

AUGUST 2026

Dear IPNFA®Members, Dear Friends

We present the next IPNFA® Newsletter prepared by the Research Committee. Below you will find the newest articles approved by the members of our committee. You can find also information about newest events in the field of our PNF. Please enjoy it



INTERESTING CONGRESS...

In June 2026, the GCMAS annual congress took place in Phoenix, Arizona, USA. During the 5-day congress, we got to hear high-quality presentations from, among others, former colleagues of Jacquelin Perry. The congress showcased the latest opportunities in gait analysis. For more information, reach out to the Research Committee Chairman.

PROJECT

FINISHED STUDY

Braiding Project :

Place : Fyzjo Instytut, Warsaw, Poland

Project finished

Results : The results will be presented in Vallejo.

The study assessing the immediate effect of PNF braiding on gait pattern in patients with gait asymmetry using the Muscle Lab system is currently ongoing. The results will be presented at AGM 2026.

Objective:

To assess the immediate effect of PNF braiding on temporo-spatial gait parameters in patients with gait asymmetry.

Participants & Setting:

Adult neurological patients with gait asymmetry (till now 12 patients). The study is conducted at Fizjo Instytut, Warsaw, Poland under the supervision of IPNFA® Instructors Attila Szabo and Joanna Jaczewska Bogacka.

Intervention:

One 15-minutes session of PNF braiding.

Methods:

Gait is assessed using the Muscle Lab system during a 10-meter walking test performed immediately before and after the intervention.

Lower-limb IMU sensors are used to measure gait parameters including velocity, cadence, gait cycle duration, stance, swing, and double-support phases.

PROJECT

NEW STUDY

Pelvic project :

The study is being conducted at Fizjo Instytut in Warsaw in Poland under the supervision of IPNFA® Basic instructors Joanna Jaczewska-Bogacka and Jakub Marciński with the support of IPNFA® Research Committee members.

Interval: from June 2026 – still in progress

Patients: with chronic low back pain

Aim of the study: Immediate effects of PNF pelvis patterns on pelvic mobility and pelvic movement control

The study includes patients with chronic low back pain who undergo an assessment of pelvic mobility, proprioception, and movement control using the PROKIN system.

Two objective tests are performed in sitting position on movable seat. First is the mobility test “star”, assessing pelvic range of motion in three dimensions. Second is proprioception test, circular trajectory test, assessing the ability to control pelvic movement and follow a predefined trajectory accurately.

Each participant performs both tests twice: before and after the intervention to evaluate immediate changes following treatment.

The intervention consists of four pelvic movement patterns—anterior elevation, posterior depression, anterior depression and posterior elevation—performed in both side-lying positions. The patterns are applied using the rhythmic initiation and combination of isotonic techniques. Each intervention session lasts approximately 15–20 minutes.

Till now 12 patients have been assessed. Preliminary results indicate an approximately 8% improvement in both pelvic mobility and proprioception/movement control following the intervention.

A total of 30 participants are planned to be included in the study.



First-Ever PNF Workshop in Iraq

We are proud to announce that in June 2026, our instructor, Jakub Marciński, conducted a two-day "Introduction to the PNF Concept" workshop in Baghdad, Iraq. It is worth noting that, despite the ongoing conflict in the region, the course took place as planned thanks to the tremendous effort and determination of both the organizers and the participants.

The course participants were highly qualified physiotherapists with university-level training. They expressed interest in the PNF concept and a desire for further professional development through subsequent courses organized in the Middle East region.



Proprioceptive Neuromuscular Facilitation-Based Physical Therapy on the Improvement of Balance and Gait in Patients with Chronic Stroke: A Systematic Review and Meta-Analysis

Phan The Nguyen, Li-Wei Chou, Yueh-Ling Hsieh

PMCID: PMC9225353 PMID: 35743913

Life 2022, 12(6), 882; <https://doi.org/10.3390/life12060882>

Abstract:

The present study aims to determine the potential benefits of PNF on balance and gait function in patients with chronic stroke by using a systematic review and meta-analysis. Systematic review in the following databases: MEDLINE/PubMed, Physiotherapy Evidence Database (PEDro), Cochrane Library and Google Scholar. Studies up to September 2020 are included. A systematic database search was conducted for randomized control trials (RCTs) that investigated the effects of PNF intervention in patients with chronic stroke using balance and gait parameters as outcome measures. The primary outcomes of interest were Berg Balance Scale (BBS), Functional Reach Test (FRT), Timed Up and Go Test (TUG) and 10-Meter Walking Test (10MWT). Nineteen studies with 532 participants were included, of which twelve studies with 327 participants were included for meta-analysis. When the data were pooled, PNF made statistically significant improvements in balance with BBS, FRT and TUG ($p < 0.05$) or gait velocity with 10MWT ($p < 0.001$) when compared to the control. This review indicates that PNF is a potential treatment strategy in chronic stroke rehabilitation on balance and gait speed. Further high-quality research is required for concluding a consensus of intervention and research on PNF.

