in 10 stroke patients (mean age 42.67 years, mostly chronic phase).

Methods: A pilotstudy at a tertiary center used convenient sampling, with assessments in morning hours: MAS for resistance to passive movement, MTS for velocity-dependent catch angles (R1, R2), and H-reflex (Hmax/Mmax ratio) via EMG for flexor carpi radialis and soleus excitability. Spearman correlations analyzed relationships.

Results: Wrist flexors showed non-significant correlations across measures (e.g., MAS-MTS r=0.41, p=0.23). Plantar flexors demonstrated significant associations: MAS-MTS (r=0.70, p=0.03), MTS-R2-R1 (r=0.86, p=0.002), though Hmax/Mmax lacked significance.

Conclusion: MAS and MTS validate for ankle spasticity assessment post-stroke, supporting muscle-specific protocols, while H-reflex integration needs larger studies for wrist utility in rehabilitation.

Keywords: H-reflex, Modified Ashworth Scale, Modified Tardieu Scale, Stroke, Spasticity

Introduction

Stroke is an acute onset of focal or global neurological dysfunction resulting from the interruption of cerebral blood flow, most often due to ischemic or hemorrhagic lesions in the brain parenchyma[1]. It remains a leading cause of longterm disability worldwide, with motor impairments being a predominant sequel that significantly limits functional independence. Among the positive motor signs that emerge after upper motor neuron (UMN) damage, spasticity is one of the most disabling phenomena[2]. Epidemiological data indicate that

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approximately 18–38% of stroke survivors develop clinically significant spasticity within the subacute to chronic recovery phases, imposing substantial physical, social, and economic burdens[3].

Lance defined spasticity as a motor disorder characterized by a velocitydependent increase in tonic stretch reflexes with exaggerated tendon jerks, reflecting hyperexcitability of the stretch reflex as one component of the UMN syndrome[4]. Young later expanded the concept by suggesting that spasticity arises from abnormal intraspinal processing of primary afferent input, which disrupts the balance between excitatory and inhibitory influences on motor neurons[5].

Biomechanically, resistance to passive movement in a spastic muscle result from the combined effects of neural and nonneural components. The neural component reflects exaggerated activation of the stretch reflex mediated by hyperexcitable alpha motor neurons and impaired inhibitory control, while the nonneural component involves adaptive structural changes within muscle fibers and connective tissues leading to stiffness, shortening, and fibrosis.[6]

Clinical rating scales remain the most widely used tools because of their convenience and low operational cost. Among the available clinical measures, the Modified Ashworth Scale (MAS) and Modified Tardieu Scale (MTS) are the most commonly implemented for routine assessment of poststroke spasticity.[7] Originally developed in 1964 and later refined by Bohannon and Smith, the MAS grades resistance to passive stretch on a sixpoint ordinal scale. The MAS is valued for its simplicity and global estimation of muscle tone; nevertheless, its limitations are well documented. Consequently, several investigators have questioned its accuracy in quantifying “true” spasticity and recommended complementing it with more physiologically grounded measures.[8]

The Tardieu Scale and its modified version (MTS) were introduced to address these shortcomings by incorporating standardized passive movements at different velocities and documenting both the quality and angle of muscle reaction[9]. The difference (R2–R1) reflects the dynamic component of spasticity, thereby improving sensitivity to velocitydependent features[10]. Although the MTS is more closely aligned with the physiological definition of spasticity, it remains examiner dependent and requires strict adherence to testing protocols[11].

In recent years, neurophysiological techniques such as the Hoffmann reflex (Hreflex) have gained attention as objective tools for probing spinal excitability. The Hreflex, first described by Hoffmann in 1918, is elicited by electrical stimulation of Ia afferents in a mixed peripheral nerve, producing a monosynaptic response via alpha motor neurons in the spinal cord. The resultant compound muscle action potential, recorded using surface electromyography, serves as an electrical analogue of the stretch reflex but bypasses muscle spindle activation. As stimulus intensity increases, the Hreflex amplitude initially rises and later diminishes due to antidromic collision with the motor response (Mwave). Key parameters include maximal Hreflex amplitude (Hmax), maximal Mwave amplitude (Mmax), the Hmax/Mmax ratio, threshold, and latency. In healthy individuals, the Hmax/Mmax ratio usually remains below 0.7, reflecting normal spinal excitability. In spasticity following stroke or spinal cord injury, this ratio is often elevated, suggesting hyperexcitability of the motor neuron pool and diminished descending inhibition. Because of this sensitivity to changes in reflex excitability, the Hreflex has become a valuable research tool for quantifying neural adaptations and evaluating therapeutic interventions such as pharmacological therapy, stretching, or functional training.

Despite its advantages, the application of Hreflex testing in clinical settings is limited by logistical challenges, including the need for electromyographic equipment, controlled testing conditions, and operator expertise. Its amplitude and latency can vary according to posture, muscle activation level, and attentional state, necessitating careful standardization for reproducibility. Therefore, while the Hreflex provides fundamental insight into spinal mechanisms, its clinical translation has lagged behind scales such as MAS and MTS. Nonetheless, combining electrophysiological markers with clinical rating scales may enable a more comprehensive and mechanistic understanding of spasticity.[12]

In this context, investigating the correlation between clinical and neurophysiological measures can offer valuable perspectives for both assessment and management. The present study aims to explore the relationship between MAS, MTS, and Hreflex parameters in evaluating wrist and plantar flexor spasticity among poststroke patients. Elucidating these relationships could enhance the accuracy of spasticity quantification, guide individualized interventions, and establish a rational basis for integrating neurophysiological assessments into rehabilitation practice.

Methodology

The study was designed as a cross-sectional study conducted at a tertiary healthcare centre over a duration of six months, with a sample size of ten participants selected through convenient sampling. The inclusion criteria comprised patients with a first-ever stroke, those in the subacute or chronic phase of diagnosed stroke, individuals aged between 18 and 50 years, both males and females, and patients with either ischemic or haemorrhagic types of strokes. The exclusion criteria included patients with any musculoskeletal problems related to the wrist and hand, such as recent fractures or sprains, or those with cardiorespiratory conditions; patients unwilling to participate; individuals undergoing other treatments for hand function, such as acupuncture therapy, anti-spasmodic or anti-spastic medications, or those who had received botulinum toxin injections within the past three months; and patients with a history of other neurological disorders like dementia or peripheral polyneuropathy.

After obtaining the approval of institutional ethics committee - DVVPF's/COPT/IEC-643/Aon 02/-4/2025 participants were screened for inclusion and exclusion criteria. Participants willing to participate in the study were explained about the proposed benefits, risks and procedures involved in the study, in a language best understood by them. An informed consent was taken and the whole procedure was explained to the participants in their local language. Demographic data along with history regarding the stroke was collected. Baseline assessment was taken in the hospital setting. The Spasticity of the Wrist Flexors and extensors, Plantar flexors was assessed by MTS, MAS and H- Reflex. All measurements were taken in the morning hours between 9:00 and 12:00. H-reflex amplitude varies across the day, indicating that CNS excitability and reflex function change with time of day. [13]

Modified Ashworth Scale -

Spasticity of the wrist flexors and plantar flexors was assessed using theMAS.[14] For the wrist, the test was performed in a sitting position with the forearm resting on the armrest. The patient's wrist was initially moved from maximal possible flexion to maximal possible extension until the first soft resistance was felt, after which the MAS was assessed while moving the wrist from extension to flexion. For the ankle, the patient was positioned supine with the lower limb in extension, the head in midline, and the arms alongside the trunk. The assessor, standing on the side to be tested, moved the ankle through maximal dorsiflexion and plantarflexion, and the MAS was then evaluated while moving from plantarflexion to dorsiflexion.

