

Added Effect of Muscle Energy Technique for Scapular Muscles on Upper Limb Function in Chronic Hemiplegia: A Randomized Controlled Pilot Study

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ABSTRACT

Background: Upper limb dysfunction affects the majority of stroke survivors and often persists into the chronic stage⁵. Scapular muscle imbalance compromises proximal stability and limits distal upper limb function, and conventional physiotherapy often fails to specifically target this deficit^{1,7,10}. Muscle Energy Technique (MET) may address scapular hypertonicity and imbalance, but its added effect in chronic hemiplegia is underexplored.

Objective: To evaluate the added effect of scapular Muscle Energy Technique combined with conventional physiotherapy, compared with conventional physiotherapy alone, on upper limb function in patients with chronic hemiplegia.

Methods: Design: Two-arm, parallel-group, randomized controlled pilot trial. Setting: Tertiary care teaching hospital, over 6 months. Participants: Twelve adults with chronic hemiplegia (>6 months post-stroke), upper extremity and hand Brunnstrom grade ≥ 3 , Mini-Mental State Examination (MMSE) score >23, randomly allocated (1:1) to a Control group (conventional physiotherapy, n=6) or an Experimental group (conventional physiotherapy plus scapular MET directed at trapezius, pectoralis major, infraspinatus, subscapularis and latissimus dorsi, n=6). Both groups received their respective protocols five sessions per week for 4 weeks. The primary outcome was the Upper Extremity Functional Index (UEFI), assessed before and after the 4-week intervention.

Results: All 12 randomized participants (6 per group) completed the trial and were analyzed (no losses to follow-up). Both groups showed statistically significant within-group improvement in UEFI scores (Wilcoxon signed-rank test, $p = 0.031$ for each group). Mean improvement was 12.83 ± 5.04 points in the Experimental group versus 6.33 ± 1.37 points in the Control group. The between-group difference favored the Experimental group (Mann-Whitney U = 34, $p = 0.009$).

Conclusion: In this pilot trial, adding scapular MET to conventional physiotherapy produced significantly greater improvement in upper limb function than conventional physiotherapy alone in chronic hemiplegia. Findings should be interpreted cautiously given the small sample size, and confirmation in an adequately powered, blinded, registered trial is warranted.

Keywords: Stroke; Muscle Energy Technique; Scapular muscles ; Upper extremity function

INTRODUCTION

Stroke is defined as the sudden onset of neurological deficit resulting from interruption of blood supply to the brain, either due to ischemia or haemorrhage¹. It is a global health problem of major concern, being the second leading cause of mortality and the third leading cause of disability worldwide².

In India, population-based studies estimate stroke incidence at 119–145 per 100,000 persons, with prevalence ranging from 84–262 per 100,000 in rural areas and 334–424 per 100,000 in urban areas³; incidence is roughly 1.25 times higher in males than females, and prevalence rises with advancing age⁴.

Approximately 80% of stroke survivors experience upper limb dysfunction, which is often more severe and persistent than lower limb involvement and continues to limit daily activities months after the event⁵. Middle cerebral artery strokes in particular produce weakness, spasticity, loss of selective motor control and impaired postural stability that compromise reaching, grasping and manipulation^{5,6}.

Stroke-related changes in scapular muscle tone alter scapular position and upper extremity biomechanics, deteriorating function and quality of life⁷. Spasticity in pectoralis major, pectoralis minor, rhomboids and latissimus dorsi contributes to abnormal scapular kinematics — downward rotation, protraction, elevation and depression — while weakness of the trapezius and serratus anterior compounds the problem^{7,9}. This proximal dysfunction reduces available shoulder range of motion and impairs reaching and grasping⁹; scapular stabilization exercises have been shown to improve upper extremity function in chronic stroke⁹, and increased flexor tone in the spastic phase can produce scapular retraction and shoulder adduction that persist into the chronic stage if uncorrected⁹.

