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Effect of Neurological Rehabilitation on Spasticity, Range of Motion and Functional Performance in Individuals with Upper Motor Neuron Disorders

Research Paper
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Abstract

Background: Upper motor neuron (UMN) disorders may be associated with spasticity, weakness, abnormal movement patterns, restricted joint range of motion and reduced functional performance. These impairments can interfere with mobility, upper-limb use and activities of daily living. Neurological rehabilitation combines positioning, stretching, active movement, task-specific training and functional practice to address these impairments.
Aim: To evaluate the effect of a structured neurological rehabilitation programme on spasticity, range of motion and functional performance in individuals with upper motor neuron disorders.
Methods: A pre-test and post-test interventional design may be used among adults with clinically diagnosed UMN disorders. A six-week rehabilitation programme, delivered five sessions per week, may include range-of-motion exercises, stretching, strengthening, weight-bearing, task-oriented training and functional activities. Spasticity may be assessed using the Modified Ashworth Scale (MAS), joint mobility using a universal goniometer, and motor performance using the Fugl-Meyer Assessment (FMA). Pre- and post-intervention scores may be compared using appropriate paired statistical tests.
Results: Illustrative data demonstrate how changes in spasticity, range of motion and motor performance can be presented. These values are not actual clinical observations and should not be reported as study findings.
Conclusion: A structured neurological rehabilitation programme can be investigated as a multidimensional intervention targeting tone, joint mobility and motor performance. Standardized outcome measures, consistent assessors and controlled study designs are recommended for future research.

Keywords: Upper motor neuron disorders; neurological rehabilitation; spasticity; range of motion; functional performance; physiotherapy; Fugl-Meyer Assessment; Modified Ashworth Scale.

1. Introduction

Upper motor neuron disorders are associated with dysfunction of descending motor pathways and may produce weakness, abnormal muscle tone, impaired selective motor control and altered movement patterns. Stroke is one of the most common clinical conditions in which these impairments are observed, although similar motor abnormalities may occur after traumatic brain injury, spinal cord disorders and other neurological conditions. The clinical presentation varies according to the location, severity and timing of neurological injury.

Spasticity is commonly encountered after lesions of the central nervous system. Clinically, increased resistance to passive movement is often used as an indicator of abnormal tone. However, resistance to passive movement is influenced by several factors and should not be interpreted as a direct measure of neural spasticity alone (Pandyan et al., 1999). The Modified Ashworth Scale remains widely used, but its reliability varies according to muscle group and examiner, which makes standardized assessment important (Meseguer-Henarejos et al., 2018; 2023).

Loss of available joint range of motion can develop in association with abnormal muscle activity, prolonged positioning, weakness, pain and reduced use. Restricted movement may further interfere with functional tasks. Therefore, rehabilitation commonly incorporates positioning, stretching and active or assisted movement to preserve available mobility.

Functional performance reflects the patient's ability to use recovered movement during meaningful activities. The Fugl-Meyer Assessment is a widely used measure of post-stroke sensorimotor impairment. Research has demonstrated high inter-rater reliability for the Fugl-Meyer Assessment when standardized assessment procedures are used (Sanford et al., 1993; See et al., 2010). More recent work has also demonstrated high reliability of the upper-extremity component (Pérez-de la Cruz et al., 2019; Wiesner et al., 2024).

Modern neurological rehabilitation emphasizes repetitive, meaningful and task-specific practice. The broader stroke rehabilitation literature supports organized multidisciplinary rehabilitation and repeated practice of relevant activities (Langhorne et al., 2011). Specific approaches such as constraint-induced movement therapy have also been investigated extensively, with systematic review evidence supporting improvements in selected upper-limb outcomes in appropriate stroke populations (Gao et al., 2023).

Because spasticity, joint mobility and functional performance interact with one another, evaluating all three domains can provide a more comprehensive picture of rehabilitation-related change.

2. Need for the Study

Individuals with UMN disorders frequently experience several impairments at the same time. Increased muscle tone can make voluntary movement difficult, while reduced joint mobility can further restrict functional activity. A rehabilitation programme that combines tone-management strategies with active movement and task-oriented training may therefore be more clinically meaningful than an intervention focused on a single impairment.

The present topic is relevant because rehabilitation outcomes are often interpreted using isolated measures. A multidimensional approach can document whether changes in muscle tone and joint mobility are accompanied by measurable changes in motor performance. Such information may assist physiotherapists in designing and monitoring individualized neurological rehabilitation programmes.

3. Problem Statement

"Effect of Neurological Rehabilitation on Spasticity, Range of Motion and Functional Performance in Individuals with Upper Motor Neuron Disorders."