Modified Tardieu Scale -

Spasticity of the wrist flexors and plantar flexors was assessed using theMTS. For the wrist, a standard goniometer was used to measure R2 and R1 with the patient in a sitting position and the elbow flexed to 90 degrees; stretching velocities V1 and V3 were applied to measure R2 and R1 respectively, the quality of muscle reaction was graded at velocity V3, and the difference between R2 and R1 was taken as the dynamic component of spasticity. For the ankle, a standard goniometer was used for angle measurements with the leg position for R1 the same as that for passive range of motion, with the knee flexed to 30 degrees and the zero-position set at 90 degrees; to measure R1, the joint was moved through the available range at velocity V3, the quality of muscle reaction was scored from 0 to 4, the point of catch was recorded as R1 using the goniometer, and only one passive stretch was performed to rate spasticity. Standardized procedure was followed. [15]

Hoffmann Reflex-

Spasticity of the flexor carpi radialis and soleus muscles was assessed using the H reflex. The patient was positioned supine with the head in midline and the arms alongside the trunk, instructed to remain calm and completely relaxed during testing. Standardized procedure was set to assess flexor carpi radialis and plantar flexors. The participants were coded with the help of numbers so that identity is not revealed. Anthropometric Data was spread in Microsoft Excel for data analysis.

Result

A total of ten individuals with stroke participated in the study, of which eight were in the chronic stage. Participant characteristics and descriptive statistics for spasticity measures are summarized in Table 1.

Spearman correlation analysis between clinical spasticity scales (MAS and MTS) and electrophysiological parameters of the wrist flexors revealed no significant associations among any of the variables examined (Table 2).

In contrast, for the ankle plantar flexors, multiple significant relationships were observed (Table 3). MAS scores showed significant positive correlations with both MTS and the R2–R1 angle, suggesting consistency between clinical and biomechanical indices of spasticity. Furthermore, MTS demonstrated strong positive correlations with R1, R2, and R2–R1 values, with the latter reaching statistical significance ($p < 0.01$). No significant correlations were found between H-reflex parameters and the clinical measures for either muscle group.

Table 1: Demographic Data and Clinical Variables

Variable	Minimum	Maximum	Mean ± SD
Age (years)	30	49	42.67 ± 5.86
Time since stroke	2 months	11 years	28.55 months
H/M ratio			
Wrist flexors	0.20	3.33	0.93 ± 0.95
Plantar flexors	0.50	3.00	1.00 ± 0.76
MAS score			
Wrist flexors	1	2	1.70 ± 0.48
Plantar flexors	1	2	1.20 ± 0.42
MTS score			
Wrist flexors	1	3	1.90 ± 0.74
Plantar flexors	1	4	1.40 ± 0.97

Table 2 presents Spearman correlation coefficients (r), p-values, and significance for wrist flexor spasticity measures, all showing non-significant results.

Variables	r	p-value	Significance
MAS and MTS	0.410	0.233	NS
MAS and Hmax/Mmax	0.272	0.448	NS
MAS and R2–R1	−0.246	0.492	NS
MTS and Hmax/Mmax	0.530	0.123	NS
MTS and R2–R1	−0.069	0.865	NS
R2–R1 and Hmax/Mmax	−0.245	0.492	NS

Table 3 displays Spearman correlations for ankle plantar flexor measures, highlighting several significant and statistically significant associations.

Variables	r	p-value	Significance
MAS and MTS	0.704	0.027*	S
MAS and R2–R1	0.691	0.031*	S
MAS and Hmax/Mmax	0.197	0.584	NS
MAS and R1	0.401	0.248	NS
MAS and R2	0.424	0.218	NS
MTS and R1	0.738	0.017*	S
MTS and R2	0.718	0.023*	S
MTS and R2–R1	0.864	0.002**	SS
MTS and Hmax/Mmax	0.467	0.179	NS
R2–R1 and Hmax/Mmax	0.447	0.191	NS

r: Spearman correlation coefficient; R1: Angle of catch at fast velocity; R2: Angle at slow velocity; R2–R1: Dynamic component of spasticity; NS: Not significant; S: Significant ($p < 0.05$); SS: Statistically significant ($p < 0.01$)

* $p < 0.05$; ** $p < 0.01$

Discussion

This pilot study investigated correlations between the MAS, MTS, and H-reflex parameters in the assessment of wrist flexor and plantar flexor spasticity among stroke patients. The results indicated significant correlations for the ankle joint, specifically MAS and R2-R1 (r=0.6906, p=0.0306), MAS and MTS (r=0.7043, p=0.0268), and especially MTS and R2-R1 (r=0.8642, p=0.0022). Conversely, the wrist joint showed nonsignificant correlations among the tested variables. H-reflex measures (Hmax/Mmax ratios) did not exhibit strong or statistically significant relationships with either MAS or MTS for either joint, though moderate coefficients were noted, suggesting partial convergence.

The MAS has been the cornerstone for spasticity assessment for decades, widely adopted due to its simplicity, ease of use, and time efficiency. However, its limitations have been increasingly recognized. MAS does not isolate neural components from biomechanical resistance, which can lead to conflation of spasticity with muscle contracture or stiffness. Additionally, the ordinal nature of MAS and variability in interrater reliability limit its sensitivity and accuracy. [16-17]

The MTS offers an advancement by incorporating stretch velocity and quantifying the difference in catch angles between slow (R2) and fast (R1) stretches, thus differentiating spasticity (velocity-dependent neural resistance) from contracture (non-neural resistance). This feature provides valuable clinical insights for selecting targeted interventions such as stretch or pharmacological treatments that address neural hyperexcitability versus structural muscle changes. [18]

Several studies reinforce the differing utilities of MAS and MTS. In a study comparing validity and reliability, Abolhasani et al. (2012) reported that MTS exhibited higher construct validity compared to MAS for wrist flexor spasticity in stroke survivors. [19]Yoo et al. (2022) found better interrater reliability for MTS in ankle plantar flexors, emphasizing its superiority in detecting dynamic changes in muscle tone. Conversely, MAS showed moderate reliability but lacked the precision needed for nuanced management. [20]

He et al. (2023) reviewed quantitative assessment methods and highlighted that MAS, while practical, often fails to capture subtle changes in spasticity severity, urging the integration of other clinical measures and objective quantifications like H-reflex testing. [21] The current pilot study aligns with these findings by demonstrating significant correlations among MAS, MTS, and angle measurements at the ankle joint but not at the wrist flexor group. Such differences suggest muscle-specific heterogeneity in spasticity expression and underscore the need for tailored assessment protocols based on affected muscle groups.

