Review Article

Allied Medical Research Journal
Vol:3 No.1:144-152

Functional Improvement in Patients with Non-Specific Neck Pain: A Meta-Analysis of Muscle Energy Technique and Proprioceptive Neuromuscular Facilitation

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ABSTRACT

Background: Neck pain is a common musculoskeletal disorder with significant societal and individual consequences. Proprioceptive Neuromuscular Facilitation (PNF) and Muscle Energy Technique (MET) are two physical therapy techniques that have shown potential in treating non-specific neck pain. This meta-analysis aims to evaluate the relative efficacy of PNF and MET to improve proprioception accuracy, minimize pain, and reduce disability in non-specific neck pain.

Methods: A thorough search was conducted across several databases, including Web of Science, PEDro, MEDLINE, Cochrane Library, EMBASE, and Google Scholar. Studies conducted between 2013 and 2023 assessed MET and PNF's effects on functional improvement in patients with non-specific neck pain were considered. The criteria for Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) were followed. Cochrane criteria were used to evaluate the risk of bias.

Results: Ten studies—five for the PNF and five for the MET interventions—met the inclusion criteria. The Neck Disability Index (NDI) and pain were subject to varying and non-significant effects from PNF. On the other hand, even with heterogeneity, MET showed a significant decrease in NDI scores and neck discomfort. The risk of biased study revealed that different studies' levels of methodological quality varied. The analyses were performed on MedCalc statistical software.

Conclusion: PNF has inconclusive effects on non-specific neck pain and NDI, necessitating further research. In contrast, MET effectively reduces neck pain and improves NDI, emphasizing its potential as a therapeutic approach for non-specific neck discomfort.

Keywords: Neck pain, Muscle energy technique, Proprioceptive neuromuscular facilitation, Quality of life.

Received: October 17, 2024**; Revised:** January 8, 2025**; Accepted:** January 20, 2025

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DOI: https://doi.org/10.59564/amrj/03.01/023

INTRODUCTION

One of the most prevalent musculoskeletal disorders is neck pain, which has a prevalence of around 42%–67% over 12-months. According to the Global Burden of Disease (GBD)[1], low back and neck pain ranks second among the population aged 20 to 24 in terms of years lived with disability (YLD)[1]. Moreover, data indicate a 21% rise in the prevalence of non-specific neck pain between 2006 and 2016[2]. Neck discomfort has far-reaching consequences, including disability, diminished quality of life, and increased economic influence, impacting both people and society owing to healthcare expenditures, insurance costs, productivity loss, and increased sick leave. The management of non-specific neck pain has been successfully achieved using physical therapy methods on numerous occasions[3].

Proprioceptive Neuromuscular Facilitation (PNF) and Muscle Energy Technique (MET) are two of the most successful techniques currently use[4]. Despite their potential to alleviate neck discomfort, a firm grasp of whether these strategies outperform standard therapies to enhance proprioception accuracy, lower pain, and minimize impairment remains elusive[5]. PNF training is highly suggested for improving sensorimotor control and promoting muscular proprioception. PNF uses basic techniques like rotating patterns and additional strategies, including rhythmic stabilization, dynamic

reversals, and combining isotonic, repetitive contractions and contract-relax to improve muscle strength, flexibility, and overall mobility[6]. The primary goal of PNF is to maximize functional levels by enhancing muscle strength, joint coordination, stability, mobility, and movement control.

On the other hand, the MET is an active manual treatment that includes isometric, concentric, and eccentric contractions, providing a dynamic range of muscle activation to address reduced joint mobility[7,8,9]. The therapy can help relieve muscle rigidity or weakness and reduce localized edema by activating regular muscular movements. MET enables isometric contractions and post-isometric relaxation by lowering sympathetic tone via fascial stimulation and localized vasodilation and promoting reciprocal agonist muscle inhibition via Golgi tendon organ activation[10]. MET uses isotonic eccentric or concentric contractions as a hands-on therapy to align with or overcome the patient's effort, producing muscular stretching, strengthening, and relaxation[11,12,13]. Therefore, MET can be a rehabilitative therapy strategy for treating non-specific neck discomfort to reduce pain and restore normal joint mobility. Evidence suggests that two physical therapy-based interventions for non-specific neck pain are PNF and MET.