Conventional physiotherapy — range of motion exercises, facilitation techniques, task-oriented training and neurodevelopmental approaches — remains the cornerstone of stroke rehabilitation, but frequently leaves scapular malalignment and muscle imbalance insufficiently addressed^{1,9}.

Muscle Energy Technique (MET) is a manual therapy in which the patient actively contracts a muscle against therapist-applied resistance, followed by relaxation and gentle stretch into the newly gained range; it is classified as a direct, active technique that engages the restrictive barrier¹¹. Its proposed mechanism involves post-isometric relaxation and reciprocal inhibition: isometric contraction activates Golgi tendon organs, producing transient inhibition of agonist and antagonist muscles that allows further movement into the restricted range, improving flexibility, reducing tone and enhancing mobility¹¹.

In young swimmers with scapular dyskinesis, MET applied to the serratus anterior, trapezius, latissimus dorsi and pectoralis minor produced significant gains in shoulder range of motion and scapular muscle strength¹³. MET has also reduced tone in children with spastic diplegic cerebral palsy¹² and improved mobility, balance and quality of life in stroke patients when combined with the Neurac method¹⁴.

Recovery of upper limb function after stroke is strongly influenced by control of the scapular muscles, which provide the proximal base for distal activity^{9,10}, and altered tone and imbalance in chronic hemiplegia compromise this control⁷. Conventional physiotherapy, while addressing mobility and task training, is often insufficient to correct scapular malalignment and restore proximal stability¹, contributing to persistent deficits despite regular therapy.

Given evidence that MET can improve scapular strength and range of motion¹³, reduce abnormal tone in neurological populations¹², and enhance quality of life when combined with other rehabilitation strategies in stroke¹⁴, but that its specific role in chronic hemiplegia remains underexplored, this pilot randomized controlled trial was designed to evaluate the added effect of scapular MET, combined with conventional physiotherapy, on upper limb function in chronic hemiplegics.

Objectives

(1) To evaluate the effect of conventional physiotherapy alone on upper limb function, using the Upper Extremity Functional Index (UEFI), in chronic hemiplegics. (2) To evaluate the effect of conventional physiotherapy combined with scapular MET on upper limb function, using the UEFI, in chronic hemiplegics. (3) To compare the effect of conventional physiotherapy alone versus conventional physiotherapy combined with scapular MET on upper limb function in chronic hemiplegics.

METHODS

Trial Design

This was a prospective, two-arm, parallel-group, analytical randomized controlled pilot trial with a 1:1 allocation ratio, conducted over 6 months at a tertiary care teaching hospital affiliated with MAEER's Physiotherapy College, Talegaon Dabhade. No changes were made to trial methods after commencement.

Participants

Eligible participants were adults of either sex with chronic hemiplegia (onset more than 6 months prior), an upper extremity and hand Brunnstrom recovery stage of 3 or above, and an MMSE score greater than 23. Participants were excluded if they had shoulder subluxation, a history of upper extremity trauma, complex regional pain syndrome, upper limb surgery in the preceding 6 months, any anti-spastic treatment (including botulinum toxin) in the preceding 6 months, or bilateral stroke involvement. Institutional ethics/review board approval was obtained prior to recruitment, and all participants provided written informed consent after the procedure was explained in detail.

Interventions

Participants in both groups received their assigned protocol five times per week for 4 consecutive weeks.

Control group (Group A) — conventional physiotherapy: Passive and active-assisted shoulder range-of-motion exercises in supine (flexion, extension, abduction, adduction; 25 repetitions, 3 times/week); Rood's inhibitory joint compression (30 seconds on/10 seconds rest, 10 repetitions); Brunnstrom facilitatory tapping over the wrist extensors for hand-opening (30 repetitions); constraint-induced movement technique (30 minutes); bilateral arm training with diagonal wood-cutter exercises (20 repetitions); functional glass-holding with elbow stabilization (20 repetitions, 20-second holds); and scapular setting/postural training with mirror feedback comprising wall slides, scapular retractions, prone wall push-ups, scaption-plane exercises with thumbs up, and scapular rowing (10 repetitions each), progressed onto a Swiss ball as tolerated.