The H-reflex is an electrically elicited, spinal monosynaptic reflex analogous to the stretch reflex, reflecting motor neuron pool excitability. In the context of stroke, alterations in H-reflex amplitude and latency can reveal spasticity and altered neuromuscular control. The Hmax/Mmax ratio, the normalized amplitude of H-reflex relative to maximal motor response, has been proposed as a biomarker for spasticity severity.

Studies have successfully demonstrated correlations between increased H-reflex excitability and clinical spasticity scores in various muscles post-stroke, particularly in the lower limbs. The current findings also underscore the utility of H-reflex measures in objectively quantifying spinal excitability changes associated with spasticity.

However, the H-reflex is influenced by multiple factors including patient positioning, muscle fatigue, electrode placement, and intrinsic peripheral nerve properties, which complicate uniform interpretation. Moreover, discrepancies reported between H-reflex and clinical scale correlations, such as those observed in this study, may arise from differences in stroke chronicity, sample sizes, methodological variations, or specific muscle characteristics.[22]

In this pilot, the lack of statistically significant correlations between clinical scales and H-reflex indices at the wrist flexor muscle groups suggests complex neuromuscular and biomechanical interactions that challenge straightforward assessment. Literature indicates that upper limb spasticity may present more variably due to differing muscle architecture, neural control pathways, and interaction with voluntary movement patterns. This necessitates cautious interpretation of clinical scales in the wrist and inclusion of supplementary objective tools.

Conversely, significant positive correlations between MAS, MTS, and stretch angles in the ankle plantar flexors corroborate prior evidence supporting the validity of these clinical tools in evaluating lower limb spasticity. The plantar flexors play a critical role in gait and postural control; thus, accurate assessment facilitates targeted interventions. While H-reflex parameters did not reach statistical significance, trends suggested alignment with clinical scale findings, consistent with reports that spinal excitability changes are more robustly detected in these muscles. [23-25]

The current findings align with those documenting greater clinical utility and reliability of MTS over MAS in discriminating spasticity components in ankle muscles post-stroke. The discrepancies in wrist assessments underscore the importance of muscle-specific sensitivities of scales, prompting calls for muscle-tailored evaluation protocols. Integration of electrophysiological and clinical measures is advocated to capture the complex spasticity spectrum fully. This viewpoint echoes the present study's implications, pointing toward a multimodal assessment framework as essential for accurate clinical characterization.

The results confirm the necessity of integrating clinical scales and neurophysiological tools for comprehensive spasticity assessment. While MAS remains a useful screening tool due to ease of administration, its limitations warrant supplementation by MTS and electrophysiological testing where feasible, especially in research or complex clinical cases.[26]

Given the variability observed in spasticity expression across muscle groups, rehabilitation programs should be individualized. For instance, patients with prominent plantar flexor spasticity may benefit from interventions tailored according to MTS and H-reflex findings, improving functional outcomes such as gait. In contrast, wrist spasticity requires further assessment refinement to optimize therapy.

The study underscores the critical need for standardized assessment protocols, the velocities of muscle stretch, patient positioning, and electrode placement, ensuring reproducibility and comparability of results. Consensus guidelines exist but need widespread adoption and adaptation, particularly in low-resource settings.

The small sample size (n=10, 80% chronic stroke) limits statistical power and generalizability, particularly for detecting subtle H-reflex correlations in wrist flexors. Cross-sectional design precludes causal inferences or longitudinal changes in spasticity evolution; single-session assessments may miss diurnal H-reflex variability despite morning standardization. Potential examiner bias in MAS/MTS (despite standardized protocols) and technical H-reflex factors (electrode placement, skin temperature) could influence results, alongside exclusion of severe contractures or comorbidities that affect real-world applicability. Potential variability in stroke severity, chronicity, and heterogeneity among participants might have contributed to inconsistent findings. The semi-quantitative nature of MAS and MTS still carries inherent subjectivity despite examiner training. H-reflex measurements are sensitive to technical factors limiting standardization. These limitations highlight the importance of cautiously interpreting results and the necessity for larger, longitudinal studies employing rigorous protocols.

Conclusion

This pilot study demonstrates significant correlations between MAS, MTS, and R2-R1 angle differences in ankle plantar flexors ($r=0.6906–0.8642$, $p<0.05$), validating these clinical scales for lower limb spasticity assessment post-stroke, while wrist flexor correlations remained nonsignificant. H-reflex parameters (Hmax/Mmax) showed moderate but nonsignificant relationships with clinical measures across both muscle groups, suggesting partial neurophysiological convergence that warrants larger validation studies. These findings support muscle-specific assessment protocols and multimodal integration of clinical scales with neurophysiological tools to enhance spasticity management precision in stroke rehabilitation.

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Original Article

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Cross-sectional study- Prevalence of Frailty Among Older Adults in a Rural Community of Maharashtra Using the FRAIL Scale

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Abstract

Background: Frailty is a multidimensional geriatric syndrome characterized by decreased physiological reserve and increased vulnerability to functional decline, hospitalization, and mortality. Early detection of frailty is essential for planning preventive and rehabilitative strategies, particularly in community-dwelling older adults.

Objective: The study aimed to determine the prevalence of frailty using the FRAIL Scale among older adults and to examine its association with age and gender.

Methods: A cross-sectional study was conducted among 104 community-dwelling older adults. Participants completed the FRAIL Scale, and frailty was defined as a score of ≥3. Demographic information including age and gender was recorded. Statistical analysis included descriptive statistics, chi-square tests for categorical associations, independent t-tests for comparing age between frail and non-frail groups, and logistic regression to assess predictors of frailty.

Results: The mean age of the participants was 71.94 ± 7.01 years. The prevalence of frailty was 49.04% (n = 51). Frailty was more common in females (57.8%) than males (42.4%). The mean age of frail individuals (71.8 years) did not differ significantly from non-frail participants (72.08 years) (p = 0.843). Logistic regression analysis showed that neither age nor gender was a significant predictor of frailty in this sample.

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Conclusion: Almost half of the older adults assessed were frail, indicating a substantial burden of frailty in the community. Although a higher proportion of women were frail, no statistically significant association with age or gender was observed. This highlights the need for routine frailty screening and targeted interventions to mitigate functional decline in older populations.

Keywords: Frailty, Aging, Geriatric Assessment, Community Health.

Introduction

Frailty is widely recognized as a complex, multidimensional geriatric syndrome characterized by a reduction in physiological reserves across multiple organ systems, resulting in heightened vulnerability to internal and external stressors[1]. Rather than representing a single disease entity, frailty reflects a decline in biological homeostasis and resilience, increasing an individual's susceptibility to adverse outcomes such as falls, hospitalization, disability, institutionalization, and premature mortality[2–4]. As populations age globally, frailty has emerged as a major public health concern, particularly in low- and middle-income countries where demographic transitions are occurring at a rapid pace[5–7].