4. Aim of the Study

To determine the effect of a structured neurological rehabilitation programme on spasticity, range of motion and functional performance in individuals with upper motor neuron disorders.

5. Objectives

To assess baseline spasticity in individuals with upper motor neuron disorders.

To measure selected joint range of motion before neurological rehabilitation.

To assess baseline functional motor performance.

To administer a structured neurological rehabilitation programme.

To determine changes in spasticity following rehabilitation.

To determine changes in selected joint range of motion following rehabilitation.

To determine changes in functional performance following rehabilitation.

To examine the overall clinical change across the selected outcome measures.

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6. Hypotheses

Null hypothesis (H0): There will be no significant difference in spasticity, range of motion and functional performance before and after the structured neurological rehabilitation programme.

Alternative hypothesis (H1): There will be a significant difference in spasticity, range of motion and functional performance before and after the structured neurological rehabilitation programme.

7. Review of Literature

7.1 Upper Motor Neuron Dysfunction

Upper motor neuron lesions may result in a combination of weakness, abnormal reflex activity, altered muscle tone, impaired fractionated movement and reduced motor control. The clinical consequences depend on the neurological site and the underlying diagnosis. Stroke rehabilitation provides a major evidence base for neurological physiotherapy, although findings should not automatically be generalized to every UMN disorder.

7.2 Spasticity and Assessment

The Modified Ashworth Scale is one of the most frequently used clinical measures of increased resistance during passive movement. A systematic review and meta-analysis found generally satisfactory inter- and intra-rater agreement, with reliability varying by limb and study characteristics (Meseguer-Henarejos et al., 2018). A later study examining 13 muscle groups after stroke reported better intra-rater than inter-rater reliability for several muscle groups and recommended caution when different examiners perform repeated assessments (Meseguer-Henarejos et al., 2023).

The limitations of the Ashworth and Modified Ashworth Scales should also be recognized. Resistance during passive movement is a complex phenomenon influenced by mechanical and neural factors; consequently, the scale should be interpreted alongside functional and movement measures rather than as a stand-alone indicator of spasticity (Pandyan et al., 1999).

7.3 Range of Motion

Joint range of motion is an important clinical outcome because restricted movement may limit reaching, grasping, transfers, gait and self-care. Standardized goniometric assessment can provide a simple numerical record of available movement. The same joint position, anatomical landmarks and measurement procedure should be maintained across pre- and post-intervention assessments.

7.4 Fugl-Meyer Assessment

The Fugl-Meyer Assessment was developed to quantify motor recovery after stroke. Sanford et al. (1993) reported high overall inter-rater reliability, while subsequent research has supported the reliability of the upper-extremity component. Standardized training and measurement procedures can further improve consistency across assessors (See et al., 2010).

Recent research continues to support the reliability of Fugl-Meyer motor scores. Wiesner et al. (2024) reported very high inter-rater reliability for total and upper-extremity motor scores when experienced assessors were trained in the assessment procedure.

7.5 Task-Oriented and Constraint-Induced Rehabilitation

Task-specific practice is a major component of contemporary neurological rehabilitation. Constraint-induced movement therapy (CIMT) is one example of an intervention designed to increase use of the affected upper limb. A 2023 systematic review and network meta-analysis included 44 studies and 1,779 participants and found improvements in selected upper-extremity outcomes with particular CIMT protocols (Gao et al., 2023). These findings support the broader principle that rehabilitation dose, repetition and task specificity are important considerations.

7.6 Stroke Rehabilitation Evidence

Langhorne et al. (2011) described stroke rehabilitation as a coordinated process aimed at reducing disability and maximizing participation. Their review emphasizes organized rehabilitation, appropriate intensity and multidisciplinary care. The present research topic extends this principle by examining changes across tone, joint mobility and functional performance.

8. Materials and Methods

8.1 Study Design

A pre-test and post-test interventional study design may be used.

8.2 Study Setting

The study may be conducted in the neurology or physiotherapy department of a hospital or rehabilitation centre.

8.3 Study Duration

A six-week intervention period may be used, with five supervised rehabilitation sessions per week.

8.4 Sample Size

A pilot sample of 30 participants may be considered for an initial study. For a definitive research project, sample size should be calculated prospectively from an expected effect size, statistical power, alpha level and anticipated attrition.

8.5 Sampling Technique

Consecutive or purposive sampling may be used depending on recruitment conditions.

8.6 Inclusion Criteria

Adults aged 18 years or older.

Clinically diagnosed upper motor neuron disorder.

Presence of measurable motor impairment.

Medical stability sufficient to participate in physiotherapy.

Ability to follow simple instructions.

Ability to participate in the prescribed programme.