Therefore, a meta-analysis is warranted to ascertain the effectiveness of these two treatments in reducing discomfort and decreasing disability in non-specific neck pain. By pooling data from different studies, this meta-analysis is aimed to give a thorough knowledge of the relative efficacy of PNF and MET in treating non-specific neck pain, thereby educating healthcare professionals for better patient outcomes.

METHODOLOGY

Electronic Repositories and Search Strategies

Two impartial reviewers conducted multi-database searches using "Google Scholar, PeDro, MEDLINE, Cochrane Library, EMBASE, and Web of Science." MeSH phrases such as "manual therapy, proprioceptive neuromuscular facilitation, neck pain" were utilized to locate research articles examining the impact of MET and PNF treatments on individuals with non-specific neck pain.

Criteria of Study Inclusion and Exclusion

Studies evaluating the effects of the MET and PNF approach on functional improvement in patients with non-specific neck pain have been selected. All research carried out between 2013 and 2023 that fulfilled these requirements was considered for inclusion. The meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Figure-1).

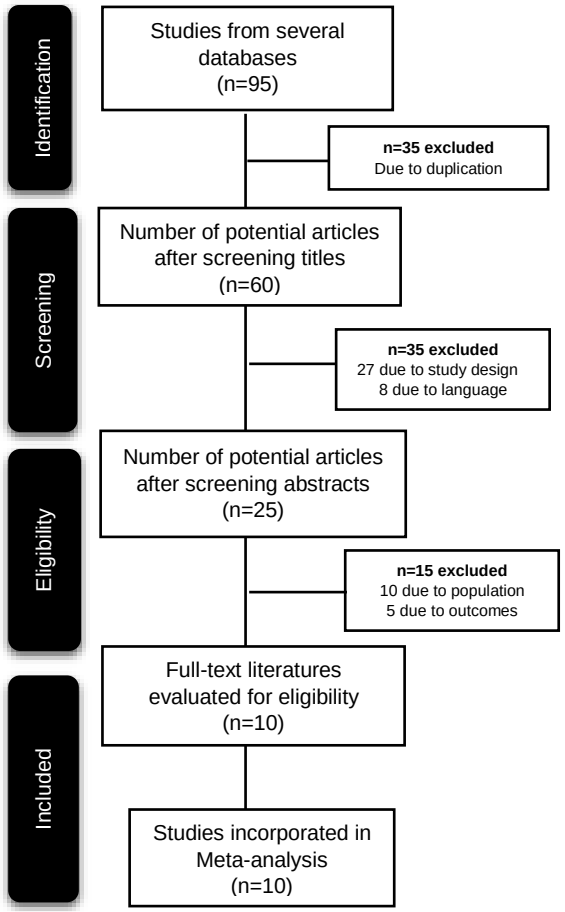

Fig.1 Flow chart based on guidelines of PRISMA

Trials using treatment protocols other than MET and PNF methods and any data not reported in English were excluded from this meta-analysis. Furthermore, papers for which contacting the respective authors via email was unsuccessful in obtaining open access were omitted. A data extraction form was designed to systematically obtain research details, including author names,

publication years, targeted populations, and treatment durations (Table-1).