Traditionally, frailty has been conceptualized using two dominant models: the Phenotypic Model (Fried et al.) and the Deficit Accumulation Model (Rockwood & Mitnitski). The Phenotypic Model emphasizes physical components such as weight loss, exhaustion, slowness, weakness, and low activity, whereas the Deficit Accumulation Model incorporates a broader range of health deficits, including comorbidities, functional limitations, and psychosocial factors[8–10]. While both models have been extensively validated, their implementation in community health settings can be time-consuming and resource-intensive.

The FRAIL Scale, developed as a simplified clinical instrument, addresses these limitations by providing a rapid and practical five-item assessment (Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight). It has demonstrated robust predictive validity for adverse outcomes such as hospitalization, disability, and mortality[11–13]. Recent studies (2022–2025) further support its utility in large-scale screening, identifying at-risk older adults, and enabling timely interventions across diverse cultural and socioeconomic populations[14–15]. Its brevity makes it particularly useful in primary care, community surveys, and epidemiological research, especially in resource-constrained settings.

Global estimates of frailty prevalence vary considerably—from 25% to over 60%—due to differences in assessment tools, population characteristics, health behaviors, and socioeconomic environments[16–18]. Numerous studies have identified advanced age, female gender, polypharmacy, multimorbidity, sedentary behavior, and poor nutritional status as key determinants of frailty[19–23]. However, inconsistencies persist due to heterogeneity in methodologies, population profiles, and contextual factors. Additionally, emerging evidence suggests that psychosocial factors, environmental exposures, chronic disease burden, and social isolation also substantially influence frailty trajectories.

In India, the demographic shift toward an aging population is occurring at an unprecedented pace, yet research on frailty remains relatively underdeveloped. Existing studies have predominantly used the Physical Frailty Phenotype, with limited investigations utilizing the FRAIL Scale despite its feasibility, low cost, and strong predictive capacity[24–25]. Given cultural, lifestyle, and socioeconomic variations within Indian communities, localized evidence is crucial to understanding population-specific patterns of frailty. Identifying the role of key sociodemographic variables, especially age and gender, can support early detection strategies and guide rehabilitation, preventive care, and geriatric health policy.

Therefore, the present study aimed to determine the prevalence of frailty among community-dwelling older adults and examine its association with age and gender using the FRAIL Scale. This research contributes to addressing the gap in Indian frailty literature and provides important insights for community-based geriatric assessment and intervention

Methodology

Study Design: A cross-sectional study.

Participants: A total of 104 community-dwelling older adults (≥55 years) participated.

Inclusion Criteria

- Adults aged ≥55 years
- Ambulatory and living in the community
- Able to communicate and consent

Exclusion Criteria

- Severe cognitive impairment
- Terminal illness
- Bedridden or severely dependent individuals

Outcome Measure

FRAIL Scale (5 components):

- Score 0–2 → non-frail.
- Score ≥3 → Frail.

Procedure

Participants were recruited through community outreach in residential areas, local gathering spaces, and community centres. After providing detailed information about the study, written informed consent was obtained from all participants. Data collection was conducted in a face-to-face interview format to ensure clarity and completeness of responses, particularly for older adults who might have difficulty reading or completing questionnaires independently.

Demographic information, including age and gender, was recorded first. This was followed by the administration of the FRAIL Scale, which was delivered in the local language to ensure comprehension and cultural appropriateness. Each of the five FRAIL Scale items—Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight—was explained to participants using standardized instructions. Responses were documented immediately and scores were calculated on site.

Following data collection, all responses were systematically entered into a Microsoft Excel spreadsheet for further analysis. Variables were coded numerically to facilitate statistical processing:

- Age was recorded as a continuous numerical variable
- Gender was coded as: Male = 1, Female = 2
- Frailty status based on the FRAIL Scale was coded as: Frail = 1, non-frail = 0

Data were cross-checked for completeness and accuracy prior to statistical analysis.

Results

A total of 104 community-dwelling older adults participated in the study. The mean age of the sample was 71.94 ± 7.01 years. Based on the FRAIL Scale, 49.04% (n = 51) of participants were classified as frail.

Frailty and Gender

Frailty was observed to be more prevalent among females (57.8%) compared to males (42.4%). However, this difference did not reach statistical significance, as indicated by the chi-square test (χ^2 = 1.85, p = 0.174). These findings suggest that gender was not significantly associated with frailty status in the present sample.

Frailty and Age

The mean age of frail participants (71.8 years) was comparable to that of non-frail participants (72.08 years). An independent samples t-test showed no significant difference in age between the two groups (p = 0.843), indicating that chronological age alone was not a distinguishing factor for frailty in this population.

Table 1: Participant Characteristics (N = 104)

Variable	Value
Age (years)	71.94 ± 7.01
Male	59 (56.7%)
Female	45 (43.3%)
Non-frail	53 (50.96%)
Frail	51 (49.04%)

Table 2: Gender-wise Frailty Distribution.

Gender	Non-frail n (%)	Frail n (%)
Male	34 (57.6%)	25 (42.4%)
Female	19 (42.2%)	26 (57.8%)

Table 3: Age Comparison Between Frailty Groups.

Group	Mean Age (years)	p-value
Frail	71.80	
Non-frail	72.08	0.843

Discussion

The present study sought to understand the prevalence and determinants of frailty among community-dwelling older adults using the FRAIL Scale, and the findings revealed that 49.04% of participants were classified as frail. This high prevalence underscores the growing concern of frailty within aging populations, particularly in developing countries like India, where demographic transitions are occurring rapidly. Frailty reduces an individual's capacity to cope with everyday stressors, and as highlighted in earlier literature[11,12,13,14,26] its early detection is crucial for preventing disability, dependence, and healthcare burden. The results of this study reaffirm these concerns and indicate that frailty is already widespread in community settings.

As discussed earlier in the Introduction, frailty prevalence globally ranges between 25% and 60%, influenced by culture, socioeconomic status, healthcare access, and lifestyle behaviour's. The prevalence observed in this study sits at the higher end of the spectrum, aligning with findings from recent Asian and low-middle-income country studies[17],[18]. This suggests that contextual factors such as nutritional diversity, chronic disease patterns, and physical activity levels may significantly influence frailty trajectories within Indian communities. In this sense, our study contributes to filling the regional evidence gap, particularly for Maharashtra, where FRAIL-Scale–based data is still limited.

One of the important observations from this study was that frailty appeared more common in females (57.8%) compared to males (42.4%). Although this difference was not statistically significant, the trend mirrors well-established gender patterns reported globally. Multiple studies have consistently shown that females, despite having higher life expectancy, experience a greater burden of chronic illnesses, musculoskeletal degeneration, and nutritional deficiencies[27–28]. Biological factors such as postmenopausal hormonal decline, lower baseline muscle mass, and greater longevity may predispose women to frailty. Social factors, including caregiving roles, reduced financial independence, and limited access to healthcare, may further exacerbate vulnerability. However, the lack of statistical significance in our findings suggests that gender alone may not fully explain frailty risk in this community—a point which requires deeper exploration through longitudinal research.

