

Taylor & Francis
Taylor & Francis Group

Physiotherapy Theory and Practice
An International Journal of Physical Therapy

ISSN: 0959-3985 (Print) 1532-5040 (Online) Journal homepage: www.tandfonline.com/journals/iptp20

The efficacy of adding proprioceptive neuromuscular facilitation to conventional treatments for myogenous temporomandibular disorders: a randomized controlled trial

Gizem Ergezen Sahin , Erkin Ergezen , Sukru Can Akmansoy , Meltem Meran Caglar & Yasemin Ozkan

To cite this article: Gizem Ergezen Sahin , Erkin Ergezen , Sukru Can Akmansoy , Meltem Meran Caglar & Yasemin Ozkan (2026) The efficacy of adding proprioceptive neuromuscular facilitation to conventional treatments for myogenous temporomandibular disorders: a randomized controlled trial, Physiotherapy Theory and Practice, 42:9, 1181-1192, DOI: 10.1080/09593985.2026.2624517

To link to this article: https://doi.org/10.1080/09593985.2026.2624517

Published online: 05 Feb 2026.

Submit your article to this journal

Article views: 218

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=iptp20

PHYSIOTHERAPY THEORY AND PRACTICE
2026, VOL. 42, NO. 9, 1181–1192
https://doi.org/10.1080/09593985.2026.2624517

Taylor & Francis
Taylor & Francis Group

RESEARCH REPORT

Check for updates

The efficacy of adding proprioceptive neuromuscular facilitation to conventional treatments for myogenous temporomandibular disorders: a randomized controlled trial

Gizem Ergezen Sahin PhD, PT[a], Erkin Ergezen PhD, DDS[b], Sukru Can Akmansoy PhD, DDS[c], Meltem Meran Caglar PhD, PT[a], and Yasemin Ozkan PhD, DDS[c]

[a]Department of Physical Therapy and Rehabilitation, Faculty of Health Science, Istanbul Medipol University, Istanbul, Turkiye; [b]Department of Prosthodontics, Institute of Health Sciences, Marmara University, Istanbul, Türkiye; [c]Department of Prosthodontics, Faculty of Dentistry, Marmara University, Istanbul, Türkiye

ABSTRACT

Background: Temporomandibular disorders (TMDs) are associatedwith orofacial pain and functional limitations. Although conventionalphysiotherapy is commonly used, the additional benefits ofproprioceptive neuromuscular facilitation (PNF) remain unclear. Thisstudy investigated the effects of adding PNF to conventional exercisetherapy in individuals with myogenous TMD.

Methods: A randomized controlled trial was conducted with 66participants aged 18–65 years diagnosed with myogenic TMD.Participants were divided into two groups for 4 weeks: a traditionalexercise group (CEG) or a traditional + PNF exercise group (PNFE).Pain intensity was assessed using the Numerical Pain Rating Scale(NPRS). Patient-reported mandibular function was evaluated using theMandibular Function Impairment Questionnaire (MFIQ). Mandibularmobility was assessed using jaw range of motion measures, includingactive range of motion (AROM) parameters (pain-free opening (PFO) andmaximum unassisted opening (MUO)) and assisted active range of motion(AAROM), measured as maximum mouth opening (MMO). Evaluations wereperformed at baseline (T0) and immediately after completion of the4-week intervention (T1).

Results: From T0 to T1, pain intensity decreased significantlyin both groups ($p < .001$), with a moderate effect size indicating a greater reduction in the PNFE group ($\eta p^2 = 0.110$, $p = .043$). Patient-reported mandibular function(MFIQ), improved in both groupsover the 4-week intervention period ($p < .001$). The PNFE groupdemonstrated greater gains in jaw range of motion (MMO and MUO);however, these changes were small ($\eta p^2 = 0.021$ and $\eta p^2 = 0.002$).

Conclusion: PNF exercises, when combined with conventionalexercises, provided greater pain relief and improved ROM compared toconventional exercises alone, suggesting their potential value inTMDs rehabilitation. Further research is needed to assess long-termeffects.

ARTICLE HISTORY
Received 30 June 2025
Revised 9 January 2026
Accepted 9 January 2026

KEYWORDS
Temporomandibular joint disorders; proprioceptive neuromuscular facilitation; Rocabado exercises; orofacial pain; mandibular function

INTRODUCTION

Temporomandibular disorders (TMDs) excluding dental caries and periodontal disease, are one of the most common pathological conditions of the orofacial region and a significant public health problem (Schiffman et al., 2014). They encompass a group of musculoskeletal disorders affecting the masticatory muscles, temporomandibular joints (TMJ), and related structures, characterized by restricted mandibular movement along with orofacial pain (Machado, Trawitzki, and de Felício, 2019; Ohrbach and Dworkin, 2016). The prevalence of TMDs in the general population ranges from 10.8% to 55.9% (Valesan et al, 2021).

TMDs encompass various pain conditions with diverse clinical presentations and multifactorial origins, such as muscular hyperactivity, joint derangement, postural dysfunction, or trauma. Due to this variability, there are a number of varied treatment strategies that exist (Gil-Martínez, Paris-Alemany, López-de-Uralde-Villanueva, and La Touche, 2018). In most cases, treatment should begin with a conservative, multifaceted plan tailored to the patient's specific complaints and clinical characteristics, focusing primarily on pain reduction and functional improvement. Current evidence supports the use of multifaceted management strategies that combine conservative interventions such as therapeutic exercise, patient education, cognitive-behavioral therapy, manual techniques, and electrotherapy, with more invasive options reserved for patients with a well-defined diagnosis and etiology, when necessary (List and Jensen, 2017; Sá, Faria, and Pozza, 2024). Such invasive treatments may include intra-articular

CONTACT Gizem Ergezen Sahin gergezen@medipol.edu.tr Department of Physical Therapy and Rehabilitation, Istanbul Medipol University School of Health Science, Atatürk St. 40/16, Istanbul 34810, Turkey

© 2026 Taylor & Francis Group, LLC

injections of hyaluronic acid or platelet-rich plasma, arthrocentesis, minimally invasive surgical techniques, or intramuscular botulinum toxin administration (De la Torre Canales et al, 2024; Guarda-Nardini, De Almeida, and Manfredini, 2021).

The primary treatment option for TMDs is conservative therapy, encompassing transcutaneous electrical nerve stimulation (TENS), active range of motion (AROM) exercises, and the Rocabado 6 × 6 exercise regimen (Ferrillo et al, 2025). TENS promotes muscle relaxation and reduces pain by activating opioid receptors in the supraspinal region; AROM exercises activate descending inhibitory pain pathways, increasing proprioceptive input and circulation; and the Rocabado 6 × 6 exercise regimen alleviates pain, optimizes masticatory muscle function and upper quadrant posture by restoring physiological muscle length (De Giorgi, Castroflorio, Sartoris, and Deregibus, 2017; Núñez, Garcez, Suzuki, and Ribeiro, 2006; Shimada et al, 2019). However, despite these conservative measures being suggested, further treatment methods need to be developed and validated due to the lack of comprehensive clinical guidelines on physiotherapy in patients with TMD (Wadhokar and Patil, 2022).

