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A Comparative Study on the Efficacy of Mirror Biofeedback with and without Functional Proprioceptive Neuromuscular Facilitation on Pain and Functional Disability in Patients with Upper Cross Syndrome

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Abstract:

- ***Background:***
Upper Cross Syndrome (UCS) is a common postural disorder caused by muscle imbalance producing tight and weak crossed muscle patterns, resulting in neck pain, poor posture, reduced strength, and functional limitations, especially in sedentary individuals and affects occupational performance.

- ***Aim:***
To compare mirror biofeedback either versus combined with functional Proprioceptive Neuromuscular Facilitation (PNF) on pain, disability, strength, and posture in UCS patient.

- ***Methodology:***
Comparative study on 60 participants aged 25–45 years were randomized into two groups: Mirror biofeedback either and Mirror biofeedback + functional PNF, treated thricely/week for 4 weeks with home exercises; NPAD, MMT, Postural assessment were measured. Treatment duration followed standardized protocol.

- ***Results:***
Both groups improved, but Mirror biofeedback + functional PNF showed greater gains (NPAD 47.33–28.67; MMT 3.07–4.83) than biofeedback either (47.2–33.53; 3.03–4.37).

- ***Conclusion:***
Mirror biofeedback is effective, but adding functional PNF provides superior improvements in pain, strength, and posture, combined visual and proprioceptive facilitation effects, which enhance neuromuscular control, motor learning, and postural correction supporting multimodal rehabilitation for UCS. This approach enhances neuromuscular control, motor learning, and postural correction without adverse effects in participants.

- ***Limitation:***
Small sample size, short intervention period, convenience sampling may affect generalizability, supervised treatment for only thricely/week, lack of long-term follow-up.

Keywords: *Upper Cross Syndrome, Mirror Biofeedback, Functional PNF, Posture Correction.*

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I. INTRODUCTION

Musculoskeletal disorders are strongly associated with workplace activities, especially prolonged poor posture that leads to postural imbalance and misalignment. One common outcome is upper crossed syndrome (UCS)[1]. In UCS, neck and chest muscles become tight and shortened, while neck and upper-back muscles weaken and lengthen. Tight muscles include the suboccipital, sternocleidomastoid, levator scapulae, pectoralis major and minor, scalene, and upper trapezius; weak muscles include deep neck flexors, serratus anterior, rhomboids, and middle and lower trapezius.

This crossed muscle imbalance disrupts posture, upper-limb alignment, and joint function of the neck, upper back, and shoulders, leading to headaches, neck and chest pain, arm tingling, and reduced mobility. [2]

UCS is characterized by forward head posture, rounded shoulders, cervical hyper lordosis, and thoracic hyper kyphosis. The shoulders shift forward and upward, and scapular positioning may become abnormal, showing internal rotation, protraction, or winging (scapular dyskinesis). [3]

Prevalence varies by occupation, affecting about 67% of IT professionals, 37.1% of students, and 28% of laundry workers, with overall rates ranging from 11%–60%. If untreated, UCS can cause secondary problems such as shoulder impingement, cervicogenic headaches, instability, impaired joint position sense, and reduced breathing capacity. Common consequences include pain, reduced function, and increased absenteeism, creating economic burden. [1]

Exercise therapy is strongly supported for postural disorders and includes stretching, strengthening, muscle energy techniques (MET), stabilization, myofascial release, and posture correction. However, single-method treatments mainly address muscle length and strength and often fail to correct motor-control deficits or long-term faulty habits. Some reviews question whether stretching and strengthening alone can fully correct posture. Since UCS is multifactorial and high-quality evidence for conservative treatment is limited, multimodal approaches may be more effective, though few randomized trials exist. Therefore, this study evaluates a multimodal program (MET, cervical and scapular stabilization, posture correction, and ergonomic advice) versus MET alone for posture, pain, and disability. [3]

Postural dysfunction is influenced by work habits, poor body awareness, and psychological factors. Modern sedentary occupations promote prolonged sitting and forward-arm activity, encouraging flexed posture, and increased computer use further contributes. Evidence supports manual therapy for UCS, and studies report that physiotherapy interventions—including Kendall exercises, corrective exercise programs, stretching, strengthening, stabilization, cervical mobilization, McKenzie traction, MET, and instrument-assisted soft tissue techniques—are effective. [4]