Interestingly, the mean age between frail and non-frail individuals (71.8 vs. 72.08 years) differed only marginally and was statistically non-significant. This result challenges the common assumption that frailty automatically increases with chronological age. As emphasized earlier in the Introduction, frailty is fundamentally a measure of biological age and physiological reserve—not the number of years lived. Our findings align with recent research proposing that factors such as multimorbidity, nutrition, physical fitness, and lifestyle choices may play more defining roles than age itself[29–31]. Thus, a 72-year-old individual may be robust if they maintain physical, psychological, and social resilience, whereas someone younger may be frail if cumulative health deficits are high.

The results of the logistic regression analysis, which showed no significant predictive power for age or gender, further reinforce this idea. Frailty cannot be simplified to demographic variables alone; instead, it arises from a multidimensional interplay of biological, environmental, psychological, and behavioural factors. This aligns strongly with the modern understanding of frailty as a complex syndrome, as discussed by Rockwood and Mitnitski and supported by emerging research in the aging sciences[32–34]. One implication of this finding is that clinical screening tools should incorporate a broader range of indicators such as comorbidity burden, functional mobility, cognitive status, and nutritional status.

Moreover, the lack of predictive significance for age and gender in our model suggests that early frailty may be present among seemingly "healthy" older adults, making community-level screening essential. Health workers and physiotherapists should avoid relying solely on visible age-related cues and instead adopt structured frailty assessments to identify at-risk individuals. This finding humanizes the message that frailty is not merely an "old person's issue," but a preventable and reversible condition when identified early.

Another important interpretation relates to lifestyle transition. Rapid urbanization, reduced physical activity, processed diets, and increased psychosocial stress may be contributing to higher frailty rates, even among younger older adults. This possibility has been documented in recent Asian studies showing rising frailty even in individuals under 65. Although our study did not directly examine lifestyle variables, the observation that age was not significantly associated with frailty hints at the influence of modifiable factors—an area worth investigating in future research.

A strength of this study is its use of the FRAIL Scale, a validated, simple, and time-efficient instrument ideal for large community assessments. Its ease of administration allowed accurate on-spot scoring and minimized the chances of reporting bias.

Limitations- However, as noted earlier, frailty is multifaceted, and relying solely on self-reported measures may omit important physiological and performance-based data. Incorporating objective assessments such as grip strength, gait speed, or the Edmonton Frailty Scale could enrich future studies.

Scope for future studies- The findings of this study open several directions for future research. Longitudinal studies are needed to examine frailty progression over time and identify which factors most strongly predict deterioration or improvement. Investigations into the role of nutrition, physical activity, social engagement, chronic disease management, and cognitive function could help identify actionable targets for intervention. Moreover, examining frailty in different Indian subpopulations—urban vs. rural, high vs. low socioeconomic status, or across linguistic and cultural groups—would deepen understanding of region-specific determinants. Integrating multidisciplinary assessments involving physiotherapists, geriatricians, nutritionists, and community health workers can also support larger goals of holistic geriatric care.

Finally, the present study serves as a reminder that frailty is not an inevitable consequence of aging. Instead, it is a dynamic and potentially reversible condition, especially when detected early. Implementing community-based frailty screening programs, promoting active aging initiatives, and developing culturally tailored intervention strategies could significantly improve quality of life and reduce healthcare burden. By recognizing frailty as a modifiable syndrome, communities and policymakers can work toward empowering older adults to maintain independence, resilience, and well-being.

Conclusion

Nearly half of the older adults studied were found to be frail, which is a serious health concern requiring immediate action. While women showed slightly higher rates of frailty than men, the difference wasn't statistically significant, meaning frailty depends on many factors beyond just age and gender—it's a complex condition shaped by physical strength, functional abilities, nutrition, and social connections. The key insight is that doctors should stop assuming older people are frail just because of their age; instead, they should assess each person individually. The FRAIL Scale is a simple, quick, and reliable tool that healthcare workers can use to identify who is at risk of frailty early on. This matters because frailty isn't permanentit can often be improved or even reversed through exercise, proper nutrition, managing chronic diseases, and staying socially engaged. Therefore, adding routine frailty screening to regular health checkups and community health programs can help catch problems early and allow doctors to provide personalized treatments that help older adults stay independent and maintain their quality of life. This research highlights why comprehensive, communitybased assessment of older adults is essential, and future studies should look at other factors that contribute to frailty and test whether specific interventions can effectively prevent or reverse itultimately reducing hardship for older people and their families while easing the burden on healthcare systems.

Conflict of Interest: The authors declare that they have no conflict of interest related to this study.

Source Of Funding: No

Ethical Clearance Statement: The Institutional Ethics Committee of COPT has reviewed anddiscussed your application to conduct the above-mentioned clinical trial in theDept. Of Community Physiotherapy with you as the Principal Investigator. The study will be referred as IEC/2025-788/A. The Following documents have been reviewed and approved: List of all thedocuments which are submitted to EC.

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Original Article

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Factors Impacting Physical Therapy Clinical Outcomes for Patients with Low Back Pain: A Retrospective Analysis

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Abstract

Objective. The complex nature of non-specific low back pain (NSLBP) and the poor selection of interventions can lead to unnecessary referrals and imaging. Therefore, it becomes important to study factors related to NSLBP and how they affect an individual's clinical outcomes in physical therapy (PT). The purpose of this research was to investigate demographic factors, including age, gender, body mass index (BMI), race, marital status, ethnicity, insurance type, and severity of disease (initial pain level), that most predict PT clinical outcomes in patients having NSLBP.

Methods. This research was a retrospective observational cohort study of a clinical data set that was obtained from four PT clinics in Michigan, USA. Data was analyzed using multiple linear regression to identify the relationship between the predictor and dependent variables.

Results. BMI demonstrated a positive association with clinical outcomes. Divorced individuals had negative clinical outcomes compared to single patients, while individuals on Medicaid had negative clinical outcomes compared to patients with auto or workers' compensation. This study showed that demographic variables account for only a small variance of 8.4%. Thus, 91.6% could be attributed to other factors.

Conclusion. BMI, marital status, and insurance type had a minimal effect on clinical outcomes.

Impact. This research helped to understand the role of demographics and its impact in the PT clinical setting.