Proprioceptive Neuromuscular Facilitation (PNF) is a widely used manual therapy method designed for the rehabilitation of individuals experiencing pain (Areeudomwong and Buttagat, 2019). This approach facilitates body movement through diagonal contraction patterns to enhance functionality, while manual resistance is applied to generate contractions in stronger muscle groups, thereby assisting weaker areas in moving more effectively and with minimal pain (Kabat and Knott, 1953). By enhancing muscle compliance and dynamic range of motion, PNF generates a superior neuromuscular response that optimizes functional movement (Hindle, Whitcomb, Briggs, and Hong, 2012; Wanderley et al, 2019). PNF has been consistently shown to improve ROM, increase functional capacity, and reduce pain intensity in various populations and pathological conditions (Gao et al, 2023; Lazarou, Kofotolis, Pafis, and Kellis, 2018; Lin et al, 2022). Various PNF techniques are used to achieve therapeutic outcomes (Kofotolis and Kellis, 2006). One of these techniques is rhythmic stabilization (RS), which involves isometric contractions in different directions against manual resistance, promoting stability and neuromuscular control (Adler, Beckers, and Buck, 2013). Another fundamental PNF technique is the combination of isotonics (CI), which incorporates concentric, eccentric, and isometric contractions against resistance in both agonist and antagonist muscles. This method is particularly effective for addressing muscle weakness and range of motion deficits, facilitating improvements in strength, mobility, and functional performance (Saliba, Johnson, and Wardlaw, 1992). Although hold – relax and contract – relax techniques are traditionally applied to improve passive range of motion, RS and CI were chosen in this study because they better align with the clinical profile of myogenous TMD. In these patients, functional restrictions are often linked to pain, muscular imbalance, or poor coordination rather than to structural tissue shortening (Kapos, Exposto, Oyarzo, and Durham, 2020). The RS and CI techniques focus on enhancing neuromuscular control and coordination while also promoting strength gains, which together may help reduce pain and allow more efficient mandibular motion. When incorporated alongside Rocabado's exercises, designed to correct posture and optimize joint alignment, these methods are expected to support mandibular mobility indirectly by improving stability and minimizing pain-related limitations.

Based on promising results from preliminary studies, particularly in TMDs (Ergezen, Atilgan, and Kilicaslan, 2022), the present randomized controlled trial was designed to further investigate the clinical effects of adding PNF to conventional physiotherapy. The primary purpose of the present study was to evaluate the effects of a structured 4-week intervention, combining PNF with conventional intervention, on orofacial pain, mandibular function, and AROM/AAROM in individuals with mild to severe chronic myogenous TMD and to compare the results with conventional physiotherapy methods. It was hypothesized that after the 4-week intervention, the addition of PNF techniques to conventional methods would experience significantly reduced orofacial pain, improved mandibular function, and increased jaw ROMs.

MATERIALS AND METHODS

Trial design and setting

This study employed a randomized controlled trial with a 1:1 allocation ratio, prospective design, conducted in parallel, with double blinding administered by a senior dentist acting as the assessor for group allocation of participants. Prior to data collection, the trial received approval from the university ethics committee (Decision no. E-10840098-772.02–7705/1094). This study was prospectively registered at ClinicalTrials.gov (Identifier: NCT04967131) on July 8, 2021. Adherence to reporting standards was ensured through compliance with the CONSORT guidelines (Schulz, Altman, and Moher, 2010).

The trial was conducted between January 2023 and December 2023 at the Physical Therapy and Rehabilitation Clinic of Istanbul Medipol University and Prosthodontics, Faculty of Dentistry Clinic of Marmara University. All assessments and interventions were carried out in a controlled clinical setting by certified physiotherapists and dental specialists. Participants were recruited from outpatient referrals to the university hospital's prosthodontics department.

Participants

Participants were recruited from individuals aged 18–65 who sought treatment between January 2023 and December 2023. Diagnosis of myogenous TMDs was conducted by a specialist dentist utilizing the Temporomandibular Disorders Diagnostic Criteria (DC/TMD) Axis I which classifies physical diagnoses such as myalgia, myofascial pain, disc displacement, and arthralgia based on clinical and imaging findings (Schiffman et al, 2014).

Inclusion criteria comprised patients exhibiting clinical manifestations consistent with Axis I of the DC/TMD, including myofascial pain with or without limitation in mouth opening (i), localized or myofascial pain along with heightened tension in masticatory muscles (ii), and experiencing pain in masticatory muscles within the month preceding treatment initiation (iii), transient or constant TMJ pain for more than 3 months (iv).

Exclusion criteria was as followed: a history of occlusal splint treatment (i), use of pharmacological agents known to affect muscle tone and pain intensity (ii), chronic pain conditions such as trigeminal neuralgia or fibromyalgia (iii), orthopedic, neurological, or rheumatological systemic/temporomandibular/cervical disorders impacting jaw movements (iii), orofacial rehabilitation received within the last 6 months (iv), inflammation in the oral cavity (v), pregnancy (vi) and vertigo hindering head movements during exercise (vii). Individuals who missed two consecutive sessions were excluded from the analysis of the study. Patients who were not included in the analysis continued their treatment to avoid ethical violations. All participants provided informed consent following the Helsinki Declaration and were informed of their right to withdraw from the study at any stage.

Randomization and blinding

Participants underwent randomization in a 1:1 ratio to one of two intervention groups. Random group assignments were determined using generated random numbers. Sequentially numbered index cards, each indicating a group assignment, were prepared by an investigator with no clinical involvement in the study. These index cards were folded and placed in sealed envelopes, concealed from the view of the participants. Envelopes were opened by the physiotherapist (GES) after baseline assessment and immediately before starting the treatment. The pre-evaluation and follow-up evaluations of all patients included in the study were performed by the same specialist dentist (EE). In this way, the risk of inconsistency between measurements was minimized. The treatment process of the patients was carried out by a physiotherapist (GES) at the university clinic and all interventions were standardized. Functional assessment questionnaires were filled out by the patients, but the scores were made by a blind dentist (SCA). The statistical analysis process was carried out by an analyst, who did not have any information about the patient groups. Thus, the risk of bias in the evaluation and analysis processes was minimized and the methodological reliability of the study was increased.

The first group, the conventional exercise group (CEG), received physiotherapy modalities and therapeutic exercises, while the second group, the proprioceptive neuromuscular facilitation exercise (PNFE) group, received an exercise program that included head, neck and jaw PNF exercises in addition to conventional exercises consisting of physiotherapy modalities and therapeutic exercises.

Intervention

The intervention was applied 16 sessions in total, over a 4-week period, with at least 24 hours between sessions, under the face-to-face supervision of the same physiotherapist. The traditional physiotherapy program included infrared (IR) and TENS modalities for pain relief, along with therapeutic exercises such as basic ROM exercises and Rocabado's 6 × 6 exercises targeting controlled mandibular movements against resistance, postural correction, and cervical – mandibular alignment as described in Table 1. All applications were standardized based on previously established studies and were applied to all patients by the same physiotherapist (Fertout, Manière-Ezvan, Lupi, and Ehrmann, 2022; Rocabado and Iglarsh, 1991; Wadhokar and Patil, 2022).

In addition to these conventional practices, the PNFE group applied head-neck-chin PNF exercises. Based on findings from our previous pilot study showing that PNF techniques using RS and CI reduced pain intensity and increased mouth opening in individuals with myogenous TMD (Ergezen, Atilgan, and Kilicaslan, 2022).