The scapula plays a key role in shoulder stability and movement through coordinated muscle activity. Scapular stabilization exercises activate weak muscles and relax overactive ones, restoring balance. Because breathing and posture are interrelated, combined treatments are recommended. Dynamic Neuromuscular Stabilization (DNS) applies developmental movement patterns to improve breathing, posture, and trunk–shoulder coordination. [5]

Mirror therapy (MT) may act through several mechanisms: activation of the mirror neuron system, stimulation of neural pathways from the healthy hemisphere, and increased attention to the affected limb due to sensory-visual mismatch. Neuroimaging studies show increased activation in attention-related brain areas such as the posterior cingulate cortex, insular cortex, superior parietal lobule, and precuneus. [6]

Proprioceptive Neuromuscular Facilitation (PNF) improves strength and range of motion by enhancing muscle activation and motor learning. It promotes coordinated agonist–antagonist activity using functional movement patterns and combined active-passive techniques, making it a holistic rehabilitation approach. Effectiveness depends on therapist skill, patient cooperation, and functional level, highlighting the need for further protocol research. [7]

The Neck Pain and Disability Scale (NPAD) meets recommended standards for self-reported measures. It uses a simple visual analog format, provides rapid results, and captures multiple dimensions of pain. The 20-item scale assesses neck problems, pain intensity, emotional impact, and activity limitations. Analyses show strong reliability and validity, with each item contributing meaningfully, so reduction is not recommended. [8] It also demonstrates good test–retest reliability. [9]

Manual Muscle Testing (MMT), studied extensively since 1915, shows good reliability and validity for evaluating neuromusculoskeletal disorders. Observational studies demonstrate strong internal and external validity, and randomized trials indicate results are not influenced by examiner bias. [10]

Although mirror biofeedback and PNF individually benefit musculoskeletal rehabilitation, strong comparative evidence regarding their combined effect in UCS is limited. [5] Their synergistic use may enhance outcomes through simultaneous visual and proprioceptive retraining, but this potential remains underexplored. [1]

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Therefore, this study aims to compare mirror biofeedback alone with mirror biofeedback combined with functional PNF in patients with UCS. Primary outcomes include pain reduction and improved functional disability, with the goal of guiding clinical decision-making and optimizing rehabilitation protocols. Given the increasing prevalence of UCS in working and general populations, this research has important clinical and public-health relevance and may improve physiotherapy practice, inform prevention strategies, and enhance functional independence and quality of life.

➢ *Need for Study:*

Upper Crossed Syndrome (UCS) is increasingly prevalent among individuals engaged in prolonged sedentary or screen-based activities, yet its management remains inadequately addressed in routine physiotherapy practice. While mirror biofeedback and functional PNF techniques have independently demonstrated effectiveness in improving posture, reducing pain, and enhancing neuromuscular control, there is a lack of high-quality comparative research evaluating their combined effect in UCS rehabilitation.

The absence of such evidence creates a gap in clinical decision-making, where therapists are left uncertain about whether integrating functional PNF into mirror biofeedback-based training provides additional therapeutic value. Moreover, given the functional limitations and quality-of-life impairments associated with UCS, there is a pressing need to identify and validate comprehensive, cost-effective, and easily applicable rehabilitation protocols.

➢ *Aim:*

To evaluate the additional effect of integrating functional Proprioceptive Neuromuscular Facilitation (PNF) with mirror biofeedback on pain intensity, functional disability, and postural alignment in patients with Upper Cross Syndrome, compared to mirror biofeedback either.

➢ *Objective:*

- To compare Mirror Biofeedback + functional PNF versus mirror biofeedback either in reducing pain intensity (NPAD) in Upper Cross Syndrome patients.
- To compare their effects on functional disability (NPAD).
- To compare improvements in muscle strength (MMT) between groups.
- To determine whether adding functional PNF provides superior overall clinical outcomes compared to mirror biofeedback either.

II. METHOD

This randomized controlled trial was conducted at Rashtrasant Janardhan Swami College of Physiotherapy, SJS Hospital, RJS Group of Institute, Sanjivani Group of Institute, outpatient physiotherapy departments, community health camps, banks, and educational institutes. A total of 60 participants were selected through random sampling, and the sample size was determined using OpenAPI. Eligible participants were skeletally mature individuals aged 25–45 years diagnosed with Upper Cross Syndrome and experiencing neck and/or shoulder pain for at least one month. Participants were randomly allocated into two groups: Group A received mirror biofeedback alone, and Group B received mirror biofeedback combined with functional PNF. The total study duration was 6 months. Prior to participation, all individuals were screened for eligibility based on specific inclusion and exclusion criteria.