Written informed consent.

8.7 Exclusion Criteria

Unstable medical condition.

Severe cognitive impairment preventing reliable assessment.

Recent orthopedic surgery affecting the assessed limb or joint.

Severe musculoskeletal pain preventing exercise.

Another neurological condition substantially confounding assessment.

Inability to complete the intervention programme.

9. Outcome Measures

9.1 Modified Ashworth Scale

The Modified Ashworth Scale may be used to document resistance to passive movement. Because reliability differs by muscle group and examiner, the same trained assessor should ideally conduct both baseline and post-intervention assessments. The literature supports reasonable reliability but also highlights measurement limitations (Gregson et al., 1999; Meseguer-Henarejos et al., 2018; 2023).

9.2 Range of Motion

A universal goniometer may be used to measure selected joint movements. Possible measurements include shoulder flexion, shoulder abduction, elbow extension deficit, wrist extension, hip flexion and ankle dorsiflexion, depending on the neurological presentation.

9.3 Fugl-Meyer Assessment

The Fugl-Meyer Assessment, particularly the upper-extremity motor component where clinically appropriate, may be used to assess motor impairment. Its high reliability has been demonstrated in stroke rehabilitation research when standardized procedures are followed (Sanford et al., 1993; See et al., 2010; Wiesner et al., 2024).

10. Intervention Protocol

The proposed programme is designed as a structured, progressive neurological physiotherapy intervention. Treatment intensity and specific exercises should be individualized according to diagnosis, stage of recovery, fatigue, pain, balance, cardiovascular status and safety considerations.

Session component	Approximate duration
Warm-up and positioning	5–10 min
Passive/active-assisted ROM	10 min
Stretching and tone-management activities	10 min
Active movement and strengthening	10 min
Task-oriented training	15 min
Functional activities	10 min
Cool-down and home programme	5 min

Total session duration: approximately 55–60 minutes. Frequency: five sessions per week. Duration: six weeks. Planned supervised sessions: approximately 30.

10.1 Positioning

Appropriate positioning can be used to maintain alignment, reduce prolonged abnormal postures and prepare the patient for movement.

10.2 Passive and Active-Assisted Movement

Controlled movement may be performed within the patient's available range, progressing from assisted to active movement as voluntary control improves.

10.3 Stretching

Slow, controlled stretching may be used where reduced flexibility or increased resistance limits movement. Stretching should be comfortable and clinically appropriate.

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10.4 Weight-Bearing and Postural Training

Supported weight-bearing and postural activities may be incorporated to promote alignment, body awareness and controlled loading where appropriate.

10.5 Task-Oriented Training

Patients may practice meaningful tasks such as reaching, grasping, releasing, object manipulation, grooming-related movements, sit-to-stand and stepping or walking activities as appropriate.

10.6 Repetitive Functional Practice

Repeated practice of meaningful movement tasks can be used to increase opportunities for motor learning and functional use.

10.7 Home Exercise Programme

A simple individualized home programme may include prescribed stretching, active movement and selected functional tasks. Adherence should be documented where possible.

11. Procedure

After institutional ethical approval, eligible participants would be screened according to the inclusion and exclusion criteria. Written informed consent would be obtained before assessment. Baseline demographic and clinical information would be recorded. MAS, goniometric range of motion and the selected Fugl-Meyer component would then be assessed.

Participants would undergo the structured neurological rehabilitation programme for six weeks. At the end of the intervention, the same outcome measures would be reassessed using the same assessor, equipment and measurement procedures wherever possible. Pre- and post-intervention scores would then be entered into a statistical database.

12. Statistical Analysis

Data may be analysed using SPSS or equivalent statistical software. Descriptive statistics should include mean, standard deviation, median and percentage as appropriate. For normally distributed continuous variables, a paired t-test may be used to compare pre- and post-intervention values. For ordinal or non-normally distributed variables, the Wilcoxon signed-rank test may be considered. Effect sizes and confidence intervals should also be reported where possible. Statistical significance may be set at $p < 0.05$.

Normality should be assessed using an appropriate combination of graphical inspection and formal tests such as the Shapiro-Wilk test. Because MAS scores are ordinal, their analysis should be selected carefully and should not automatically rely on parametric assumptions.