Table 1. Conventional approaches applied to all participants.

Approach, time	Features
Physiotherapy Modalities	
Infrared, 10 mins	From 70 cm distance
Transcutaneous Electrical Nerve Stimulation (TENS), 30 mins	Conventional TENS Continuous mode f: 70–100 Hz λ: 50 to 200 μs Intensity: Adjusted to the intensity at which the patient felt a comfortable tingling sensation. Surface electrodes on painful areas on orofacial area
Therapeutic Exercises	
ROM exercises, 10 mins • *Jaw opening with stretch* • *Active mandibular movements (opening, closing, rightward and leftward jaw translation, protrusion, and retrusion)* • *Active mandibular movements against resistance (opening, closing, rightward and leftward jaw translation, protrusion, and retrusion)*	• Sustained stretch for 10 s., 10 reps ×3 sets • 10 reps ×3 sets • Sustained movements against resistance for 6 s., 10 reps ×3 sets
Rocabado's 6 × 6 Exercises, 15 mins • *Tongue clucking* • *Controlled TMJ rotation on opening* • *Mandibular rhythmic stabilization* • *Upper cervical distraction* • *Axial extension of the cervical spine* • *Shoulder girdle retraction*	6 exercises, each with 6 repetitions Hold the positions for 10 s.

mins: Minutes, cm: Centimeter, f: Frequency, Hz: Hertz, λ: Wavelength, μs: Microsecond, ROM: Range of Motion, s.: Second, reps: Repetitions, TMJ: Temporomandibular Joint

Therefore, in this study, RS and CI techniques were applied using cervical (head-neck-chin) patterns with integrated mandibular movements to reduce pain intensity and increase functionality, which were the primary outcomes of the current study.

Two diagonal movement patterns were utilized during the PNF application. The first pattern involved head and neck motion transitioning from flexion with right rotation and right lateral flexion to extension with left rotation and left lateral flexion. The second pattern followed the reverse sequence, moving from flexion with left rotation and left lateral flexion to extension with right rotation and right lateral flexion.

During transitions from cervical flexion to extension, participants were instructed to close their mouths, elevate the tongue to the palate, and perform gentle mandibular protrusion, whereas during the return to flexion, the mouth was opened, the tongue relaxed, and the mandible retracted in a controlled downward – backward direction. These coordinated movements were intended to facilitate activation of the suprahyoid and infrahyoid musculature, thereby enhancing mandibular control, muscle balance, and cervico-mandibular coordination. The diagonal and rotational PNF patterns applied in this study were based on established cervical facilitation models, with RS and CI techniques applied across all patterns to elicit effects on the temporomandibular joint (Adler, Beckers, and Buck, 2013).

Participants were positioned comfortably in the supine position on the treatment table. Manual contact was provided in line with PNF principles to guide movement direction, apply appropriate resistance, and facilitate motor responses. For cervical patterns, the therapist placed the hands on the mastoid and temporal regions to direct head and neck motion with controlled resistance and assist flexion – extension transitions. During mandibular facilitation, one hand was placed under the mandible to guide the opening motion, while the other hand stabilized the occipital region to maintain symmetry and fluidity. In trunk patterns, both hands were positioned bilaterally on the scapular and pelvic regions to guide diagonal movements and ensure coordinated trunk activation. Resistance was applied to the mandible during mouth opening and to the forehead during cervical stabilization (Adler, Beckers, and Buck, 2013), with intensity adjusted individually to ensure effective activation without discomfort.

The RS technique was performed through diagonal and functional movement patterns that aimed to enhance neuromuscular coordination, improve functional stability, and minimize pain-related movement restrictions, rather than through isolated contractions. The agonist pattern was applied with the mouth closed and the tongue pressed against the upper palate during right and left extension cross-sections, while the antagonist pattern was applied with the mouth open and the tongue relaxed in the oral cavity during right and left flexion diagonals.

Following a 2-minute rest, the CI technique was applied, consisting of sequential concentric, isometric, and eccentric contractions of the agonist muscles, each lasting 5 seconds. Each set included 5–15 repetitions,

and a 30-second rest was provided between sets. A total of 3 sets of RS were performed.

Before initiating the main session, participants completed a familiarization warm-up. The warm-up session consisted of unresisting diagonal PNF movements, allowing patients to learn and internalize all the patterns included in the intervention. These movements aimed to facilitate neuromuscular preparation and increase blood flow before applying RS and CI techniques. Each diagonal pattern was repeated 15 times under the supervision of a physical therapist, ensuring correct execution and a full ROM without resistance or pain.

The PNF exercise component lasted approximately 15 minutes per session. Throughout all repetitions, participants were encouraged to exert maximum effort, with verbal cues provided to ensure accurate movement execution. The primary goal of these exercises was to improve muscle strength, stability, and mobility, while alleviating jaw pain (Adler, Beckers, and Buck, 2013).

Outcome measures

The study assessed pain intensity, joint AROM/AAROM, and mandibular function parameters. The primary outcome measures focused on pain intensity, whereas joint ROM and functionality served as a secondary outcome measure. Evaluations were conducted at two time points: before the exercise program (baseline, T0) and after completion of the 4-week program (post-exercise, T1).

Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS). Participants rated their average pain intensity digitally, allowing continuous input values on a 0–10 scale over the past month, where zero (0) indicated no pain and ten (10) represented the worst imaginable pain (Hawker, Mian, Kendzerska, and French, 2011). For individuals with TMDs, the estimated minimal clinically important difference (MCID) for the NPRS is 0.8 points (Son et al, 2024). As there was no significant difference between left and right NPRS scores, the mean of both sides was used in the statistical analysis.

The ROM of the jaw, included both active and assisted measures. Active range of motion (AROM) was assessed using pain-free opening (PFO) and maximum unassisted opening (MUO), while assisted active range of motion (AAROM) was evaluated using maximum mouth opening (MMO). Jaw range of motion was measured in millimeters using calipers according to the DC/TMD guidelines (Gonzalez, Chwirut, List, and Ohrbach, 2014). For PFO, the subjects were asked to open their mouth as much as they could until pain occurred and to stop at the point where the pain started. The distance between the incisal of the mandibular incisor tooth and the mesial-distal center of the maxillary central incisor was measured with a ruler. In the MUO measurement, the subjects were forced to open their jaws to the maximum even though in pain, and the ruler was positioned in the same way as the PFO. For MMO, the dentist first places the ruler in its place in the other measurements and asks the patient to open his mouth as much as he did during MUO. The dentist tries to open the mouth more by placing his fingers in a scissors position on the front teeth. The minimum detectable difference for maximum mouth opening for painfully restricted TMDs was established to be 6 mm (Kropmans et al, 2000).

Mandibular Function Impairment Questionnaire (MFIQ) consists of 17 items, each scored from 0 to 4, with higher scores indicating greater impairment in patient-reported mandibular function. MFIQ is a valid and reliable tool for assessing mandibular dysfunction in Turkish patients with TMDs (Yıldız, Alkan, and Külünkoğlu, 2024). The total score derived from the questionnaire was utilized in the statistical analysis. The minimal amount of change to be detected is 14 units on a scale of 0 to 68 (Kropmans, Dijkstra, Stegenga, and de Bont, 1999).