Keywords: stroke, postural balance, gait, proprioceptive neuromuscular facilitation, stroke rehabilitation

Effect of Irradiation by Proprioceptive Neuromuscular Facilitation on Lower Limb Extensor Muscle Force in Adults

Gupta S, Hamdani N and Sachdev HS

Gupta et al., J Yoga Phys Ther 2014, 5:2

ISSN: 2157-7595

DOI: 10.4172/2157-7595.1000192

Abstract

Background and purpose: This study aims at comparing the effectiveness of PNF technique applied by upper extremity and lower extremity on opposite lower limb muscle strength in adults.

Method: 200 subjects including both males and females of age 20-35 years were recruited. All selected subjects were randomly divided into 4 groups according to the PNF pattern applied to them through lottery system. PNF patterns were applied isometrically at final position and isotonicly throughout the ROM on contralateral upper and lower limb (dominant). A pre-test post-test same subject design was used in which the maximum voluntary isometric contractions (MVIC) of the extension forces of non-dominant lower limb was measured during isometric PNF pattern at final position and after isotonic PNF patterns. Each subject received a two session of PNF. A strain gauge measured the extension force of lower limb.

Results: In subjects, the maximum voluntary isometric contraction (MVIC) of extension force of non-dominant lower limb improved significantly while performing extension PNF pattern (extension-abduction-internal rotation) on dominant lower limb.

Discussion and conclusion: The extension force of the opposite lower limb increased more with PNF pattern of contralateral lower limb than contralateral upper limb and in lower limb homologous pattern was most effective than non-homologous pattern. The result suggests that possible mechanism can be explained by “cross activation” hypothesis and the excitability of non-decussated descending motor fibers, corticospinal tract fibers.

Keywords: PNF, Cross education, Irradiation

Effectiveness of Electrical Muscle Elongation and Proprioceptive Neuromuscular Facilitation Programs on Muscle Flexibility and Stiffness in Young Adults with Functional Hamstring Disorder: A Randomized Clinical Trial with 4-Week Follow-Up

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Life 2025, 15(4), 523; <https://doi.org/10.3390/life15040523>

Abstract

Background: Adequate hamstring flexibility is crucial for musculoskeletal health as increased muscle tone can lead to stretch-type injuries, muscle weakness, dysfunctional neuromuscular control, postural changes, and lower back pain. The aim was to compare the effectiveness of a program based on Electrical Muscle Elongation (EME), Proprioceptive Neuromuscular Facilitation (PNF), and no intervention in improving flexibility and viscoelastic properties of hamstring and quadriceps muscles in active young adults with functional hamstring disorder (type 2B according to the Munich Consensus).

Methods: Sixty-five participants (45 male, 20 female) were randomly assigned to three groups: the EME group (n = 21) received a simultaneous combination of interferential current and stretching, the PNF group (n = 22) underwent active stretching, and the Control group (n = 22) received no intervention. Hamstring and quadricep flexibility and muscle stiffness were measured in both limbs at baseline, post-intervention, and at the 4-week follow-up.

Results: The EME group showed significant improvements in hamstring flexibility in the left limb compared to the Control group and in some myotonometric variables of the quadriceps muscle compared to the PNF and Control groups ($p < 0.05$). Within-groups differences indicated higher improvements in the EME group.

Conclusions: This study suggests that EME may offer greater benefits than PNF stretching in young adults with functional hamstring disorder.

Keywords: muscle disorder; hamstring; electrical stimulation; stretching; flexibility; stiffness

Effect of proprioceptive neuromuscular facilitation on pain and joint mobility in knee osteoarthritis: a systematic review and meta-analysis of randomized controlled trials

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PeerJ. 2026 Jan 16;14:e20581. eCollection 2026.

PMID: 41561818 PMCID: PMC12814904 DOI: 10.7717/peerj.20581

Abstract

Objective: To systematically assess the effect of proprioceptive neuromuscular facilitation (PNF), compared to control interventions or other rehabilitation techniques (RT), on pain intensity and knee active range of motion (AROM) in adults with knee osteoarthritis (KOA).