13. Results

13.1 Illustrative Demographic Characteristics

S. No.	Category	Participants (n)	Percentage (%)
1	Male	18	60.0
2	Female	12	40.0
3	Total	30	100.0

13.2 Illustrative Age Distribution

S. No.	Age group	Participants (n)	Percentage (%)
1	18–39 years	5	16.7
2	40–59 years	13	43.3
3	60–79 years	12	40.0
4	Total	30	100.0

13.3 Illustrative Pre- and Post-Intervention Outcomes

S. No.	Outcome measure	Pre-intervention Mean	Post-intervention Mean
1	Modified Ashworth Scale	2.10	1.47
2	Shoulder flexion ROM	103.4°	124.8°
3	Elbow extension deficit	28.6°	17.2°
4	FMA-UE score	38.7	50.9

Illustrative interpretation: the demonstration values show a lower mean MAS score, greater shoulder flexion and improved FMA-UE score after the intervention. These changes are presented only as an example of how findings may be written. No claim of statistical significance should be made until actual participant-level data are analysed.

14. Discussion

The proposed study examines neurological rehabilitation as a multidimensional intervention. The rationale is that UMN-related disability is not explained by muscle tone alone. Functional movement depends on the interaction of strength, selective motor control, joint mobility, balance, sensation, cognition and task practice.

The Modified Ashworth Scale can be useful for documenting changes in resistance to passive movement, but the scale has recognized limitations. Pandyan et al. (1999) emphasized that passive resistance is influenced by several factors and should not be equated directly with neural spasticity. More recent reliability research similarly recommends consistent administration and caution when different examiners conduct repeated assessments (Meseguer-Henarejos et al., 2023).

The Fugl-Meyer Assessment provides a complementary measure of motor impairment. Sanford et al. (1993) reported high overall inter-rater reliability, and subsequent work has continued to demonstrate high reliability for the upper-extremity motor assessment when standardized procedures are used (See et al., 2010; Wiesner et al., 2024).

The intervention proposed in this study combines movement preparation with active and task-specific practice. This is consistent with the broader rehabilitation literature emphasizing organized, repetitive and meaningful practice (Langhorne et al., 2011). Evidence from CIMT research further demonstrates that appropriately selected task-focused upper-limb interventions can improve motor and functional outcomes in stroke populations (Gao et al., 2023).

However, the present title includes all UMN disorders, which represent a heterogeneous population. Stroke, traumatic brain injury, spinal cord disorders and multiple sclerosis differ in pathology, recovery trajectories and rehabilitation requirements. Consequently, future studies should either focus on one diagnostic group or stratify analyses by diagnosis.

If the illustrative outcome pattern observed in the demonstration tables were reproduced in a properly conducted study, it would suggest clinically relevant changes across several domains. Statistical significance, however, should be determined only from actual participant-level observations and should be accompanied by effect sizes and confidence intervals.

15. Clinical Implications

Assessment should include both impairment-level and functional outcome measures.

Tone should be interpreted alongside active movement and function rather than in isolation.

Joint mobility should be monitored regularly when abnormal tone or prolonged positioning is present.

Task-specific practice should be incorporated where clinically appropriate.

The same trained assessor should ideally perform repeated outcome measurements.

Home exercise adherence should be monitored when it is part of the intervention.

16. Limitations

A small sample may limit generalizability.

A single-group pre-test/post-test design cannot fully separate intervention effects from spontaneous recovery or other influences.

Heterogeneous UMN diagnoses may respond differently to rehabilitation.

The Modified Ashworth Scale has recognized measurement limitations.

Six weeks may not establish long-term maintenance of improvement.

Home exercise adherence may vary between participants.

Blinding the treating physiotherapist is difficult.

Long-term follow-up may be required.

17. Recommendations for Future Research

Use randomized controlled study designs where feasible.

Calculate sample size prospectively from an expected effect size.

Recruit diagnosis-specific populations or conduct stratified analyses.

Standardize intervention intensity and treatment dose.

Include follow-up assessments after treatment completion.

Combine impairment, activity and participation measures.

Report effect sizes and confidence intervals in addition to p-values.

Document adherence to supervised and home-based rehabilitation.

18. Conclusion

Neurological rehabilitation provides a framework for addressing multiple impairments associated with upper motor neuron disorders. A structured programme combining positioning, stretching, active movement, strengthening, task-oriented practice and functional activities can be investigated using

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complementary measures of muscle tone, joint mobility and motor performance.

The available evidence supports structured rehabilitation and standardized assessment, particularly in stroke populations. However, evidence from one neurological diagnosis should not automatically be generalized to all UMN disorders. Future research should use adequately powered controlled designs, standardized treatment protocols and diagnosis-specific analyses to determine the magnitude and durability of rehabilitation-related change.

19. Ethical Considerations

Before recruitment, the study protocol should receive approval from the relevant Institutional Ethics Committee. Participants should receive clear information about study procedures, potential benefits and possible risks. Written informed consent should be obtained. Participant identity should be kept confidential, and participants should be free to withdraw from the study according to the approved protocol.

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