Experimental group (Group B) — conventional physiotherapy plus scapular MET: Group B received the identical conventional protocol described above, plus MET directed at five scapular muscles: (1) trapezius (anterior, middle and posterior fibres, positioned via graded neck lateral flexion/rotation, light resisted isometric contraction for 7–10 seconds followed by relaxation); (2) pectoralis major (lateral rotation to available range, 20% effort isometric contraction into adduction for 7–10 seconds); (3) infraspinatus (medial rotation to available range, isometric contraction lifting the wrist dorsum against resistance for 5–7 seconds); (4) subscapularis (lateral rotation to available range, isometric contraction raising the forearm against minimal resistance for 5–7 seconds); and (5) latissimus dorsi (abduction to available range, isometric contraction returning the arm toward the side against firm resistance), each followed by a relaxation phase and gentle stretch into the newly available range.

Outcomes

The primary (and only) outcome was the Upper Extremity Functional Index (UEFI), a patient-reported

outcome measure comprising 20 tasks, each scored 0 (extreme difficulty/unable) to 4 (no difficulty), for a total possible score of 0–80, with higher scores indicating better function (reliability 0.85, validity 0.50⁹). UEFI was recorded once at baseline (pre-intervention) and once after the 4-week intervention (post-intervention) by the treating therapist. No outcomes were added or omitted after trial commencement.

Sample Size

The sample size of 12 (6 per group) was calculated a priori using OpenEpi version 3 (open-source SSmean calculator), referencing effect estimates from a comparable upper-extremity function study in hemiparetic patients⁹. As a pilot trial, this sample was intended to establish feasibility and provide preliminary effect estimates rather than to be definitively powered for the primary comparison; this limitation is discussed further below.

Randomization

Sequence generation and allocation: Twelve eligible, consenting participants were assigned to Group A or Group B using a random allocation technique (simple randomization) in a 1:1 ratio, generated independently of the treating and assessing therapist.

Allocation concealment: The specific concealment mechanism (e.g., sequentially numbered, sealed, opaque envelopes) was not separately documented in the trial protocol; this is acknowledged as a reporting limitation of this pilot study (see Limitations).

Implementation: Participants were enrolled after screening against the eligibility criteria, and group allocation was implemented by trial personnel independent of outcome scoring wherever feasible.

Blinding

Because MET and the associated manual contact could not be concealed from the treating therapist or the participant, this trial was unblinded (open-label) for participants and treating therapists, consistent with the inherent limitations of manual therapy trials. Blinding of the outcome assessor was not implemented in this pilot study; this is discussed as a source of potential detection bias.

Statistical Methods

Data distribution was assessed and, given the small pilot sample size, non-parametric tests were used throughout. The Wilcoxon signed-rank test was used to compare pre- and post-intervention UEFI scores within each group. The Mann-Whitney U test was used to compare the magnitude of change (and post-intervention scores) between groups. Descriptive statistics are reported as mean $\pm$ standard deviation. A two-sided p-value <0.05 was considered statistically significant. No interim analyses or stopping rules were applied, consistent with the fixed short duration of this pilot trial.

RESULTS

Participant Flow (Figure 1)

Twelve participants meeting the eligibility criteria were enrolled and randomized 1:1 to Group A (Control, conventional physiotherapy, n=6) or Group B (Experimental, conventional physiotherapy plus scapular MET, n=6). All 12 participants received their allocated intervention as planned, and all 12 completed the 4-week protocol and the post-intervention assessment; there were no losses to follow-up, protocol deviations, or discontinuations in either group. All randomized participants (n=6 per group) were included in the final analysis (intention-to-treat = per-protocol, as no attrition occurred).