➢ *Inclusion Criteria:*

- Individuals aged between 25 to 45 years.
- Participants must be present with a clinical diagnosis of Upper Cross Syndrome (UCS), characterized by muscular imbalances.
- History of neck and/or shoulder pain persisting for a minimum duration of one month.

➢ *Exclusion Criteria:*

- History of cervical spine, shoulder or upper limb trauma or surgical interventions within the preceding 6 months.
- Presence of neurological disorders known to affect neuromuscular control, postural alignment, or muscle tone, such as Multiple Sclerosis, Parkinson's Disease or Cervical Radiculopathy.
- Congenital musculoskeletal deformities or spinal abnormalities.
- Pregnancy.
- Cognitive or psychological impairments.
- Regular use of NSAID's within the past 2 weeks prior to baseline assessment.

➢ *Outcome Measure:*

- *Neck Pain and Disability (NPAD) Scale-*

The NPAD, developed by A H Wheeler, is a 20-item self-reported scale measuring neck pain intensity and related disability. Scores range up to 100, with higher scores indicating greater disability. It has excellent reliability and good validity.

- *Manual Muscle Testing (MMT)-*

MMT assesses muscle strength using a 0–5 grading scale based on movement against gravity and resistance. It is simple, cost-effective, and widely used clinically. It demonstrates moderate to high reliability and good validity.

- *Postural Deviation Assessment-*

Postural deviation was evaluated using plumb line assessment and digital photogrammetry in all views. It is a non-invasive, objective method with good reliability and sensitivity to postural changes.

➢ *Procedure:*

Individuals from the general population who fulfilled the inclusion and exclusion criteria and were willing to participate were provided with an informed consent form and detailed information about the study. Participants were informed that they had the right to withdraw from the study

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at any time, and their decision would be respected without any consequences.

Baseline data were collected at 0 week using the Neck Pain and Disability Scale (NPAD), Manual Muscle Testing (MMT), and standardized photographic postural assessment. A total of 60 participants (25–45 years) with clinically diagnosed Upper Cross Syndrome and neck/shoulder pain were randomly allocated into two groups: Group A – Mirror Biofeedback (n=30) and Group B – Mirror Biofeedback + Functional PNF (n=30). Participants received 12 sessions over 4 weeks (3 sessions per week, 30–40 minutes each). Post-intervention assessment was conducted at the end of 4 weeks, and reassessment was performed at 8 weeks post-intervention. Participants were educated about posture correction, exercise techniques, and safety precautions prior to intervention.

➢ *Intervention:*

- *Group A*

✓ *Mirror Biofeedback Setup and Real-Time Visual Feedback Training:*

- Participant stands in front of a full-length mirror. Ideal posture demonstrated (chin tuck, neutral cervical spine, scapular set, neutral pelvis) with tactile cues at chin, shoulder and thoracic spine and verbal cues provided by therapist.
- Hold 10–30 seconds, relax 5–10 seconds, 10 repetitions (before and after exercises).

✓ *Exercise Protocol Execution:*

- Deep Cervical Flexor Activation- Gentle chin tuck (nod yes) without neck flexion or SCM activation.
- Scapular Retraction- Participant is asked to Pull bilateral shoulder blades together then slide downward avoiding elevation.
- Thoracic Extension Mobilization- Participant clasped hands behind head gently extend upper back and ask to look slightly upward, avoid lumbar extension.
- Stretching Pectoralis major/minor- Standing in corner with forearm on wall, lean forward until comfortable stretch is felt.
- Stretching Upper Trapezius Muscle- Passively patient neck is bended on one side until a comfortable stretch is felt in upper back
- All these exercises are done with hold-20 sec, relax-10 sec, repetitions 10 x 2 sets, only stretching 3 -4 repetitions bilaterally.

✓ *Motor Control Reinforcement Phase:*

- Therapist corrects posture, maintains posture, performs slow arm elevation 90° and return to neutral.
- Speed- 5 sec up and 5 sec down, hold- 15 sec, relax- 10 sec, repeat- 10 times.

- *Group B*

Same as group A intervention and additional as below-

✓ *Functional PNF Integration:*

✓ *Scapular Pattern Training:*

- Anterior Elevation Pattern- ask participant to move shoulder in posterior depression in side-lying position and then therapist moves scapula forward, upward, around rib cage against resistance.
- Command- Lift shoulders up towards nose.
- Posterior Depression Pattern- Ask Participant to move shoulder in anterior elevation in side-lying position and then therapist moves scapula upward-forward; patient moves scapula back and down toward spine against resistance. Command- Pull shoulder blades down and back.

