ASEAN

e-ISSN 2673-0863

Journal of Rehabilitation Medicine

ASEAN J Rehabil Med
Volume 36, Number 1
January - April 2026
Formerly known as J Thai Rehabil Med

ASEAN Journal of Rehabilitation Medicine (ASEAN J Rehabil Med)

(Formerly Journal of Thai Rehabilitation Medicine)

Publication frequency

ASEAN J Rehabil Med published three issues a year: (1) January-April (2) May-August (3) September-December
Each issue contains 6-8 articles..

Open access policy

ASEAN J Rehabil Med provides an immediate open access to its content on the principle of making research freely available to the public and supporting a greater global exchange of knowledge.
The main access its content is https://www.tci-thaijo.org/index.php/aseanjrm/

ASEAN Journal of Rehabilitation Medicine (ASEAN J Rehabil Med)

(Formerly Journal of Thai Rehabilitation Medicine)

Ownership and publisher

ASEAN J Rehabil Med is owned by the Thai Rehabilitation Medicine Association, which oversees its publication and fully funds all associated management expenses. The association also facilitates operations and management to maintain high publication standards, implement strict peer review processes, and ensure open access for readers worldwide. However, this funding does not influence the editorial board's decision on reviewing or publishing articles

Office address:

11th Floor, Royal Golden Jubilee Buildings, 2 SoiSoonvijai, New Petchburi Road, Bangkok 10310, Thailand
Telephone/Facsimile: 66-(0)2716-6808 / 66-(0)2716-6809; E-mail address: asean.jrm@gmail.com

Content

Editorial

Original Articles

Notes from the Editor-in-Chief

On behalf of the Editorial Board of the ASEAN Journal of Rehabilitation Medicine (ASEAN J Rehabil Med), we are pleased to share a significant update regarding our ongoing journey toward international excellence.

Following valuable feedback from the Content Selection & Advisory Board (CSAB) and in close collaboration with the Thai Journal Citation Index Centre (TCI), our journal underwent a comprehensive transformation in 2024. This effort was dedicated to aligning our editorial and publishing standards with international best practices for transparency and accountability.

The improvement process is built upon three core pillars:

1. Strategic Editorial Overhaul

We conducted a top-to-bottom review of our entire management cycle—from initial screening to final publication. This ensures a rigorous, consistent academic standard and ensures that every article published meets the high scholarly quality expected by the global community.

2. Standardization via the EQUATOR Network

To ensure research transparency and reproducibility, we have integrated international reporting standards:

• Mandatory Guidelines: Authors are now required to follow specific protocols based on their study design (e.g., CONSORT for randomized trials, STROBE for observational studies).

• Verified Submission: The submission process now includes a mandatory checklist, requiring authors to submit their completed reporting forms as supplementary files.

3. Strengthening the Peer Review Process

We have transitioned from a generalized review format to a structured, evidence-based assessment:

• Public Transparency: Our peer review process is now publicly detailed on our website to build trust with authors and readers.

• Reviewer Accountability: Reviewers are now required to use mandatory checklist forms corresponding to the specific study type, ensuring that every manuscript is evaluated against objective, high-level benchmarks.

These systematic updates represent our commitment to fostering high-quality research across ASEAN countries and beyond. We are confident that these enhancements provide a clear roadmap for our journal's growth and its future recognition in global databases.

We thank our authors, reviewers, and the TCI team for their dedication and collaborative effort during this intensive process.

Next, I would like to welcome readers to the first issue of the ASEAN Rehab Med Journal for the year 2026

• Tochaiwat K. and colleagues found that both Thai traditional massage and focused extracorporeal shockwave therapy statistically significantly reduce pain and improve foot function in treating chronic plantar fasciitis.

• Wongsawan P. and colleagues found that combining cranio-cervical flexion training (CCFT) with deep cervical flexor and lower trapezius strengthening exercises yielded the most rapid and pronounced improvements in proprioceptive accuracy, postural control, and neck disability in office workers with chronic neck pain.

• Sawatruang J. and Assawapalangchai S. concluded that combining shoulder-posture-corrector belts with stretching exercise showed a significant improvement only in the pain domain of the Thai version of the Neck Disability Index compared to stretching alone after two weeks for managing chronic neck pain in office workers.

• Tayati W. and Tairattanasuw T. reported that while canalith repositioning procedure combined with home-based vestibular rehabilitation is effective for benign paroxysmal positional vertigo, older adults and females experience greater dizziness-related handicaps. This highlights the need for age- and sex-specific considerations in rehabilitation programs.

• Ruamsuk S. and colleagues suggested that adding melodic intonation therapy (MIT) to conventional therapy may enhance repetition and naming abilities in Thai-speaking stroke patients with Broca's aphasia, supporting its adaptation for tonal language contexts.

• Supasirimontri and colleagues identified stroke rehabilitation, pressure ulcers, and osteoarthritis as the most relevant rehabilitation medicine topics for general practice within the undergraduate medicine curriculum, urging consideration for appropriate teaching hours and assessments.

I extend my sincere thanks to all readers, authors, reviewers, and the editorial board for their hard work and support. I also hope to have your continued support for the upcoming issues.

Assoc. Prof. Kingkaew Pajareya
Editor-In-Chief
The ASEAN Journal of Rehabilitation Medicine

Original Article

A Comparison of the Efficacy of Thai Traditional Massage and Focused Extracorporeal Shockwave Therapy for the Treatment of Chronic Plantar Fasciitis: A Randomized, Single-Blind Clinical Trial

Krongkaew Tochaiwat, Suttatip Yingdilukpantakul and Jiraporn Tantipongsirikul
Department of Rehabilitation Medicine, Banglamung Hospital, Chonburi, Thailand

ABSTRACT

Objectives: To compare the effectiveness of Thai traditional massage (TTM) and focused extracorporeal shockwave therapy (fESWT) in reducing pain and improving foot function in patients with chronic plantar fasciitis (PF)

Study design: A randomized, single-blinded, non-inferiority clinical trial

Setting: Department of Rehabilitation Medicine, Banglamung Hospital in Chonburi, Thailand.

Subjects: Sixty-six patients (≥ 18 years) with chronic plantar fasciitis

Methods: Participants were randomly assigned to one of two groups (n = 33 each) using a block-of-four method. The intervention group received TTM once a week for four weeks, and the control group received fESWT using a BJC-80414 device for the same period. Both groups were instructed to perform daily muscle stretching exercises. Outcomes were assessed using the visual analog scale (VAS) and the foot function Index (FFI) at baseline and at 2, 4, and 8 weeks.

Results: The patients' characteristics in the TTM and fESWT groups showed no significant differences. After treatment, however, The TTM and fESWT groups were significantly different, with the TTM group having lower pain scores than the fESWT group. Comparison of VAS and FFI at the two-week timepoint found they were not different in FFI (pain, disability, activity limitation) after TTM between the two groups. There was, however, a statistically significantly difference at weeks 4 and 8 at the $p = 0.05$ level. A comparison of VAS and FFI at baseline and after 2, 4 and 8 weeks of treatment showed the average VAS scores were statistically significant decreased, whereas FFI (pain, disability, activity limitation) scores were statistically significantly increased at those time points.

Conclusions: The treatment of chronic plantar fasciitis using either Thai traditional massage or focused extracorporeal shockwave therapy can statistically significantly reduce pain and improve foot functionality. However, there is no statistically significant difference in foot functionality between the two treatment methods.

Keywords: chronic plantar fasciitis, Thai traditional massage, extracorporeal shockwave therapy
ASEAN J Rehabil Med. 2026; 36(1): 2-8.

Introduction

Plantar fasciitis, also known as heel spur syndrome, is a condition in which the fascia under the sole of the foot becomes inflamed. It is the most common cause of foot pain in patients seeking treatment in hospitals. In the United States, about 2 million people receive treatment for plantar fasciitis each year, with a prevalence of 11.0-15.0% of patients with foot pain symptoms.[1] Globally, the incidence of plantar fasciitis is around 10.0%, most commonly occurring in individuals between 40-70 years old, with particularly overweight patients, athletes, and individuals with a sedentary lifestyle.[2,3]

Patients experience heel pain when first stepping on the ground after sleeping or sitting for extended periods, which gradually subsides after walking for a while. Physical examinations typically reveal tenderness near the front of the heel bone (calcaneus), closer to the inner side of the foot. When the ankle is flexed, the pain worsens. Although the exact cause of plantar fasciitis is unknown, pathological findings show tissue degeneration and repeated minor injuries at the attachment point of the fascia to the inner side of the heel bone (calcaneal tuberosity), leading to tearing and inflammation.[4,5]

Treatment for plantar fasciitis can be divided into two categories: conservative management and surgical intervention. Most patients receive conservative treatment, while surgery is reserved for cases where conservative measures fail.[6] Conservative treatments include nonsteroidal anti-inflammatory drugs (NSAIDs), appropriate footwear, shoe modifications, steroid injections, and physical therapy methods such as warm water baths, stretching exercises, ultrasound therapy, and shockwave therapy.[7]

Extracorporeal shockwave therapy (ESWT) is widely used for treating chronic plantar fasciitis. It stimulates new blood

Correspondence to: Krongkaew Tochaiwat, MD, FRCPhysiatrT; Department of rehabilitation medicine, Banglamung Hospital 669 Moo 5, Na Kluea Subdistrict, Bang Lamung District, Chon Buri 20150, Thailand; E-mail: Krongkaew899@gmail.com

Received: December 11, 2024 Revised: April 13, 2025 Accepted: April 13, 2025

vessel formation and accelerates tissue repair by increasing growth factors, thereby reducing pain.[8] A study by Haimanot Melese et al. found that shockwave therapy can reduce pain and improve foot function in patients with chronic plantar fasciitis.[9] However, side effects may include pain, swelling, numbness, and bruising at the treatment site.[10] Due to the high cost of the equipment and treatment, shockwave therapy is not widely available in all healthcare settings.

Recently, alternative treatments such as Thai traditional massage have gained popularity for musculoskeletal conditions due to their effectiveness, fewer complications, and proven benefits, especially for pain relief.[11] Massage stimulates blood circulation and relaxes muscles and tendons.[12] Thai traditional massage can help alleviate plantar fasciitis by stimulating blood circulation, reducing tension in the plantar fascia, and improving the flexibility of the foot and leg muscles.[13] Both manual therapy and kinesiotherapy (taping and stretching) can enhance plantar mobility and the quality of life of patients with plantar fasciitis. Which may help reduce pain and inflammation.[14] A study by Saban et al. found that posterior calf muscle massage was more effective in reducing pain than ultrasound therapy for plantar fasciitis.[15] However, another study by Somphrai et al., found that physical therapy was more effective than Thai traditional massage.[16] These differing results may be due to the different types of massage used and to variations in study designs. The present study compared the effects of Thai traditional massage and focused extracorporeal shockwave therapy on patients with chronic plantar fasciitis.

Methods

Study design

This study is a single-blind randomized controlled trial conducted at Banglamung Hospital between September 2021 and August 2022. The Chonburi Provincial Public Health Office approved the trial protocol (Ref. No. 031-2563) on August 17, 2021. The Thai clinical trials registry number is TCTR20250402001.

All participants provided written informed consent prior to participation. This study was reported following the CONSORT 2010 guidelines for randomized controlled trials.

Participants

The participants were adults age 18 or older who had been diagnosed with chronic plantar fasciitis. Patients who met the following inclusion criteria were recruited: 1) aged ≥ 18 years who had been diagnosed with chronic plantar fasciitis, 2) the diagnosis of plantar fasciitis was based on medical history and physical examination, as well as where the patient experienced pain in the plantar medial heel, especially during the initial weight-bearing steps after waking up or after prolonged periods without weight-bearing. Tenderness was present in the medial tubercle of the calcaneus, 3) symptoms had persisted for more than 6 months, and 4) pain level was 4 or higher based on Visual Analog Scale (VAS) assessment.[17,18]

The exclusion criteria included: 1) foot deformities such as hallux valgus or Charcot's foot, 2) a history of using anti-inflammatory pain medication within 2 weeks prior to the study, 3) a history of receiving injections in the heel area within 3 months prior to the study, 4) a history of previous heel or foot surgery, 5) a history of underlying conditions such as diabetes, peripheral neuropathy, arthritis, or blood disorders, 6) presence of wounds on the heel, 7) being pregnant, and 8) the current use of immunosuppressants or anticoagulant medications.

Sample size

The number of participants included in this study was determined based on studies by Traijiwaran et al., 2016.[19] The pain VAS was selected as the primary data source. According to the Pornsri study, the mean difference score of VAS on fESWT was 4.9, which had a standard deviation (SD) of 2.6. The sample size was based on a power of 90% (beta 0.1), a dropout rate of 20.0%, and a statistical significance (alpha = 0.05) of 95% (p = 0.05). As a result, 66 patients were required, with 33 patients per group using the sample size formula based on a randomized, single-blinded, non-inferiority clinical trial.

The sample size for the present study was calculated using the formula by Chow et al.[20] as shown below.

$$n_2 = \frac{(z_{1-\alpha}+z_{1-\beta})^2\sigma^2(1+\frac{1}{k})}{(\epsilon-\delta)^2}$$
$$\epsilon = \mu_2 - \mu_1$$
$$k = \frac{n_1}{n_2}$$
$$n_1 = kn_2$$

Randomization and blinding

Randomization and allocation concealment. The sample was randomized using the block of 4 method. Allocation concealment was ensured by placing the randomization results in sealed opaque envelopes. A research nurse in the outpatient department of Banglamung Hospital distributed the envelopes to the participants. The nurse did not participate in the treatment or the data collection processes. The individual responsible for sealing the envelopes was different from the person distributing them. Participants were allocated in a 1:1 ratio to either the intervention group or the control group. The analyzer was blinded to the treatment allocation, but the participants were not blinded due to the different nature of the intervention in each of the groups (Figure 1).

Intervention

Thai traditional massage (TTM)

Participants in the TTM group received traditional Thai massage once a week for four consecutive weeks. The treatment was administered by a Thai traditional medicine practitioner with at least five years of experience. Each weekly

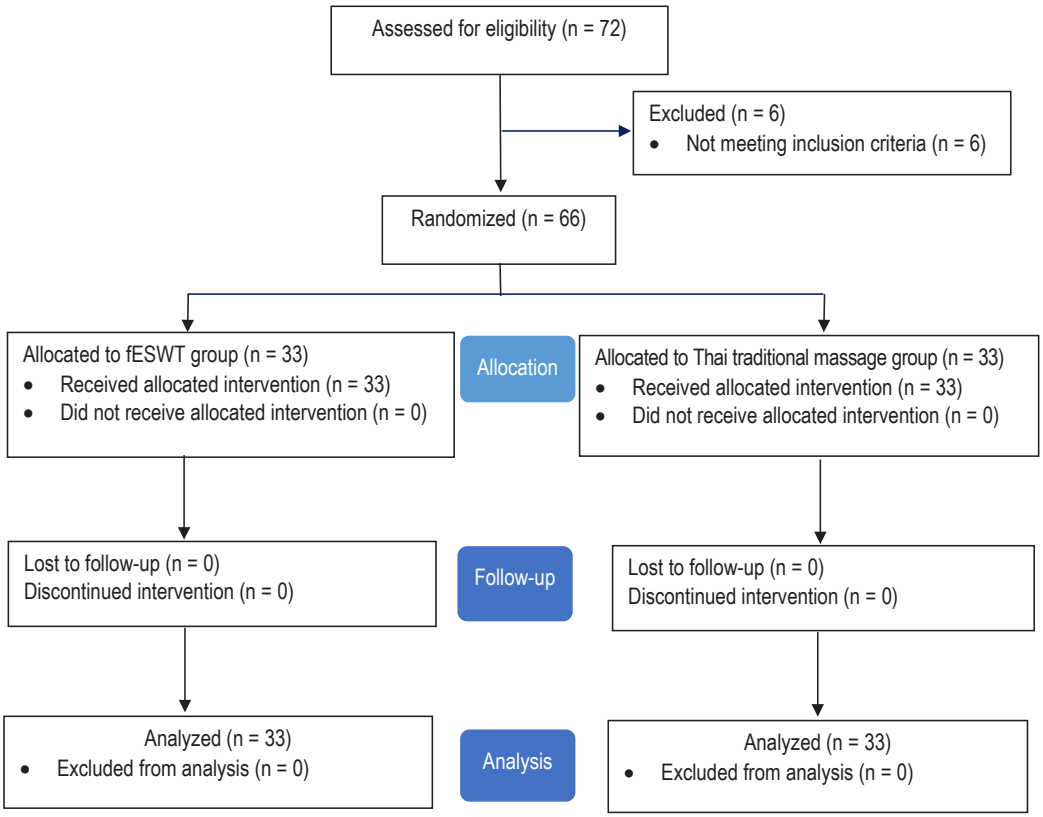


Figure 1. CONSORT diagram of the study

session lasted 30 minutes and was repeated for four consecutive weeks.[21] The Thai traditional massage procedure involved the following steps.[14,22]

1. Basic leg massage focusing on the ankle area for 7 minutes to "open the wind gates."
2. Basic leg massage along with the signals 1 (press the fascia covering the gluteus medius muscle), 2 (press the gluteus medius muscle through the tensor fascia lata muscle), 3 (press the gluteus maximus muscle), 4 (press the biceps femoris and Iliotibial band muscles), 5 (press the fibularis longus muscles) on the outer leg for 8 minutes.
3. Basic leg massage along with the signals 1 (press the semimembranosus muscle), 2 (press the adductor magnus muscles), 3 (press the vastus medialia muscle), 4 (press the popliteal fossa), 5 (press the tendon of tibialis posterior) on the inner leg for 7 minutes.
4. Focus on the heel and painful points, massaging the Achilles tendon area, both inside and outside, for 8 minutes.[23]

The fESWT group was treated with a BJC-80414 focused shockwave device (EMS electro medical systems SA, Switzerland), with the probe placed on the inner heel. Patients received a total of 2,000 pulses at a rate of 4 Hz at each treatment session. The treatment was administered by a rehabilitation physician with at least five years of experience. Each session lasted 30 minutes and was repeated once a week for four weeks.[24]

Additional treatments

The same standard treatment (plantar fascia stretching exercises) was provided to both groups. Participants were instructed to sit in a cross-legged position and to use the hand on the same side as the affected foot to grasp all toes on that foot and gently pull them backward until a stretch was felt in the sole. The stretch was then held for a count of 1 to 10. Each session consisted of 10 repetitions which were repeated three times per day. Participants were encouraged to perform the exercises regularly at home throughout the study period.[25]

Outcomes measurement

The primary outcomes of this study were pain level and Foot Function Index (FFI) including pain level, loss of function, and limitation in performing activities. All of outcomes were measured before the study and at 2, 4 and 8 weeks. For pain level assessment (VAS), a pain measurement tool consisting of a 10 cm straight line was used on which participants marked their pain level. A measurement of 0 cm (VAS = 0) represents no pain, and a measurement of 10 cm (VAS = 10) represents the worst pain possible. FFI, a questionnaire assessing problems related to the feet and ankles was used. It consisted of 23 items divided into three sections: 1) assessment of pain (FFI pain) with 9 items, 2) assessment of disability (FFI disability) with 9 items, and 3) assessment of activity limitations (FFI activity) with 5 items. The questionnaire had been translated into Thai, and each part had a

rating scale of 0-9. A score of 0 means no pain, no difficulty, or never experienced the issue, while a score of 9 means the highest level of pain, extreme difficulty, or always experiencing the issue.[26-28]

Statistical analysis

Statistical analyses were performed using SPSS version 23 with a statistical significance threshold of $p < 0.05$. Baseline and clinical characteristics of both groups are shown as mean and standard deviation for continuous data and number (%) for categorical data. Normality of distribution and equality of variance of VAS and FFI scores were assessed to confirm that parametric tests could be used. The comparison of VAS and FFI was conducted for both the TTM and the fESWT groups, both within and between groups, before the experiment and after 2, 4, and 8 weeks of treatment. Repeated Measure ANOVA was employed for this analysis.