Methodology: This systematic review and meta-analysis was reported in accordance with PRISMA guidelines. A systematic search was conducted in PubMed, Embase, Web of Science, CENTRAL, CNKI, Wanfang, and VIP for studies published from database inception to August 2025. Randomized controlled trials comparing PNF with control interventions or RT were identified in adults with KOA. Primary outcomes were change in pain and change in AROM from baseline to post-intervention. Data were pooled using a random effects model, with risk of bias assessed using the Revised Cochrane risk-of-bias tool (RoB-2) and the certainty of evidence rated using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach.

Results: Five studies (n = 201) comparing PNF versus control and four studies (n = 202) comparing PNF versus RT were included. Meta-analysis was conducted only for comparisons between PNF and control. In addition, PNF was qualitatively compared with RT, which included soft tissue mobilization (two randomized controlled trials (RCTs)), neuromuscular exercise (one RCT), and stretching (one RCT). Compared to control interventions, PNF demonstrated significantly greater benefits in pain reduction (standardized mean difference (SMD) = -1.14, $p < 0.001$) and knee AROM improvement (weighted mean difference (WMD) = 10.08, $p < 0.001$), albeit the reduction in pain (WMD = -1.66, $p < 0.001$, four RCTs) did not reach the minimal clinically important difference (MCID). When compared with RT, findings for change in pain were mixed across four RCTs (one favored RT, two showed no difference, one favored PNF); for knee AROM, one favored PNF, while the other showed no difference (no pooling due to methodological heterogeneity).

Conclusions: PNF appears to yield greater improvements in pain reduction and joint mobility compared to control interventions among individuals with KOA. While its efficacy relative to RT remains inconclusive, PNF shows potential as an alternative or adjunct rehabilitation approach. Further high-quality RCTs are needed to determine the effects of PNF on pain reduction and joint mobility in KOA.

Keywords: Knee osteoarthritis; PNF; Rehabilitation; Sports health.

The effect of Proprioceptive Neuromuscular Facilitation (PNF) therapy on functional recovery in patients with knee joint injury: a systematic review and meta-analysis

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BMC Musculoskelet Disord. 2025 Dec 17;27(1):47.

PMID: 41408617 PMCID: PMC12821984 DOI: 10.1186/s12891-025-09407-z

Abstract

Objective: This study employed a meta-analytic approach to systematically evaluate the effects of proprioceptive neuromuscular facilitation (PNF) therapy on functional recovery in patients with knee joint injuries.

Methods: Randomized controlled trials investigating the effects of PNF on functional recovery in patients with knee joint injuries were retrieved from the China National Knowledge Infrastructure, PubMed, Embase, Cochrane Library, and Web of Science databases. The methodological quality of the included studies was assessed using the Cochrane Risk of Bias Assessment Tool. Meta-analysis was performed using RStudio, Review Manager 5.4 and Stata 17 software. Pooled effect sizes were calculated as weighted mean differences (WMDs) or standardized mean differences (SMDs) with corresponding 95% confidence intervals (CIs) and 95% prediction intervals (PIs). Heterogeneity was evaluated using the I^2 statistic. A fixed-effects model was applied when $I^2 \leq 50\%$, whereas a random-effects model was used when substantial heterogeneity was present ($I^2 > 50\%$).

Results: A total of 13 studies involving 762 participants were included. PNF demonstrated significant benefits in patients with knee injuries, including improvements in knee flexion range of motion (WMD = 11.09, 95%CI: 4.60-17.57, 95%PI: -10.73-32.90), extension range of motion (WMD = 5.42, 95% CI: 1.29-9.56, 95%PI: -40.77-51.61), pain reduction (SMD = -0.93, 95% CI: -1.68 - -0.19, 95%PI: -4.01-2.14), Lysholm Knee Scoring Scale scores (WMD = 13.96, 95% CI: 6.44-21.49, 95%PI: -17.63-45.55), Berg Balance Scale scores (WMD = 2.83, 95% CI: 0.49-5.17, 95%PI: -21.54-27.20), and Activities of Daily Living scores (SMD = 0.51, 95% CI: 0.12-0.91, 95%PI: -0.79-1.81). Subgroup analyses suggested that combined PNF interventions of 8-12 weeks, performed six times per week for 10-30 min per session, were associated with the greatest improvements in knee joint range of motion during traumatic or postoperative recovery. Similarly, the most pronounced reductions in pain were observed with combined PNF programs of 8-12 weeks, delivered 5-7 times per week for 10-30 min per session, were more effective in alleviating pain in this population.