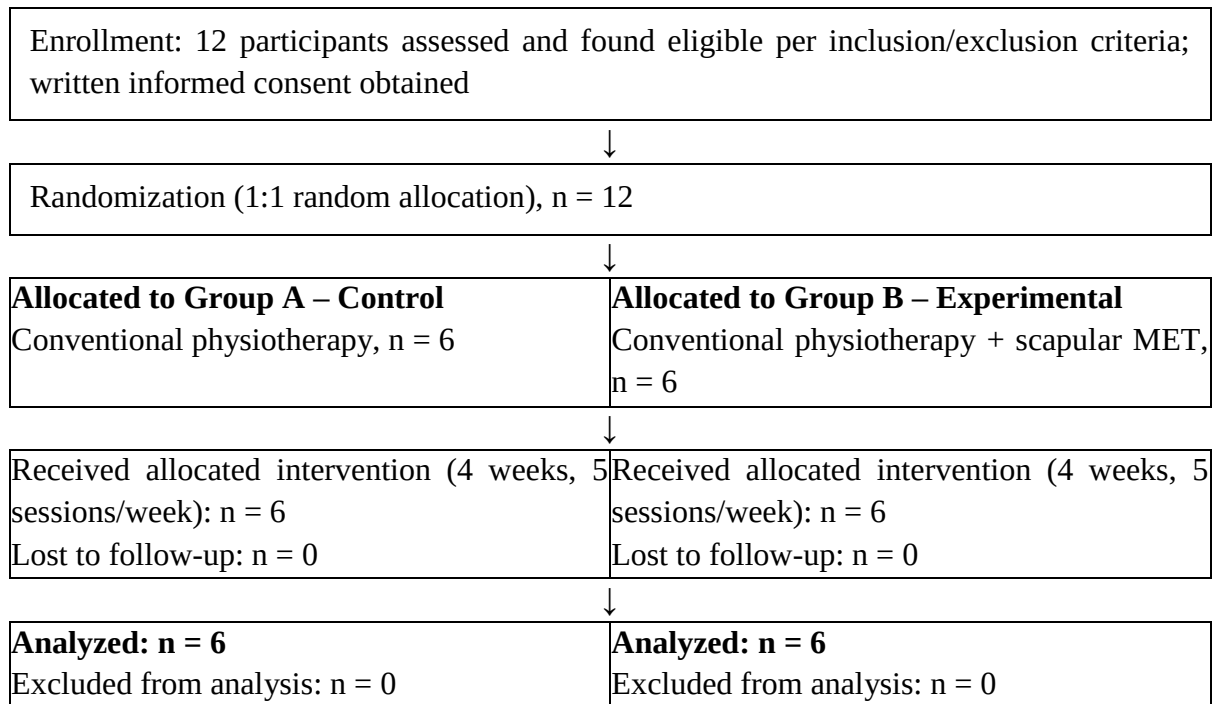


Figure 1. CONSORT participant flow diagram.

Recruitment

Recruitment, intervention delivery and follow-up assessment were conducted over the 6-month study period at a single tertiary care teaching hospital. The trial was stopped after the pre-specified pilot sample size (n=12) completed the 4-week protocol and final assessment; the trial was not stopped early for benefit, harm, or futility.

Baseline Data

Baseline demographic and clinical characteristics of the two groups are summarized in Table 1. The groups were broadly comparable at baseline, though the small sample size precludes formal balance testing.

Characteristic	Group A (Control) n=6	Group B (Experimental) n=6
Age, years (mean ± SD)	57.3 ± 6.4	55.3 ± 12.7
Sex, n (Male/Female)	5 / 1	4 / 2
Baseline UEFI score (mean ± SD)	41.67 ± 9.52	39.17 ± 11.32

Numbers Analyzed

All analyses were conducted on all 12 randomized participants (6 per group) as allocated; no participant was excluded from the analysis and no participant crossed over between groups.

Outcomes and Estimation

Table 2 summarizes the within-group (pre- versus post-intervention) comparison for each group. Both the

Control group and the Experimental group demonstrated statistically significant improvement in UEFI scores after 4 weeks (Wilcoxon signed-rank test, $p = 0.031$ for each group).