Results

Sixty-six participants were enrolled and randomly assigned to either the TTM (n = 33) or the fESWT group (n = 33). No participants were withdrawn from the study. All participants' data were included in the analysis (Figure 1). Comparison of the general data such as age, gender, body mass index (BMI), affected foot, duration of pain, standing and walking time per day, previous treatment, and pretreatment FFI score comparison between the two groups showed no statistically significant differences (Table 1).

A comparison of VAS and FFI in patients with chronic plantar fasciitis between the TTM and fESWT groups was conducted before the experiment and after 2, 4, and 8 weeks of treatment. It was found that the average levels of pain, functional ability, and limitations in performing activities in both the experimental and control groups significantly decreased at statistical statistically significantly at all levels (between 0.01 and 0.001). There was at least one occasion where differences were observed compared to other time points (Table 2).

A comparison of VAS between the TTM and fESWT groups was conducted before the start of treatment and after 2, 4, and 8 weeks of treatment. It was found that the VAS between the TTM and fESWT groups differed at a statistically significant level of 0.01. (Table 3). However, the levels of FFI across the three aspects did not show any significant differences (Table 3).

Discussion

Patients with chronic plantar fasciitis in the TTM and fESWT groups were assessed before the trial and at 2, 4, and 8 weeks after the start of the intervention. The average levels of pain and foot functionality, including pain severity, loss of ability, and limitations in performing activities, significantly decreased in both groups at statistically significance levels of 0.01 or 0.001 in all measurements. Both groups underwent supportive treatments for plantar fasciitis, emphasizing pain management through various methods such as NSAIDs, appropriate footwear selection, steroid injections, and physical

Table 1. General background information of the research participants

Characteristics	TTM (n = 33)	fESWT (n = 33)	*p-value
Age (years)[1]	54.3 (12.9)	55.1 (8.7)	0.949[a]
Sex[2]			
Male	7 (50.0)	7 (50.0)	1.000[b]
Female	26 (50.0)	26 (50.0)	
BMI[1]	26.6 (3.9)	25.1 (3.3)	0.346[a]
Affected foot[1]			0.868[b]
Right	12 (54.5)	10 (45.5)	
Left	7 (46.7)	8 (53.3)	
Both	14 (48.3)	15 (51.7)	
Duration of pain (months)[1]	7.0 (1.9)	7.2 (2.5)	0.840[a]
Standing/walking time per day (hours)[1]	2.3 (0.9)	2.2 (0.8)	0.677[a]
Previous treatment (VAS)[1]	6.2 (1.1)	6.3 (1.2)	0.696[a]
Pretreatment FFI score[1]			
Pain	40.0 (17.0)	40.9 (16.2)	0.900[a]
Disability	41.8 (16.6)	42.1 (22.7)	0.941[a]
Activity limitation	4.2 (4.6)	5.9 (8.2)	0.989[a]
Total	86.4 (35.2)	88.9 (41.7)	0.790[a]
Previous treatment[2]			
No	10 (47.6)	11 (52.4)	0.792[b]
Yes	23 (51.1)	22 (48.9)	

[1]Mean (SD), [2]number (%); [a]Mann-whitney U test, [b]Chi-square, *$p < 0.05$ indicates statistical significance
BMI, body mass index; VAS, Visual Analogue Scale; FFI, foot function index; TTM, Thai traditional massage; fESWT, focused extracorporeal shockwave therapy

Table 2. Visual Analogue Scale and Foot Function Index at baseline, 2 weeks, 4 weeks, and 8 weeks

Outcomes	Before	After 2 weeks	After 4 weeks	After 8 weeks	*p-value (1-tailed)
Visual Analogue Scale					
TTM	6.21 (1.08)	5.09 (0.98)	3.73 (1.00)	2.94 (1.00)	< 0.001
fESWT	6.30 (1.18)	5.91 (1.49)	4.88 (1.39)	4.36 (1.32)	< 0.001
Foot Function Index					
• Pain					
TTM	40.42 (17.04)	34.70 (15.04)	26.55 (14.96)	23.64 (15.68)	< 0.001
fESWT	40.94 (16.17)	39.82 (15.34)	34.30 (15.05)	32.36 (15.11)	< 0.001
• Disability					
TTM	41.76 (16.59)	37.39 (15.01)	29.09 (15.05)	26.12 (15.05)	< 0.001
fESWT	42.12 (22.66)	42.00 (21.82)	36.00 (17.70)	34.58 (16.84)	0.002
• Activity limitation					
TTM	4.24 (4.62)	2.94 (3.75)	0.73 (1.21)	0.24 (0.71)	< 0.001
fESWT	5.88 (8.23)	4.91 (7.07)	3.52 (6.48)	3.09 (6.57)	0.001

Data are presented as mean (SD); TTM, Thai traditional massage; fESWT, focused extracorporeal shockwave therapy, *$p < 0.05$ indicates statistical significance

Table 3. Visual Analogue Scale and Foot Function Index between groups at baseline and at 2, 4, and 8 weeks

Source of variation	Sum-of-squares	Degrees of freedom	Mean squares	F ratio	*p-value
Visual Analogue Scale					
Between groups					
Group	50.09	1	50.09	10.61	0.002
Error	302.29	64	4.72		
Foot Function Index					
• Pain					
Between groups					
Group	2,018.56	1	2,018.56	2.23	0.140
Error	57,884.76	64	904.45		
• Disability					
Between groups					
Group	1,705.46	1	1,705.46	1.53	0.221
Error	71,539.15	64	1,117.80		
• Activity limitation					
Between groups					
Group	352.37	1	352.37	3.38	0.071
Error	6,672.53	64	104.26		

*$p < 0.05$ indicates statistical significance

therapies. Physical therapy included warm water immersion, muscle stretching, ultrasound therapy and shockwave therapy. These supportive treatments contributed to symptom improvement over time. If these treatments proved ineffective, surgical intervention remained an alternative.

Pain levels and foot functionality in chronic plantar fasciitis patients between the TTM and fESWT groups differed statistically significantly after 2, 4, and 8 weeks of intervention at the *p* value of 0.01. Pairwise testing using the Bonferroni method revealed significant differences across all four evaluations. Thai traditional massage has been demonstrated to beneffective in managing various pain syndromes, particularly in alleviating pain.[11] Massage is one of the processes which promote relaxation of the body as well as increasing blood circulation and reduction of swelling, and also relaxes muscles and tendons.[12] A study by Bernice Saban and colleagues found that posterior calf muscle massage was more effective in reducing pain than ultrasound therapy.[13] Conversely, research by Supamas Somphrai et al. indicated that physical therapy combined with ultrasound therapy was superior to Thai traditional massage in pain reduction.[14] In those studies, both treatments demonstrated good therapeutic outcomes with minimal complications. Systematic reviews have shown that shockwave therapy effectively reduces pain and improves foot function in chronic plantar fasciitis patients, with potential adverse effects such as pain, swelling, numbness, and bruising at the treatment site.[9,10] However, the levels of foot functionality (pain, loss of ability, limitations in performing activities) were not significantly different between the treatments. Both TTM and fESWT stimulate blood circu-

lation, alleviate body pain, and promote relaxation. However, the high cost of focused extracorporeal shockwave therapy devices limits accessibility in healthcare facilities nationwide, making widespread use in Thailand challenging. This study suggests that incorporating Thai traditional massage could play a significant role in managing this condition without involving excessive cost.

Study limitations

There are some limitations to this study. Due to the small sample size in both groups, the effectiveness may not be as significant as could be desired. Further study may be needed with a larger sample size. Furthermore, non-significant results in this study may be due to the short follow-up period; hence, a longer follow-up should be considered in future studies.

Conclusions

The study found that a Thai traditional massage program administered for 30 minutes per session, once a week, over a period of 4 weeks is an appropriate supportive treatment for patients with chronic plantar fasciitis. This approach can be implemented in healthcare facilities at all levels where Thai traditional medicine practitioners are available. Facilities without access to focused extracorporeal shockwave therapy (fESWT) should consider incorporating this method as an alternative treatment option for patients.

Conflict of interest declaration

The authors confirm that there is no conflict of interest related to the manuscript.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript, including the writing, editing, or preparation of figures and tables, with the exception of Grammarly for basic spell-checking.

Acknowledgements

None.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability

The data that support the findings of this study are available from the corresponding author, Krongkaew Tochaiwat, upon reasonable request.

Author contributions

Krongkaew Tochaiwat: conceptualization, methodology, software, writing- original draft preparation, writing – review & editing, visualization, investigation, supervision, validation,
Suttatip Yingdilukpantakul: data curation,
Jiraporn Tantipongsirikul: software.

References

1. Young CC, Rutherford DS, Niedfeldt MW. Treatment of plantar fasciitis. Am Fam Physician [Internet]. 2001 [cited 2001 Aug 15];63(3):467-74. Available from: https://www.aafp.org/pubs/afp/issues/2001/0201
2. Mcpoil TG, Martin RL, Cornwall MW, Wukich DK, Irrgang JJ, Godges JJ. Heel pain-plantar fasciitis: clinical practice guidelines linked to the international classification of function, disability, and health from the orthopaedic section of the American Physical Therapy Association. J Orthop Sports Phys Ther [Internet]. 2008 [cited 2008 Mar 31];38(4):A1-A18. Available from: https://pubmed.ncbi.nlm.nih.gov/18434670/ doi: 10.2519/jospt.2008.0302
3. Chatchawanpanich N. Foot pain and deformities. In: Pajreya K, editor. Rehabilitation medicine for general practice. 1st ed. Bangkok: P.A. Living 2005; p.241-267. (in Thai)
4. O'Brian D, Martin WJ. A retrospective analysis of heel pain. J Am Podiatr Med Assoc [Internet]. 1985 [cited 1985 Aug 1];75(8):416-8. Available from: https://pubmed.ncbi.nlm.nih.gov/4020666/ doi: 10.7547/87507315-75-8-416
5. Murphy GA. Disorder of tendon and fascia and adolescent and adult pes planus. In: Canale ST, editor. Campbell's operative orthopaedics. 10th ed [Internet]. Philadelphia: Mosby 2013 [cited 2013 Jan 1];4217-24. Available from: https://www.researchgate.net/publication/301058311 doi: 10.1016/B978-0-323-07243-4.00082-7
6. Sinaeve F, Vandeputte G. Clinical outcome of surgical intervention for recalcitrant infero-medial heel pain. Acta Orthop Belg [Internet]. 2008 [cited 2008 Aug 1]; 74(4):483-8. Available from: https://pubmed.ncbi.nlm.nih.gov/18811031
7. Crawford F, Thomson C. Interventions for treating plantar heel pain. Cochrane Databases Syst Rev [Internet]. 2010 [cited 2010 Jan 20]; CD000416 Available from: https://pubmed.ncbi.nlm.nih.gov/12917892/ doi: 10.1002/14651858.CD000416
8. James D, Robert C. Diagnosis and treatment of plantar fasciitis. Am Fam Physician [Internet]. 2011 [cited 2011 Sep 15];84(6):676-82. Available from: https://pubmed.ncbi.nlm.nih.gov/21916393/
9. Haimanot M, Abayneh A, Kefale G, Fetene N, Sileshi A. Extracorporeal shock wave therapy on pain and foot functions in subjects with chronic plantar fasciitis: systematic review of randomized controlled trials. Disabil Rehabil [Internet]. 2021 May 26 [cited 2022 Sep 28]; 44(18):5007-14. Available from: https://pubmed.ncbi.nlm.nih.gov/34038642/ doi: 10.1080/09638288.2021.1928775
10. Roerdink RL, Dietvorst M, Zwaard B, Worp H, Zwerver J. Complications of extracorporeal shockwave therapy in plantar fasciitis: systematic review. Int J Surg [Internet]. 2017 Sep 7 [cited 2017 Sep 7];46:133-45. Available from: https://pubmed.ncbi.nlm.nih.gov/28890412/ doi: 10.1016/j.ijsu.2017.08.587
11. Leesiriwattanakul S, Charoenkit K, Pibanwong W. The effects of a Thai massage program on the office syndrome among personnel. Nurs J Min Public health. [Internet]. 2018 Dec 3 [cited 2019 Apr 20];29(2):129-41. Available from: https://he02.tci-thaijo.org/index.php/tnaph/article/view/214906 (in Thai)

12. Chinnoros S, Panyim W. Foot reflexology and pain relief. Ramathibodi Nurs J [Internet]. 2001 [cited 2001 Sep 1]; 7(3): 220-7. Available from: https://www.rama.mahidol.ac.th/nursing/sites/default/files/public/journal/2544/issue_03/04.pdf (in Thai)
13. Boonruab J, Poonsuk P, Damjuti W, Supamethangkura W. Myofascial pain syndrome focused on the upper trapezius muscle: a comparative randomized controlled trial of the court-type traditional Thai massage versus the Thai hermit. J Evid Based Integr Med [Internet]. 2021 [cited 2021 Jan 1];26:2515690X211030852.2 Available from: https://pubmed.ncbi.nlm.nih.gov/34293959/ doi:10.1177/2515690X211030852
14. Poonsuk P, Pattaraarchachai J, Niempook S, Damjuti W, Boonruab J. Manual therapy versus kinesio taping and stretching to enhance plantar mobility and the quality of life of patients with plantar fasciitis. J Exerc Physiol Online [Internet]. 2022 [cited 2022 Aug 1];25(4):37-52. Available from: https://www.asep.org/asep/asep/JEPonlineAUGUST2022_Boonruab.pdf
15. Saban B, Deutscher D, Ziv T. Deep massage to posterior calf muscles in combination with neural mobilization exercise as a treatment for heel pain: A pilot randomized clinical trial. Man Ther [Internet]. 2013 [cited 2013 Sep 3];19(2):102-8. Available from: https://pubmed.ncbi.nlm.nih.gov/24090993/ doi: 10.1016/j.math.2013.08.001
16. Somphrai S, Chatchawan U. The effect of traditional Thai massage and physical therapy on plantar heel pain related with myofascial trigger point of calf muscle: A randomized controlled trial. Khon Kaen Univ J [Internet]. 2020 [cited 2020 Mar 27];84-98. Available from: https://app.gs.kku.ac.th/gs/th/publicationfile/item/21th-ngrc-2020/MMP6/MMP6.pdf (in Thai)
17. Mcpoil TG, Martin RL, Cornwall MW, Wukich DK, IRRgang JJ, Godges JJ. Heel pain-plantar fasciitis: clinical practice guildelines linked to the international classification of function, disability, and health from the orthopaedic section of the American Physical Therapy Association. J Orthop Sports Phys Ther [Internet]. 2008 Mar 31 [cited 2008 Apr 1];38(4):A1-A18. Available from: https://pubmed.ncbi.nlm.nih.gov/18434670/ doi: 10.2519/jospt.2008.0302
18. Crawford F, Thomson C. Interventions for treating plantar heel pain. Cochrane Databases Syst Rev [Internet]. 2010 [cited 2010 Jan 20];(3):CD000416 Available from: https://pubmed.ncbi.nlm.nih.gov/12917892/ doi: 10.1002/14651858.CD000416
19. Traijeewornporn P, Leelasamran W. Comparison the effectiveness of dry needling vs extracorporeal shockwave therapy for chronic plantar fasciitis treatment: a randomized control trial. J Thai Rehabil Med [Internet]. 2016 [cited 2016 Jan 1];26(1):1-7 Available from: https://www.rehabmed.or.th/main/wp-content/uploads/2016/04/L-400
20. Chow SC, Shao J, Wang H. Sample size calculation in clinical research. 3rd ed. [Internet]. New York: Marcel Dekker 2017 [cited 2017 Aug 15]. Available from: https://www.taylorfrancis.com/books/mono/10.1201/9781315183084/sample-size-calculations-clinical-research-shein-chung-chow-jun-shao-hansheng-wang-yuliya-lokhnygina doi: 10.1201/9781315183084
21. Juchli L. Effectiveness of massage including proximal trigger point release for plantar fasciitis: a case report. Inter J Ther Massage Bdywork [Internet]. 2021 [cited 2021 Jun 1];14(2):22-29. Available from: https://pubmed.ncbi.nlm.nih.gov/34079601
22. Foundation for the rehabilitation and promotion of Traditional Thai Medicine Ayurveda School. Thai traditional medicine (Royal Massage). Bangkok: Pickanes Printing Centre; 2005.124-5 p. (in Thai)
23. Sumalee A. Massage therapy for leg and foot disorders. [Internet]. Bangkok; 2023 [cited 2023 Jun 29]. Available from: https://www.stou.ac.th/Schools/Shs/upload (in Thai)
24. Gollwitzer H, Diehl P, Von Kroff A, Rahlfs VW, Gerdesmeyer L. Extracorporal shockwave therapy for chronic painful heel syndrome: A prospective, double blind, randomized trial assessing the efficacy of a new electromagnetic shock wave device. J Foot Ankle Surg [Internet]. 2007 [cited 2007 Sep 1];46(5):348-57. Available from: https://pubmed.ncbi.nlm.nih.gov/17761319/ doi: 10.1053/j.jfas.2007.05.011
25. Digiovanni BF, Nawoczenski DA, Malay DP, Graci PA, Williams TT, Wilding GE, et al. Plantar fascia-specific stretching exercise improves outcomes in patients with chronic plantar fasciitis: A prospective clinical trial with two-year follow up. J. Bone Joint Surg Am [Internet]. 2006 [cited 2006 Aug 1];88(8):1775-81. Available from: https://pubmed.ncbi.nlm.nih.gov/16882901/ doi: 10.2106/JBJS.E.01281.
26. Srimakarat P, Jaroenarpornwatana A, Janchai S, Tantisiriwat N. Reliability and validity of foot Function Index Thai Version (FFI-TH). J Med Assoc Thai [Internet]. 2018 [cited 2018 May 1];101(2):253-60. Available from: https://www.thaiscience.info/Journals/Article/JMAT/10989056.pdf
27. Limtiyayothin A. Thai royal massage training manual. In: Sitthilertpisan T. editor. 3rd ed. Bangkok: PK Max Design; 2010.p. 97-9. (in Thai)
28. Ninlert J. Shockwave therapy in chronic plantar fasciitis patients in physical therapy. Siriraj Med Bull [Internet]. 2017 [cited 2017 May 2];10(2):97-102. Available from: https://he02.tci-thaijo.org/index.php/simedbull/article/view/97672/76078