✓ *Cervical Stabilizing Reversals:*

- Therapist places hands on forehead and occiput alternatively and gentle resistance is applied forward and backward without visible head movement (co-contraction). Command- Hold, don't let me move you.

✓ *Rhythmic Initiation:*

- Patient sitting/standing; therapist positioned diagonally along PNF pattern.

Sequence: Passive → Active-assisted → Active → Active against resistance. Commands: "Relax" → "Help me" → "Do it yourself" → "Now hold."

Hold- 5-10 sec, relax-5 to 10 sec, repeat-Bilateral 10 reps.

➢ *Diagonal Movement Patterns:*

- *D1 Pattern*

✓ *Upper Limb D1 Flexion Pattern:*
Start position for D1 Flexion = D1 Extension

- Movement: Shoulder elevation+ flexion + adduction + external rotation + Elbow Flexion + Forearm supination + Wrist flexion + wrist radial deviation + Finger flexion + Thumb adduction.

Command = "Pull up and across."

- *Upper Limb D1 Extension Pattern:*
Start position for D1 Extension = D1 Flexion

- Movement: Shoulder depression + Extension + Adduction + Internal rotation + Elbow Extension + Forearm pronation + Wrist extension + wrist ulnar deviation + Finger extension + Thumb abduction.

Command = "Push down and out."

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✓ *D2 Pattern*

- *Upper Limb D2 Flexion Pattern:*
  Start position for D2 Flexion = D2 Extension

- Movement: Shoulder elevation+ flexion + Abduction + external rotation + Elbow Flexion + Forearm supination + Wrist extension + wrist radial deviation + Finger extension + Thumb adduction.

Command = "Lift up and open."

- *Upper Limb D2 Extension Pattern:*
  Start position for D2 Extension = D2 Flexion

- Movement: Shoulder depression + Extension + Adduction + Internal rotation + Elbow Extension + Forearm pronation + Wrist flexion + wrist ulnar deviation + Finger flexion + Thumb abduction.

Command = "Pull down and across."

Resistance- Applied along diagonal pattern.

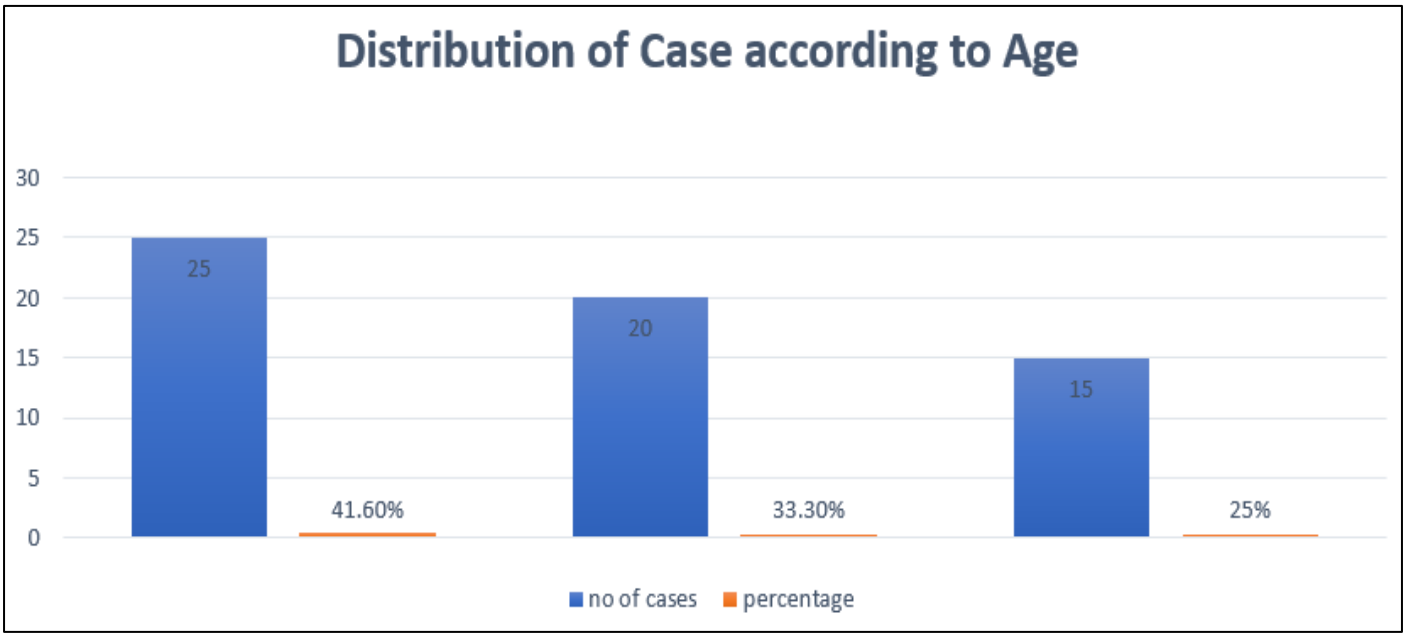
Hold- 5-10 sec at end range, Relax- 5 sec, Repetitions- 10 reps x 2 sets.