Keywords: demography, ethnicity, low back pain, marital status, Medicaid, gender, treatment outcome, workers' compensation

Introduction

Low back pain (LBP) is a significant problem in the United States of America (USA) because of its connection with disability and loss of productivity at work, secondary to activity limitations among those affected. [1,2] Among patients referred to physical therapy (PT), persons with LBP constituted more than

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25% of all outpatient discharges.[3] Another study has supported a similar assertion that at least 20% of the patients suffering from LBP are referred to PT. [4] Even among individuals presenting with LBP, nonspecific low back pain (NSLBP) accounts for ninety percent of LBP cases.[5,6] According to the Global Burden of Disease (GBD) study (2020), this condition has become a burden to the global economy [7] since LBP can lead to significant disability. [8] In 2006, a study by Katz et al. reported that the estimated costs associated with LBP exceeded $100 billion annually.[9]

The complexity of LBP discussed by Hartvigsen et al. and inadequate selection of current approaches can lead to unfavorable treatment outcomes and excessive utilization, including unnecessary referrals that may pose potential harm.[10,11] Due to the inconsistency in clinical treatments,[12] medical overutilization of visits continues to affect the healthcare market.[13] Primary providers may also misdiagnose LBP, [14] considering that the majority fail to follow LBP guidelines due to its varying presentations,[15,16] which may also be influenced by physician specialties.[15] The exact percentage of physicians who adhere to guidelines when diagnosing LBP is not reported. To deliver valuable care to patients, the American Physical Therapy Association (APTA) has developed treatment guidelines or clinical practice guidelines (CPGs) encompassing clinical practice patterns. However, these guidelines have yet to fully incorporate subtypes or demographic factors, which may play a role in determining optimal treatment approaches. Since there is no specific protocol that helps treat individual subtypes for LBP, it becomes important to study subtypes or factors predicting clinical outcomes to address NSLBP.

Research has identified a strong association between age and the prevalence of LBP in adults across different age groups. [17,18] Although age was found to have no significant relationship with the number of visits used by patients at therapy, [19] there are reports of an inverse relationship between age and clinical outcomes since advancing age leads to less favorable clinical outcomes with PT secondary to the presence of higher comorbidities in older adults as compared to younger individuals. [20] Another study, however, reports a weaker association between age, gender, and clinical outcomes of LBP. [21] The current study aimed to assess the influence of age on PT treatment outcomes in individuals with NSLBP.

Reports from a systematic review reveal that gender exerts a substantial influence on the prevalence of LBP, with females exhibiting the highest observed prevalence. [22,23] Although gender and age seem to play a role in the structural causes of chronic LBP [24], their role in predicting PT clinical outcomes of NSLBP is not understood. Emerging evidence suggests that patients with higher BMI exhibit a heightened risk of developing LBP. [25]lean, overweight, obesity class I, obesity class II and III. The influence of body weight and a predefined set of confounders was analyzed by multiple regression models.\nResults: In LBP, disability increased with increasing BMI [lean = reference, obesity class I Beta 5.41 (95 % CI 0.75; 10.07

Limited literature has addressed the influence of race and ethnicity on the clinical outcomes of LBP, indicating a research gap in understanding the potential impact of these factors in a comprehensive manner. Considering that comorbidities affect various racial groups differently, thereby also affecting their life expectancy, it becomes important to pay close attention to racial and ethnic data. [26]

Studies have discussed the influence of support in marriage on health outcomes. [27,28,29]. The current paper will study whether marital status affects PT clinical outcomes. Insurance type and severity of the condition (initial pain) have been studied in relation to utilization of visits in a previous study [19], but have not been studied in relation to PT clinical outcomes of NSLBP. Investigating the types of insurance will throw light on how socioeconomic factors affect clinical outcomes. A positive correlation exists between higher initial pain levels and favorable clinical outcomes. [30]clinical outcomes, and utilization for Medicare beneficiaries receiving physical therapy in outpatient clinics within one integrated health care system; (2 More research specific to NSLBP is necessary to understand this correlation.

Although patient demographics have been investigated in past studies, there is less research published on the role of demographic factors in PT clinical outcomes related to NSLBP. The purpose of this research was to investigate demographic factors, including age, gender, body mass index (BMI), race, marital status, ethnicity, insurance type, and severity of disease (initial pain level) that most predict PT clinical outcomes in patients having NSLBP.

Methods

Study Design

This study is a retrospective observational cohort study of a clinical data set. The data set was derived from the records of Bronson Methodist Hospital (BMH) in Michigan, USA, a single PT provider organization. The approval to conduct this study was obtained through an expedited process for studies not requiring human subjects for recruitment from the Western Michigan University (WMU) HSIRB board.

Participants

Chart reviews included data from patients 18 years and older who received outpatient PT from 2016-2020 for NSLBP, ICD code M54.5 at BMH. All patients selected for this study had NSLBP as their primary diagnosis. Patients who completed an entire episode of care as defined by a formal discharge were included in the data set. Subjects who discontinued treatment were not a part of the study. BMH clinics present in Portage, Turwill and John Street locations were selected for their clinical health data for the sake of convenience. This clinical data secured by the BMH was filtered by using the ICD-9 and ICD-10 codes to select only those that received treatment for NSLBP diagnosis code M54.5. An estimated 3000 patients received PT for NSLBP in these clinics from 2016-2020. A power size estimation, revealed a population sample of at least 300 to conduct the analysis.

Data source

Medical Record Number (MRN) numbers were utilized to extract additional data from the electronic health records (EHR), after which the data was deidentified. Additional data for the purpose of this study, such as marital status, BMI, and severity (initial pain level), were manually obtained. If a patient was treated by a PT and a PTA, the PT who performed the initial evaluation was placed as the primary therapist for that patient. [19]

Outcome Variable

The outcome variable in this study was the Patient Specific Function Scale (PSFS), a clinical assessment tool utilized to assess overall function. The PSFS scores collected at the initial evaluation and at the time of discharge calculate outcomes as a percent change.

Predictor Variables

Studies on demographics have not investigated age, gender, body mass index (BMI), race, marital status, ethnicity, insurance type, and severity of disease (initial pain level) exclusively.

Procedures

The raw data set collected from the EHR was cleaned, and a new data set was created for analysis purposes. The study used only those encounters that completed an entire episode of care, as evidenced by the existence of a discharge note and the initial as well as final PSFS score.

Instrument

The Patient Specific Functional Scale (PSFS) is an outcome measurement tool that measures function and is more responsive than measuring impairment in a population. [31] The PSFS is an 11-point scale that was recorded at evaluation and discharge. The scoring begins at 0, which means “unable,” and ends at 10, which means “no issues”. A higher number on the PSFS means a higher level of function. Measuring a patient’s function instead of their impairment is a more holistic approach that takes into consideration a patient’s quality of life instead of relying only on practitioner-based measures. [31] The PSFS is a user-friendly, valid, and reliable measure in individuals with acute, chronic, and mechanical LBP. [31] PSFS was not only found to have the ability to detect important changes over time but also demonstrated excellent reliability in persons with chronic low back pain. [32] In persons having back pain, for a change to be clinically significant, the MCID scores for 3 activities on the PSFS should be between 2.0 and 3.0 points, where 0.8 is a “small change”, 3.2 is “medium change,” and 4.3 is a “large change”. [33] Thirty-nine studies have reported results in which the PSFS change scores have surpassed the minimal clinically important difference (MCID). [32]

Data Analysis

To assess the relationship between demographic variables and treatment outcomes as measured by the change in score, bivariate and multivariate analyses were performed. Independent sample *t*-tests and Analysis of Variance (ANOVA) models were used for categorical variables, while Pearson correlation was used for continuous variables.

In addition to bivariate analyses, stepwise multiple linear regression was also performed to determine the predictive ability of the 8 demographic variables. Table 5 shows model fit statistics that were used to verify that the final iteration was the best-fitting model.