Original Article

Effects of Cervical Proprioception Training Versus Strengthening Exercise of the Deep Neck and Lower Trapezius Muscle Combined with Cranio-Cervical Flexion Training (CCFT) to Improve Postural Control of the Neck in Office Workers with Chronic Neck Pain: A Single-Blind, Parallel-Group Randomized Controlled Trial

Peerapong Wongsawan, Thanit Veerapong and Supinda Rattanawihok
Chakri Naruebodindra Medical Institute, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Samut Prakan, Thailand

ABSTRACT

Objectives: To compare the effects of cervical proprioception training versus strengthening exercises of the deep cervical flexor and lower trapezius muscles, each combined with cranio-cervical flexion training (CCFT) on postural control of the neck in office workers with chronic neck pain

Study design: A single-blind, parallel-group randomized controlled trial

Setting: Outpatient Department (OPD), Physical Therapy Clinic, Ramathibodi Chakri Naruebodindra Hospital, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Thailand

Subjects: Thirty-three office workers with neck pain lasting more than 3 months were included. After three participants were excluded prior to the first assessment, twenty-eight people remained in the study (average age 31.2 years; 11 men, 17 women).

Methods: All treatments lasted 45-60 minutes per session, twice a week for 6 weeks (total of 12 sessions). Group 1 did CCFT plus neck position training (n = 10). Group 2 did CCFT plus neck and shoulder muscle strength training (n = 9). The control group did only CCFT (n = 9). Cervical joint position error (JPE), cervical range of motion (ROM), pain intensity (VAS), and the Neck Disability Index (NDI). Outcomes were assessed at baseline, at 4- and 6-weeks post-intervention, and at the 12-week follow-up.

Results: All groups showed significant within-group reductions in mean JPE error angles across all directions by T3 ($p < 0.05$). Group 2 exhibited the earliest improvement, with a significant reduction in JPE at T1 (week 4), whereas Group 1 reached significance at T2 (week 6). Between-group comparisons revealed that both intervention groups (groups 1 and 2) demonstrated significantly greater improvements in JPE than the control group. Cervical ROM increased over time in all groups. group 1 showed greater improvements in right/left lateral flexion than group 2, with no differences compared to the control group. Pain intensity (VAS) and NDI scores decreased significantly from baseline in every group ($p < 0.05$). However, the magnitude of reduction did not differ significantly between groups for VAS, while NDI reduction was greatest in Group 2.

Conclusions: Combining CCFT with deep cervical flexor and lower trapezius strengthening exercises yielded the most rapid and pronounced improvements in proprioceptive accuracy, postural control (ROM), and neck disability. All combinations of interventions were more effective than CCFT alone in reducing JPE, pain, and disability.

Keywords: chronic neck pain, cervical proprioception, strength training, cranio-cervical flexion training, lower trapezius

ASEAN J Rehabil Med. 2026; 36(1): 9-17.

Introduction

According to studies on musculoskeletal disorders among the working-age population in Thailand, the three most common complaints are neck pain, low back pain, and upper back pain, in that order. These conditions are largely attributed to inappropriate work environments, including prolonged sitting and a lack of postural variation during work hours.[1] With the increasing use of electronic devices and computers in modern workplaces, the prevalence of work-related musculoskeletal disorders has risen significantly. Risk factors include individual characteristics such as general health status, stress, anxiety, and underlying medical conditions, as well as occupational factors, including duration of work, nature of tasks, posture, and workplace ergonomics. These factors can contribute directly or indirectly to the development of musculoskeletal symptoms.[2,3]

Neck pain is commonly observed among working individuals, particularly those who also experience shoulder and upper back pain due to prolonged poor posture.[4] Chronic neck pain is a form of work-related musculoskeletal disorder that often results from repetitive strain on muscles, ligaments, joints, and nerves due to the continuous use of the same muscle groups.[5]

Correspondence to: Peerapong Wongsawan, B.Sc. (Physical Therapy); Chakri Naruebodindra Medical Institute, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Samut Prakan 10540, Thailand; E-mail: Peerapong.won@mahidol.ac.th

Received: July 16, 2025 Revised: September 8, 2025 Accepted: September 23, 2025

Dysfunction in the control system of the cervical spine and deep neck muscles may lead to impaired joint control and repeated injuries to bones, muscles, and joints, which in turn contributes to the chronicity of neck pain.[6]

Ravi Shankar Reddy and colleagues found that patients with chronic neck pain and cervical spondylosis demonstrated deficits in joint position sense and movement control compared to healthy individuals. These patients also showed impaired function of deep neck muscles. In some cases, chronic neck pain can affect postural stability, in addition to the neuromuscular control of the cervical spine.[6,7] Sremakaew. et al. reported that patients with cervicogenic headache associated with upper cervical dysfunction exhibited postural instability during standing on unstable surfaces and tandem gait tasks.[8] Moreover, a systematic review by de Vries et al. indicated that joint position error tests could effectively differentiate patients with neck pain (whether traumatic or non-traumatic) from healthy controls, though differences among neck pain subgroups were not statistically significant.[9]

Various physical therapy interventions exist for managing chronic neck pain, including cervical mobilization and manipulation, neuromuscular exercises, stretching and strengthening of cervical muscles, cranio-cervical flexion exercises, thermotherapy, laser therapy, transcutaneous electrical nerve stimulation (TENS), and ergonomic education. The primary goals of these treatments are to reduce pain and improve cervical neuromuscular function.[10] While many interventions focus on short-term pain relief, specific muscle training, particularly targeting the deep neck flexors, has shown promise for long-term improvement and is recommended for physical therapy patients with chronic neck pain.[10,11]

Schomacher, J. and colleagues found that training the deep cervical extensor muscles can enhance coordination with the deep cervical flexors, improving muscle function and reducing overactivity of the extensors, ultimately leading to pain reduction in patients with chronic neck pain.[12] This form of training enhances sensorimotor control and proprioception of the cervical spine.[6] Similarly, research by O'Leary et al. highlighted the specificity and effectiveness of deep cervical flexor training, recommending this method for strengthening and endurance enhancement in patients with chronic neck pain.[13]

Gallego Izquierdo et al. compared cranio-cervical flexion training (CCFT) with joint position sense training in patients with chronic neck pain. CCFT, a low-intensity exercise, activates the motor control of deep neck flexors in coordination with deep neck extensors. Both types of training were found to improve deep neck flexor function, reduce pain, and enhance functional outcomes in terms of disability indices and daily activities.[14]

In another study by Shannon M. Petersen et al., patients with unilateral neck pain were found to have weakness in the lower trapezius muscle. Strengthening exercises targeting both the ipsilateral and contralateral lower trapezius muscles resulted in significant pain reduction, indicating the therapeutic potential of this approach for managing neck pain.[15,16]

Despite the growing evidence, research focusing on postural control in individuals with chronic neck pain remains limited. This randomized controlled trial aims to compare the effects of two protocols in working-age adults with chronic neck pain and investigate the effects of joint position sense training compared to lower trapezius strengthening exercises combined with CCFT on cervical postural control in working-age individuals with chronic neck pain. The findings from this study could help to inform and enhance physical therapy practices for this patient population in the future.

Methods

Study design

This randomized controlled trial was prospectively registered at the Thai Clinical Trials Registry (TCTR20230124005). Ethical approval was obtained from the Institutional Review Board, Faculty of Medicine Ramathibodi Hospital, Mahidol University (approval No. COA-MURA2021/361; approved on May 14, 2021). All participants provided written informed consent prior to enrollment. The study complied with the Declaration of Helsinki.

Participants

The study population comprised working-age patients presenting with chronic neck, shoulder, and scapular pain lasting for more than 3 months who sought treatment at the Outpatient Department (OPD) of the Physical Therapy Clinic, Ramathibodi Chakri Naruebodindra Hospital. All patients underwent a comprehensive evaluation by a physician specializing in rehabilitation medicine.

Eligibility screening

Potential participants were screened for eligibility based on predefined inclusion and exclusion criteria. To be included, individuals had to be office workers aged 20-50 years whose occupation involved computer- or desk-based tasks for more than 4 hours per day who reported chronic neck pain persisting for over 3 months; an average neck pain intensity of at least 30 millimeters on a 100-millimeter Visual Analog Scale (VAS) over the past week demonstrating a cervical joint position error (JPE) of more than 4.5 degrees, and be willing to provide written informed consent. Participants were excluded if they had any history of cervical spine or spinal cord injury or surgery, had been diagnosed with vestibular disorders (e.g., vertigo, BPPV), neurological sensory deficits or central nervous system disorders, circulatory disorders affecting the cervical region (e.g., migraine, vertebrobasilar insufficiency), musculoskeletal or neurological conditions impairing movement, inflammatory arthropathies of the cervical joints (e.g., rheumatoid arthritis), having received physical therapy for the neck and shoulder or upper back within the previous 6 months, a lower back condition such as scoliosis or lumbar disc hernia-

tion with nerve root compression or had been pregnant within the past 12 months, used analgesic, anti-inflammatory or steroid medications regularly, had communication difficulties preventing cooperation with study procedures, or declined or withdrew consent to participate.

All inclusion criteria and none of the exclusion criteria underwent a comprehensive medical assessment and diagnosis conducted by a rehabilitation medicine physician prior to enrollment. The study procedures and objectives were thoroughly explained to eligible participants, who then provided written informed consent to confirm their voluntary participation. At baseline, enrolled participants completed detailed history taking and physical examination in accordance with the research protocol. This assessment included evaluation of cervical JPE in multiple directions, measurement of pain intensity, cervical range of motion (ROM) testing, and completion of the Neck Disability Index (NDI) questionnaire. All outcome measurements were performed by an independent physical therapist who was not involved in delivering the interventions and who was blinded to group allocation (Figure 1).

Outcomes

Primary outcome measurement

Joint position error: Cervical joint position sense was assessed using the JPE test. Participants were seated in an upright position with their feet flat on the floor and wore a laser pointer mounted on a headband, aimed at a target placed on the wall at eye level. With eyes closed, participants were instructed to actively rotate or move their head in one of the tested directions: flexion, extension, left rotation, or right rotation, and then attempt to return to the starting (neutral) position. The deviation from the original target was measured in degrees and recorded as the JPE. Each direction was tested three times, and the mean error was calculated for each trial.

Secondary outcome measurement

VAS was measured using a 100-millimeter VAS consisting of a single horizontal line anchored at 0 representing no pain and 100 representing the worst pain imaginable. Participants were instructed to mark a point on the line that best reflected their average pain over the past seven days. This continuous scale was used to reduce score clustering and enhance measurement sensitivity.

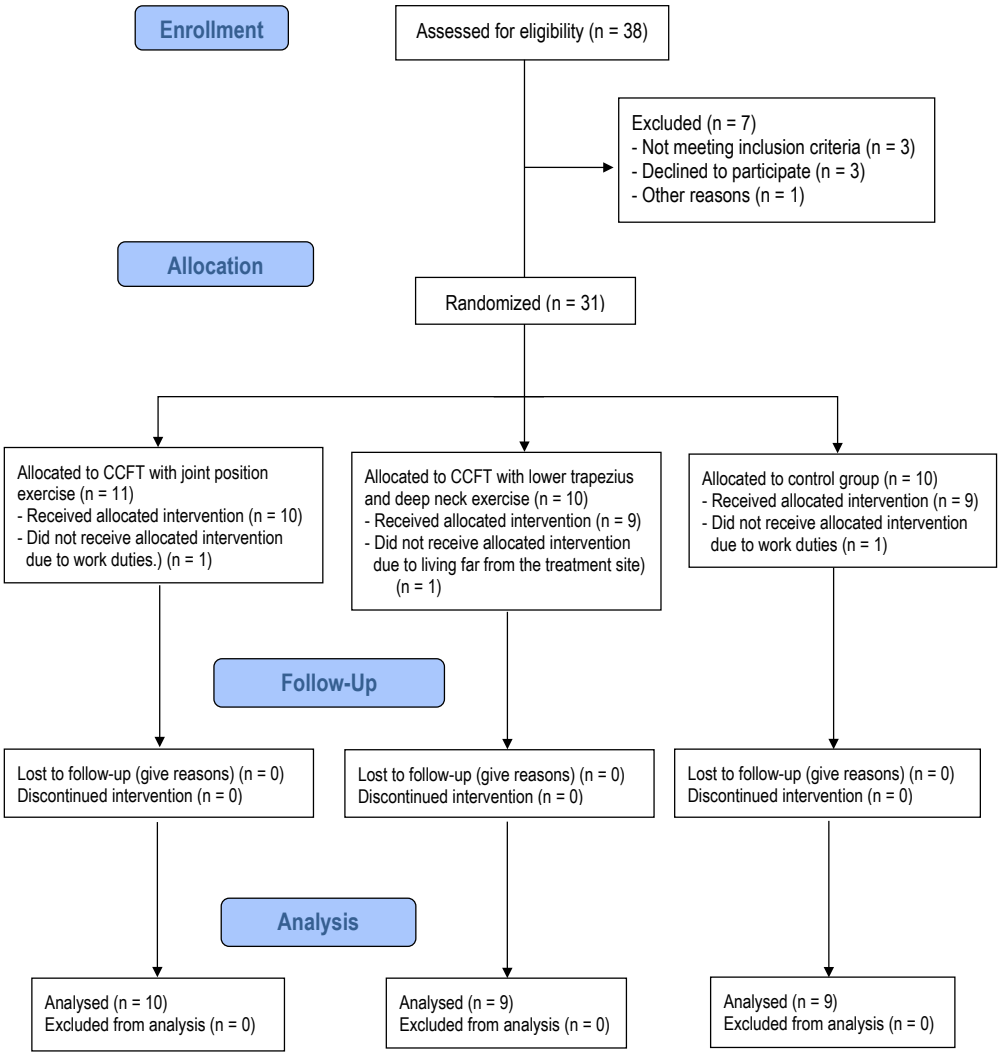


Figure 1. CONSORT flow diagram

Range of motion

Cervical range of motion was assessed in six directions (flexion, extension, left and right lateral flexion, left and right rotation). A digital inclinometer was mounted on a head strap to measure angular displacement. Participants were seated upright with both feet flat on the floor and head in a neutral position. Each movement was performed three times, and the average value was recorded as the representative range of motion for each direction.

Neck disability index

Neck-related disability was assessed using the Thai version of the NDI, a validated questionnaire commonly used in Thailand for evaluating patients with neck pain. The NDI consists of items related to activities of daily living and functional tasks, providing a comprehensive measure of the impact of neck pain on daily activities.

Statistical analysis

Descriptive statistics were used to summarize baseline characteristics. Categorical variables were presented as frequencies and percentages, and continuous variables as mean (SD) or medians (range), depending on distribution. Between-group comparisons were analyzed using Chi-square or Fisher's exact test for categorical variables and ANOVA or Kruskal-Wallis test for continuous variables. Changes in outcomes (JPE, ROM, Pain Score, %NDI) over time were analyzed using mixed-effects models with time, group, and their interaction as fixed effects and subjects as random effects. Results were reported as least-squares means (95%CI). Statistical significance was set at $p < 0.05$. Analyses were performed using Stata version 18 (Stata Corp LLC, College Station, TX, USA).

Sample size calculation

The sample size was calculated based on previous literature by Gallego Izquierdo et al. (2016), using pooled data from all directions of JPE, with a standard deviation of 15 degrees. This corresponds to a large effect size (Cohen's f = 0.7). Using one-way ANOVA with three groups, a significance level of 0.05, and a power of 80%, the required sample size was 30 participants (10 per group).[14]

Intervention

All programs were delivered at the hospital OPD physical therapy twice weekly for 6 weeks (12 sessions total). Outcome assessments were conducted at T0 (baseline, week 0), T1 (week 4, mid-intervention), T2 (week 6, post-intervention), and T3 (week 12, follow-up). Eligible participants were randomly assigned to one of three physical therapy intervention groups using sealed opaque envelopes containing the group allocation. Group 1 received CCFT combined with cervical joint position sense training designed to improve proprioceptive accuracy through JPE exercises. Group 2 participated in CCFT along with strengthening exercises targeting the deep cervical flexor muscles and the lower trapezius muscle. Group 3, the control group, performed CCFT exclusively. Throughout the study, participants were informed of their right to withdraw at any time without consequence. Outcome assessments were conducted at four times: T0 (baseline), T1 (week 4 intervention), T2 (week 6 intervention), and T3 (week 12 follow-up). These follow-up evaluations aimed to monitor progress and treatment effectiveness over the course of the intervention period. (Figures 2-5)

Supine with sub-occipital cuff starting at 20 mmHg at baseline; gentle nodding to targets 22, 24, 26, 28, and 30 mmHg while keeping neutral alignment and avoiding superficial substitution. Dose: hold 10 seconds, 10 repetitions per target.