Table-1 Studies Incorporated for the Purpose of Meta-Analysis

Author & Year of Publication	Sample Size	Target Population	Study Design	Age in Years	Intervention		Outcome
					Intervention Group	Control Group	
Studies in which PNF Techniques were used							
Suresh et al. 2023[14]	66	Chronic Mechanical Neck Pain	RCT	18-60 years	PNF	Cranio-cervical flexor training	NPRS NDI
Gashi et al. 2023[15]	30	Cervical Radiculopathy	RCT	20-80 years	PNF	Myofascial release	NDI VAS
Bansal et al. 2020[16]	60	Cervical Spondylosis	RCT	45-65 years	PNF	Motor Control Therapeutic Exercises	VAS NDI
Matho et al. 2019[17]	20	Chronic Non Specific Neck Pain	RCT	25-40 years	PNF	Deep Cervical Flexors	VAS
Lee et al. 2013[18]	32	Myofascial Pain Syndrome	RCT	25-50 years	PNF	General Physical Therapies	VAS NDI
Studies in which MET were used							
Samiullah et al. 2022[19]	46	Mechanical Neck Pain	Experimental study	30-50 years	MET	Routine Physical Therapy	VAS NDI
Nazir et al. 2022[20]	30	Mechanical Neck Pain	RCT	18-55 years	MET	DNF	VAS NDI
Seemal et al. 2022[21]	22	Text Neck Syndrome	RCT	18-35 years	MET + Bowen Therapy	MET alone	VAS NDI
Joshi et al. 2022[22]	48	Non-specific chronic neck pain	RCT	21-60	MET	Control	VAS NDI
Siddiqui et al. 2022[23]	80	Neck Pain	RCT	20-50 years	MET RI	MET AI	VAS NDI

EG denotes Experimental group performed interval training exercises
CG denotes Control Group performed continuous exercises or no exercises
PNF: Proprioceptive Neuromuscular Facilitation
MET: Muscle Energy Technique

Risk of Bias Assessment

The risk of bias was evaluated in the included studies using the Cochrane tool's criteria. An analysis of the risk associated with allocation was part of this assessment, taking randomization and concealment into account. In addition, the authors considered data evaluation (looking at completeness and selective reporting), blinding factors (both for participant engagement and outcome assessment), and other kinds of bias.

Statistical Analysis

Version 20.112 of MedCalc Statistical Software was used for the quantitative analysis. A Continuous Measure Analysis was conducted to determine the pooled impact using a 95% Confidence Interval (CI) and the Standardized Mean Difference (SMD). Using Cohen's rule of thumb, the effect size was assessed and divided into three categories: small (0.2 to 0.5), moderate (0.5 to 0.8), and significant (>0.8). The degree of heterogeneity was evaluated using the I^2 value (I^2<50 for fixed effect, I^2>50 for random effect) to determine whether to use a random or fixed-effect model.

RESULTS

Study Flow

Six database searches yielded a total of n=95 articles in the initial search. A total of 60 articles were left for additional review after the titles were screened. Following the abstract screening, n=25 research was deemed appropriate for full-text publications; ultimately, n=10 studies satisfied the inclusion requirements; of these, 5 studies dealt with PNF approaches and 5 with MET-based interventions for treating neck pain.

Pool Effects of PNF

Intervention on Pain and NDI

Various findings have been identified in the meta-analysis of studies evaluating PNF's impact on patients with non-specific neck pain. Using the fixed and random effects models, the pooled effect size was determined to be -0.0867 and -0.242, respectively. With an I^2 value of 81.35%, the studies' heterogeneity was noticeably high and indicated significant inconsistency. Even if the individual research findings varied, the study does not offer solid proof that PNF has a meaningful impact on non-specific neck pain. More research is needed to understand better the complicated effects of PNF methods on this specific group of patients (Table-2).

Furthermore, a meta-analysis examining the impact of PNF on the NDI in patients presenting with non-specific neck pain yielded all non-significant results. The fixed and random effects models produced a pooled effect size of 0.0232, and the 95% confidence interval included the range of -0.260 to 0.306. The study was statistically significant, which is crucial for PNF in NDI, and the results of the fixed and random effects models were equivalent. It has not been demonstrated to have an effect. With an I2 score of 0.00%, the studies' heterogeneity was negligible, indicating consistency in the findings. The test of heterogeneity's p-value of 0.8298 provided additional evidence that the included studies' variability was not statistically significant. Based on this meta-analysis, it can be concluded that there is not enough evidence overall to indicate a substantial impact of PNF on the NDI Index in people with non-specific neck pain. (Table-2).