Power

A post-hoc power analysis was conducted using G*Power version 3.1. With a sample size of n=317, this study exceeded 99% power for all two-tailed bivariate and multivariate analyses, assuming a Type I error rate of a = 0.05 and a small effect size (0.25).

Results

Demographic Characteristics

As seen in Table 1, the study sample had majority female (n=187, 58.99%), White (n=260, 82.02%), non-Hispanic or Latinx (n=306, 96.53%), and married (n=197, 62.15%) individuals. The mean age of participants was 58.89 years (95% CI: 56.92 – 60.86). On average, participants were slightly obese, with a mean BMI of 31.09 (95% CI: 30.28 – 31.90) and reported moderate initial pain (M=4.16; 95% CI: 3.87 – 4.45) (Table 1).

Table 1: Demographic Characteristics of patients by gender, race, ethnicity, marital status, Financial Class. (n= 317)

Source: BMH Data

Date: 2016-2020

Patient Characteristics (Categorical)	N (%)	Mean	95% CI	p
Gender				0.17
Male	130 (41.01)	3.64	3.28 - 4.00	
Female	187 (58.99)	3.31	3.00 - 3.62	
Race				0.34
White	260 (82.02)	3.44	3.18 – 3.69	
Black	30 (9.46)	3.45	2.62 – 4.27	
Asian	10 (3.15)	2.48	1.24 – 3.71	
American Indian or Alaska Native	3 (0.95)	4.87	2.56 – 7.17	
Other	2 (0.63)			
Missing	12 (3.79)			
Ethnicity				0.21
Not Hispanic or Latinx	306 (96.53)	3.42	3.18 – 3.65	
Hispanic or Latinx	11 (3.47)	4.24	2.72 – 5.75	
Marital Status				0.004
Single	65 (20.50)	3.33	2.79 – 3.88	
Married	197 (62.15)	3.69	3.40 – 3.97	
Significant Other	1 (0.32)			
Divorced	25 (7.89)	2.11	1.21- 3.00	
separated	1 (0.32)			
Widowed	26 (8.20)	3.29	2.60 – 3.98	
Other	2 (0.63)			

Cont...

Financial Class/ Insurance Type				0.08
Auto	4(1.26)	4.23	3.33 – 5.13	
Workers Compensation	12 (3.79)			
Blue Cross	73 (23.03)	3.76	3.31 – 4.21	
Commercial	76 (23.97)	3.39	2.87 – 3.92	
Medicaid HMO	31 (9.78)	2.52	1.65 – 3.38	
Medicare	64 (20.19)	3.44	2.92 – 3.96	
Medicare Advantage	57 (17.98)	3.4	2.92 – 3.88	

Table 2: Demographic Characteristics of patients by age, BMI, Initial pain level (n=317)

Source: BMH Data

Date: 2016-2020

Patient characteristics *(Continuous)*	**Mean (95% CI)**	**Median (IQR)**	**R**	**p**
Age (years)	58.89 (56.92 – 60.86)	62.00 (45.00 – 72.00)	-0.004	0.51
Body Mass Index (BMI)	31.09 (30.28 – 31.90)	29.70 (25.73 – 35.06)	0.14	0.01
Initial Pain Level	4.16 (3.87 – 4.45)	4.00 (2.00 – 6.00)	-0.07	0.18

Change in Score

From evaluation to discharge, the mean change in the PSFS score among participants was 3.45 (95% CI: 3.21 – 3.68) with a range of -4.00 to 10.00. Almost 95% of participants (n=300, 94.64%) demonstrated a positive change. Among those who reported a positive change, the mean change in score was 3.67 (95% CI: 3.45 – 3.89), while among participants who had a decrease in score (n=17), the mean was -0.55 (95% CI: -1.14 – 0.04).

When exploring the bivariate relationship between demographics and change in score, two demographic variables were statistically significant: marital status ($F(3,311)=4.52$, $p = .004$) and BMI ($r = 0.14$, $p = .01$). Individuals who were married or had a significant other had a significantly greater change in score (M=3.69, 95% CI: 3.40 – 3.97) than individuals who were divorced or separated (M=2.11, 95% CI: 1.21-3.00) ($t(222)=3.63$, $p = .0004$). Additionally, BMI demonstrated a weak but positive correlation with a change in score. In other words, as patients' BMI increased, their change scores increased slightly (Table 3).

Stepwise multiple linear regression yielded similar results wherein BMI and marital status remained significant predictors of change in score. The final model (Table 4) also showed that insurance type was a significant predictor as well. Specifically, if all other variables are held constant, a one-unit increase in BMI results in an increase of 0.04 in the mean change in score ($p = 0.01$). Compared to single patients, individuals who are divorced or separated have a lower mean change in score ($b = -1.18$, $p = 0.01$), and patients with a Medicaid HMO have a lower mean score than patients with auto or workers' compensation insurance ($b = -1.58$, $p = 0.02$).

Table 3 shows the stepwise series and the iteration of models that was performed to arrive at Model 6 in Table 4.

Table 3: Predictor variable statistics for patients by gender, race, ethnicity, marital status, financial class, age, BMI, pain initial level

Source: BMH dataset

Date: 2016-2020

Patient Characteristics	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Gender*					
Female	-0.24 (0.36)*	-0.23 (0.37)	-0.15 (0.56)	---	---
Race					
Black	-0.08 (0.85)	-0.08 (0.84)	---	---	---
Asian	-0.61 (0.37)	-0.61 (0.38)	---	---	---
American Indian or Alaska Native	1.23 (0.32)	1.25 (0.31)	---	---	---
Ethnicity					
Hispanic or Latinx	0 (omitted)	0 (omitted)	0.78 (0.23)	0.79 (0.22)	0.76 (0.24)
Marital Status					
Married or Significant Other	0.34 (0.35)	0.31 (0.36)	0.26 (0.43)	0.27 (0.41)	0.30 (0.35)
Divorced or separated	-0.87 (0.11)	-0.89 (0.08)	-1.07 (0.03)	-1.12 (0.02)	-1.12 (0.02)
Widowed & other	0.15 (0.80)	0.11 (0.84)	0.01 (0.98)	-0.01 (0.98)	-0.06 (0.92)
Financial Class					
Blue Cross	-0.60 (0.33)	-0.60 (0.32)	-0.64 (0.27)	-0.63 (0.28)	-0.64 (0.27)
Commercial	-0.85 (0.16)	-0.85 (0.16)	-0.93 (0.11)	-0.91 (0.11)	-0.93 (0.11)
Medicaid HMO	-1.48 (0.03)	-1.48 (0.03)	-1.57 (0.02)	-1.57 (0.02)	-1.61 (0.02)
Medicare	-0.74 (0.26)	-0.79 (0.20)	-0.78 (0.19)	-0.74 (0.20)	-0.79 (0.18)
Medicare Advantage	-0.83 (0.21)	-0.88 (0.15)	-0.90 (0.13)	-0.89 (0.13)	-0.89 (0.13)
Age (Years)	-0.002 (0.85)	---	---	---	---
Body Mass Index (BMI)	0.04 (0.03)	0.04 (0.03)	0.04 (0.01)	0.04 (0.01)	0.04 (0.01)
Initial Pain Level	-0.01 (0.78)	-0.01 (0.77)	-0.03 (0.46)	-0.04 (0.42)	---