Seated with a headband-mounted laser aimed at a target 90 cm away at eye level, starting position, eyes closed. Move flexion, extension, and left/right rotation then return to perceived neutral. Each direction had 3 trials.

Supine chin-tuck (with/without slight head lift) on towel roll, emphasizing gentle deep flexor activation and neutral cervical alignment. Dose: 10 repetitions, 3 sets.

Results

A total of 31 participants were randomized to one of three groups (group 1 CCFT with joint position error training, n = 11; group 2 CCFT with deep cervical flexor and lower trapezius strengthening, n = 10; control group CCFT alone, n = 10). One participant per group withdrew during the intervention, and 28 participants were included in the final analysis (group

Figure 2. Cranio-cervical flexion training (CCFT)

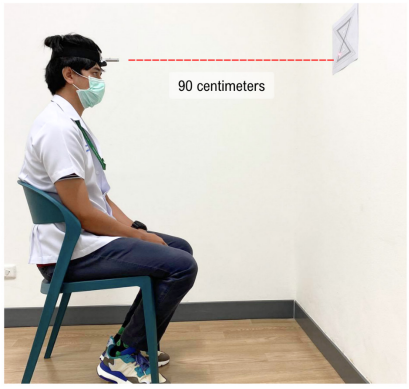


Figure 3. Joint position error (JPE)

Figure 4. Deep neck exercise

1, n = 10; group 2, n = 9; Control, n = 9; 11 males and 17 females; mean age, 31.2 years). The most frequently reported occupational activities were desk-based work, followed by computer use and smartphone use. Baseline characteristics showed no statistically significant differences among groups (Table 1). No adverse events or increases in neck pain were reported in any group during the intervention period.

All groups demonstrated a statistically significant reduction in mean JPE error angles across all directions at the 12-week follow-up (T3) ($p < 0.05$). Within-group analysis showed that Group 2 exhibited a significant reduction in JPE at week 4 (T1), while Group 1 demonstrated significant improvement at week 6 (T2). These findings suggest that group 2 experienced earlier improvement in proprioceptive accuracy compared to the other groups (Table 2).

Between-group comparisons revealed statistically significant improvements in JPE for both group 1 and group 2 compared to the control group, with no significant difference observed between the two intervention groups (Table 5).

Direction-specific intra-group analysis showed the following statistically significant reductions in JPE relative to baseline (T0):

- Right rotation: Significant reduction in the control group at T3.
- Left rotation: Significant reductions in groups 1 and 2 at T2 and T3; the control group showed significant reductions at T1 and T3.

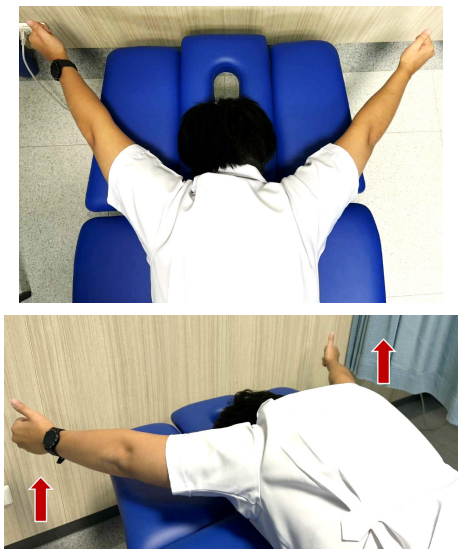


Figure 5. Lower trapezius exercise
Exercises in position "Y", prone horizontal abduction with external rotation. Dose: 10 repetitions, 3 sets

- Flexion: Significant improvements in groups 1 and 2 at T1 and T3; no significant changes in the control group.
- Extension: Significant reduction observed only in group 1 at T1.

Between-group comparisons indicated statistically significant differences in flexion and extension directions between each intervention group and the control group.

Cervical ROM: statistically significant increases in cervical ROM were observed in various directions over time:

- Extension: Increased ROM at T1 in the control group; at T2 in both group 1 and the control group; and at T3 in all three groups.
- Right Lateral Flexion: Increased ROM at T1 in the control group; at T2 in group 1 and the control group; and at T3 in all groups.
- Left lateral flexion: No significant changes at T1; increased ROM at T2 in the control group; and at T3 in all groups.

Table 1. Baseline characteristics of the participants (n = 28)

Baseline characteristics	Group 1 (n = 10)	Group 2 (n = 9)	Control group (n = 9)	*p*-value
Gender (n %)				
Male[1]	3 (27.3)	3 (27.3)	5 (45.5)	0.621[a]
Female[1]	7 (41.2)	6 (35.3)	4 (23.5)	
Age (years)[1]	30.2 (5.2)	32.2 (7.3)	31.3 (5.4)	0.763
BMI (kg/m^2)[1]	24.9 (9.4)	22.4 (10.2)	23.7 (4.0)	0.798[b]
Duration of neck, shoulder, scapular pain (months)[2]	12 (12, 24)	7 (6, 24)	12 (12, 12)	0.712[c]
Usage activities (hours)				
Computer[1]	4.5 (2.6)	4.0 (2.9)	5.3 (3.3)	0.626[b]
Desk[1]	4.1 (1.5)	7.7 (5.2)	7.7 (5.4)	0.136[b]
Smartphone[2]	2 (0, 2)	1 (0, 3)	2 (2, 8)	0.116[c]
Driving a car, motorcycle[2]	1 (1, 2)	1 (0.5, 3)	0 (0, 2)	0.354[c]
Heavy lifting[2]	0.5 (0, 1)	0.5 (0, 1)	0 (0, 1)	0.977[c]

[1]Mean (SD), [2]Median (p25, p75);
[a]*p*-value from Chi-square test, [b]*p*-value from One-way ANOVA, [c]*p*-value from Kruskal–Wallis test

Table 2. Joint position error (JPE)

	Group	Degrees[1]				*p*- value
		Baseline	Follow-up			
		T0	T1	T2	T3	
Mean JPE error angle	CCFT (JPE)	4.9 (4.3, 5.6)	4.4 (3.7, 5.2)	3.7 (2.8, 4.7)*	4.0 (3.0, 5.0)*	
	CCFT (LTE)	4.9 (3.9, 5.9)	4.0 (3.1, 5.0)*	4.0 (3.2, 4.8)*	4.1 (3.4, 4.8)*	0.009**
	Control	5.2 (4.6, 5.9)	5.2 (4.7, 5.8)	5.2 (4.1, 6.3)	4.2 (3.4, 4.9)*	
Right rotation	CCFT (JPE)	5.3 (4.9, 5.7)	6.1 (4.7, 7.6)	4.2 (2.9, 5.6)	4.4 (2.5, 6.3)	
	CCFT (LTE)	5.5 (3.8, 7.2)	4.3 (2.8, 5.8)	4.8 (3.2, 6.4)	4.9 (3.6, 6.2)	0.467
	Control	5.6 (4.4, 6.8)	6.3 (5.0, 7.5)	5.2 (3.9, 6.6)	3.9 (3.1, 4.7)*	
Left rotation	CCFT (JPE)	5.4 (4.0, 6.8)	4.7 (3.4, 5.9)	3.9 (2.4, 5.5)*	4.0 (3.1, 5.0)*	
	CCFT (LTE)	5.4 (4.2, 6.6)	4.2 (3.1, 5.3)	4.0 (3.0, 5.0)*	3.6 (2.5, 4.8)*	0.454
	Control	5.7 (4.4, 7.0)	4.6 (3.2, 6.0)*	4.9 (3.5, 6.4)	3.2 (1.9, 4.5)*	
Flexion	CCFT (JPE)	4.6 (3.4, 5.8)	3.4 (2.5, 4.3)*	3.4 (2.2, 4.5)	3.5 (2.6, 4.4)*	
	CCFT (LTE)	4.5 (3.8, 5.1)	3.1 (2.1, 4.0)*	3.5 (2.6, 4.4)	3.0 (1.9, 4.1)*	0.002**
	Control	4.8 (4.0, 5.6)	4.7 (3.7, 5.7)	4.8 (3.6, 6.0)	4.9 (4.2, 5.6)	
Extension	CCFT (JPE)	4.5 (3.6, 5.4)	3.4 (2.7, 4.1)*	3.3 (2.3, 4.3)	4.1 (3.2, 5.0)	
	CCFT (LTE)	4.5 (3.1, 5.8)	4.4 (3.4, 5.4)	3.3 (2.9, 4.0)	4.6 (3.9, 5.3)	< 0.001**
	Control	4.9 (4.0, 5.7)	5.5 (4.6, 6.4)	5.9 (3.9, 7.9)	4.8 (3.5, 6.1)	

[1]Mean (95% confidence interval); Mean JPE error angle, difference in angle compared with the initial angle before treatment;
CCFT, cranio-cervical flexion training; JPE, joint position error;
CCFT (JPE), CCFT with joint position exercise (Group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (Group 2);
Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$) compared with baseline (T0) within groups;
**Statistical significance ($p < 0.05$) in ANOVA analysis between groups

Table 3. Range of motion of neck (ROM)

ROM	Group	Mean (95 % confidence interval)				*p*- value
		Baseline	Follow-up			
		T0	T1	T2	T3	
Flexion	CCFT (JPE)	43.7 (39.4,47.9)	46.0 (39.8, 52.1)	47.7 (41.8, 53.5)	50.9 (44.8, 56.9)*	
	CCFT (LTE)	42.4 (32.9, 52.0)	44.0 (36.8, 51.2)	44.0 (35.1, 52.9)	45.5 (36.1, 54.9)	0.009**
	Control	40.5 (35.9, 45.2)	39.4 (32.8, 46.0)	41.5 (35.4, 47.6)	42.7 (38.6, 46.8)	
Extension	CCFT (JPE)	47.6 (43.6, 51.6)	53.2 (48.1, 58.4)	58.5 (54.2, 62.8)*	55.5 (48.4, 62.5)*	
	CCFT (LTE)	50.5 (44.3, 56.7)	49.1 (40.7, 57.5)	51.0 (40.2, 61.8)	48.8 (41.2, 56.4)	0.467
	Control	43.8 (32.0, 55.5)	52.0 (43.6, 60.5)*	55.5 (48.7, 62.3)*	57.1 (52.1, 62.1)*	
Right lateral flexion	CCFT (JPE)	31.1 (27.3, 34.8)	32.6 (29.1, 36.1)	39.8 (36.8, 42.9)*	39.6 (35.4, 43.8)*	
	CCFT (LTE)	29.5 (25.6, 33.4)	30.5 (25.8, 35.1)	31.5 (26.9, 36.1)	31.3 (26.9, 35.7)	0.454
	Control	27.3 (23.6, 30.9)	32.9 (29.0, 36.8)*	35.5 (28.7, 42.2)*	35.4 (30.8, 39.9)*	
Left lateral flexion	CCFT (JPE)	32.1 (27.8, 36.4)	33.2 (28.2, 38.2)	38.7 (34.3, 43.1)	40.4 (34.7, 46.1)*	
	CCFT (LTE)	31.4 (28.9, 34.0)	31.4 (28.3, 34.5)	31.7 (28.6, 34.9)	30.4 (27.9, 32.8)	0.002**
	Control	31.7 (28.5, 34.8)	32.7 (27.9, 37.5)	36.5 (30.6, 42.5)*	36.9 (33.6, 40.1)*	
Right rotation	CCFT (JPE)	59.2 (51.9, 66.6)	70.2 (65.7, 74.7)*	70.5 (62.6, 78.4)*	67.1 (60.5, 73.6)	
	CCFT (LTE)	59.0 (50.3, 67.8)	64.2 (52.8, 75.6)	69.8 (57.9, 81.6)*	69.2 (59.1, 79.3)*	
	Control	55.7 (48.2, 63.3)	64.6 (58.1, 71.0)	64.0 (60.3, 67.6)*	62.6 (58.9, 66.3)	0.002**
Left rotation	CCFT (JPE)	60.5 (53.5, 67.5)	69.1 (63.6, 74.5)*	73.1 (68.0, 78.2)*	71.7 (66.7, 76.7)*	
	CCFT (LTE)	59.4 (52.7, 66.1)	65.2 (54.0, 76.5)	71.6 (63.4, 79.9)*	69.7 (61.4, 77.9)*	
	Control	57.6 (49.9, 65.2)	64.5 (58.5, 70.6)	65.4 (59.9, 70.8)*	65.5 (61.2, 69.8)*	

CCFT, cranio-cervical flexion training; JPE, joint position error; CCFT, cranio-cervical flexion training;
CCFT (JPE), CCFT with joint position exercise (Group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (Group 2); Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$) compared with baseline (T0) within groups; **Statistical significance ($p < 0.05$) in ANOVA analysis between groups

Table 4. Pain score and Neck Disability Index (NDI)

ROM	Group	Mean (95 % confidence interval)				*p*- value
		Baseline	Follow-up			
		T0	T1	T2	T3	
Pain score	CCFT (JPE)	6.5 (6.0, 6.9)	2.2 (1.3, 3.1)*	1.1 (0.4, 1.9)*	1.9 (1.0, 2.8)*	
	CCFT (LTE)	5.7 (4.9, 6.6)	1.3 (0.8, 1.7)*	0.5 (0.2, 0.9)*	0.6 (0.2, 1.0)*	0.346
	Control	6.4 (5.5, 7.3)	2.0 (1.0, 2.9)*	1.2 (0.4, 2.1)*	1.6 (0.4, 2.7)*	
% NDI	CCFT (JPE)	24.9 (19.6, 30.1)	12.5 (9.9, 15.1)*	8.1 (5.1, 11.1)*	11.8 (7.5, 16.2)*	
	CCFT (LTE)	20.2 (14.7, 25.8)	5.0 (1.8, 8.2)*	2.2 (-0.4, 4.9)*	2.2 (-0.6, 5.0)*	0.017**
	Control	23.3 (15.8, 30.9)	12.2 (7.9, 16.5)*	9.2 (4.7, 13.6)*	8.2 (2.6, 13.8)*	

CCFT, cranio-cervical flexion training; JPE, joint position error; CCFT, cranio-cervical flexion training;
CCFT (JPE), CCFT with joint position exercise (Group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (Group 2); Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$) compared with baseline (T0) within groups; **Statistical significance ($p < 0.05$) in ANOVA analysis between groups

Table 5. Multiple pairwise comparisons of study results (Bonferroni test)

Outcome	Mean (SD)			*p*-value
	CCFT (JPE)	CCFT (LTE)	Control	
Joint position error (degree)				
Mean JPE error angle	4.3 (1.4)	4.1 (1.3)	5.1 (1.2)	0.009*
Right rotation	5.0 (2.2)	4.7 (2.3)	5.4 (1.9)	0.467
Left rotation	4.6 (2.2)	4.2 (1.8)	4.8 (2.2)	0.454
Flexion	3.7 (1.7)	3.5 (1.5)	4.8 (1.4)	0.002*
Extension	3.8 (1.5)	4.1 (1.5)	5.3 (2.0)	< 0.001*
ROM (degree)				
Flexion	46.5 (8.9)	43.6 (13.1)	41.0 (8.1)	0.082
Extension	53.7 (9.0)	50.3 (12.3)	53.3 (13.7)	0.425
Right lateral flexion	35.6 (7.0)	31.0 (6.5)	32.9 (7.9)	0.028*
Left lateral flexion	35.8 (8.3)	31.2 (4.2)	34.7 (6.9)	0.016*
Right rotation	66.3 (11.3)	65.3 (16.4)	62.1 (9.3)	0.370
Left rotation	68.1 (10.1)	65.4 (13.4)	63.7 (9.8)	0.253
Pain (score)	3.0 (2.5)	2.2 (2.4)	2.8 (2.6)	0.346
NDI (%)	14.6 (9.1)	8.0 (9.5)	12.9 (10.6)	0.017*

JPE, joint position error; ROM, range of motion of neck; NDI, Neck Disability Index; CCFT, cranio-cervical flexion training; CCFT (JPE), CCFT with joint position exercise (group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (group 2); Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$)

- Right rotation: Increased ROM at T1 in group 1; at T2 in all groups; and at T3 in control group only.
- Left rotation: Increased ROM at T1 in group 1; at T2 in all groups; and at T3 in the control group and group 1.

Between-group comparisons revealed no significant differences in lateral flexion ROM between the intervention groups and the control group. However, group 1 exhibited significantly greater improvement in both right and left lateral flexion compared to group 2 (Table 3, Table 5).

Pain Scores decreased over time in all groups. Although between-group comparisons showed no statistically significant differences, within-group comparisons revealed significant reductions from baseline (T0) in all groups (Table 4). NDI scores significantly decreased in all groups both within and between time points. There was no significant difference in NDI reduction between the intervention groups and the control group. group 1 demonstrated significantly greater improvement than group 2 in both pain score and NDI and multiple pairwise comparisons of study results (Bonferroni test). (Table 4, Table 5)

Discussion

The findings of this study demonstrate that supplementing CCFT with either JPE training or lower trapezius exercises (LTE) produces greater pain relief, increases cervical ROM, enhances cervical postural control, and lowers NDI scores in patients with chronic neck, shoulder and scapular pain than CCFT alone.

Both the CCFT plus JPE and the CCFT plus LTE groups showed similar improvements in the measured outcomes, suggesting that combining specific muscle training with proprioceptive exercises is key to enhancing motor control and modulating pain.

Chronic neck pain reflects not only deficits in cervical proprioception but also impaired motor control of the neck, shoulder, and scapula. These impairments often manifest as inappropriate activation patterns, such as overuse of the upper trapezius and levator scapulae muscles which can exacerbate pain and further disrupt joint proprioception and postural stability.