No adverse events or harms related to the interventions were reported by any participants throughout the duration of the study. All exercise protocols and physiotherapy modalities procedures were conducted under the direct supervision of a licensed physiotherapist, and standardized safety procedures were followed. Participants were monitored closely during each session, and any potential discomfort was addressed immediately to ensure safety and tolerability.

Sample size

Calculated with previously obtained data according to the significant change in maximum pain intensity (Calixtre et al, 2016), a minimum of 27 participants for each group with a total of 54 participants were needed with a statistically significant level of 5%, a statistical power of 80%, and an effect size of 0.781 using G*Power Software (version 3.1.9.2). With a 15% dropout rate, 66 individuals were included in the study.

Statistical analysis

Data was analyzed using IBM SPSS (Statistical Package for Social Science) 22.0 software. Mean, minimum (min), maximum (max), frequency (n), and percentage (%) values were given from descriptive statistics. Shapiro-Wilk test and histogram plots were used to

test the normal distribution. Mean differences between groups regarding baseline characteristics were investigated using the Mann Whitney-U Test, according to meeting normal distribution conditions, and comparisons of rates were examined using the Chi-Square Test. Initially, differences between T0 and T1 were calculated using the Wilcoxon Matched-Pairs Test. When the normal distribution condition was not met, the difference between the groups was calculated using the Mann Whitney-U test. However, for each parameter that met the normal distribution condition [NPRS (T1), PFO, MUO (T0), and MMO (T1)], the differences between the groups were examined with 2 (group) × 2 (time) repeated measures ANOVA. When a significant main effect was found over time, post hoc comparisons were made. A significant level was set at $p < .05$. In addition to group mean comparisons, the proportion of participants achieving the MCID threshold for each outcome measure was calculated. Clinical significance was defined as an improvement of ≥0.8 points on the NPRS, ≥14 units on the MFIQ, and ≥6 mm on the MMO (Kropmans et al, 2000; Kropmans, Dijkstra, Stegenga, and de Bont, 1999; Son et al, 2024).

RESULTS

A total of 237 patients were assessed for eligibility, of whom 171 were excluded. The remaining 66 participants were randomized into two groups. Of these, 62 completed the study. The flow chart of the study is shown in Figure 1. The demographic characteristics of the participants are described in Table 2. PNFE was composed of 17 females and 13 males: CEG 18 females and 14 males, ranging from 18 to 35 years of age. No

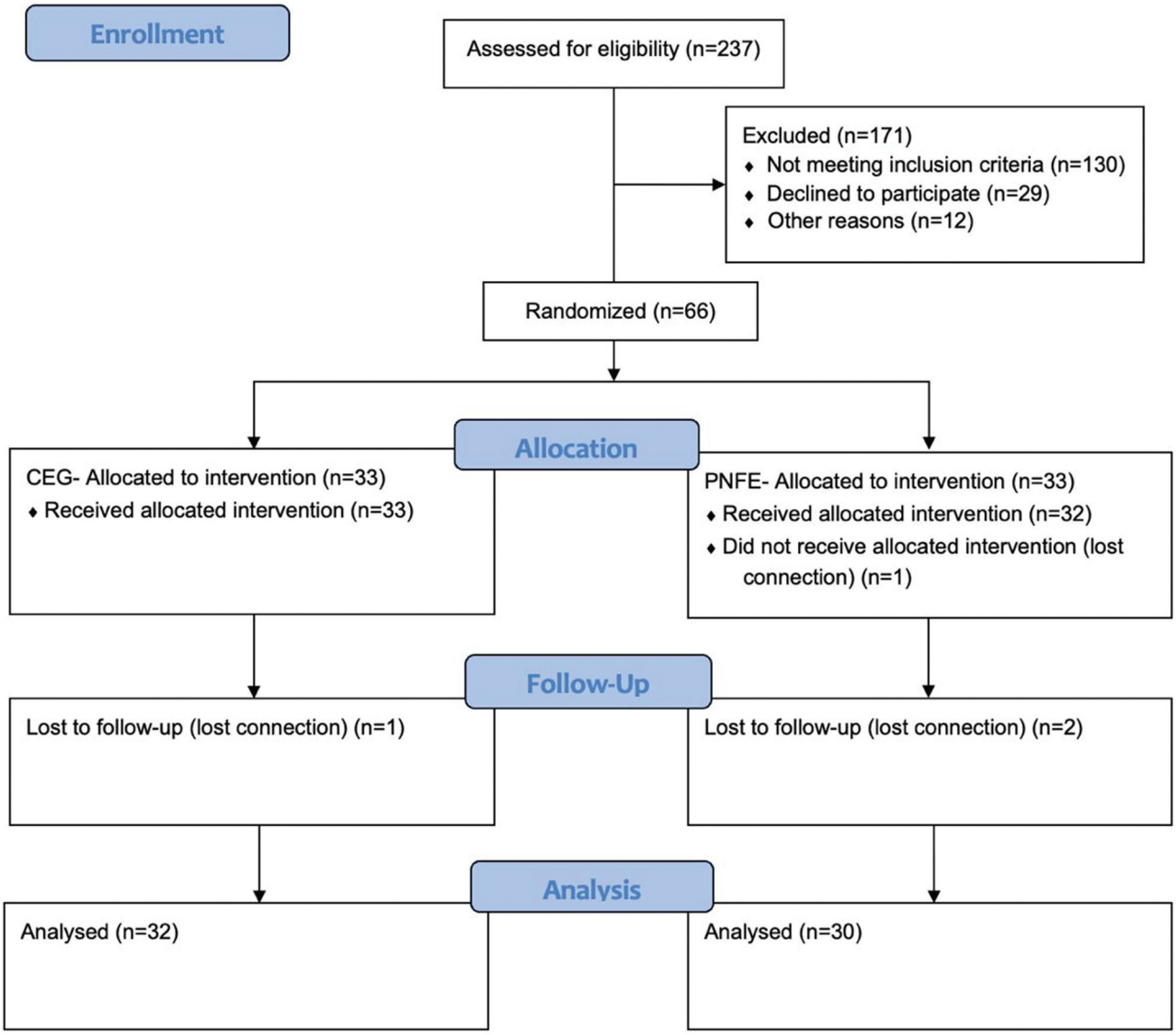

Figure 1. No caption.

Table 2. Baseline characteristics of participants.

Participant Characteristics		PNFE ($n = 30$)		CEG ($n = 32$)		χ2	p[a]
Gender	Male, n (%)	16%50.0)		16%50.0)		0.276	0.621
	Female, n (%)	17%56.7)		13%43.3)			
Education	High School	3%10.0)		5%15.62)		3.092	0.570
	University	25%83.3)		24%75)			
	Higher Education	2%6.66)		3%9.38)			
		Mean (SD)	Min-Max	Mean (SD)	Min-Max	Z	p[b]
Age (years)		22.20 (3.74)	18.00–32.00	23.21 (4.86)	18.00–35.00	−0.575	0.565
Body height (cm)		167.36 (5.97)	155.00–180.00	167.12 (8.00)	152.00–188.00	−0.523	0.601
Body mass (kg)		57.13 (7.63)	43.00–71.00	61.28 (11.41)	47.00–86.00	−1.171	0.242
BMI (kg/m2)		20.39 (2.50)	15.92–26.67	21.83 (3.09)	17.69–30.12	−1.726	0.084

p[a:] Chi-Square Test, p[b]: Mann Whitney-U Test, χ2: Chi-square test, Min: Minimum, Max: Maximum, cm: Cantimetre, kg: Kilogram, kg/m2: Kilograms per square meter, BMI: Body Mass Index, CEG: Conventional Exercise Group, PNFE: PNF Exercise Group.

differences between groups were identified at baseline in any of the variables ($p > .05$).