Conclusions: PNF can significantly improve the active flexion range, extension range, pain, knee joint function, balance ability, and activities of daily living in patients with knee disorders. More high-quality studies with larger samples are still needed for further research.

Keywords: Functional recovery; Knee joint injury; Meta-analysis; Proprioceptive neuromuscular facilitation; Randomized controlled trials; Rehabilitation exercise.

Effect of proprioceptive neuromuscular facilitation (PNF) technique on posture, balance and gait characteristics of older adults with scapular dyskinesis: a randomized controlled trial

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Abstract

Background: Proprioceptive neuromuscular facilitation (PNF) techniques are being utilized among rehabilitation protocols for older adults because they are based on proprioception and coordination activities. The main purpose of this study was to analyze whether including scapular PNF in an intervention improves the posture, balance, and gait characteristics of older adults with scapular dyskinesis.

Methods: Forty-eight older adults (26 females; 22 males; mean $\pm$ SD age, 69.17 ± 4.36) with scapular dyskinesis were randomized into two groups: PNF and conventional exercise group (PNF+Ex) ($n = 23$) and conventional exercise group (Ex) ($n = 25$). Both groups received treatment three times a week for eight weeks and each session lasted 60 min. Outcome measurements included the Lateral Scapular Slide Test (LSST), Dynamic Gait Index (DGI), Walking Speed Test, Timed Up and Go Test (TUG), Functional Reach Test (FRT), and PostureScreen Mobile (PSM) iOS application, which were collected at baseline, after treatment, and three months after the last session.

Results: Both groups showed improvements in scapular dyskinesis, gait characteristics, and posture. When the two groups were compared, the PNF+Ex group had significantly different LSST results in three positions (0° , 45° , and 90°) ($P < 0.000$, $F = 5.414$, $F = 11.440$ and $F = 31.234$) and postural results for head tilt ($F = 4.116$, $P = 0.045$), vertical displacement of head ($F = 5.790$, $P < 0.000$) and shoulder tilt ($F = 6.959$, $P < 0.008$). There were no statistically significant differences in the improvement in balance and gait characteristics between the groups ($P > 0.05$).

Conclusion: Scapular PNF can be added to the rehabilitation of older adults with scapular dyskinesis to improve their scapular disposition and posture. A longer treatment duration is suggested to improve the gait and balance.

Keywords: Aging; Balance; Postural stability; Rehabilitation; Scapula.

Effects of Multidirectional Head Lift Exercise Based on Proprioceptive Neuromuscular Facilitation Techniques on Oropharyngeal Swallowing Muscles in Community-Dwelling Older Adults With Oral Frailty

Ji-Su Park, HyunDong Kim, NaMi Han

J Oral Rehabil. 2025 Aug 6;52(12):2282–2290. doi: 10.1111/joor.70031

PMCID: PMC12624186 PMID: 40767365

ABSTRACT

Background

Dysphagia rehabilitation using proprioceptive neuromuscular facilitation (PNF) was recently introduced. However, the clinical evidence for this technique remains unclear.

Objective

This study aimed to investigate the effects of multidirectional head-lift exercise using PNF techniques for the oropharyngeal swallowing muscles in older adults with oral frailty.

Methods

Older adults with oral frailty were enrolled in this study and randomly assigned to the experimental or control group. The experimental group performed multidirectional head-lift exercises based on PNF techniques, whereas the control group performed conventional head-lift exercises (90 times/day, 5 days/week for 6 weeks). Tongue strength and thickness were measured using an Iowa Oral Performance Instrument and ultrasonography, respectively. Additionally, suprahyoid muscle activation and thickness were measured using surface electromyography and ultrasonography, respectively.

Results

The experimental group showed significant improvements in tongue strength and thickness compared to the control group, as well as significant improvements in suprahyoid muscle activation and thickness (all, $p < 0.05$).

Conclusion

This study demonstrates that multidirectional head-lift exercise based on PNF techniques is more effective than conventional head-lift exercise in increasing the strength and thickness of the oropharyngeal muscles related to swallowing in older adults.