Table-2 Pool Effects of PNF on Pain

Studies	N1	N2	Total	SMD	Standard Error	95% Confidence Interval	t	P	Fixed Model	Random Model
Suresh et al. 2023	33	33	66	-0.0910	0.243	-0.577 to 0.395	-	-	32.95	22.27
Gashi et al. 2023	15	15	30	-1.844	0.428	-2.719 to -0.968	-	-	10.68	17.93
Bansal et al. 2020	30	30	60	0.454	0.258	-0.0626 to 0.971	-	-	29.29	21.95
Matho et al. 2019	10	10	20	0.000	0.428	-0.900 to 0.900	-	-	10.65	17.91
Lee et al. 2013	16	16	32	0.0432	0.345	-0.661 to 0.747	-	-	16.44	19.94
Total (fixed effects)	104	104	208	-0.0867	0.140	-0.362 to 0.189	-0.620	0.536	100.00	100.00
Total (random effects)	104	104	208	-0.242	0.337	-0.907 to 0.422	-0.719	0.473	100.00	100.00
Test for heterogeneity										
Q	21.45	**DF**	4	**P-value**	0.003	**I^2 Consistency**	81.35	**95/% CI**	56.67 to 91.98%	
Pool Effects of PNF on NDI										
Suresh et al. 2023	33	33	66	-0.00477	0.243	-0.491 to 0.481			34.82	34.82
Gashi et al. 2023	15	15	30	0.0873	0.355	-0.641 to 0.815			16.31	16.31
Bansal et al. 2020	30	30	60	0.160	0.255	-0.351 to 0.671			31.63	31.63
Lee et al. 2013	16	16	32	-0.233	0.346	-0.939 to 0.474			17.23	17.23
Total (fixed effects)	94	94	188	0.0232	0.144	-0.260 to 0.306	0.162	0.872	100.00	100.00
Test for Heterogeneity										
Q	0.88	**DF**	3	**P-value**	0.82	**I^2 Consistency**	0.00	**95/% CI**	0.00 to 56.08%	

Pool Effects of MET

Intervention on Pain and NDI

The results of this meta-analysis, which examined the effects of MET on non-specific neck pain, were noteworthy and reliable. The fixed effects model and the random effects model yielded a pooled effect size of -0.601 and -0.717, respectively, with a 95% confidence range for the fixed effects model of -0.886 to -0.316. The outcomes showed that MET had a statistically significant effect in reducing generalized neck discomfort. An I2 score of 93.89% revealed significant variability in the analysis of the heterogeneity test. Despite its variability, All results confirmed MET's effectiveness in reducing non-specific neck pain. Further studies may be needed to understand better the causes of heterogeneity in this setting and the unique effects of MET.

Furthermore, the results of the meta-analysis on the effect of MET on NDI in individuals with non-specific neck pain were significant and consistently permanent. Pooled effect sizes for the fixed effects and random effects models emerged at -0.630 and -0.649, respectively, with 95% confidence intervals ranging from -0.913 to -0.347 for the fixed effects model. The outcomes showed that MET had a statistically significant effect on NDI scores. With an I2 score of 93.07%, the test for heterogeneity revealed considerable diversity among the studies. Despite the observed variability, the overall results—demonstrated by the significant decrease in NDI scores throughout the included studies—strongly indicate the effectiveness of MET in treating non-specific neck pain (Table-3).

Table-3 Pool Effects of MET on Pain

Studies	N1	N2	Total	SMD	Standard Error	95% Confidence Interval	t	P	Fixed Model	Random Model
Samiullah et al. 2022	23	23	46	-2.558	0.394	-3.352 to -1.764			13.50	19.81
Nazir et al. 2022	15	15	30	1.714	0.419	0.856 to 2.571			11.96	19.60
Seemal et al. 2022	11	11	22	-1.494	0.468	-2.471 to -0.518			9.56	19.17
Joshi et al. 2022	23	25	48	-1.102	0.306	-1.717 to -0.487			22.42	20.46
Siddiqui et al. 2022	40	40	80	-0.166	0.222	-0.607 to 0.276			42.56	20.96
Total (fixed effects)	112	114	226	-0.601	0.145	-0.886 to -0.316	-4.152	<0.001	100.00	100.00
Total (random effects)	112	114	226	-0.717	0.618	-1.934 to 0.500	-1.162	0.247	100.00	100.00
Test for heterogeneity										
Q	**65.45**	**DF**	**4**	**P-value**	**0.001**	**I^2 Consistency**	**93.89**	**95/% CI**	**88.61 to 96.72**	
Pool Effects of MET on NDI										
Samiullah et al. 2022	23	23	46	-2.327	0.378	-3.089 to -1.565			14.43	19.85
Nazir et al. 2022	15	15	30	1.721	0.419	0.862 to 2.579			11.74	19.47
Seemal et al. 2022	11	11	22	-1.204	0.449	-2.139 to -0.268			10.25	19.18
Joshi et al. 2022	23	25	48	-1.102	0.306	-1.717 to -0.487			22.07	20.47
Siddiqui et al. 2022	40	40	80	-0.312	0.223	-0.756 to 0.131			41.52	21.04
Test for Heterogeneity										
Q	**57.68**	**DF**	**4**	**P-value**	**<0.001**	**I^2 Consistency**	**93.07**	**95/% CI**	**86.77 to 96.37%**	