III. DATA ANALYSIS

The data analysis was done using Microsoft Excel, and all statistical analyses were conducted using the latest version of IBM SPSS Statistics software. Descriptive statistics were used to summarize demographic data (age and gender) and clinical outcome measures: Neck Pain and Disability (NPAD) Scale, both pre- and postintervention. Measures such as mean, median, standard deviation, range, and confidence intervals were reported.

Table 1 Distribution of Cases According to Age

Sr. No.	Age group (Years)	Number of cases N	Percentage %
1	25 to 31	25	41.6 %
2	32 to 38	20	33.3 %
3	39 to 45	15	25%
Total		60	100 %



Graph 1 Distribution of Case According to Age

Table 2 Distribution of Case according to Gender

Sr. No.	Gender	Number of cases N	Percentage %
1	Male	40	66.6 %
2	Female	20	33.3 %
Total		60	100 %

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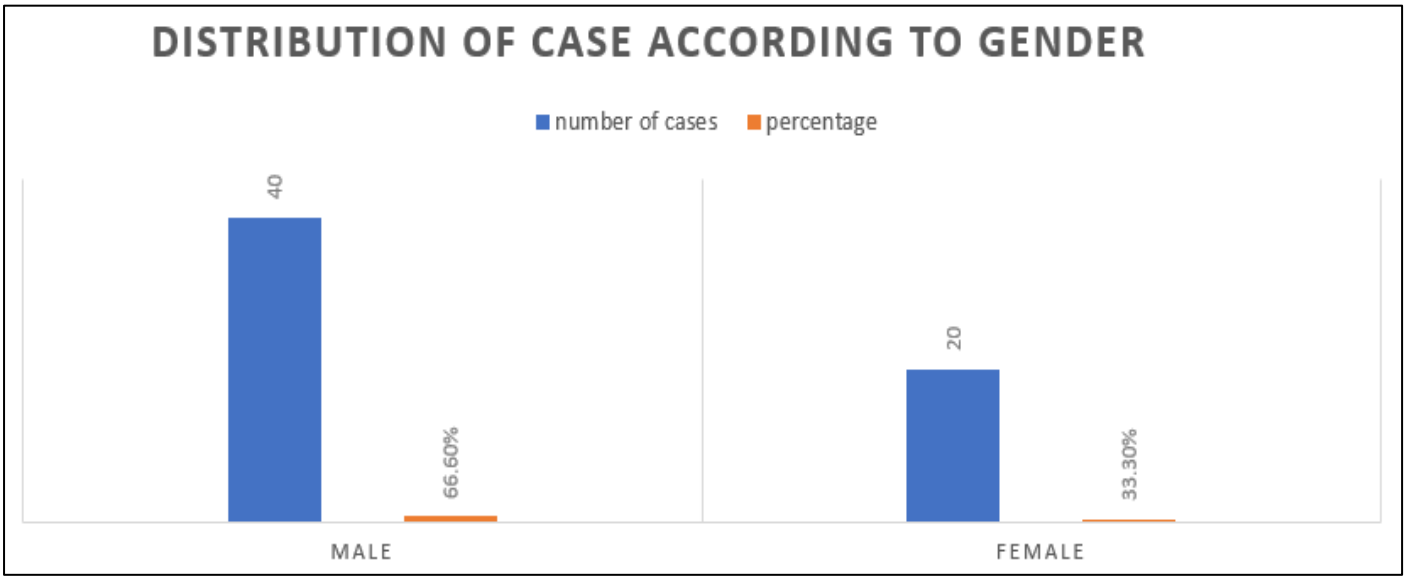


Graph 2 Distribution of Cases according to Gender

Table 3 Comparison of Pre-Intervention and Post-Intervention NPAD Scores Between Both Groups