Keywords: dysphagia, head lift exercise, proprioceptive neuromuscular facilitation, suprahyoid muscle, tongue

Surface electromyography analysis of contralateral muscle irradiation in proprioceptive neuromuscular facilitation

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Fisioter. Mov., 2025, v. 38, e38108 DOI: 10.1590/fm.2025.38108

Abstract

Introduction: Proprioceptive neuromuscular facilitation (PNF) is a concept that promotes functional movement through facilitation, inhibition, strengthening, and relaxation of muscle groups. Among its principles, irradiation is defined as the propagation of the response to the stimulus, which can be evidenced as increased contraction or relaxation in synergistic muscles and movement patterns.

Objective: To evaluate PNF patterns in muscle irradiation to the contralateral lower limb through surface electromyography in physical therapy students. **Methods:** This is a cross-sectional study with a quantitative and analytical approach. Thirty healthy volunteers participated in the study and were evaluated with surface electromyography as they performed PNF and rectilinear movement patterns.

Results: It was found that PNF patterns radiate to the contralateral limb, with the flexion abduction-internal rotation pattern with knee flexion being statistically significant ($p < 0.05$). It was observed that the upper patterns do not significantly irradiate to the contralateral limb when compared with lower limb movements (LL). In the correlation between strength and electromyographic activation, the medial gastrocnemius obtained the greatest strength and the lowest muscle activation in movements involving hip or shoulder flexion.

Conclusion: PNF diagonals irradiate to the LL contralateral to that tested in the electromyography. New studies with a larger sample size are needed to investigate contralateral muscle irradiation in healthy individuals through surface electromyography in order to obtain a more robust correlation.

Keywords: Health research evaluation. Muscle strength. Stretching exercises. Electromyography

Home Physiotherapy Using the Proprioceptive Neuromuscular Facilitation Concept in a Patient with Chronic Hemiplegia in a Rural Area: A Case Report

Tomasz Zwoliński, ORCID, Kamila Gworys, Michał Licznarski and Katarzyna Zorena

J. Clin. Med. 2025, 14(24), 8913; <https://doi.org/10.3390/jcm14248913>

Abstract

Background/Objectives: The growing population of stroke survivors living in rural communities, who require ongoing rehabilitation, highlights the need for effective, home-based rehabilitation methods. The aim of this study was to evaluate the potential benefits of Proprioceptive Neuromuscular Facilitation (PNF) on segmental and global motor function, gait performance, Activities of Daily Living (ADLs), and quality of life in a patient with chronic hemiplegia living at home. **Methods:** A 71-year-old woman, five years after an ischemic stroke of the left cerebral hemisphere, presented with severe right-sided hemiplegia and participated in a two-month home-based PNF rehabilitation programme consisting of 20 one-hour sessions delivered 2–3 times per week. To evaluate the effectiveness of the intervention, the following standardised outcome measures were used in given order: Fugl-Meyer Assessment of Lower Extremity (FMA-LE), Trunk Impairment Scale (TIS), Timed Up and Go Test (TUG), Rivermead Motor Assessment Scale (RMA), Barthel Scale (BS), and the Short Form Health Survey (SF-36).

Results: Improvements were observed in lower limb motor function (FMA-LE), gait performance (TUG), and overall quality of life (SF-36).

Conclusions: PNF-based physiotherapy delivered at home environment may provide meaningful benefits for patients living in rural areas, even years after stroke.

Keywords: proprioceptive neuromuscular facilitation (PNF); postural balance; gait; activities of daily living; quality of life; stroke rehabilitation; stroke; home-based rehabilitation

Augmented Effect of Combined Robotic Assisted Gait Training and Proprioceptive Neuromuscular Facilitation-irradiation Technique on Muscle Activation and Ankle Kinematics in Hemiparetic Gait: A Preliminary Study

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Abstract

Background: Proprioceptive neuromuscular facilitation (PNF) alone has limited effectiveness in restoring gait, while robotic-assisted gait training (RAGT) improves motor relearning through repetitive, task-specific movements. Combining PNF with robotic gait training (PRGT) may enhance locomotor recovery by promoting proprioceptive awareness and muscle activation alongside repetitive gait retraining in stroke patients.

Objective: This study compares the immediate effects of PRGT and RAGT on ankle dorsiflexion and muscle activity in chronic hemiparetic stroke patients and healthy controls.

Methods: Thirty participants, including 15 stroke patients and 15 healthy controls, were randomly assigned to PRGT or RAGT for a single 30-min session. Muscle activity (pectoralis major, external oblique, internal oblique/transverse abdominis, rectus femoris, tibialis anterior) was measured using electromyography, while ankle dorsiflexion angle was assessed using a dual-axis inclinometer.