While there was no significant difference in mean pain intensity (NPRS) between the groups at baseline ($p = .756$), a statistical difference was found in favor of the PNFE group after intervention ($p = .043$). Pain intensity decreased significantly in both groups from T0 to T1 ($p < .001$). Furthermore, the reduction in NPRS scores exceeded the established MCID of 0.8 for individuals with TMDs, indicating that the observed changes reached the threshold considered clinically meaningful. Pain intensity showed a significant group-by-time interaction ($F_{1,0.610} = 7.41$, $p = .008$, $\eta p^2 = 0.110$), the effect size indicating a moderate effect in favor of the PNFE group (Table 3).

There was no significant difference in mean scores of functional statuses (MFIQ) between the groups at T0 ($p = .084$) or T1 ($p = .511$). However, functional status improved significantly from the T0 to the final assessment T1 in both groups ($p < .001$). Despite this improvement, the mean change in MFIQ scores did not exceed the minimal clinically important difference (MCID) of 14 units on a 0–68 scale. In terms of mandibular function (MFIQ, MCID = 14 points), 14 participants (46.7%) in the PNFE group achieved meaningful improvement, compared to only 2 participants (6.3%) in

Table 3. Comparison of pain intensity and functionality within and between groups at T0 and T1.

		T0		T1			
Outcomes	Groups	Mean (SD) (95%CI)	Min-Max	Mean (SD) (95%CI)	Min-Max	Z	Within Group p[a]
NRS[d] (0-10 cm)	PNFE	6.32 (1.56) (5.74–6.90)	3.70–9.00	2.59 (1.06) (2.19–2.99)	0.90–4.90	−4.784	**0.000*****
	CEG	6.45 (1.44) (5.93–6.97)	3.70–8.90	3.49 (0.92) (3.16–3.82)	1.50–5.30	−4.938	**0.000*****
	Between Group-p	0.756[b]		**0.043[c] ***			
MFIQ[d]	PNFE	23.73 (9.13) (20.32–27.14)	8.00–42.00	11.86 (6.27) (9.52–14.20)	0.00–24.00	−4.786	**0.000*****
	CEG	20.43 (6.39) (18.13–22.73)	12.00–38.00	11.96 (4.71) (10.26–13.66)	2.00–24.00	−4.949	**0.000*****
	Between Group-p	0.084[b]		0.511[b]			
PFO	PNFE	31.46 (9.14) (28.05–34.87)	14.00–49.00	35.24 (8.78) (31.96–38.52)	18.00–49.00	4.204	**0.000*****
	CEG	28.52 (8.84) (25.33–31.71)	13.00–44.00	31.75 (9.14) (28.45–35.05)	16.00–45.00	−4.440	**0.000*****
	Between Group-p	0.841[c]		0.577[c]			
MUO	PNFE	42.23 (7.61) (39.39–45.07)	24.00–57.00	45.63 (7.16) (42.96–48.30)	31.00–57.00	−4.119	**0.000*****
	CEG	35.65 (8.24) (32.68–38.62)	19.00–48.00	38.71 (8.35) (35.70–41.72)	20.00–52.00	−4.274	**0.000*****
	Between Group-p	0.367[c]		**0.003 [b] ****			
MMO	PNFE	45.93 (7.64) (43.08–48.78)	26.00–59.00	48.33 (7.44) (45.55–51.11)	28.00–58.00	−4.071	**0.000*****
	CEG	40.00 (7.75) (37.21–42.79)	24.00–52.00	42.21 (7.45) (39.52–44.90)	28.00–55.00	−4.697	**0.000*****
	Between Group-p	**0.007 [b]****		**0.005[c] ****			

p[a]: Wilcoxon Signed-Rank Test, p[b]: Mann Whitney-U Test, p[c]: ANOVA, T0: Baseline, T1: Post-exercise, SD: Standard Deviation, Min: Minimum, Max: Maximum, cm: Cantimeter, CEG: Conventional Exercise Group, PNFE: PNF Exercise Group, CEG: Conventional Exercise Group, NPRS: Numerical Pain Rating Scale, MFIQ: Mandibular Function Impairment Questionnaire, PFO: Pain Free Opening, MMO: Maximum Mouth Opening, MUO: Maximum Unassisted Mouth Opening, *$p < .05$, **$p < .01$, ***$p < .001$, [d]: ANOVA group-by-time interaction ($p < .05$).

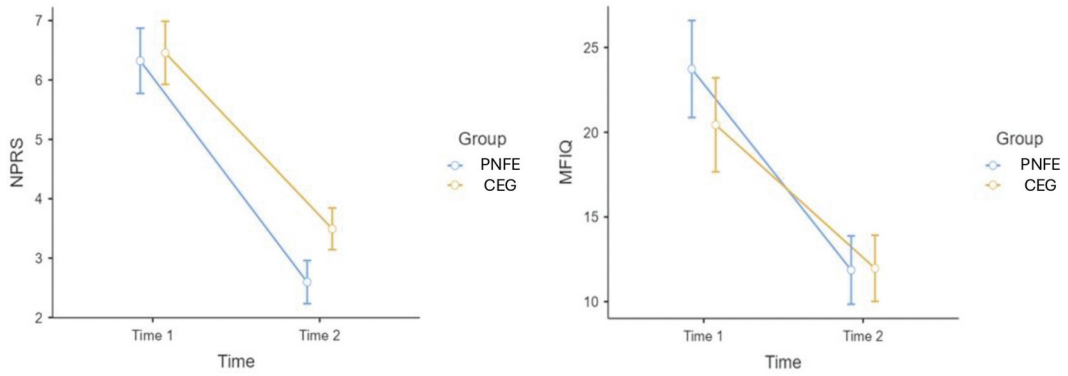

Figure 2. No caption.

the CEG. Furthermore, the MFIQ showed a significant group-by-time interaction ($F_{1,9.91} = 9.02$, $p = .004$, ηp2 = 0.131), the effect size suggesting a moderate to large effect of the intervention over time (Table 3).

There was no significant difference in mean PFO at baseline between groups at T0 ($p = .841$) and T1 ($p = .577$). However, mean MUO and MMO were significantly higher in the PNFE group compared to the CEG group ($p = .003$ and $p = .005$, respectively). Despite these statistical improvements, the observed changes did not exceed the minimum detectable difference of 6 mm for clinically meaningful improvement in painfully restricted TMDs. For MMO, only 1 participant (3.1%) in the RocE group exceeded this threshold, compared to 3 participants (10%) in the PNFE group. Furthermore, no significant group-by-time interaction was found for any mouth opening outcome measures (PFO: $F_{1,\ 5.85} = 0.483$, $p = .528$, ηp2 = 0.007; MUO: $F_{1,8.47} = 1.28$, $p = .263$, ηp2 = 0.021; MMO: $F=_{1,\ 1.825} = 0.134$, $p = .715$, ηp2 = 0.002) (Table 3). Despite statistical significance, the effect size for MUO ($\eta p^2 = 0.021$) was small; for PFO ($\eta p^2 = 0.007$) a negligible impact, and a small effect size for MMO ($\eta p^2 = 0.002$). All group-time interactions were shown in Figure 2.