Group	Pre-intervention (mean $\pm$ SD)	Post-intervention (mean $\pm$ SD)	Wilcoxon p-value
Group A – Control (conventional physiotherapy)	41.67 $\pm$ 9.52	48.00 $\pm$ 8.92	0.031
Group B – Experimental (conventional physiotherapy scapular MET) +	39.17 $\pm$ 11.32	52.00 $\pm$ 9.51	0.031

Table 3 summarizes the between-group comparison. The mean improvement in UEFI score was more than double in the Experimental group (12.83 $\pm$ 5.04 points) compared with the Control group (6.33 $\pm$ 1.37 points). This difference was statistically significant on the Mann-Whitney U test ($U = 34$, $p = 0.009$), and the Experimental group also achieved a numerically higher post-intervention mean UEFI score (52.00 $\pm$ 9.51) than the Control group (48.00 $\pm$ 8.92).

Variable	Group A (Control)	Group B (Experimental)	Mann-Whitney U / p-value
Mean change in UEFI score (post – pre)	6.33 $\pm$ 1.37	12.83 $\pm$ 5.04	$U = 34$, $p = 0.009$
Post-intervention UEFI score	48.00 $\pm$ 8.92	52.00 $\pm$ 9.51	—

Ancillary Analyses

No pre-specified subgroup or adjusted analyses (e.g., by age, sex, or Brunnstrom stage) were conducted given the small pilot sample size; any such post-hoc comparisons would be underpowered and are not reported to avoid spurious findings.

Harms

No adverse events, increased pain, or intervention-related complications were reported or observed in either group during the 4-week intervention period.

DISCUSSION

This pilot randomized controlled trial found that adding scapular MET to conventional physiotherapy produced significantly greater improvement in upper limb function, as measured by the UEFI, than conventional physiotherapy alone in patients with chronic hemiplegia. While both groups improved significantly from baseline — consistent with the established benefit of structured conventional

physiotherapy for post-stroke upper limb rehabilitation — the magnitude of improvement was approximately twice as large in the group receiving scapular MET, and this between-group difference was statistically significant.

Conventional physiotherapy often addresses gross motor tasks and distal movement, whereas the MET intervention in this trial targeted proximal scapular muscle groups directly. Because the scapula provides the foundation for arm and hand movement, impaired scapular stability can limit the efficacy of distal-focused rehabilitation approaches, and improved proximal stability has previously been linked to gains in distal function such as reaching, grasping and object manipulation⁹.

The MET protocol used controlled isometric contractions followed by stretch, consistent with the proposed post-isometric relaxation and reciprocal inhibition mechanism, in which Golgi tendon organ activation produces transient inhibition of agonist and antagonist muscles, increasing extensibility and enabling greater active and passive range of motion¹¹. This may explain the additional gains observed alongside improved scapular control relevant to shoulder stabilization during dynamic tasks.

Improved balance and activation among scapular force-couple muscles — serratus anterior, trapezius and pectoralis minor — is important for upward rotation, posterior tilt and retraction of the scapula, movements fundamental to pain-free arm elevation; MET has been reported to help restore the timing and strength of these force couples in populations with scapular dyskinesis¹³, potentially reducing compensatory overflow to non-target muscles and lowering the risk of secondary complications such as impingement or subluxation.

These findings are consistent with prior reports of MET reducing muscle tone across neurological populations¹² and improving mobility, balance and quality of life when combined with other rehabilitation strategies in stroke¹⁴, supporting a broader role for MET as an adjunct in neurorehabilitation directed at proximal muscle control.