Results: PRGT significantly increased muscle activations compared to RAGT in stroke patients ($p < 0.05$). Additionally, there was a significant difference in ankle dorsiflexion between RAGT and PRGT in both groups ($p < 0.05$).

Conclusion: PRGT demonstrated superior immediate effects on muscle activation and ankle movement, suggesting that combining PNF with robotic-assisted gait training is beneficial for chronic stroke rehabilitation.

Keywords: robotic assisted-gait training (RAGT), proprioceptive neuromuscular facilitation, stroke rehabilitation, muscle activation, irradiation

Ipsilateral proprioceptive neuromuscular facilitation patterns improve overflow and reduce foot drop in patients with demyelinating polyneuropathy

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DOI: 10.12965/jer.1836178.089

Abstract

The purpose of this study was to evaluate the response of the tibialis anterior muscle (TAm) using surface electromyography in patients with Charcot-Marie-Tooth disease (CMT-IA), after ipsilateral proprioceptive neuromuscular patterns (PNF). Thirteen CMT-IA patients (both sexes) were treated twice a week, for 5 weeks, with bilateral PNF pattern, four times per treatment. During the execution of the patterns, we recorded the bilateral activation of the TAm in root mean square (RMS). We used the Student paired t-test for the first and last treatments, P-value set at <0.05. Clinical significance (CS) was obtained by subtracting the values of the first treatment from the last. Chopping pattern to the right side increased RMS for the right ($t=-3.52$, CS=52%), but not the left TAm ($t=-3.35$). Flexion-abduction with external rotation pattern to the right ($t=-2.46$, CS=55%) and left ($t=-2.07$, CS=53%) significantly increased RMS for TAm on both sides. Extension-adduction with internal rotation pattern to the right ($t=-0.25$) and left ($t=-1.84$) did not produce any changes in TAm. Ipsilateral PNF patterns selectively produce TAm overflow in peripheral polyneuropathy patients and can be successfully used as supportive therapy for foot drop.

Keywords: Char-cot-Marrie-Tooth disease; Foot drop; Overflow; Proprioceptive neuromuscular facilitation.

Flexibility-enhancing Interventions for Ankle Range of Motion: A Network Meta-analysis

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Affiliations Expand Int J Sports Med. 2026 Jun 10. doi: 10.1055/a-2876-9237. Online ahead of print.

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Abstract

This systematic review and network meta-analysis compared the effectiveness of five flexibility-enhancing interventions-static stretching, dynamic stretching, ballistic stretching, proprioceptive neuromuscular facilitation, and foam rolling-on ankle dorsiflexion range of motion in physically active healthy adults. A comprehensive search of multiple databases was conducted up to August 4, 2025. This review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines and was registered in prospectively registered in the International Prospective Register of Systematic Reviews. Effect sizes were synthesized using a random-effects network meta-analysis, and intervention rankings were based on the surface under the cumulative ranking curve. Forty-one randomized controlled trials (n=1,670) were included. For the passive range of motion, proprioceptive neuromuscular facilitation (surface under the cumulative ranking curve: 76.8%) and foam rolling (67.8%) were the most effective overall. In long-term protocols (>1 mo), both proprioceptive neuromuscular facilitation (standardized mean difference 1.04 [0.64-1.44]) and foam rolling (standardized mean difference 1.03 [0.53-1.53]) remained superior to controls. For active range of motion, foam rolling ranked the highest (surface under the cumulative ranking curve: 87.2%) and demonstrated the largest short-term improvement, while static stretching showed the most favorable long-term maintenance (surface under the cumulative ranking curve: 72.4%). No intervention-related adverse events were reported. Proprioceptive neuromuscular facilitation and foam rolling are optimal for long-term flexibility enhancement, whereas foam rolling is recommended for short-term, pre-exercise movement preparation. Static stretching may support sustained active range of motion across extended training periods. Intervention selection should align with specific performance goals and training timelines.

Acute neuromechanical effects of static and PNF hamstring stretching on explosive power and balance

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Front Physiol. 2026 Mar 10;17:1751808. doi: 10.3389/fphys.2026.1751808. eCollection 2026. Copyright © 2026 Tai, Chen, Li, Lin, Lai and Yu.

PMID: 41884266 PMCID: PMC13008731 DOI: 10.3389/fphys.2026.1751808

Abstract

Background: Hamstring stretching is widely incorporated into warm-up routines, yet the acute neuromuscular consequences of different stretching modalities on flexibility, explosive performance, and balance remain unclear.