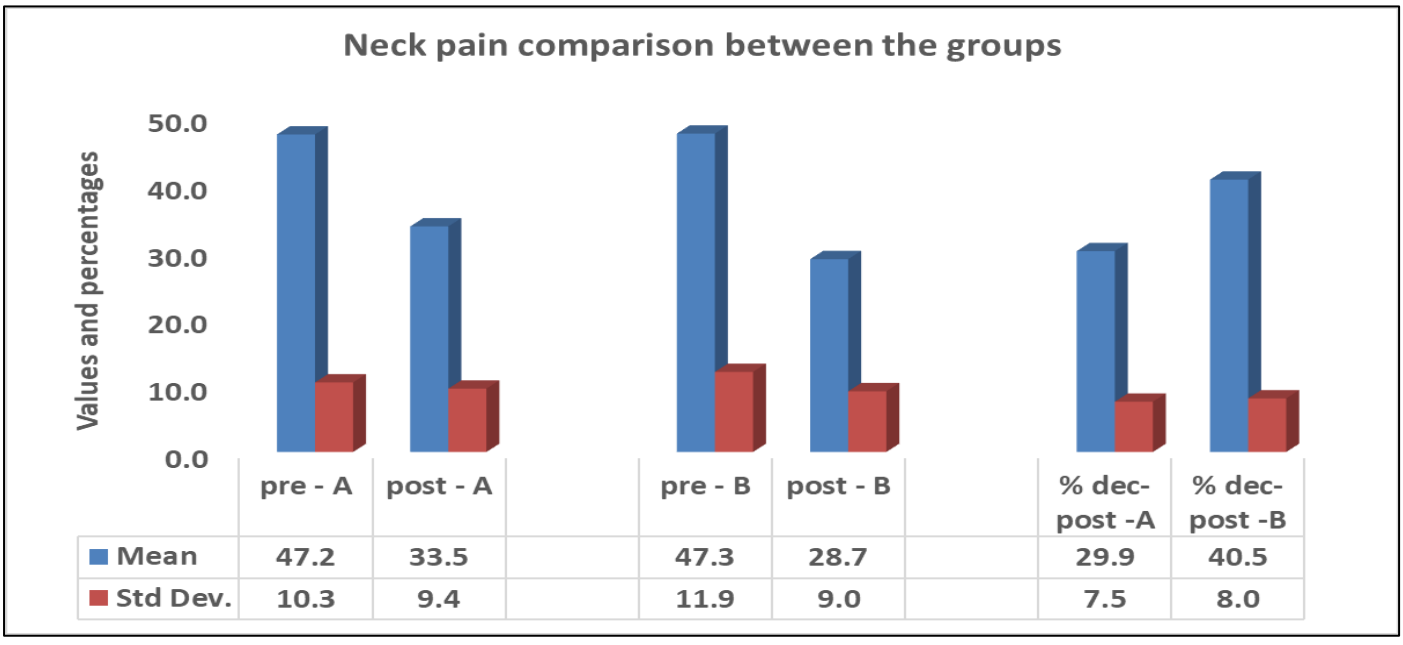
Sr. No.	Variable	Mean	Standard Deviation
1	Pre-A	47.2	10.3
2	Post-A	33.5	9.4
3	Pre-B	47.3	11.9
4	Post-B	28.7	9.0
% Dec-post-A		29.9	7.5
% Dec-post-B		40.5	8.0

Table 4 Descriptive Statistics of Pre-Intervention and Post-Intervention NPAD Scores Between Both Groups

Variable	Mean	Std Dev	Std Err	Lower 95% CL	Upper 95% CL	N
% dec in post neck pain-group A	29.9	7.5	1.4	27.067	32.648	30
% dec in post neck pain-group B	40.5	8.0	1.5	37.516	43.466	30

1-Tailed t-Test (% Dec in Post Neck Pain-Group AB > % Dec in Post Neck Pain-Group A)

Ho.Diff	Mean Diff	SE diff	T	DF	P
0.000	10.633	1.994	5.332	58	0.000



Graph 3 Comparison of Pre-Intervention and Post-Intervention NPAD Scores Between Both Groups

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Table 5 Comparison of Pre-Intervention and Post-Intervention MMT Scores Between Both Groups