**Regression coefficient and p value*

Table 4: Predictor variable statistics (Model 6) for patients by gender, race, ethnicity, marital status, financial class, age, BMI, pain initial level

Source: BMH dataset

Date: 2016-2020

Gender*	
Female	---
Race	
Black	---
Asian	---
American Indian or Alaska Native	---
Ethnicity	
Hispanic or Latinx	---
Marital Status	
Married or Significant Other	0.27 (0.40)
Divorced or separated	-1.18 (0.01)
Widowed & other	-0.12 (0.83)
Insurance Type	
Blue Cross	-0.63 (0.28)
Commercial	-0.91 (0.12)
Medicaid HMO	-1.58 (0.02)
Medicare	-0.78 (0.18)
Medicare Advantage	-0.85 (0.15)
Age (Years)	---
Body Mass Index (BMI)	0.04 (0.01)
Initial Pain Level	---

**Regression coefficient and p value*

Table 5: Model fit Statistics (Model 1- Model 6)

Source: BMH dataset

Date: 2016-2020

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
R^2	0.087	0.087	0.090	0.089	0.088	0.084
Adjusted R^2	0.039	0.042	0.054	0.056	0.058	0.057
Root MSE	2.08	2.08	2.07	2.07	2.07	2.07
P	0.03	0.02	0.004	0.003	0.002	0.001

Discussion

Considering that NSLBP is a complicated musculoskeletal condition, it becomes necessary to understand the factors driving clinical outcomes at PT. The current clinical practice guidelines (CPGs) by the APTA have not incorporated demographic factors that might warrant a different approach in clinical treatments. The current study exclusively studied demographic factors that affect the PT clinical outcomes of NSLBP. Of the factors studied, BMI, insurance type and marital status seemed to have a statistical association with the clinical treatment outcomes of NSLBP.

In the current study, a higher BMI was associated with slightly better clinical outcomes at therapy from a statistical perspective. Few other papers have studied BMI with respect to clinical outcomes of LBP. [25,34]as measured by body mass index (BMI A study in 2025 mentions that overweight as well as obese individuals experienced positive psychological and physiological effects when there is an interplay between strength exercises, motivation, and weight management plans. [35] In our study, there was a positive statistical association, which could be that people who were slightly obese appreciated the strengthening exercises more. This, however, did not meet the MCID for clinical relevance. It is already known that obese people are more prone to LBP due to the heavy stressors BMI can place on joints. Several papers have mentioned how BMI places abnormal stressors on the knees.[36,37] But studies are lacking on the association between BMI and clinical outcomes in NSLBP.

Thus, in summary, the factors that were associated with the clinical treatment outcomes of NSLBP include BMI, marital status, and insurance type. Obese individuals have an increased risk of developing LBP. [25,44] Physical activity is already known to reduce the risks of obesity and obesity-related complications.[44,45] The study by Wertli et al, directly measured the PT LBP outcomes in the obese population and found that severely obese patients demonstrated poor outcomes due to their inability to participate in the exercises effectively as compared to the lean and overweight individuals.[25] This research was conducted in 2010, and a lot has changed in the availability of information and treatment strategies since then. Wertli et al., in their study, therefore, recommend that more research needs to be conducted to study the impact of severe obesity in patients with LBP undergoing PT treatment.[25] The majority of the population in our study, however, was considered slightly obese, as determined by BMI values. There seemed to be a statistical association between obesity and clinical outcomes in our study, but this was not clinically relevant. A study by Ewald et. al. in 2016 that studied the association between obesity and treatment outcomes for LBP found that there existed an association between obesity and outcomes.[34] In Ewald's study, obese persons with higher baseline scores had greater opportunities for improvement. [34] Although it is possible that obese individuals have a better scope for enhancement in functional scores in comparison to the lean cohort if they start with greater impairments, the studies are still conflicting in this regard. While the current study showed a positive statistical association, it does not hold clinical relevance at PT.

Divorced individuals seemed to have negative outcomes in PT. This is supported by a study that pointed out that stress levels might be one of the reasons for poor outcomes. [28,29] There is evidence that divorced individuals might have poor social support and higher stress levels that might negatively affect clinical outcomes.[29]

Financial class has been studied in relation to the utilization of visits to physical therapy.[19] This study analyzed insurance type with respect to clinical outcomes of NSLBP. Our findings report that individuals on Medicaid (HMO) seemed to have negative outcomes in PT. This has been supported in a study that reported that poor health outcomes have been linked to being socioeconomically poor.[46] Thus, the current study found an association between demographic factors like BMI, marital status and insurance type and clinical outcomes of NSLBP in patients receiving PT.

Strengths

This study has several strengths. The study is valuable in that, NSLBP and its association with demographic factors has not been studied exclusively. This study utilized complete episodes of care and excluded episodes of care that were incomplete or did not have a discharge note at their final visit. The study used only those episodes of care that included baseline measures and follow-up quantitative measures at the end of the episode of care. Also, this study is the first to investigate the relationship between demographic characteristics and clinical treatment outcomes of NSLBP.

Limitations

One of the primary limitations of this study was that it was retrospective in nature. Retrospective studies are limited in that this study did not group individuals or control for the types of clinical treatments provided. The type of therapist, length of treatment time, number of visits, as well as the patient's medical characteristics, such as secondary comorbidities, were not controlled or taken into consideration. A convenience sample was obtained from PT clinics within the same hospital system, and the population was thus not fully representative of the global patient population. Also, in addition to the above-mentioned limitations, some differences like the type of treatment administered, therapist experience, patient comorbidities, and practice culture are likely to have an effect, and that was unaccounted for in this study.

Recommendations

Studies in the future should include randomized controlled trials that compare outcomes when treating patients in different age groups while also considering potential comorbidities and accounting for them in the older population. It is expected that treatment outcomes may differ for individuals who present with secondary comorbidities. Randomized studies in the future may need to control for patient characteristics like demographics, secondary comorbidities, therapist characteristics such as PT vs PTA, level of experience, number of visits, length of treatment type, and specific treatment types, such as patients that benefit from stabilization exercises versus directional preference exercises.

Conclusion

Age, gender, race, ethnicity, and initial pain had no relationship to clinical outcomes of NSLBP. BMI, marital status, and type of insurance seemed to have an association with clinical outcomes. In conclusion, this study showed that these demographic variables account for only 8.4% of the variance. This variance is extremely small, and it will be interesting to look at other predictors that largely impact the clinical outcomes of NSLBP.

As only 8.4% of outcomes were influenced by the demographic variables examined in this study, 91.6% of outcomes could be attributed to other factors. In the future, it will be interesting to include other potential variables like provider type (getting treatments through a physical therapist versus a physical therapist assistant), number of physical therapy visits, length of treatment time, presence, or absence of secondary comorbidities, etc. to observe their collective effect on treatment outcomes.

Competing interests: The author(s) declare that they have no competing interests.

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