Quality Appraisal and Risk of Bias

The risk of bias was evaluated using the Cochrane tool to assess the risk of bias in the following domains, as shown in Table-4.

Random Sequence Generation

Nine studies showed a low risk of bias as they followed a randomization sequence[14,15,16,17,18,20,21,22,23], whereas one study[19] showed a high risk of bias.

Allocation Concealment

Four studies[14,17,21,23] had concealed allocation of participants, five studies[16,18,19,20,22] had unknown risk in allocation concealment, and one study showed high risk of bias[15].

Blinding of Participants and Personnel

Two studies[17,23], considered participant and personnel blinding; one study[15] showed a high risk of bias, whereas seven studies, [14,16,18,19,20,21,22] showed an unknown risk of bias.

Blinding of Outcome Assessment

Six studies [15,17,22,23] showed a high risk of bias, whereas six studies [14,16,1819,20,21] showed an unknown risk.

Incomplete Outcome Data

One study[19] showed a high risk of bias, while the remaining had a low risk.[14,15,16,17,18,20,21,22,23.]

Selective Reporting

A low risk of reporting bias was demonstrated in all ten studies[14,15,16,17,18,19,20,21,22,23]

DISCUSSION

The meta-analysis revealed inconsistent findings regarding the effects of PNF on non-specific neck pain. The pooled effect sizes (-0.0867 and -0.242) derived from fixed and random effects models lacked statistical significance, indicating limited evidence to support PNF's efficacy. Significant differences between studies were marked by high heterogeneity (I^2=81.35%), emphasizing the need for more studies to understand better the complex effects of PNF technique in this patient population.

The effect of PNF on NDI was also reviewed, but the findings were not statistically significant. This revealed insufficient data on whether PNF significantly affects NDI in individuals with non-specific neck pain.

Table-4 Estimation of Risk of Bias through Cochrane's Tool

Author' Year	Selection Bias		Blinding of Outcome Assessment		Attrition Bias	Reporting Bias
	Random Sequence Generation	Allocation Concealment	Participants	Personnel	Incomplete Outcome Data	Selective Reporting
Suresh et al. 2023[14]	+	+	?	?	+	+
Gashi et al. 2023[15]	+	-	-	-	+	+
Bansal et al. 2020[16]	+	?	?	?	+	+
Mahto et al., 2019[17]	+	+	+	-	+	+
Lee et al. 2013[18]	+	?	?	?	+	+
Samiullah et al. 2022[19]	-	?	?	?	-	+
Nazir et al. 2022[20]	+	?	?	?	+	+
Seemal et al. 2022[21]	+	+	?	?	+	+
Joshi et al. 2022[22]	+	?	?	-	+	+
Siddiqui et al. 2022[23]	+	+	+	-	+	+