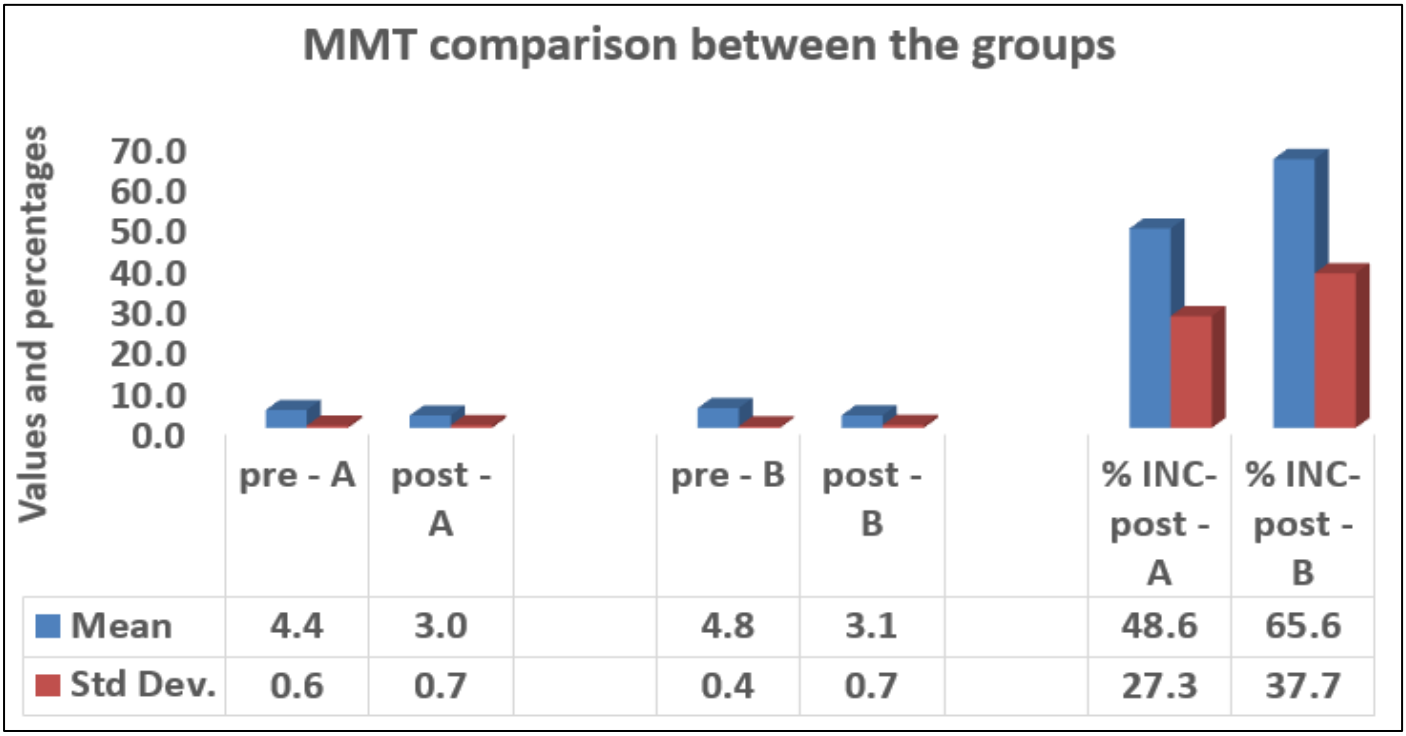
Sr. No.	Variable	Mean	Standard Deviation
1	Pre-A	4.4	0.6
2	Post-A	3.0	0.7
3	Pre-B	4.8	0.4
4	Post-B	3.1	0.7
% INC-post-A		48.6	27.3
% INC-post-B		65.6	37.7

Table 6 Descriptive Statistics of Pre-Intervention and Post-Intervention MMT Scores Between Both Groups

Variable	Mean	Std Dev	Std Err	Lower 95% CL	Upper 95% CL	N
% INC in post neck pain-group A	48.6	27.3	5.0	38.435	58.788	30
% INC in post neck pain-group B	65.6	37.7	6.9	51.479	79.632	30

1-Tailed T-Test (% INC in Post MMT-Group B > % INC in Post MMT-Group A)

Ho.Diff	Mean Diff	SE diff	T	DF	P
0.000	16.944	8.493	1.995	58	0.026



Graph 4 Comparison of Pre-Intervention and Post-Intervention MMT Scores Between Both Groups