CCFT effectively activates the deep cervical flexors, including the longus capitis and longus colli muscles, by stimulating proprioceptive receptors such as muscle spindles and golgi tendon organs. These receptors drive neuromuscular adaptations that improve cervical joint-position sense. Falla et al. (2004) reported that patients with chronic neck pain tend to overuse superficial muscles, namely the sternocleidomastoid and anterior scalene muscles, underscoring the necessity of deep cervical flexor training for sustained functional recovery.[17]

The CCFT plus LTE group showed the earliest improvements in mean JPE angle error, with significant changes by week 4. This likely reflects the role of the lower trapezius muscle in optimizing scapular alignment and maintaining cervical posture. These biomechanical gains may reduce inflammation and improve mechanoreceptor sensitivity. Juerjan et al. (2021) similarly found that targeted scapular exercises significantly reduced pain, increased muscle strength, and lowered NDI scores[18], underscoring the importance of scapular stabilizers in maintaining cervical posture and controlling movement.

Cervical range of motion improved in all groups, with the largest improvements in lateral flexion attributed to stretching of the upper trapezius and levator scapulae muscles. The CCFT plus JPE group achieved greater lateral flexion improvements than the CCFT plus LTE group, suggesting enhanced central nervous system processing and sharper kinesthetic awareness. These results align with those of Winter et al. (2022), who reported a 46% increase in joint position sense and a 45% improvement in motor system function following proprioceptive training.[19]

All three groups showed significant post-intervention improvements in NDI scores. The CCFT plus LTE group achieved the greatest reduction in disability. This finding is consistent with Park and Lee (2020), who found that lower trapezius training improves both the craniovertebral and cranial rotation angles, increases muscle thickness, and reduces pain.[20] All interventions reduced neck pain and improved cervical function; however, the CCFT plus LTE intervention produced the fastest recovery. Both joint position error training and lower trapezius exercises served as effective adjuncts to CCFT in office workers with chronic neck, shoulder, and scapular pain.

Conclusions

In this randomized three-arm trial of office workers with chronic neck pain, adding either proprioception training targeting joint position error or targeted strengthening of the deep cervical flexors and lower trapezius to cranio-cervical flexion training produced greater improvements in cervical sensorimotor control than cranio-cervical flexion training alone over a six-week period, with benefits observed at short-term follow-up. Targeted strengthening tended to yield larger reductions in pain and disability, whereas proprioception training appeared to produce the greatest gains in joint position accuracy. These findings suggest that combining cranio-cervical flexion training with a goal-matched adjunct can enhance clinical outcomes in practice. Clinicians can prioritize strengthening when pain and disability predominate, and focus on proprioception drills when sensorimotor inaccuracy is the primary deficit. Confirmation in larger, multi-center cohorts with longer follow-up and cost-effectiveness evaluation is warranted, along with optimization of dose and training duration, as well as stratified analyses to identify patients most likely to benefit.

Limitations

This study has several limitations. Daily loading and use of neck-shoulder-scapular muscles likely varied across participants, and some may have had undiagnosed early-stage cervical spondylosis which could have affected joint position sense and training response. The sample was small and single-center, and, although outcome assessors were blind, participants and physical therapists were not, introducing potential performance bias. Long-term follow-up was not conducted, and workplace ergonomics were not assessed. Future studies should utilize larger, multi-center cohorts with extended follow-up and incorporate ergonomic assessments and interventions to provide more durable outcomes.

Conflict of interest declaration

The authors declare that they have no conflicts of interest.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript. Grammarly was used solely to check and refine grammar throughout the manuscript prior to submission. All content was fully written, organized, and reviewed by the authors.

Acknowledgments

The authors would like to express their sincere gratitude to the patients and the clinical staff of the Department of Rehabilitation Medicine, Chakri Naruebodindra Medical Institute, Faculty of Medicine Ramathibodi Hospital, Mahidol University, for their kind cooperation and support.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability

All relevant data and materials are available from the corresponding author upon reasonable request.

Author contributions

Peerapong Wongsawan: conceptualization, methodology, data collection, formal analysis, writing - original draft,

Thanit Veerapong: supervision, methodology, resources, validation, writing - review & editing,

Supinda Rattanawihok: investigation, data curation, visualization, writing - review & editing.

References

1. Janwantanakul P, Pensri P, Jiamjarasrangsri V, Sinsongsook T. Prevalence of self-reported musculoskeletal symptoms among office workers. [Internet] 2008 Sep [cited 2021 March 12];58(6): Available from: doi: 10.1093/occmed/kqn072
2. Côté P, van der Velde G, Cassidy JD, Carroll LJ, Hogg-Johnson S, Holm LW, et al. The burden and determinants of neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. [Internet] 2008 Feb 15 [cited 2021 Jul 20];33(4 Suppl): Available from: doi: 10.1097/BRS.0b013e3181643ee4
3. Chen X, O'Leary S, Johnston V. Modifiable individual and work-related factors associated with neck pain in 740 office workers: a cross-sectional study. [Internet] 2018 Jul-Aug [cited 2021 May 02];22(4): Available from: doi: 10.1016/j.bjpt.2018.03.003
4. Cohen SP, Hooten WM. Advances in the diagnosis and management of neck pain. [Internet] 2017 Aug 14 [cited 2021 April 10];358(Available from: doi: 10.1136/bmj.j3221
5. Van Eerd D, Munhall C, Irvin E, Rempel D, Brewer S, van der Beek AJ, et al. Effectiveness of workplace interventions in the prevention of upper extremity musculoskeletal disorders and symptoms: an update of the evidence. [Internet] 2016 Jan [cited 2021 June 04];73(1): Available from: doi: 10.1136/oemed-2015-102992
6. Falla D, Farina D. Neural and muscular factors associated with motor impairment in neck pain. [Internet] 2007 Dec [cited 2025 June 15];9(6): Available from: doi: 10.1007/s11926-007-0080-4
7. Reddy RS, Tedla JS, Dixit S, Abohashrh M. Cervical proprioception and its relationship with neck pain intensity in subjects with cervical spondylosis. [Internet] 2019 Oct 15 [cited 2021 April 01];20(1): Available from: doi: 10.1186/s12891-019-2846-z
8. Sremakaew M, Jull G, Treleaven J, Barbero M, Falla D, Uthaikhup S. Effects of local treatment with and without sensorimotor and balance exercise in individuals with neck pain: protocol for a randomized controlled trial. [Internet] 2018 Feb 13 [cited 2021 May 03];19(1): Available from: doi: 10.1186/s12891-018-1964-3
9. de Vries J, Ischebeck BK, Voogt LP, van der Geest JN, Janssen M, Frens MA, et al. Joint position sense error in people with neck pain: A systematic review. [Internet] 2015 Dec [cited 2021 May 18];20(6): Available from: doi: 10.1016/j.math.2015.04.015
10. Blanpied PR, Gross AR, Elliott JM, Devaney LL, Clewley D, Walton DM, et al. Neck Pain: Revision 2017. [Internet] 2017 Jul [cited 2021 Feb 24];47(7): Available from: doi: 10.2519/jospt.2017.0302
11. Kashfi P, Karimi N, Peolsson A, Rahnama L. The effects of deep neck muscle-specific training versus general exercises on deep neck muscle thickness, pain and disability in patients with chronic non-specific neck pain: protocol for a randomized clinical trial (RCT). [Internet] 2019 Nov 14 [cited 2021 May 10];20(1): Available from: doi: 10.1186/s12891-019-2880-x
12. Schomacher J, Falla D. Function and structure of the deep cervical extensor muscles in patients with neck pain. [Internet] 2013 Oct [cited 2021 March 12];18(5): Available from: doi: 10.1016/j.math.2013.05.009
13. O'Leary S, Jull G, Kim M, Vicenzino B. Specificity in retraining craniocervical flexor muscle performance. [Internet] 2007 Jan [cited 2021 Feb 24];37(1): Available from: doi: 10.2519/jospt.2007.2237
14. Gallego Izquierdo T, Pecos-Martin D, Lluch Girbés E, Plaza-Manzano G, Rodríguez Caldentey R, Mayor Melús R, et al. Comparison of cranio-cervical flexion training versus cervical proprioception training in patients with chronic neck pain: A randomized controlled clinical trial. [Internet] 2016 Jan [cited 2022 May 14];48(1): Available from: doi: 10.2340/16501977-2034
15. Petersen SM, Wyatt SN. Lower trapezius muscle strength in individuals with unilateral neck pain. [Internet] 2011 Apr [cited 2021 May 08];41(4): Available from: doi: 10.2519/jospt.2011.3503
16. Petersen SM, Domino NA, Cook CE. Scapulothoracic muscle strength in individuals with neck pain. [Internet] 2016 Aug 10 [cited 2021 June 11];29(3): Available from: doi: 10.3233/bmr-160656
17. Falla DL, Jull GA, Hodges PW. Patients With Neck Pain Demonstrate Reduced Electromyographic Activity of the Deep Cervical Flexor Muscles During Performance of the Craniocervical Flexion Test. [Internet] 2004 [cited 2025 June 15];29(19): Available from: https://journals.lww.com/spinejournal/fulltext/2004/10010/patients_with_neck_pain_demonstrate_reduced.5.aspx doi: 10.1097/01.brs.0000141170.89317.0e
18. Chuachan S, Kaewmunee W, Thongnun K, Prom-in J, Saelao T, Assawawongsawat N. The effects of modified scapular exercises in participants with neck, scapular and shoulder pain: a randomized trial. Thai J Phys Ther. 2021;43(1):31-44. [Internet]. [cited 2025 Nov 10]. Available from: https://he02.tci-thaijo.org/index.php/tjpt/article/download/224054/170270/886375
19. Sakinepoor A, Letafatkar A, Mazidi M. Effect of sensorimotor training on proprioception, pain, and posture in participants with chronic non specific neck pain. [Internet] 2021 09/02 [cited 2025 May 30];7 Available from: doi: 10.22034/IJRN.7.4.61
20. Park SH, Lee MM. Effects of Lower Trapezius Strengthening Exercises on Pain, Dysfunction, Posture Alignment, Muscle Thickness and Contraction Rate in Patients with Neck Pain; Randomized Controlled Trial. [Internet] 2020 Mar 23 [cited 2025 May 12];26 Available from: doi: 10.12659/msm.920208

Original Article

A Study of Short-Term Effects of Using Shoulder-Posture-Corrector Belts Combined with Stretching Exercise in the Management of Chronic Neck Pain in Office Workers: A Single-Blind Randomized Controlled Trial

Jakrapat Sawatruang and Santi Assawapalangchai[2]
Department of Rehabilitation Medicine, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

ABSTRACT

Objectives: To investigate the short-term effects of combining shoulder-posture-corrector belts with stretching exercise in the management of chronic neck pain in office workers, compared with stretching exercise alone.

Study design: Single-blind randomized controlled trial

Setting: Outpatient Unit, Department of Rehabilitation Medicine, Siriraj Hospital, Thailand

Subjects: Sixty patients, aged 20 to 50, with a moderate degree of nonspecific neck pain lasting for at least three months

Methods: Sixty participants were randomly assigned to a control group or an intervention group. All participants were instructed to perform a neck stretching program at home for two weeks. The intervention group received the additional use of the shoulder-posture-corrector belts while sitting at work for two weeks. The primary outcome was the improvement in the management of chronic neck pain, measured using a visual analogue scale (VAS). Secondary outcomes were evaluated using the Neck Disability Index-Thai version (NDI-TH) score, cervical range of motion (CROM), and craniovertebral angle (CVA). Data collection also included compliance, satisfaction, and adverse effects. The outcome measurement was evaluated at baseline and after two weeks.

Results: The study outcomes revealed no statistically significant differences between groups in terms of VAS, NDI-TH (total) scores, CROM (all movement directions), or CVA ($p = 0.244, 0.140, 0.119–0.836$, and 0.207, respectively). The intervention group demonstrated greater improvements than the control group, with a statistically significant difference only in NDI-TH (pain domain) score ($p = 0.010$). However, both groups showed improvements in VAS, NDI-TH (pain domain), and NDI-TH (total) scores ($p < 0.05$). Regarding patients' compliance and satisfaction, subjects from both groups showed comparable good compliance and satisfaction. There were no serious adverse effects reported by either group.

Conclusions: The use of shoulder-posture-corrector belts combined with stretching exercises demonstrated a significant improvement only in the pain domain of the Thai version of the Neck Disability Index (NDI-TH) compared with stretching exercises alone in the management of chronic neck pain in office workers after two weeks of treatment.

Keywords: neck pain, shoulder brace, muscle stretching exercises, office workers

ASEAN J Rehabil Med. 2026; 36(1): 18-27.

Introduction

For the majority of neck disorders, the identifiable underlying disease or abnormal anatomical structure remains inconclusive. As a result, these conditions are categorized as nonspecific neck pain (NS-NP).[1] Various factors can precipitate NS-NP. For individuals who work in office settings, improper sitting posture and sitting for extended periods are the main risk factors contributing to neck pain.[2] Examples of poor posture include forward head posture (FHP) and rounded shoulder posture (RSP). Previous research has revealed a significant correlation between neck pain and FHP.[3] Nearly half of office workers experienced neck pain within the past year.[4] Additionally, neck pain plays a major role in these employees' absences from work.[5]

There are several non-surgical methods for the management of NS-NP. These include patient education, stretching exercise, strengthening or endurance training of neck muscles, medication use, physical therapy, and ergonomic interventions. Various methods can be combined to help alleviate neck pain.[6] According to a study by Tunwattanapong P and colleagues in 2016, the impacts of neck muscle stretching exercise on office workers were examined. The findings revealed that a four-week program of regular stretching exer-

Correspondence to: Santi Assawapalangchai, MD, Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Wanglang Rd., Siriraj, Bangkok Noi, Bangkok 10700, Thailand; E-mail:drjaii@yahoo.com

Received: May 27, 2025 Revised: May 27, 2025 Accepted: May 29, 2025

cises significantly reduced neck and shoulder pain, improved cervical function, and enhanced quality of life among office workers experiencing chronic moderate-to-severe neck or shoulder pain. Nevertheless, neither postural changes nor changes in neck range of motion were measured.[7]

Another treatment involves organizing the work environment and adjusting workers' physical posture. Nowadays, ergonomics is widely used in neck pain treatment. By ensuring proper posture and positioning of work tools like chairs, tables, and computer monitors.[8] A randomized controlled trial by Mahmud et al. demonstrated that office ergonomics training led to improved work habits and significant reductions in neck, upper back, and lower back pain among workers. However, this study did not measure pain intensity, postural changes, or range of motion.[9] In 2018, a randomized trial by Shariat et al. found that both exercise and a combination of exercise and ergonomic modifications were effective in reducing neck pain among desk workers over six months. However, the combination did not outperform exercise alone. Additionally, the ergonomic modifications did not involve the use of any devices.[10] One commonly used ergonomic tool is the lumbar roll. A 2010 study by Horton demonstrated that attaching a lumbar roll to an office chair significantly improved head and neck posture, as measured by the craniovertebral angle (CVA). However, this study has two limitations. First, it only evaluated posture immediately after chair adjustments, without a follow-up period to assess the effects over the short and long term. Second, it did not study patients with neck pain.[11] A 2023 review by Dandale indicated that ergonomic training, when paired with therapeutic exercises, can alleviate pain, enhance posture, and decrease impairment in the neck area. However, since no ergonomic equipment was used, the impact of posture correction could not be determined.[12]

We hypothesized that ergonomic interventions, such as a device, may provide benefits in managing neck pain in office workers with poor sitting posture when combined with exercise. At present, shoulder-posture-corrector belts are becoming increasingly popular as a tool to help maintain proper posture while sitting. According to a 2020 study by Tae-Lim Yoon and colleagues, the use of shoulder-posture-corrector belts in dental hygiene practitioners while working was found to decrease upper trapezius muscle activity, as measured by surface EMG, and enhance thoracic and lumbar extension, leading to improved sitting postures. However, this study did not focus on workers with neck pain, and no assessments of pain scores or neck disability were conducted.[13]

In addition, research by Furukawa Y in 2020 investigated the effects of a Tasuki-style kimono strap, which resembles the shoulder straps, when used for one week in patients with neck pain. The study found that the group using the strap showed significant improvement in the modified neck disability index compared to the waiting list (control) group. However, this study has several limitations. First, the follow-up period was quite short. Second, this equipment is not widely available. Third, they did not measure the posture change. Finally, other key treatments, such as exercise, were not combined.[14]

Ergonomic changes in the workplace can be challenging to implement; using purpose-built devices may be more practical. Based on observations, it has been noted that a device commonly recommended and widely available in pharmacies and online shopping platforms is the shoulder-posture-corrector belts. This device is claimed to correct posture and alleviate neck pain. However, there has been no research investigating the effectiveness of the belt on pain relief or the impact on posture, especially in office workers who are suffering from chronic neck pain. As far as we know, there is no published evidence that posture-corrector belts alone can relieve neck pain. Adding them to stretching exercises, which have proven effective, may provide even greater relief of neck pain than stretching exercises alone. We use a two-week duration of intervention to assess the short-term effect. While exercise may take several weeks to show its effects, the use of an additional belt can immediately improve workers' posture while sitting at work, so the effects would be expected to be noticeable sooner. Moreover, since this device is relatively new and not commonly used for patient treatment, we are cautious about potential side effects if the study were to extend over a longer period. Based on this, our objective is to investigate the short-term effects of combining shoulder-posture-corrector belts with stretching exercises in the management of chronic neck pain in office workers, compared to stretching exercises alone. We hypothesize that combining shoulder-posture-corrector belts with stretching exercises for two weeks will lead to significant improvement in pain, function, posture, and range of motion in office workers, compared to stretching exercises alone. A survey of shoulder-posture-corrector belts on the market revealed that there are many brands and various styles, including commercial brands such as "Futuro", "Tynor", and "Elife". From consideration, it was found that the Futuro brand (Figure 1) has broad straps, soft edges, is easy to wear, and can be adjusted for a tight fit. Additionally, it is reasonably priced, so it has been considered as a prototype for use in the research. There is no conflict of interest between the researchers and the funding source.