DISCUSSION

The findings of this study indicate that incorporating RS and CI techniques into conventional physiotherapy may offer additional benefits for individuals with myogenic TMD. Both groups demonstrated significant reductions in pain and improvements in mandibular function and jaw range of motion; however, the greater decrease in pain and increase in MMO and MUO observed in the PNFE group suggests that PNF-based interventions may enhance pain modulation by improving neuromuscular control and promoting muscle relaxation which also provides mobility. Outcomes suggest that while the impact of PNF cervical patterns with integrated mandibular movements on joint mobility may require longer or more intensive interventions, its integration with conventional therapy can meaningfully enhance pain reduction and in jaw mobility.

It is known that the severity of pain decreases with the use of PNF applications in different regions such as the knee, neck, and low back (Maicki, Bilski, Szczygieł, and Trąbka, 2017; Nafees, Baig, Ali, and Ishaque, 2023; Pourahmadi, Sahebalam, and Bagheri, 2020). Similarly, in a randomized controlled study evaluating the effects of PNFE, myofascial release techniques and home exercises on TMJ pain and jaw function in individuals with bruxism, it was observed that the decrease in pain level was greater in the PNF group after treatment. It is thought that the results of this study will make significant contributions to the treatment of bruxism patients (Calisgan et al, 2018). Preliminary findings from a pilot study applying PNFE to individuals with mixed-type TMDs revealed a significant reduction in pain intensity, as measured instantly by the VAS, and an increase in pain threshold (Ergezen, Atilgan, and Kilicaslan, 2022). However, the present findings indicate that adding PNF to conventional physiotherapy does make a difference, particularly in terms of pain reduction. Although both groups demonstrated significant improvements over time, the PNFE group showed a greater reduction in pain intensity, exceeding the MCID and demonstrating a moderate effect size. Considering that the MCID for NPRS is reported as 0.8 (Son et al, 2024), the reduction in pain intensity observed in both groups exceeded this benchmark. This suggests that the neuromuscular facilitation and stabilization mechanisms inherent to PNF may enhance pain modulation beyond what is achieved with conventional exercises alone. In a double-blinded randomized controlled trial, it was reported that adding PNF stretching exercises to a rehabilitation program resulted in significantly greater reductions in pain intensity and disability, as well as improvements in mandibular function, compared to conventional interventions

alone in patients with TMD and forward head posture (Saleh, Mohamed, Elsayed, and Abdelatief, 2024). By improving cervico-mandibular coordination, muscle activation patterns, and proprioceptive input, PNF may reduce protective muscle guarding and nociceptive input, thereby contributing to superior pain outcomes. Therefore, adding PNF can be suggested as a supportive intervention for pain reduction in individuals with myogenous TMD. These observations are consistent with earlier research showing that neuromuscular exercise approaches can effectively alleviate pain in musculoskeletal disorders (Ergezen, Atilgan, and Kilicaslan, 2022; Maicki, Bilski, Szczygieł, and Trąbka, 2017; Nafees, Baig, Ali, and Ishaque, 2023; Pourahmadi, Sahebalam, and Bagheri, 2020).

Manual therapy, therapeutic exercise, and dry needling are used to increase function in individuals with TMDs (González-Sánchez et al, 2023). A single session of exercise and cervical mobilization statistically improved pain and function in individuals with TMD with myofascial pain (Brochado et al, 2018). However, their clinical relevance is questionable. Studies have shown the possibility of increasing function assessed by MFIQ with Rocabado exercises (Rocabado and Iglarsh, 1991; Seyhan and Atalay, 2023). However, in the same studies, it is stated that core stabilization and ischemic compression exercises added to Rocabado do not contribute more to the increase in function. The present study demonstrated that all participants showed significant functional improvements over time, with a moderate effect size. However, no significant between-group differences were observed, suggesting that while both interventions were beneficial, neither was superior for improving patient-reported function assessed by MFIQ. Despite this, the observed change did not meet the MCID threshold of 14 points (Kropmans, Dijkstra, Stegenga, and de Bont, 1999), indicating that improvements may not have been large enough to be perceived as meaningful by patients. PNF applications contribute to the increase in function by facilitating contraction with diagonal movements and neural facilitation (Kabat and Knott, 1953). Different PNF techniques and patterns have been used in rehabilitation to improve function and increase joint ROM (İğrek and Çolak, 2022; Kruse et al, 2022; Silva, Oliveira, Azevedo-Santos, and DeSantana, 2022).

Earlier research has reported mixed outcomes regarding the effectiveness of various physiotherapy interventions for temporomandibular disorders. For example, adding cervico-mandibular manual therapy that targets the cervical and masticatory muscles to a six-week physiotherapy program has been shown to produce greater improvements in jaw ROM than exercise alone (Delgado de la Serna et al, 2020). However, applying high-velocity, low-amplitude thrust (HVLAT) mobilization solely to the cervical spine did not yield significant changes in mouth opening or pain intensity in individuals with TMD (Reynolds, Puentedura, Kolber, and Cleland, 2020). In a case report by Lee (2018), a 4-week, 12-session PNF program consisting of contract-relax, stabilizing reversals, RS, and CI techniques was applied to a patient with limited mouth opening. A program emphasizing cervical alignment and TMJ pain reduction resulted in a significant increase in pain-free mouth opening, suggesting that PNF may improve TMJ stability and mobility. Similarly, our earlier pilot study examining the immediate effects of a single PNF session with RS and CI techniques demonstrated a significant increase in MMO, though unaided and passive functional opening remained unchanged (Ergezen, Atilgan, and Kilicaslan, 2022). Based on these short-term results, the current study examined the four-week intervention effects of PNFE combined with traditional exercises on objective functional jaw opening. Although this combined program statistically improved MUO and MMO mouth opening parameters, the effect sizes were small, and the mean MMO improvement did not exceed the MCID threshold, suggesting limited clinical significance. Overall, these findings imply that PNF-based approaches may contribute to enhanced mobility on jaw opening, but additional techniques such as stabilizing reversals or contract-relax may be required to achieve meaningful functional improvement (Gao et al, 2023). To our knowledge, this study evaluating the effect of PNF applications on TMJ function is the first randomized controlled study. Based on the present findings, PNF techniques combined with conventional exercises may serve as a supportive approach to improve jaw mobility in individuals with myogenous TMD; however, such improvements should not be interpreted as functional recovery. Additional or alternative intervention strategies may be required to achieve clinically meaningful improvements in patient-reported functional outcomes.

Limitations

The present study has several limitations that should be considered when interpreting the findings. One limitation concerns the baseline differences in MMO between groups, which may have influenced the overall interpretation and reduced the generalizability of the results. To minimize this effect, group – time interactions were analyzed to observe changes throughout the intervention period, providing

a more balanced understanding despite the initial discrepancy. Another limitation is that some variables did not fully meet the normality assumption, which restricted the ability to perform interaction analyses for all parameters. Moreover, the relatively small effect sizes found in jaw ROM outcomes suggest that the current intervention protocol might not have been sufficient to fully address restricted mouth opening. The short duration of the intervention and the absence of post-treatment follow-up further restrict conclusions about long-term effects. Finally, since the sample consisted mainly of younger adults, the applicability of these findings to older populations remains uncertain.