IV. RESULT

The study included 60 participants aged 25–45 years, with the majority in the 25–31 years group (41.6%), followed by 32–38 years (33.3%) and 39–45 years (25%); males constituted 66.6% (n=40) and females 33.3% (n=20). In Group A (Mirror Biofeedback), the mean NPAD score reduced significantly from 47.20 ± 10.34 to 33.53 ± 9.42 (mean difference = 13.67; $p < 0.001$), while in Group B (Mirror Biofeedback + Functional PNF), it decreased from 47.33 ± 11.90 to 28.70 ± 9.0 (mean difference = 18.66; $p < 0.001$). The percentage reduction was greater in Group B (40.49%) compared to Group A (29.86%), indicating superior improvement in the combined intervention group. Regarding muscle strength, Group A showed a significant increase in MMT scores from 3.0 ± 0.6 to 4.4 ± 0.6 ($p < 0.001$), whereas Group B improved from 3.1 ± 0.7 to 4.8 ± 0.4 ($p < 0.001$). Post-intervention comparison revealed significantly higher MMT scores in Group B than Group A (4.8 ± 0.4 vs 4.4 ± 0.6; $p = 0.00026$), with percentage increases of 65.6% and 48.6%, respectively. Overall, both interventions were effective, but the combination of Mirror Biofeedback with Functional PNF demonstrated greater improvement in reducing neck pain and enhancing muscle strength among individuals with Upper Cross Syndrome.

V. DISSCUSION

The present study compared the effectiveness of mirror biofeedback alone and mirror biofeedback combined with functional PNF in individuals with Upper Cross Syndrome (UCS), a condition characterized by muscular imbalance,

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forward head posture, rounded shoulders, and associated neck pain and functional limitations. Given the increasing prevalence of sedentary lifestyles and prolonged screen exposure, identifying an effective rehabilitation strategy for UCS is clinically important.

Mirror biofeedback alone proved effective in reducing pain and improving functional outcomes. [11] By providing real-time visual feedback, it enhanced postural awareness, enabled active self-correction, and improved motor control and neuromuscular coordination. Repeated visual correction likely facilitated motor relearning and cortical reorganization, contributing to sustained improvements. Its simplicity, low cost, and ease of application make it a valuable tool in both clinical and home-based settings.

The addition of functional PNF provided further benefits. Through diagonal and functional movement patterns, PNF enhanced proprioception, muscle activation, strength, coordination, and joint mechanics. It helped activate weak muscles, inhibit tight muscles, and restore proper muscle sequencing—key factors in correcting the muscular imbalance seen in UCS.

Participants receiving the combined intervention demonstrated greater improvements than those receiving mirror biofeedback alone. This suggests a synergistic effect, where mirror therapy enhances conscious postural correction while PNF improves automatic neuromuscular responses and movement efficiency. Together, they address both voluntary and reflex components of motor control.

Both groups showed reduction in pain and improvement in muscle strength; however, the combined group achieved superior outcomes. Pain reduction may be attributed to improved posture, decreased muscular tension, better biomechanical alignment, and possible neural modulation effects from proprioceptive stimulation. Greater improvements in muscle strength indicate enhanced muscle recruitment and functional carryover with PNF.

The findings emphasize the importance of a multimodal rehabilitation approach, as UCS involves complex factors including muscular imbalance, impaired motor control, altered proprioception, and faulty posture habits. A single modality may not adequately address all components. Integrating mirror biofeedback with functional PNF enhances treatment efficiency, supports individualized rehabilitation planning, and may reduce recurrence rates.

The results are consistent with previous research supporting combined physiotherapy interventions and mirror-based rehabilitation for improving motor performance and cortical activation. Clinically, incorporating both techniques offers a practical, cost-effective, and evidence-based strategy. Early intervention along with patient education on posture, ergonomics, and corrective exercises is essential for long-term maintenance and prevention of symptom progression.

VI. CONCLUSION

The present study concludes that both mirror biofeedback alone and mirror biofeedback combined with functional PNF are effective in reducing pain, improving functional disability, enhancing muscle strength, and correcting postural alignment in individuals with Upper Cross Syndrome. However, the combined intervention demonstrated significantly superior outcomes across all measured variables. While mirror biofeedback improved postural awareness, motor control, and alignment through visual feedback, the addition of functional PNF further enhanced proprioceptive stimulation, neuromuscular coordination, and muscle activation, producing a synergistic therapeutic effect.

Therefore, integrating mirror biofeedback with functional PNF represents a more effective, practical, and evidence-based rehabilitation strategy for managing Upper Cross Syndrome and promoting long-term functional improvement.

ABBREVIATIONS

UCS - Upper Cross Syndrome
NPAD – Neck Pain And Disability SCALE
PNF – Proprioceptive Neuromuscular Facilitation
MET – Muscle Energy Technique
MT – Mirror Therapy

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