Methods

Study design

The study design was a single-blind randomized controlled trial, which was conducted at the Outpatient Unit, Department of Rehabilitation Medicine, Siriraj Hospital, from September 2023 to March 2024. The study protocol was approved by the Siriraj SIRB (COA no. si 487/2023) on July 5, 2023. It was registered in the Thai Clinical Trials Registry (TCTR20230708001). The reporting of the research adhered to the CONSORT Guideline.

Figure 1. Shoulder-posture-corrector belt

Figure 2. Stretching exercise program (A) 1st position; (B) 2nd position; (C) 3rd position

Study participants

Patients diagnosed with nonspecific neck pain, aged 20-50 years, were recruited for the study. They had to experience sitting-related neck pain for at least 3 months. Their pain score, measured by the numeric pain rating scale (NRS), must range between 3 and 8 out of 10. They had to sit while working at least 4 hours per day. We excluded people with cervical disc herniation, cervical radiculopathy, cervical spondylotic myelopathy, rheumatoid arthritis, diseases of the shoulder such as adhesive capsulitis or rotator cuff syndrome, history of severe neck injury, history of neck or shoulder surgery, severe psychiatric disorder, and pregnancy. Patients who cannot take a questionnaire due to a communication problem and patients who plan to take a leave for 2 weeks of attendance would be excluded. In addition, all of them had to discontinue analgesic drugs, physical therapy program, massage, and dry needling at least 1 week prior to enrollment.

Sample size was calculated from the study of Tunwattanapong P7, which reported that a regular stretching exercise program performed for four weeks could decrease neck and shoulder pain better than the control group. In that study, the mean difference was -1.4 (95%CI: -2.2, -0.7) measured by VAS, and the SD was 1.8. Then, the sample size was 26 per group. When reassuring for a dropout by 10%, the total number of subjects was 60.

Study protocol

Sixty participants were enrolled in this prospective trial. All of them were provided with information regarding the study and had to complete the written informed consents. The block of four randomization method was used by computer-generated random numbers. The patients were then randomly allocated with sealed opaque envelopes into two groups by a third party who was not involved in the study. The control group was neck stretching exercise, while the intervention group was neck stretching exercise with the additional use of the shoulder belt during daily work. The demographic characteristics, including age, sex, sitting hours for work per day and week, and duration of neck pain, were assessed at baseline.

All participants received instructions to perform neck stretching exercises from a rehabilitation doctor who did not know which group the patient was in. The targeted muscles included the upper trapezius and levator scapulae. Three stretching exercises were instructed (Figure 2). Each was to be performed for 10 seconds, 5 repetitions, and 3 times a day bilaterally. The exercise was done for 14 consecutive days. The participants in the intervention group were additionally instructed to use the belt by a rehabilitation doctor. They were advised to use the belts while sitting during work for at least 2 hours each business day for 2 weeks. Complications such as wounds, numbness, motor weakness, or progressive neck or shoulder pain were recorded.

Each subject from both groups was asked not to use other treatments, including massage, physical therapy program, dry needling, acupuncture, and analgesic drugs, during their participation in the study. In case of severe pain exacerbation, a tablet of acetaminophen 500 mg was allowed one tablet every 4-6 hours as needed, with a maximum of 3,000 mg per day for rescue therapy, and the number of pills taken must be recorded in the logbook.

The logbook provided information regarding photos showing stretching exercises for both groups and steps for wearing a shoulder belt for the intervention group. The stretching frequency and time of using the shoulder belt had to be recorded in the logbook, including any additional drug use. We contacted the participants by telephone twice a week to monitor compliance and complications.

The outcomes were assessed by a research assistant who was blinded to the patients' allocation groups. The primary outcome was pain score, measured by VAS.[15] The secondary outcomes were neck disability, neck range of motion, and degree of forward head posture. The neck function was assessed using the Neck Disability Index-Thai version (NDI-TH)[16], which measures neck pain and consequent disabilities. It is composed of ten-item questions. The scores range from 0 to 5 per question; the overall scores range from 0 to 50 or 0 to 100%. The higher score represents a more severe disability. We analyzed the NDI-TH pain domain separately from the NDI-TH total domain. The NDI-TH reported high test-retest reliability (ICC = 0.99), excellent internal consistency (Cronbach's alpha = 0.92), and a strong correlation with pain severity (r = 0.89, $p < 0.001$).16 For neck range of motion, we measured the cervical range of motion (CROM), including flexion, extension, lateral flexion, and rotation, by using inclinometers (Figure 3). The participant sat on a chair with a straight back and back support, and looked straight ahead at eye level. Flexion, extension, and lateral flexion were measured with a double inclinometer. For rotation, participants lay on a bed, and a single inclinometer was used. In each position, three measurements were made, and then the average was calculated. Cervical range of motion evaluation using inclinometers has shown good Inter-rater reliability in all directions (ICC = 0.89-0.93).[17] There is a correlation between forward head posture (FHP) and neck pain and disability. Thus, we evaluated FHP by using the craniovertebral angle (CVA). A smaller CVA indicates a greater FHP. A CVA less than 48°-50° is defined as FHP.[18] CVA was measured by taking lateral photographs (Figure 4), which have high reliability, test-retest reliability (ICC = 0.91), and intra-rater reliability (ICC = 0.86).[19] During measurement, the subject was in a straight back seated position with back support and looked at eye level. The spinous process of C7 and the tragus of the ear are marked with a sticker. A horizontal line is drawn passing through C7, making a right angle with the vertical. Then, the angle between the line connecting the C7 spinous process with the tragus of the ear and the horizontal line is measured using the smartphone application, Angle Meter 360. The average of 3 measurements was recorded. All outcomes were evaluated at baseline and the end of the second week.

Figure 3. Cervical range of motion measurement (A) flexion; (B) extension; (C) left lateral flexion; (D) right lateral flexion; (E) left rotation; (F) right rotation

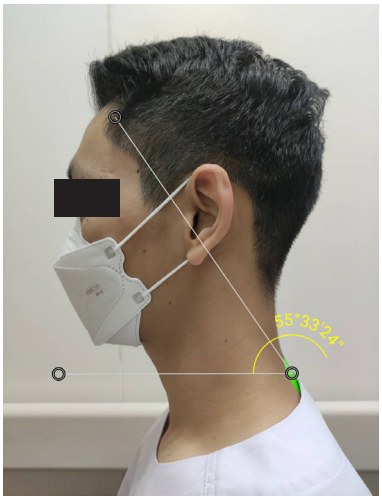


Figure 4. Craniovertebral angle measurement

Statistical analyses

Statistical analysis was performed using SPSS version 28. The continuous data with a normal distribution was demonstrated as mean and standard deviation, while continuous data with a non-normal distribution was demonstrated as median and interquartile range (IQR). The categorical data were shown as numbers and percentages. Independent sample t-test and Mann-Whitney U test were performed to compare the differences in continuous data between the two groups. A dependent sample t-test was used to compare the differences within groups. Chi-square or Fisher's exact test was used to compare categorical data between two groups. The mean difference between the intervention and the control group at the 2nd week, adjusted for baseline, was compared using analysis of covariance (ANCOVA). The $p < 0.05$ was set to consider a statistically significant difference. The primary and secondary outcomes were analyzed using the intention-to-treat population with the worst-case scenario. No interim analysis was performed.

Results

A total of 60 patients were screened and included, of whom 59 completed the trial, as will be seen in the flow diagram (Figure 5). One participant in the control group was lost to follow-up.

Baseline characteristics between groups were not significantly different in terms of age, sex, sitting time per day, sitting days per week, and duration of neck pain, as shown in Table 1.

In terms of pain reduction, both groups showed a significant decrease in VAS after 2 weeks of treatment, as shown in Table 2. However, the magnitude of improvement was not significantly different between groups ($p = 0.244$), despite the intervention group experiencing a greater percentage reduction (-34.3%) compared to the control group (-25.0%).

From the neck disability point of view, both groups showed a significant reduction in NDI-TH total scores after 2 weeks ($p < 0.05$), with greater improvement in the intervention group

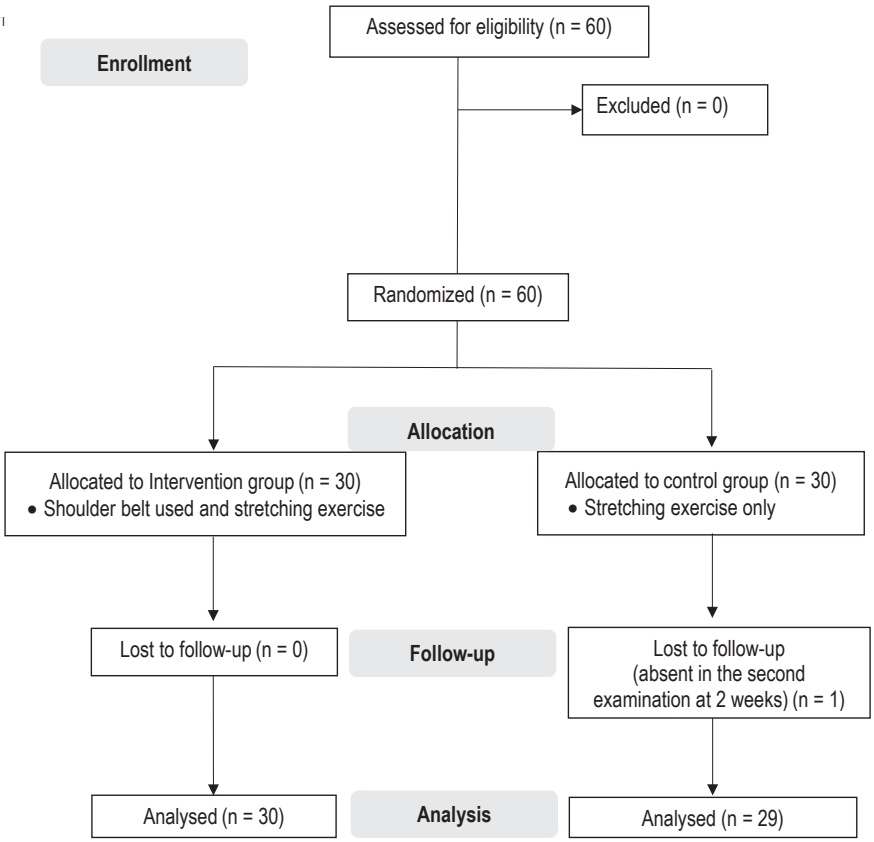


Figure 5. CONSORT flow diagram

Table 1. Baseline characteristics of the study participants

	Intervention (n = 30)	Control (n = 30)	*p*-value
Age (years)[1]	39.6 (7.9)	36.5 (6.5)	0.102[a]
Female[2]	26 (86.7)	24 (80.0)	0.488[b]
Sitting time (hours/day)[1]	7.3 (2.0)	6.9 (1.4)	0.397[a]
Sitting days per week (days)[1]	5.4 (0.7)	5.4 (0.6)	1.000[a]
Duration of neck pain (month)[3]	6.0 (3.0-10.5)	5.0 (3.0-6.0)	0.494[c]

[1]Mean (SD), [2]Number (%), [3]Median (IQR)

Statistical significance; *p*-value < 0.05

[a], independent t-test; [b], Fisher's exact test; [c], Mann-Whitney U test

Table 2. Outcome measures of clinical assessment of the study participants (intention-to-treat analysis: worst-case scenario)

Outcomes	Intervention (n = 30)			Control (n = 30)			Mean difference (95% CI)[2]	*p*-value**
	Week 0	Week 2	*p*-value*	Week 0	Week 2	*p*-value*		
VAS (0-10)[1]	5.1 (1.2)	3.4 (1.9)	< 0.001[a]	5.5 (1.2)	4.1 (1.9)	< 0.001[a]	-0.54 (-1.47, 0.38)	0.244[b]
NDI-TH (pain domain) (0-5)[1]	2.1 (1.0)	0.9 (0.8)	< 0.001[a]	2.0 (0.8)	1.5 (0.9)	0.001[a]	-0.58 (-1.00, -0.15)	0.010[b]
NDI-TH (total) (0-50)[1]	12.9 (7.0)	5.4 (4.6)	< 0.001[a]	14.1 (6.0)	8.4 (8.7)	0.002[a]	-2.67 (-6.25, 0.91)	0.140[b]
CVA (degree)[1]	47.3 (6.2)	49.1 (7.8)	0.067[a]	43.9 (7.8)	43.2 (12.1)	0.636[a]	2.48 (-1.41, 6.37)	0.207[b]
CROM (degree)[1]								
Flexion	39.5 (9.4)	40.7 (10.1)	0.505[a]	34.7 (6.9)	36.1 (10.1)	0.472[a]	2.07 (-2.90, 7.03)	0.408[b]
Extension	41.9 (8.4)	46.0 (9.0)	0.013[a]	39.6 (8.3)	40.7 (12.2)	0.604[a]	3.89 (-1.03, 8.80)	0.119[b]
Right lateral flexion	39.0 (6.1)	41.8 (6.5)	0.008[a]	37.3 (6.3)	39.6 (10.5)	0.183[a]	0.97 (-2.86, 4.81)	0.614[b]
Left lateral flexion	40.1 (7.2)	41.5 (7.9)	0.331[a]	37.6 (6.8)	40.8 (10.2)	0.063[a]	-0.75 (-5.07, 3.58)	0.730[b]
Right rotation	68.5 (9.4)	74.7 (9.5)	0.002[a]	67.8 (10.4)	72.2 (16.9)	0.150[a]	2.07 (-4.50, 8.63)	0.531[b]
Left rotation	69.6 (11.2)	75.2 (9.6)	0.009[a]	69.4 (11.7)	74.4 (18.5)	0.143[a]	0.74 (-6.38, 7.87)	0.836[b]

*Statistical significance within group; *p*-value < 0.05; **Statistical significance between group; *p*-value < 0.05

[a], dependent t-test; [b], ANCOVA

[1]Mean (SD), [2]Mean difference between intervention and control at week 2 adjusted for week 0 using analysis of covariance

VAS, Visual Analogue Scale; NDI-TH, Neck Disability Index Thai version; CVA, craniovertebral angle; CROM, cervical range of motion; CI, confidence interval

than in the control group (57.9% vs. 40.7%). However, the between-group difference was not statistically significant (p = 0.140). When considering the NDI-TH pain domain, the NDI-TH (pain domain) was significantly decreased in the intervention group (56.5%) than in the control group (27.6%) (*p* = 0.010).

Regarding change in CVA, neither group showed a significant improvement in CVA at the end of treatment (*p* = 0.207). In terms of CROM difference, after two weeks, the intervention group showed significant improvements in extension (*p* = 0.013), right lateral flexion (*p* = 0.008), right rotation (*p* = 0.002), and left rotation (*p* = 0.009), as shown in Table 2. The control group, on the other hand, did not reveal any significant changes. However, there was no significant difference in CROM between groups (*p* > 0.05) as shown in Table 2.

In terms of patient satisfaction, 83.3% of participants in the intervention group and 93.1% in the control group rated their treatment at least 4 out of 5 on the satisfaction Likert scale. Nonetheless, the satisfaction was not significantly different between groups (*p* = 0.424). For the intervention group, 80.0% plan to continue using the shoulder belt after completing the 2-week intervention, while 96.7% plan to continue stretching exercises. For the control group, 93.1% plan to continue stretching exercises. Regarding compliance, most participants in both groups perform the stretching exercise for over 80.0% of the recommended duration; however, there was no statistically significant difference observed between the two groups (*p* = 1.000) as shown in Table 3. On average, the intervention group wore the belt for about 3.1 hours per day.

No serious adverse effects were reported in our study. Fifty percent of patients in the intervention group reported minor adverse effects from using the shoulder belt, which were linked to various symptoms, including axilla pain (40.0%), discomfort (16.7%), increased neck pain (13.3%), limited head movement (6.7%), scapular pain (6.7%), shoulder pain (3.3%), and arm paresthesia without weakness (3.3%). Additionally, 23.3% of the intervention group reported side effects from stretching, including increased neck pain (10.0%), limited head movement (6.7%), arm paresthesia without weakness (3.3%), and scapular pain (3.3%). The control group reported adverse effects from stretching at a rate of 27.6%, including increased neck pain (13.8%), limited head movement (13.8%), and shoulder pain (3.4%). One patient in the intervention group and two in the control group took paracetamol for rescue neck pain. Additionally, one patient in the intervention group used an analgesic spray once during the study. Compliance, satisfaction levels, and adverse effects are presented in Table 3.

Table 3. Compliance, adverse effect and satisfaction of all 59 participants

	Intervention (n = 30)	Control (n = 29)	*p*-value
Satisfaction[1]	25 (83.3)	27 (93.1)	0.424[a]
Plan to continue stretching: yes[1]	29 (96.7)	27 (93.1)	0.612[a]
Plan to continue using shoulder brace: yes[1]	24 (80.0)		
Compliance			
Stretching/day (≥ 80%)[1]	26 (86.7)	26 (89.7)	1.000[a]
Average belt using (hours/day)[2]	3.1 (1.4)		
Adverse effects			
From stretching: yes[1]	7 (23.3)	8 (27.6)	0.708[b]
- Increased neck pain	3 (10.0)	4 (13.8)	0.696[a]
- Scapular pain	1 (3.3)	1 (3.4)	1.000[a]
- Limited head movement	2 (6.7)	4 (13.8)	0.418[a]
- Arm paresthesia without weakness	1 (3.3)		
From shoulder belt: yes[1]	15 (50.0)		
- Axilla pain	12 (40.0)		
- Discomfort	5 (16.7)		
- Increased neck pain	4 (13.3)		
- Scapular pain	2 (6.7)		
- Limited head movement	2 (6.7)		
- Shoulder pain	1 (3.3)		
- Arm paresthesia without weakness	1 (3.3)		

[1]Number (%), [2]Mean (SD)

Statistical significance between group; *p*-value < 0.05

[a]; Fisher's exact test, [b]; Chi-square test

Satisfaction is at least 4 points from the 5-point satisfaction Likert scale

Discussion

In our study, we found that treating the neck pain with either stretching exercise alone or stretching exercise combined with the shoulder belt can reduce VAS and NDI-TH total scores after 2 weeks of treatment and the changes exceeded the minimum clinically important difference in VAS and NDI-TH (total) in both groups (MCID = 0.8 points for the VAS in chronic NS-NP, MCID = 3.5 points for the NDI in NS-NP).[20-22] However, no statistically significant difference between groups was observed for the VAS or total NDI-TH scores, except in the NDI-TH pain domain, where the intervention group showed significantly greater improvement (p = 0.010). This discrepancy may be explained by the nature of these two assessment tools. While VAS primarily measures pain intensity at a single point in time, the NDI pain domain evaluates the impact of pain on daily functions such as lifting, concentration, and reading. Therefore, the posture-corrector belt, which provides proprioceptive feedback and encourages upright posture during work, may not have been sufficient to lower pain intensity significantly, but it may have helped reduce the functional burden of pain during work-related tasks. Another possible explanation is that the NDI-TH pain domain may be more sensitive to short-term functional changes than the VAS, especially in chronic conditions where baseline pain levels are moderate. In our study, participants in the intervention group wore the belt for an average of 3.1 hours per day during work, and had an average total sitting duration of 7.3 hours. This duration may not have been sufficient to reduce pain intensity overall, but may have offered functional improvements during periods of belt use. Most similar studies to date, such as those by Tunwattanapong et al.[7] and Shariat et al.[10], have evaluated only the total NDI score and pain intensity (e.g., VAS), without exploring domain-specific outcomes. These differences make it difficult to compare with our findings, where only the pain domain of the NDI-TH showed significant between-group improvement. Nevertheless, our results suggest that combining a posture-corrector belt with stretching may offer functional pain relief even if global pain intensity (VAS) remains unchanged.