Methods: Using a randomized crossover design, twenty-one healthy young adults completed three conditions: static stretching (SS), proprioceptive neuromuscular facilitation (PNF) stretching, and a no-stretch control (NS). Hamstring flexibility, vertical and broad jump performance, dynamic balance (Y-Balance Test), and static balance via center of pressure (COP) metrics were assessed immediately pre- and post-intervention.

Results: PNF elicited the most favorable acute outcomes, producing significant improvements in hamstring flexibility, broad jump distance, and both static and dynamic balance compared with SS and NS (all $p < 0.05$). SS increased hamstring flexibility but consistently impaired static balance, reflected by larger COP area, trajectory length, and sway velocity across eyes-open and eyes-closed conditions. Vertical jump height showed no significant differences among conditions. Dynamic balance improved significantly following PNF and partially following SS.

Conclusion: PNF stretching is the most effective modality for enhancing immediate flexibility, horizontal power, and postural stability, making it suitable for performance-oriented warm-ups. In contrast, static stretching may compromise neuromuscular control despite improving hamstring flexibility and is therefore better suited for non-performance or recovery contexts.

Keywords: PNF; YBT; balance ability; explosive; hamstring

Effectiveness of respiratory proprioceptive neuromuscular facilitation techniques on pulmonary function and other health-related parameters in chronic obstructive pulmonary disease: A systematic review

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) affects the pulmonary system and leads to various symptoms. Proprioceptive neuromuscular facilitation (PNF) is used in rehabilitation, however its application in pulmonary rehabilitation is limited.

Objective: The primary aim was to investigate the effects of PNF on pulmonary function in Individuals with copd: The secondary aim was to investigate its effects on any other COPD. health-related parameter.

Methods: The protocol of the review was registered in Prospero (CRD 42024526280). Databases were searched up to June 10, 2024, for related studies that investigated the effects of PNF in any COPD health-related parameter. The inclusion criteria were set based on a population, intervention, comparison, outcome and study framework. The studies risk of bias was assessed using the Cochrane risk-of-bias tool for randomized clinical trials.

Results: Eight (8) studies satisfied the inclusion criteria and demonstrated significant improvements in pulmonary function parameters post intervention across all studies. The walking distance, exertion, dyspnoea and chest expansion improved significantly. In addition, range of motion, the impact of disease on quality-of-life and physiological parameters improved significantly following PNF but between-group analysis demonstrated that the improvements were not significantly different between PNF-group and the comparator group. Finally, the majority of the studies had high risk of bias.

Conclusion: This systematic review demonstrated that PNF techniques can be applied in this clinical population and improve several health-related parameters within the group. However, due to the limited number of included studies, the high risk of bias and the differences among the interventions the results are mixed and lack consistency. These findings should be interpreted with caution because the results are constrained not only by the reasons mentioned above, but also due to the co-interventions and the absence of mechanistic data.

Keywords: COPD; Chronic obstructive pulmonary disease; PNF; Proprioceptive neuromuscular facilitation.

Effects of pelvic proprioceptive neuromuscular facilitation on strength, balance and gait in patients with multiple sclerosis:

A randomized controlled study

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Abstract

Objectives: Pelvic stability and mobility are essential for proper trunk and lower extremity function during locomotion. This study aimed to investigate the effects of Pelvic Proprioceptive Neuromuscular Facilitation (PNF) exercises on muscle strength, balance, and gait in patient with MS (pwMS).

Method: Thirty-one pwMS were included in the study. Participants were randomly assigned into two groups. The study group received pelvic PNF exercises, while the control group underwent lower extremity strengthening training for 3 days /a week for six weeks. Muscle strength was assessed using a digital dynamometer, balance with the Figure-of-8 Walk Test, and gait performance with the 12-Item MS Walking Scale.

Results: Muscle strength significantly increased in the study group ($p < 0.05$). The 12-Item MS Walking Scale scores decreased in both groups ($p < 0.05$). However, between-group comparisons revealed that hip extensor and adductor strength improved more in the study group, and the Figure-of-8 Walk Test time decreased significantly in the study group compared to the control group ($p < 0.05$).

Conclusions: This study demonstrated that pelvic PNF exercises effectively enhanced muscle strength and were superior to traditional strengthening exercises in improving balance.