Considering these factors together, future research should include larger and more heterogeneous samples, incorporate long-term follow-up, and examine intervention protocols that build upon the current approach by combining PNF with other evidence-based components already used in TMD rehabilitation to strengthen and expand upon these results.

CONCLUSION

Combining PNF with conventional physiotherapy regimen provides greater pain relief compared to conventional exercises alone. Patient-reported mandibular function, as assessed by the MFIQ, improved significantly in both groups, with no statistically significant between-group differences, indicating comparable patient-reported functional recovery. Jaw range of motion measures showed statistically greater improvements in the PNF group, although these changes did not exceed the MCID. These findings suggest that combining PNF with conventional exercises may serve as a supportive approach in myogenous TMD, particularly for pain management and jaw range of motion, but further research is needed to explore long-term effects, optimizing rehabilitation protocols and clinical applicability.

From a clinical perspective, these results suggest that incorporating PNF into conventional physiotherapy may be particularly beneficial for patients with myogenous TMD who present with prominent pain and mobility restrictions, whereas conventional exercise programs alone may be sufficient when the primary goal is to improve patient-reported functional limitations.

ACKNOWLEDGMENTS

We are extremely grateful to all participants for his great effort in achieving this work. We would also like to express our sincere gratitude to Prof. Dr. Esra Atılgan for her substantial contributions during the conceptual development of our previous related work, which provided important guidance and direction for the present study.

AUTHOR CONTRIBUTIONS

CRediT: **Gizem Ergezen Sahin:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing – review & editing; **Erkin Ergezen:** Conceptualization, Data curation, Methodology, Writing – original draft; **Sukru Can Akmansoy:** Formal analysis, Investigation, Writing – review & editing; **Meltem Meran Caglar:** Formal analysis, Writing – original draft; **Yasemin Ozkan:** Resources, Supervision, Writing – review & editing.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

FUNDING

The author(s) reported thereis no funding associated with the work featured in this article.

DATA AVAILABILITY STATEMENT

The data generated and analyzed during the current study is available from the corresponding author upon a reasonable request.

REFERENCES

Adler SS, Beckers D, Buck M 2013 PNF in practice: An illustrated guide 3rd ed. Heidelberg: Springer Medizin Verlag.

Areeudomwong P, Buttagat V 2019 Proprioceptive neuromuscular facilitation training improves pain-related and balance outcomes in working-age patients with chronic low back pain: A randomized controlled trial. Brazilian Journal of Physical Therapy 23: 428–436.

Brochado FT, Jesus LH, Carrard VC, Freddo AL, Chaves KD, Martins MD 2018 Comparative effectiveness of photobiomodulation and manual therapy alone or combined in TMD patients: A randomized clinical trial. Brazilian Oral Research 32: e50.

Calisgan E, Talu B, Altun O, Dedeoglu N, Duman B 2018 The effects of proprioceptive neuromuscular facilitation, myofascial releasing maneuvers, and home exercises on pain and jaw function in patients with bruxism. Medical Sciences 7: 617–621.

Calixtre LB, Grüninger BL, Haik MN, Alburquerque-Sendín F, Oliveira AB 2016 Effects of cervical mobilization and exercise on pain, movement and function in subjects with temporomandibular disorders: A single group pre-post test. Journal of Applied Oral Sciences 24: 188–197.

De Giorgi I, Castroflorio T, Sartoris B, Deregibus A 2017 The use of conventional transcutaneous electrical nerve

stimulation in chronic facial myalgia patients. Clinical Oral Investigations 21: 275–280.

De la Torre Canales G, Câmara-Souza MB, Ernberg M, Ea A-M, Grigoriadis A, Poluha RL, Christidis M, Jasim H, Lövgren A, Christidis N 2024 Botulinum toxin-A for the treatment of myogenous temporomandibular disorders: An umbrella review of systematic reviews. Drugs 84: 779–809.

Delgado de la Serna P, Plaza-Manzano G, Cleland J, Fernández-de-Las-Peñas C, Martín-Casas P, Díaz-Arribas MJ 2020 Effects of cervico-mandibular manual therapy in patients with temporomandibular pain disorders and associated somatic tinnitus: A randomized clinical trial. Pain Medicine 21: 613–624.

Ergezen G, Atilgan E, Kilicaslan A 2022 Immediate effect of proprioceptive neuromuscular facilitation on pain and maximal mouth opening in temporomandibular dysfunction: A pilot study. Rawal Medical Journal 47: 125–128.

Ferrillo M, Nucci L, Giudice A, Calafiore D, Moratta N, Minervini G, d'Apuzzo F, Ammendolia A, Perillo L, de Sire A 2025 Efficacy of conservative approaches on pain relief in patients with temporomandibular joint disorders: A systematic review with network meta-analysis. Cranio 43: 258–274.

Fertout A, Manière-Ezvan A, Lupi L, Ehrmann E 2022 Management of temporomandibular disorders with transcutaneous electrical nerve stimulation: A systematic review. Cranio 40: 217–228.

Gao B, Li L, Shen P, Xu P, Sun W, Zhang C, Song Q 2023 Effects of proprioceptive neuromuscular facilitation stretching in relieving pain and balancing knee loading during stepping over obstacles among older adults with knee osteoarthritis: A randomized controlled trial. PLOS ONE 18: e0280941.

Gil-Martínez A, Paris-Alemany A, López-de-Uralde-Villanueva I, La Touche R 2018 Management of pain in patients with temporomandibular disorder (TMD): Challenges and solutions. Journal of Pain Research 11: 571–587.

Gonzalez Y, Chwirut J, List T, Ohrbach R 2014 DC/TMD examination protocol. Journal of Teaching and Learning Resources 10: 9946.

González-Sánchez B, García Monterey P, Ramírez-Durán MDV, Garrido-Ardila EM, Rodríguez-Mansilla J, Jiménez-Palomares M 2023 Temporomandibular joint dysfunctions: A systematic review of treatment approaches. Journal of Clinical Medicine 12: 4156.

Guarda-Nardini L, De Almeida AM, Manfredini D 2021 Arthrocentesis of the temporomandibular joint: Systematic review and clinical implications of research findings. Journal of Oral & Facial Pain and Headache 35: 17–29.

Hawker GA, Mian S, Kendzerska T, French M 2011 Measures of adult pain: Visual analog scale for pain (VAS pain), numeric rating scale for pain (NRS pain), Mcgill pain questionnaire (MPQ), short-form Mcgill pain questionnaire (SF-MPQ), chronic pain grade scale (CPGS), short form-36 bodily pain scale (SF). Arthritis Care and Research 63: 240–252.

Hindle KB, Whitcomb TJ, Briggs WO, Hong J 2012 Proprioceptive neuromuscular facilitation (PNF): Its mechanisms and effects on range of motion and muscular function. Journal of Human Kinetics 31: 105–113.

İğrek S, Çolak TK 2022 Comparison of the effectiveness of proprioceptive neuromuscular facilitation exercises and shoulder mobilization in patients with subacromial impingement syndrome: A randomized clinical trial. Journal of Bodyweight Movement Therapy 30: 42–52.