Additionally, there were no differences in CVA and CROM between the groups. Furthermore, the intervention group reported a relatively high rate of mild discomfort from using the belt (50.0%), while both groups reported adverse events from stretching exercises at the same rate.

While the intervention group showed a slightly greater improvement in pain (VAS) and NDI-TH total score than did the control group, there was no statistically significant improvement between groups. Possible reasons for this include, firstly, the treatment duration may be too short. We have chosen a two-week intervention period to assess the short-term effects. While exercise may require several weeks to show results, the use of an additional belt can immediately improve workers' posture while sitting, resulting in more rapid improvements. However, we realized that after implementing ergonomic changes, it may take time to see effects on pain reduction. A randomized controlled trial by Mahmud et al. showed that office ergonomics training resulted in better work habits and significant decreases in neck, upper back, and lower back pain among employees. This research fol-

lowed up at six and twelve months after the initial assessment.[9] Therefore, extending the study to a longer term may reveal significant outcomes for the shoulder belt.

Without information regarding the safety of the belt, we must be aware of potential adverse effects and limit our study to only two weeks. As a result, the duration of usage may have been insufficient. We advised the participants to use the belts while sitting during their daily work for at least two hours each business day over two weeks. Since no recommendation regarding duration for daily use of the device was provided by the manufacturer, we have no reference for determining the proper usage time. Additionally, no research similar to ours has combined this type of belt with stretching exercises to establish the optimal duration of belt use. More extended belt usage may lead to discomfort and increase the risk of participant dropout. Our study found that participants in the intervention group used the belt for an average of only 3.1 hours per day, despite spending an average of 7.3 hours sitting at work. A study by Bankhele et al. reported that the combination of an upper back belt and scapular exercises could improve posture from CVA and could reduce pain.[23] The participants in their study wore the belt for six hours a day without any discomfort. In contrast, the participants in our study wore the belt only three hours a day, and 50.0% reported minor adverse effects. For the design of the belt, Bankhele's research uses a belt with a figure-eight design made of cloth, adjustable straps, padding, and pressure sensors (two Flexiforce sensors of 100 lbs and four flex sensors of 4.5 lbs)[23], which is different from our belt. Although our belt allows for adjusting the tightness of the strap, it is a one-size (free size) design, and the weight of our participants ranges from 41.0 to 102.5 kg. Therefore, it may not fit every patient, although we allow patients to try it on and evaluate it before they begin the intervention. As a result, the type of device we selected for the study may not be well-designed, and the way to fit the device may be different. This difference in usage duration might explain why the Bankhele study found more significant results. From another perspective, it is also important to note that Bankhele et al. used a pre-post design without a control group, which can show significant within-group improvements. In contrast, our study included both intervention and control groups. Due to these differences in study design, the lack of a large difference between groups in our study may be explained by a follow-up period that was too short to observe substantial benefits.

In addition, discomfort from wearing the belt could affect the compliance and the dosage of use. So far, we do not know precisely how long the belt should be worn. Our research indicated that wearing this brand resulted in mild side effects. This outcome aligns with findings from a previous study by Furukawa14, which also noted minor discomfort in the neck and shoulder (23.1%) as well as cosmetic concerns (11.5%). Notably, 50.0% of our participants in the intervention group reported minor adverse effects which is relatively high. These adverse events caused the satisfaction of participants in the intervention group to be lower than that of the control group (83.3% in the intervention group and 93.1% in the control group rated at least 4 points on the 5-point satisfaction Likert scale). Even though there were considerable adverse effects (50.0% from the belt and 23.3% from the stretching exercises), participants still reported high overall satisfaction.

Furthermore, 80.0% of those in the intervention group intended to continue using the belt, and more than 90% in both groups planned to keep doing the stretching exercises. This finding indicates that participants felt the benefits outweighed the drawbacks. Additional research is needed to investigate the potential long-term risks and benefits of using these kinds of shoulder braces in the management of neck pain associated with poor posture.

Limitations

Further studies should include a more extended follow-up period, as our research did not cover intermediate or long-term effects. The research should recommend wearing the shoulder belt for an extended period each day. In our study, we did not follow participants after the treatment to evaluate their continued use of the belt and adherence over the subsequent weeks and months. Moreover, we did not know the carry-over effect of the belt in any patients who decided to discontinue wearing it. Additionally, our study did not assess posture change during wear of the belt to determine if it could improve poor posture. Other designs of the posture-corrector belt, especially the custom-made one, could potentially increase comfort and improve compliance more than a prefabricated device. Finally, future studies could be improved by adding a placebo group (such as a sham or low-tension belt) to account for the psychological impact of simply wearing a device.

Conclusions

The use of shoulder-posture-corrector belts combined with stretching exercises demonstrated a significant improvement only in the pain domain of the Thai version of the Neck Disability Index (NDI-TH) compared with stretching exercises alone; however, this combined intervention did not offer additional benefits over stretching exercises alone in terms of pain measured by Visual Analogue Scale (VAS), overall neck disability, posture, or range of motion in the management of chronic neck pain in office workers after two weeks of treatment.

While shoulder-posture-corrector belts may provide subjective benefit or act as biofeedback tools in the short term, stretching exercises alone are as effective as combining them with shoulder-posture-corrector belts in managing neck pain in office workers. From a cost-effectiveness and clinical practicality standpoint, routine prescription of posture belts may not be warranted unless further benefits are demonstrated in long-term studies.

Conflict of interest declaration

The authors declare no conflicts of interest.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript, including the writing, editing, or preparation of figures and tables, with the exception of Grammarly and QuillBot, which was used solely for basic spell-checking and grammar correction.

Acknowledgements

The authors would like to thank Ms. Julaporn Pooliam for her assistance with the statistical analyses.

Funding

This project was funded by the Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand (reference: IOR016631061).

Data availability

The data that support the findings of this research article are available from the corresponding author upon reasonable request.

Author contributions

Jakrapat Sawatruang: investigation, methodology, writing - original draft,

Santi Assawapalangchai: conceptualization, supervision, writing- review and editing.

References

1. Binder A. The diagnosis and treatment of nonspecific neck pain and whiplash. Eura Medicophys [Internet]. 2007 Mar [cited 2024 Oct 4];43(1):79-89. Available from: https://pubmed.ncbi.nlm.nih.gov/17369782/
2. Kim R, Wiest C, Clark K, Cook C, Horn M. Identifying risk factors for first-episode neck pain: A systematic review. Musculoskelet Sci Pract [Internet]. 2018 Feb [cited 2024 Oct 4];33:77-83. Available from: https://pubmed.ncbi.nlm.nih.gov/29197234/. doi: 10.1016/j.msksp.2017.11.007
3. Nejati P, Lotfian S, Moezy A, Moezy A, Nejati M. The relationship of forward head posture and rounded shoulders with neck pain in Iranian office workers. Med J Islam Repub Iran [Internet]. 2014 May 3 [cited 2024 Oct 4];28:26. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC4154278/ doi: 10.1016/j.msksp.2017.11.007
4. Hush JM, Michaleff Z, Maher CG, Refshauge K. Individual, physical and psychological risk factors for neck pain in Australian office workers: a 1-year longitudinal study. Eur Spine J [Internet]. 2009 Oct [cited 2024 Oct 4];18(10):1532-40. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC2899383. doi: 10.1007/s00586-009-1011-z
5. Hoe VC, Urquhart DM, Kelsall HL, Sim MR. Ergonomic design and training for preventing work-related musculoskeletal disorders of the upper limb and neck in adults. Cochrane Database Syst Rev [Internet]. 2018 Oct 23 [cited 2024 Oct 4];10:CD008570. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6486299. doi: 10.1002/14651858.CD008570.pub2.
6. Corp N, Mansell G, Stynes S, Wynne-Jones G, Morsø L, Hill JC, et al. Evidence-based treatment recommendations for neck and low back pain across Europe: A systematic review of guidelines. Eur J Pain [Internet]. 2021 Feb [cited 2024 Oct 4];25(2):275-95. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7839780/. doi: 10.1002/ejp.1679
7. Tunwattanapong P, Kongkasuwan R, Kuptniratsaikul V. The effectiveness of a neck and shoulder stretching exercise program among office workers with neck pain: a randomized controlled trial. Clin Rehabil [Internet]. 2016 Jan [cited 2024 Oct 4];30(1):64-72. Available from: https://pubmed.ncbi.nlm.nih.gov/25780258/. doi: 10.1177/0269215515575747
8. Aas RW, Tuntland H, Holte KA, Røe C, Lund T, Marklund S, et al. Workplace interventions for neck pain in workers. Cochrane Database Syst Rev [Internet]. 2011 Apr 13 [cited 2024 Oct 4];2011(4):CD008160. Available from: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD008160.pub2/full. doi: 10.1002/14651858.CD008160.pub2
9. Mahmud N, Kenny DT, Md Zein R, Hassan SN. The effects of office ergonomic training on musculoskeletal complaints, sickness absence, and psychological well-being: a cluster randomized control trial. Asia Pac J Public Health [Internet]. 2015 [cited 2024 Oct 4];27. Available from: https://pubmed.ncbi.nlm.nih.gov/21878465/. doi: 10.1177/1010539511419199
10. Shariat A, Cleland JA, Danaee M, Kargarfard M, Sangelaji B, Tamrin SBM. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: a randomized controlled trial. Braz J Phys Ther [Internet]. 2018 Mar-Apr [cited 2024 Oct 4];22(2):144-53. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5883995/. doi: 10.1016/j.bjpt.2017.09.003
11. Horton SJ, Johnson GM, Skinner MA. Changes in head and neck posture using an office chair with and without lumbar roll support. Spine [Internet]. 2010 May 1 [cited 2024 Oct 4];35(10):1081-7. Available from: https://pubmed.ncbi.nlm.nih.gov/20445477/. doi: 10.1097/BRS.0b013e3181cb8f82
12. Dandale C, Telang PA, Kasatwar P. The effectiveness of ergonomic training and therapeutic exercise in chronic neck pain in accountants in the healthcare system: a review. Cureus [Internet]. 2023 Mar 4 [cited 2024 Oct 4];15(3). Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10072180/. doi: 10.7759/cureus.35762
13. Yoon TL, Min JH, Kim HN. Effect of using an 8-figure shoulder brace on posture and muscle activities during the performance of dental hygiene procedures. Int J Environ Res Public Health [Internet]. 2020 Nov 16 [cited 2024 Oct 4];17(22):8494. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7696399/. doi: 10.3390/ijerph17228494
14. Furukawa Y. Tasuki for neck pain: An individually randomized, open-label, waiting-list-controlled trial. J Occup Health [Internet]. 2020 Jan [cited 2024 Oct 4];62(1). Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6970410/. doi: 10.1002/1348-9585.12097
15. Salaffi F, Ciapetti A, Carotti M. Pain assessment strategies in patients with musculoskeletal conditions. Reumatismo [Internet]. 2012 Sep 28 [cited 2024 Oct 4];64(4):216-29. Available from: https://www.reumatismo.org/index.php/reuma/article/view/reumatismo.2012.216. doi: 10.4081/reumatismo.2012.216
16. Luksanapruksa P, Wathana-apisit T, Wanasinthop S, Sanpakit

S, Chavasiri C. Reliability and validity study of a Thai version of the Neck Disability Index in patients with neck pain. J Med Assoc Thai [Internet]. 2012 May [cited 2024 Oct 4];95(5):681-8. Available from: https://pubmed.ncbi.nlm.nih.gov/22994028/. doi: 10.2519/jospt.2009.2930

17. Bush KW, Collins N, Portman L, Tillett N. Validity and intertester reliability of cervical range of motion using inclinometer measurements. J Man Manip Ther [Internet]. 2000 Apr [cited 2025 July 22];8(2):52–61. Available from: https://www.researchgate.net/publication/233567761_Validity_and_Intertester_Reliability_of_Cervical_Range_of_Motion_Using_Inclinometer_Measurements doi:10.1179/106698100790819546
18. Shaghayegh Fard B, Ahmadi A, Maroufi N, Sarrafzadeh J. Evaluation of forward head posture in sitting and standing positions. Eur Spine J [Internet]. 2016 Nov [cited 2024 Oct 4];25(11):3577-82. Available from: https://pubmed.ncbi.nlm.nih.gov/26476717/. doi: 10.1007/s00586-015-4254-x
19. Dimitriadis Z, Podogyros G, Polyviou D, Tasopoulos I, Passa K. The reliability of lateral photography for the assessment of forward head posture through four different angle-based analysis methods in healthy individuals. Musculoskelet Care [Internet]. 2015 Sep [cited 2024 Oct 4];13(3):179-86. Available from: https://onlinelibrary.wiley.com/doi/10.1002/msc.1095. doi: 10.1002/msc.1095
20. Lauche R, Langhorst J, Dobos GJ, Cramer H. Clinically meaningful differences in pain, disability, and quality of life for chronic nonspecific neck pain: a reanalysis of four randomized controlled trials of cupping therapy. Complement Ther Med [Internet]. 2013 Aug [cited 2024 Oct 4];21(4):342-7. Available from: https://pubmed.ncbi.nlm.nih.gov/23876565/. doi: 10.1016/j.ctim.2013.04.005
21. Leung M, Kan MMP, Cheng HMH, De Carvalho DE, Anwer S, Li H, et al. Effects of using a shoulder/scapular brace on the posture and muscle activity of healthy university students during prolonged typing: a randomized controlled crossover trial. Healthcare (Basel) [Internet]. 2023 May 25 [cited 2024 Oct 4];11(11):1555. Available from: https://www.mdpi.com/2227-9032/11/11/1555. doi: 10.3390/healthcare11111555
22. Pool JJM, Ostelo RWJG, Hoving JL, Bouter LM, de Vet HCW. Minimal clinically important change of the Neck Disability Index and the numerical rating scale for patients with neck pain. Spine [Internet]. 2007 Dec 15 [cited 2024 Oct 4];32(26):3047-51. Available from: https://pubmed.ncbi.nlm.nih.gov/18091500/. doi: 10.1097/BRS.0b013e31815cf75b
23. Bankhele JR, Yeradkar RS, Mulye MM. Effect of upper back brace with auditory feedback for forward head rounded shoulder posture among office workers with chronic neck pain: a pre-post single group study. Indian J Occup Ther [Internet]. 2020 Jul-Sep [cited 2024 Oct 4];52(3):85-9. Available from: https://www.researchgate.net/publication/346591897_Effect_of_upper_back_brace_with_auditory_feedback_for_forward_head_rounded_shoulder_posture_among_office_workers_with_chronic_neck_pain_-_A_pre-post_single_group_study. doi: 10.4103/ijoth.ijoth_26_20

Original Article

A Retrospective Study on the Association of Age and Sex with the Effectiveness of Canalith Repositioning and Home-Based Rehabilitation in Benign Paroxysmal Positional Vertigo Patients

Watcharin Tayati[1] and Tidaporn Tairattanasuwan[2]
[1]Vestibular Rehabilitation Clinic, Physical Therapy Division, Department of Rehabilitation Medicine, Trang Hospital, [2]Vestibular Rehabilitation Unit, Faculty of Physical Therapy, Huachiew Chalermprakiet University, Samut Prakan, Thailand

ABSTRACT

Objectives: To investigate the association between sex, age, and the effectiveness of the canalith repositioning procedure (CRP) combined with home-based vestibular rehabilitation in patients with benign paroxysmal positional vertigo (BPPV), and to examine their influence on dizziness-related quality of life as measured by the Dizziness Handicap Inventory (DHI).

Study design: Retrospective observational study

Setting: The Outpatient Departments of Otolaryngology and Physical Therapy, Trang Hospital, Trang Province, Thailand

Subjects: Seventy-eight adults with benign paroxysmal positional vertigo (BPPV) treated with canalith repositioning and home-based vestibular rehabilitation.

Methods: In this retrospective observational study, 78 patients who underwent CRP and home-based vestibular exercises between October 2023 and February 2024 were analyzed. Patients were divided into two age groups (18-59 years and ≥ 60 years) and compared by sex. Treatment outcomes were measured based on symptom resolution and changes in DHI scores before and after treatment. Group comparisons were performed using chi-square tests, t-tests, and correlation analyses, with statistical significance set at $p < 0.05$.

Results: The overall resolution rate was 97.4%. There were no significant differences by age or sex. Age correlated positively with DHI pre- and post-scores ($r = 0.83$ and 0.73, $p < 0.01$), and post-treatment DHI was higher in females than males ($p = 0.02$).

Conclusions: This study highlights that while CRP combined with home-based vestibular rehabilitation is effective for BPPV treatment, older adults and females experience greater dizziness-related handicaps. These findings emphasize the need for age- and sex-specific considerations in rehabilitation programs, particularly regarding realistic outcome expectations for older adults and enhanced support for females who may experience greater residual handicap.