Keywords: Balance; Gait; Multiple sclerosis; Proprioceptive neuromuscular facilitation; Strength.

Effects of proprioceptive neuromuscular facilitation and core stabilization on physical and functional parameters in adolescents with idiopathic scoliosis: a randomized controlled trial

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Abstract

BACKGROUND: Adolescent Idiopathic Scoliosis (AIS) is a three-dimensional spinal deformity that negatively affects postural alignment, functional capacity, and quality of life. Exercise-based interventions such as Proprioceptive Neuromuscular Facilitation (PNF) and Core Stabilization (CS) are increasingly utilized to improve structural and functional outcomes in AIS, yet comparative evidence remains limited.

OBJECTIVE: To evaluate and compare the isolated effects of Proprioceptive Neuromuscular Facilitation (PNF) and Core Stabilization (CS) exercises on spinal curvature, trunk rotation, physical function, and health-related quality of life in adolescents with Adolescent Idiopathic Scoliosis (AIS), with the aim of informing evidence-based conservative treatment strategies.

METHODS: This randomized controlled trial included 52 adolescents aged 10–18 years diagnosed with AIS. Participants were randomly assigned to either a PNF group (n = 26) or a CS group (n = 26). Both groups underwent supervised exercise interventions three times per week for 10 weeks. The primary outcome was the Cobb angle. Secondary outcomes included Angle of Trunk Rotation (ATR), Scoliosis Research Society-22 (SRS-22) questionnaire scores, and physical function tests (six-minute walk test, sit-to-stand test). Assessments were conducted by blinded evaluators.

RESULTS: Both groups demonstrated significant improvements in Cobb angle, ATR, SRS-22 scores, and physical function ($p < 0.05$). The PNF group showed a greater reduction in Cobb angle ($6.8^\circ \pm 1.2^\circ$) compared to the CS group ($5.4^\circ \pm 1.1^\circ$, $p < 0.05$), as well as superior improvements in ATR. Quality of life and physical performance improved significantly in both groups, with no statistically significant differences between groups in SRS-22 scores.

CONCLUSION: Both PNF and CS exercises are effective in improving spinal alignment, trunk symmetry, and physical function in adolescents with AIS. PNF appears to offer greater structural benefits, while both interventions are equally effective in enhancing quality of life. These findings support the integration of exercise-based rehabilitation into conservative management protocols for AIS.

Keywords: Adolescent idiopathic scoliosis; Angle of trunk rotation; Cobb angle; Core stabilization; Proprioceptive neuromuscular facilitation; Randomized controlled trial; SRS-22.

Acute contralateral lower-limb muscle activation induced by PNF patterns: an sEMG comparison of contraction modes

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Abstract

Objectives: This study aimed to conduct a comprehensive comparative analysis of different proprioceptive neuromuscular facilitation (PNF) patterns and their effects on contralateral muscle irradiation in the lower-limb muscles, and to systematically identify which specific muscle groups exhibit the greatest activation in response to various PNF patterns and facilitation techniques.

Methods: Four PNF movement patterns were assessed: an upper limb diagonal, a lower limb diagonal, a trunk diagonal, and a pelvic anteroelevation pattern.

Each pattern was performed under four contraction conditions: active-assisted movement, concentric isotonic contraction, isometric contraction, and combination of isotonics. Surface electromyography was recorded from eight muscles in the lower limb not receiving manual resistance. For each trial, the mean root mean square amplitude within the segmented movement window was normalised to maximal voluntary isometric contraction (%MVIC), and the mean of three valid trials was analysed.

Results: Isometric contractions produced high activation in several muscle–pattern combinations; however, the optimal contraction mode varied by muscle and pattern. Pelvic anteroelevation produced the largest contralateral activation of the gluteal muscles and gastrocnemius, whereas the lower-limb diagonal best targeted the quadriceps.

Conclusion: When contralateral facilitation is desired, resisted PNF, particularly pelvic anteroelevation, tends to maximise lower limb activation in healthy adults under upright, weight-bearing testing conditions, although optimal contraction mode remains muscle and pattern-dependent. Specifically, pelvic anteroelevation produced the largest contralateral activation of the gluteal muscles and gastrocnemius, whereas the lower-limb diagonal best targeted the quadriceps; because the optimal contraction mode differed by muscle, pattern and contraction should be selected jointly against the target muscle rather than by a single universal rule.

Keywords: Proprioceptive neuromuscular facilitation, Contralateral irradiation, Surface electromyography, Lower limb muscles, Resistance-based contractions