Limitations

This pilot trial has several important limitations that temper the strength of its conclusions. First, the sample size was very small ($n=6$ per group), calculated to establish feasibility rather than to be definitively powered for the primary comparison; this limits statistical precision and generalizability. Second, the intervention and follow-up period was short (4 weeks, single post-intervention assessment), with no longer-term follow-up, so the durability of the observed functional gains is unknown. Third, participants and treating therapists could not be blinded to group allocation given the manual nature of MET, and outcome assessor blinding was not implemented; both raise the possibility of performance and detection bias. Fourth, the allocation concealment mechanism was not explicitly documented. Fifth, this trial was not prospectively registered in a clinical trials registry, and only a single outcome measure (UEFI) was used, without objective or biomechanical measures of scapular kinematics, spasticity, or strength to corroborate the functional findings. Finally, being a single-center pilot study, results may not generalize to other settings, stroke etiologies, or more/less severe presentations of hemiplegia.

Generalizability

Given the restrictive eligibility criteria (Brunnstrom stage ≥ 3 , MMSE >23 , exclusion of subluxation, recent botulinum toxin, or bilateral involvement) and single-center, small-sample design, findings should be considered hypothesis-generating and applicable primarily to similarly-selected chronic hemiplegic

patients with preserved cognition and at least moderate voluntary motor recovery, rather than to the full spectrum of post-stroke upper limb impairment.

Interpretation

Within the constraints of a small, unblinded pilot trial, these results suggest that scapular MET may offer a clinically meaningful adjunctive benefit over conventional physiotherapy alone for upper limb function in chronic hemiplegia, plausibly by improving proximal scapular stability and force-couple balance. However, given the noted methodological limitations, these findings should be regarded as preliminary. A confirmatory, adequately powered, prospectively registered randomized controlled trial — incorporating assessor blinding, a concealed allocation mechanism, longer follow-up, and adjunct biomechanical/kinematic outcome measures — is warranted before scapular MET can be recommended for routine clinical practice in this population.

CONCLUSION

In this pilot randomized controlled trial, adding scapular Muscle Energy Technique to conventional physiotherapy produced significantly greater improvement in upper limb function, measured by the Upper Extremity Functional Index, than conventional physiotherapy alone in patients with chronic hemiplegia. These preliminary findings support further investigation of scapular MET as an adjunct in stroke upper-limb rehabilitation, pending confirmation in a larger, blinded, registered trial.

CLINICAL SIGNIFICANCE

- Scapular MET, added to conventional physiotherapy, was associated with greater improvement in upper limb function than conventional therapy alone in this pilot trial of chronic hemiplegia.
- Restoring proximal (scapular) stability may support distal hand movement and skilled activities of daily living.
- MET may help reduce muscle tone/spasticity and support more efficient movement patterns.
- Correcting scapular muscle imbalance may improve force-couple action and overall shoulder mechanics.
- If confirmed in larger trials, scapular MET could be considered as an adjunctive technique within stroke upper-limb rehabilitation programs.

FUTURE SCOPE

- Adequately powered, multi-center, prospectively registered trials with assessor blinding and concealed allocation.
- Longer intervention duration and follow-up to establish sustainability of functional gains.
- Combination of MET with other advanced approaches (e.g., Neurac, proprioceptive neuromuscular facilitation).
- Inclusion of objective scapular kinematic and muscle strength measures alongside patient-reported outcomes.
- Development of standardized scapular MET protocols for routine clinical use in stroke rehabilitation.

OTHER INFORMATION**Protocol**

A full trial protocol was developed and approved by the institutional ethics/review board prior to enrolment; it is available from the corresponding author on reasonable request.

Ethics Approval

Institutional review board/ethics committee approval was obtained before the study was conducted (EC/NEW/INST/2019/377/278). Written informed consent was obtained from all participants after the study procedures were explained in detail, using a standardized consent form (Annexure).

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Conflicts of Interest

The authors declare no conflicts of interest.

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Author Contributions

Conception and design: all authors. Data collection and intervention delivery: D.J.P. Supervision: N.P., S.P., S.G. Analysis and manuscript drafting: D.J.P., with critical revision by N.P., S.P., and S.G. All authors approved the final manuscript.

Data Availability

De-identified individual participant data (master chart) are presented in the Annexure and are available from the corresponding author on reasonable request.

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