Kabat H, Knott M 1953 Proprioceptive facilitation technics for treatment of paralysis. Physical Therapy Reviews 33: 53–64.

Kapos FP, Exposto FG, Oyarzo JF, Durham J 2020 Temporomandibular disorders: A review of current concepts in aetiology, diagnosis and management. Oral Surgery 13: 321–334.

Kofotolis N, Kellis E 2006 Effects of two 4-week proprioceptive neuromuscular facilitation programs on muscle endurance, flexibility and functional performance in women with chronic low back pain. Physical Therapy 86: 1001–1012.

Kropmans T, Dijkstra P, Stegenga B, Stewart R, de Bont L 2000 Smallest detectable difference of maximal mouth opening in patients with painfully restricted temporomandibular joint function. European Journal of Oral Sciences 108: 9–13.

Kropmans TJ, Dijkstra PU, Stegenga B, de Bont LG 1999 The smallest detectable difference of mandibular function impairment in patients with a painfully restricted temporomandibular joint. Journal of Dental Research 78: 1445–1449.

Kruse A, Habersack A, Jaspers RT, Schrapf B, Weide G, Svehlik M, Tilp M 2022 Acute effects of static and proprioceptive neuromuscular facilitation stretching of the plantar flexors on ankle range of motion and muscle-tendon behavior in children with spastic cerebral palsy: A randomized clinical trial. International Journal of Environmental Research and Public Health 19: 11599.

Lazarou L, Kofotolis N, Pafis G, Kellis E 2018 Effects of two proprioceptive training programs on ankle range of motion, pain, functional and balance performance in individuals with ankle sprain. Journal of Back and Musculoskeletal Rehabilitation 31: 437–446.

Lee BK 2018 Influence of proprioceptive neuromuscular facilitation therapeutic exercise on a woman with temporomandibular joint disorder: A case study. Journal of Exercise Rehabilitation 14 : 1074–1079.

Lin P, Yang M, Huang D, Wang J, Zhong C, Guan L 2022 Effect of proprioceptive neuromuscular facilitation technique on the treatment of frozen shoulder: A pilot randomized controlled trial. BMC Musculoskeletal Disorders 23: 1–10.

List T, Jensen RH 2017 Temporomandibular disorders: Old ideas and new concepts. Cephalalgia 37: 692–704.

Machado BCZ, Trawitzki LVV, de Felício CM 2019 Tongue strength, masticatory and swallowing dysfunction in patients with chronic temporomandibular disorder. Physiology Behaviour 210: 112616.

Maicki T, Bilski J, Szczygieł E, Trąbka R 2017 PNF and manual therapy treatment results of patients with cervical spine osteoarthritis. Journal of Back and Musculoskeletal Rehabilitation 30: 1095–1101.

Nafees K, Baig AAM, Ali SS, Ishaque F 2023 Dynamic soft tissue mobilization versus proprioceptive neuromuscular facilitation in reducing hamstring muscle tightness in patients with knee osteoarthritis: A randomized control trial. BMC Musculoskeletal Disorders 24: 447.

Núñez SC, Garcez AS, Suzuki SS, Ribeiro MS 2006 Management of mouth opening in patients with temporomandibular disorders through low-level laser therapy and transcutaneous electrical neural stimulation. Photomedicine and Laser Surgery 24: 45–49.

Ohrbach R, Dworkin SF 2016 The evolution of TMD diagnosis: past, present, future. Journal of Dental Research 95: 1093–1101.

Pourahmadi M, Sahebalam M, Bagheri R 2020 Effectiveness of proprioceptive neuromuscular facilitation on pain intensity and functional disability in patients with low back pain: A systematic review and meta-analysis. Archives of Bone and Joint Surgery 8: 479–501.

Reynolds B, Puentedura EJ, Kolber MJ, Cleland JA 2020 Effectiveness of cervical spine high-velocity, low-amplitude thrust added to behavioral education, soft tissue mobilization, and exercise for people with temporomandibular disorder with myalgia: A randomized clinical trial. Journal of Orthopedic and Sports Physical Therapy 50: 455–465.

Rocabado M, Iglarsh ZA 1991 Musculoskeletal approach to maxillofacial pain. Philadelphia: JB Lippincott.

Sá M, Faria C, Pozza DH 2024 Conservative versus invasive approaches in temporomandibular disc displacement: A systematic review of randomized controlled clinical trials. Dental Journal (Basel) 12: 244. 10.3390/dj12080244

Saleh MS, Mohamed WM, Elsayed WH, Abdelatief EEM 2024 Proprioceptive neuromuscular facilitation stretching exercises for treatment of temporomandibular dysfunction in patients with forward head posture: A double-blinded, randomized, controlled trial. J Back Musculoskelet Rehabil 37: 1259–1268.

Saliba V, Johnson GS, Wardlaw C 1992 Proprioceptive neuromuscular facilitation. In: Basmajian JV Nyberg RE (Eds) Rational Manual Therapies, pp. 243–284. Baltimore, USA: Williams & Wilkins.

Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, List T, Svensson P, Gonzalez Y, Lobbezoo F, et al. 2014 Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: Recommendations of the international RDC/TMD consortium network and orofacial pain special interest group. Journal of Oral Facial & Pain and Headache 28: 6–27.

Schulz KF, Altman DG, Moher D 2010 CONSORT 2010 statement: Updated guidelines for reporting parallel group randomized trials. BMJ 340: c332.

Seyhan M, Atalay ES 2023 Is core stability training effective in temporomandibular disorder? A randomized controlled trial. Clinical Oral Investigations 27: 7237–7246.

Shimada A, Ishigaki S, Matsuka Y, Komiyama O, Torisu T, Oono Y, Sato H, Naganawa T, Mine A, Yamazaki Y, et al. 2019 Effects of exercise therapy on painful temporomandibular disorders. Journal of Oral Rehabilitation 46: 475–481.

Silva MC, Oliveira MT, Azevedo-Santos IF, DeSantana JM 2022 Effect of proprioceptive neuromuscular facilitation in the treatment of dysfunctions in facial paralysis: A systematic literature review. Brazilian Journal of Physical Therapy 26: 100454.

Son J, Kim ES, Lee YJ, Lee NW, Ha IH 2024 Minimum clinically important difference and substantial clinical benefit in patients with chronic temporomandibular disorders. Journal of Oral Rehabilitation 51: 1468–1474.

Valesan LF, Da-Cas CD, Réus JC, Denardin ACS, Garanhani RR, Bonott D, Januzzi E, de Souza BDM 2021 Prevalence of temporomandibular joint disorders: A systematic review and meta-analysis. Clinical Oral Investigations 25: 441–453.

Wadhokar OC, Patil DS 2022 Current trends in the management of temporomandibular joint dysfunction: A review. Cureus 14: e29314.

Wanderley D, Lemos A, Moretti E, Barros MMMB, Valença MM, de Oliveira DA 2019 Efficacy of proprioceptive neuromuscular facilitation compared to other stretching modalities in range of motion gain in young healthy adults: A systematic review. Physiotherapy Theory and Practice 35: 109–129.

Yıldız NT, Alkan A, Külünkoğlu BA 2024 Validity and reliability of the Turkish version of mandibular function impairment questionnaire. Cranio 42: 160–170.