+ Low Risk of Bias
- High Risk of Bias
? Unknown Risk of Bias

The fixed and random effects models yielded a pooled effect size of -0.601 and -0.717, respectively, indicating a statistically significant reduction in generalized neck pain, although there was a large variability (I^2=93.89). %) in the treatment of non-specific neck pain, though the overall results confirm the benefits of MET. Further studies are needed to understand the causes and effects of differences in this condition; the specificity of MET is well understood. Significant and reliable results were also obtained from a meta-analysis that examined the effect of MET on the NDI in subjects with non-specific neck pain, yielding a cumulative effect size of -1.0.630 and -0.649 in both fixed and random effects models, where fixed effect. The fixed effect model had a 95% confidence range from -0.913 to -0.347. The study clearly showed that MET statistically significantly reduces neck disability index scores. The overall results demonstrated the effectiveness of MET in treating non-specific neck pain despite significant heterogeneity (I^2=93.07%), and the authors called for more investigation into the causes of variability. In a study conducted to determine the effects of MET versus deep neck flexor training, the study finds that when compared with the muscle energy approach, deep neck flexor training significantly improves pain, functional impairment (as judged by NDI), and range of motion (as measured by a goniometer) in individuals with mechanical neck discomfort[20]. Another research examining MET's effects on mechanical neck pain reported that the group getting METs in addition to RPT showed a statistically significant and more considerable improvement than the RPT-only group. Similarly, the functional status measured by the NDI in the METs plus RPT group showed a more notable improvement. The results indicate that, for those with mechanical neck discomfort, combining MET with standard physical therapy is a more effective way to reduce pain and enhance functional outcomes than just using standard physical therapy[19]. Another research compared the benefits of PNF exercise and deep cervical strengthening exercise utilizing pressure biofeedback on non-specific neck pain. It was found that there was no statistically significant difference between the two approaches in terms of pain reduction (VAS)[17]. In another study, the authors compared the benefits of PNF methods with Craniocervical Flexor Training (CCFT) on pain and function throughout a 4-week intervention. The NDI and Numerical Pain Rating Scale showed statistically significant improvements in both groups. According to the study's findings, PNF therapy reveals pain as estimated using VAS among chronic mechanical neck pain patients and similar findings were observed in the CCFT group[14]. More studies with bigger sample sizes and varied demographics are advised to improve the generalizability of findings. It would also be beneficial to investigate the therapies' long-term effects on chronic neck pain that were the subject of this meta-analysis.

CONCLUSION

The meta-analysis showed PNF had variable and non-significant effects on the ND) and non-specific neck pain. The PNF studies showed high variability, indicating that further research is necessary to understand its complicated effects on this patient population. However, MET demonstrated notable and sustained efficacy in lowering non-specific neck pain and increasing NDI scores. Despite observed heterogeneity, the considerable reduction in NDI ratings across trials and the significant pooled effect sizes highlight the general effectiveness of MET in treating non-specific neck pain. More studies are recommended better to understand the distinctive contributions of MET in this environment and investigate the origins of heterogeneity.

Strengths and Limitations

This study is rigorous due to its broad measurement of hip and knee muscle strength from the surgery and non-surgery side, giving the complete picture of recovery. Additionally, the measurements of strength could be objective, thus increasing the reliability of the findings. The study population altogether included women, thus filling an important gap in sex-specific research regarding THA recovery. However, there are some limitations to this study. One of them is that the sample size was small, making the findings less generalizable to a broader audience. Also, although strength deficits were determined, the functional influence on performance, like gait speed or balance, could not be assessed.

Therefore, rehabilitation treatment among THA patients should not be less than 6 months complete within progressive resistance exercise

to cover existing strength deficiencies. Surgeons and physiotherapists, too, need to consider the possible effects of the direction of the hip joint on muscle recovery before considering subsequent interventions. Future studies should focus on assessing the delayed effects of specific rehabilitation programs with ambiguous designs for functional mobility and quality of living.

Acknowledgments
None.

Author Contributions
Qurat-ul-Ain Ahmad contributed to the conceptualization, literature search, study selection, and manuscript drafting. **Syed Abid Mehdi Kazmi** was responsible for study screening, quality assessment, and critical revision of the manuscript. **Sagar Kumar** assisted in data extraction, methodology evaluation, and manuscript editing. **Faisal Ali Khan** provided supervision, critical review, and final approval of the manuscript. All authors reviewed and approved the final version.

Ethical Approval
Not Applicable.

Grant Support and Funding Disclosure
None.

Conflict of Interests
None.

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