Keywords: benign paroxysmal positional vertigo, canalith repositioning procedure, vestibular rehabilitation, age factors, sex factors

ASEAN J Rehabil Med. 2026; 36(1): 28-34.

Introduction

Benign paroxysmal positional vertigo (BPPV) is the most prevalent vestibular disorder. The annual incidence of BPPV across all ages is reported to be 171.5 per 100,000, with a significantly lower incidence in children, at 9.5 per 100,000, highlighting its rarity in younger populations.[1] BPPV occurs when calcium carbonate crystals (otoconia) become dislodged from the utricle and migrate into the semicircular canals, causing abnormal endolymph movement and inappropriate vestibular stimulation during head movements, resulting in characteristic rotatory vertigo and nystagmus.[2] These symptoms can severely impact patients' quality of life, leading to anxiety, fear, and activity avoidance.[3]

The primary treatment for BPPV is the canalith repositioning procedure (CRP), which involves a series of head maneuvers to reposition the otoconia.[2] CRP works by guiding displaced otoconia out of the affected semicircular canal back to the utricle through specific sequential head and body position changes, utilizing gravity to facilitate crystal repositioning. Common techniques include the Epley maneuver for posterior canal BPPV and the Gufoni or barbecue roll maneuver for horizontal canal BPPV.[2] Alongside CRP, vestibular rehabilitation (VR) plays a critical role in long-term management by promoting vestibular system adaptation and compensatory mechanisms, potentially reducing recurrence rates and improving quality of life.[4, 5] VR facilitates central nervous system adaptation to peripheral vestibular dysfunction through neuroplasticity mechanisms.

CRP combined with VR is highly effective for treating BPPV.[6-8] However, recurrence remains a concern. Studies have reported a 37.0% recurrence rate, with 28.0% of cases recurring in the same ear, and 56.0% of recurrences occurring within the first year.[9] Female sex and a history of prior BPPV are associated with an increased risk of recurrence,[9] emphasizing the need to consider demographic factors in long-term manage-

Correspondence to: Tidaporn Tairattanasuwan, MSc, PT, Faculty of Physical Therapy, Huachiew Chalermprakiet University, 18/18 Debaratna Road, Bang Chalong, Bang Phli District, Samut Prakan 10540, Thailand; E-mail: tidaporn.tai@hcu.ac.th

Received: April 2, 2025 Revised: June 25, 2025 Accepted: June 25, 2025

ment. Despite the effectiveness of CRP and VR, not all patients achieve full symptom resolution.[10] Sex, age, comorbidities, and disease duration are key factors influencing treatment outcomes.[11, 12] While some studies have reported no significant association between age or sex and resolution rates.[13, 14] Batuecas et al.[10] reported higher rates of persistent dizziness in patients over 70 years old, highlighting the need for further investigation into how these factors affect BPPV outcomes. Thailand has a growing elderly population, and BPPV is increasingly prevalent among older adults. However, studies on the effectiveness of CRP and home-based vestibular rehabilitation in Thai populations remain limited. Therefore, this study aimed to examine the association between age, sex, and the effectiveness of CRP combined with home-based vestibular rehabilitation in improving the quality of life among patients with BPPV. We hypothesized that age and sex may influence the post-treatment outcomes of patients undergoing CRP and home-based vestibular rehabilitation.

This study aims to investigate the association between sex, age, and the effectiveness of BPPV treatment with CRP combined with VR in Thai patients, with the goal of providing insights for the development of tailored treatment guidelines.

Methods

Study design and setting

This retrospective analytical study was conducted at the Outpatient Departments of Otolaryngology and Physical Therapy, Trang Hospital, Trang Province, Thailand, using data collected between October 2023 and February 2024. The study received approval from the Ethics Committee of Trang Hospital on April 10, 2024 (Project ID: 012/04/2567).

This report followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.

Participants

Patients were selected using purposive sampling based on the following inclusion criteria: (1) aged ≥ 18 years; (2) diagnosed with BPPV (ICD-10: H81.10); (3) treated with canalith CRP and home-based vestibular rehabilitation; and (4) complete follow-up data available. Exclusion criteria included a history of central nervous system disorders, inner ear conditions, or cervical spine limitations.

BPPV diagnosis was established by qualified ENT specialists using standardized diagnostic criteria including positive Dix-Hallpike test for posterior canal BPPV and supine roll test for horizontal canal BPPV. Diagnostic procedures were performed according to current clinical practice guidelines with inter-examiner reliability established. No missing data were encountered as complete follow-up data availability was an inclusion criterion, ensuring 100.0% data completeness for all 78 participants.

Intervention and follow-up

All CRP and home-based vestibular rehabilitation instructions were delivered by trained physical therapists following the same protocol based on clinical practice guidelines. The intervention protocol comprised the following components:

1. Canalith repositioning procedure (CRP): This was performed by certified physiotherapists using the Epley maneuver for posterior canal BPPV and the Gufoni maneuver or barbecue roll for horizontal canal BPPV.

2. Vestibular rehabilitation (VR): The VR program was standardized and designed by certified physiotherapists, including: (1) gaze stabilization exercises (X1 and X2 viewing), (2) balance training (static and dynamic), (3) habituation exercises, and (4) functional mobility training. Programs were standardized across all patients with intensity modifications based on individual tolerance. Patients were instructed to complete these exercises for 15-20 minutes daily, at least five days per week.

3. The intervention combined both hospital-based CRP with supervised VR training AND daily home-based VR exercises. Home-based Vestibular Rehabilitation: Customized exercise manuals were provided to patients and their caregivers. Weekly telephone follow-ups were conducted by physiotherapy assistants to assess patient progress and ensure adherence to the prescribed rehabilitation program. Additionally, patients attended weekly follow-up consultations at the dizziness clinic for further assessment and necessary adjustments to their treatment regimen.

Patients were discharged upon meeting the following criteria: (1) normalization of Dix-Hallpike and supine roll test results; (2) resolution of vertigo symptoms; and (3) the ability to resume normal daily activities. Most patients required 1-3 treatment sessions prior to discharge.

Outcome measurement

The primary outcome measures were the resolution rate, defined as the resolution of symptoms within three treatment sessions, and the Dizziness Handicap Inventory (DHI) scores, which were assessed both pre- and post-treatment. DHI was assessed only twice: (1) at baseline before any intervention, and (2) at discharge when resolution criteria were met. DHI was not assessed at intermediate weekly visits. DHI assessments were conducted at baseline (pre-treatment) and at discharge (post-treatment), with an average interval of 2.10 (SD = 0.80) weeks between assessments. For patients achieving early resolution (n = 8), post-treatment DHI was assessed at their discharge visit. The Thai version of the DHI, which has been validated for reliability and validity, was used in this study.[15] The DHI is a widely accepted tool for evaluating the impact of dizziness on patients' quality of life, with scores ranging from 0 to 100, where higher scores indicate greater impairment.

Sample size calculation

As this was a retrospective observational study, all patients diagnosed with BPPV between October 2023 and February 2024 who met the inclusion criteria were included. No a priori sample size calculation was performed. This

approach is acceptable for exploratory studies, as it reflects real-world data and helps minimize selection bias.

Data collection

Retrospective data were extracted from outpatient medical records, including demographic details, treatment specifics, and pre- and post-treatment DHI scores. The validated Thai version of the DHI, comprising 25 items across physical, emotional, and functional domains, was used, with higher scores reflecting greater impairment in quality of life.

Statistical analysis

Descriptive statistics summarized demographic data (frequencies, percentages, means, standard deviations). Chi-square and independent t-tests were used for group comparisons, and point-biserial correlation assessed associations between age, sex, and DHI scores. Multiple linear regression was performed to control for potential confounding factors. Subgroup analyses by age and sex were conducted; however, interaction terms (e.g., age × sex) were not included due to limited sample size in some subgroups, which may reduce model stability. Effect sizes (Cramér's V, Cohen's d) and 95% confidence intervals were reported. No a priori sample size calculation was performed; all eligible patients during the study period were included. A sensitivity analysis using an age cutoff of 65 years confirmed the robustness of findings. No missing data were present due to inclusion criteria requiring complete follow-up. Statistical significance was set at $p < 0.05$.

Results

A total of 85 patients were initially screened for eligibility. Seven patients were excluded due to incomplete follow-up data (missing final DHI assessment, n = 5; incomplete medical records, n = 2), resulting in 78 patients included in final analysis (Figure 1). All included participants completed the intervention protocol and follow-up assessments, yielding 100.0% completion rate among eligible participants.

A total of 78 patients (17 males, 21.8%; 61 females, 78.2%) were included (Table 1). The mean age was similar between males (64.1 (SD = 6.4) years) and females (63.7 (SD = 11.8) years; $p = 0.86$) (Table 2). Most patients (61.5%) were aged ≥ 60 years. The posterior canal was most affected (100% in males, 98.4% in females), with no significant differences by sex ($p = 0.28$) or age ($p = 0.20$) (Tables 1 and 2). A trend towards right-sided BPPV was observed in older adults ($p = 0.05$) (Table 2).

Primary outcome: resolution rate

The overall BPPV resolution rate within three CRP sessions was 97.4% (76/78; 95%CI: 93.9-100.0%). There were no statistically significant differences between age groups (94.7% in ≥ 60 vs. 100.0% in < 60 years, $p = 0.25$) or sexes (88.2% in males vs. 100.0% in females, $p = 0.39$) (Table 1, Supplementary Table S5).

Secondary outcomes: DHI scores and quality of life

Pre- and Post-treatment DHI Scores

Older adults had significantly higher DHI scores than younger patients at baseline (53.8 (SD = 6.5) vs. 36.7 (SD = 4.2), $p < 0.01$) and post-treatment (6.29 (SD = 3.4) vs. 0.3 (SD = 1.1), $p < 0.01$), reflecting greater perceived dizziness and residual symptoms (Table 2). Females also had higher post-treatment DHI scores than males (4.6 (SD = 3.9) vs. 2.00 (SD = 3.7), $p = 0.02$). These differences remained statistically significant after adjusting for covariates (Table S1), with adjusted mean DHI scores of 4.6 in females and 1.9 in males ($p < 0.01$), and 2.4 in patients with successful resolution vs. 4.1 in unresolved cases ($p = 0.02$).

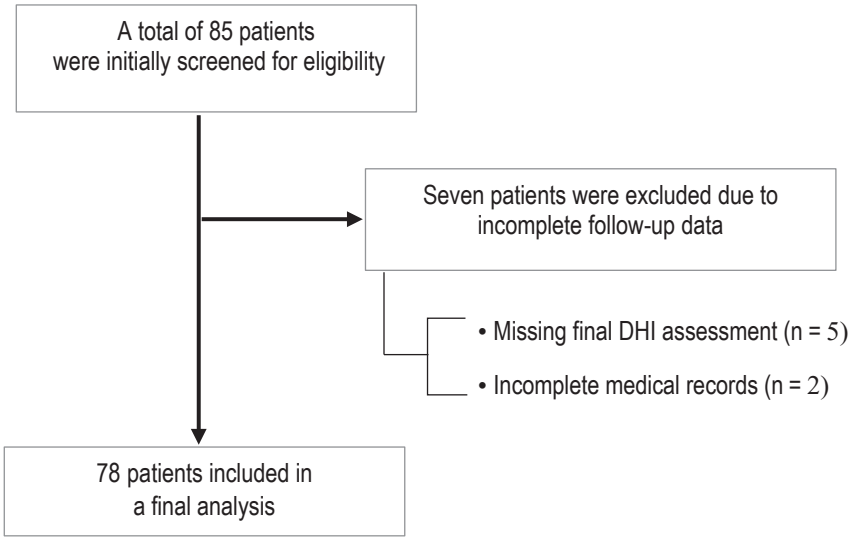


Figure 1. Flow of participants through the study. The diagram illustrates the number of patients who were screened for eligibility, the number of patients excluded with specific reasons for exclusion, and the final number of patients included in the analysis.

Table 1. Baseline characteristics and resolution rate stratified by age group (n = 78)

Variable	Younger group (n = 30)	Older group (n = 48)	χ^2 / t	*p*-value
Demographics				
Age[1]	52.3 (5.9)	70.9 (5.9)	t = –13.2	< 0.01**
Sex[2]			χ^2 = 0.75	0.39
Male	5 (16.7)	12 (25.0)		
Female	25 (83.3)	36 (75.0)		
Clinical characteristics				
BPPV location[2]			χ^2 = 1.62	0.20
Posterior canal	29 (96.7)	48 (100.0)		
Horizontal canal	1 (3.3)	0 (0.0)		
Affected side[2]			χ^2 = 3.76	0.05
Right side	12 (40.0)	30 (62.5)		
Left side	18 (60.0%)	18 (37.5)		
CRP treatment[2]			χ^2 = 1.62	0.20
Epley plus VR	29 (96.7)	48 (100.0)		
Gufoni/Barbecue plus VR	1 (3.3)	0 (0.0)		
Primary outcome			χ^2 = 1.28	0.25
Resolution rate (n/N)	30/30 (100.0)	46/48 (95.83)		
95%CI[a]	88.6-100.0	86.0-98.8		

[1]Mean (SD), [2]Number (%)

p-values calculated using independent t test for continuous variables and chi-square test for categorical variables. [a]95%CI = 95% confidence interval calculated using Wilson Score Interval.

Statistical significance: $p < 0.05$; $p < 0.01$; BPPV, benign paroxysmal positional vertigo; CRP, canalith repositioning procedure; VR, vestibular rehabilitation

Table 2. Comparison of age, dizziness handicap inventory (DHI) pre and post scores, and correlations by age group and gender

BPPV (n = 78)	Age group		*p*-value	Gender		*p*-value
	Younger group (n = 30)	Older group (n = 48)		Male (n = 17)	Female (n = 61)	
Age (mean (SD))	52.3 (5.9)	70.9 (5.9)	-	64.1 (6.4)	63.7(11.8)	0.86
DHI-pre	36.7 (4.2)	53.8 (6.5)	< 0.01**	46.7 (7.1)	47.4 (10.8)	0.76
95%CI	(35.2, 38.2)	(52.0, 55.6)		(43.4, 50.1)	(44.7, 50.1)	
DHI-post	0.3 (1.1)	6.3 (3.4)	< 0.01**	2.0 (3.7)	4.6 (3.9)	0.02*
95%CI	(-0.0, 0.7)	(5.3, 7.2)		(0.2, 3.8)	(3.6, 5.5)	

[a]Independent t test *p-value significant at the 0.01 level (2-tailed) **p-value significant at the 0.01 level (2-tailed) †95%CI calculated using standard error of the mean (SEM); CI may extend below 0 in groups with very low mean DHI post-treatment scores. Since DHI scores range from 0–100, negative lower bounds reflect statistical estimation rather than actual values; BPPV, benign paroxysmal positional vertigo; CRP, canalith repositioning procedure; VR, vestibular rehabilitation

Effect sizes and clinical significance

The mean DHI improvement (ΔDHI) exceeded the MCID threshold of 18 points in all subgroups except for males ≥ 60 years (ΔDHI = 14.3) (Table S3, Figure S1). The largest improvements were observed in females < 60 years (ΔDHI = 24.1, 95%CI: 18.1, 30.0). Cohen's d calculations indicated large effect sizes for age-related differences in DHI scores both pre-treatment (d = 2.96) and post-treatment (d = 1.00), as well as a moderate effect for the post-treatment sex difference (d = 0.65), supporting the clinical relevance of these findings.

Correlations

Age showed strong positive correlations with DHI scores both pre-treatment (r = 0.83) and post-treatment (r = 0.73) (p < 0.01) (Table 3). A weak but statistically significant negative correlation was found between sex (female = 1) and post-treatment DHI score (r = –0.27, p = 0.02). Multiple linear regression confirmed that sex and resolution status were significant independent predictors of post-treatment DHI, while age was not a significant predictor in the model (p = 0.10) (Table S2).

Discussion

This study investigated the association between sex, age, and the effectiveness of vestibular rehabilitation in BPPV patients. Our results showed that although sex and age did not significantly influence BPPV resolution rates with CRP combined with home-based vestibular rehabilitation,

Table 3. Correlations between age, sex, and dizziness handicap inventory (DHI) scores before and after treatment

Variable	*r*	*p*-value
Age vs. DHI-pre-treatment	0.83	< 0.01**
Age vs. DHI-post-treatment	0.73	< 0.01**
Sex vs. DHI-pre-treatment	-0.03	0.81
Sex vs. DHI-post-treatment	-0.27	0.02*

r = correlation coefficient; [b]point biserial correlation (used for continuous vs. dichotomous variables with equal variance); [c]Spearman's rank correlation (used for ordinal/non-normally distributed data) *p-value < 0.05 = significant; **p-value < 0.01 = highly significant (2-tailed)

significant differences were observed in the quality of life, as measured by DHI scores.

Our study aligns with previous research showing that age is a key factor in BPPV prevalence, with older adults being more susceptible. The mean onset age is around 54 years, and older individuals often face prolonged symptoms and higher rates of comorbidities, like cerebrovascular and cardiovascular diseases.[16, 17] In our study, older adults had significantly higher pre- and post-treatment DHI scores, reflecting a greater dizziness-related burden, likely due to age-related vestibular degeneration and reduced neuroplasticity. These findings suggest that older patients may benefit from tailored vestibular rehabilitation programs.[18-20]

Sex significantly influences BPPV prevalence and impact. In line with prior studies,[16,21] our study found a higher prevalence in females, with a female-to-male ratio of about 2:1. Although resolution rates did not differ by sex, females had higher post-treatment DHI scores, suggesting that hormonal, psychosocial, and physiological factors may affect their quality of life.[22] These findings highlight the need for tailored vestibular rehabilitation programs that address both physical and psychosocial factors, especially for female patients.

The overall resolution rate of 97.4% aligns with previous studies demonstrating the efficacy of CRP combined with vestibular rehabilitation.[19,23] The mechanical nature of CRP, which repositions otoconia, explains the consistent resolution rates across age and sex groups. However, some patients, particularly older adults, experienced persistent dizziness, underscoring the importance of combining CRP with home-based rehabilitation to facilitate neural adaptation.[24]

Our findings agree with Bruintjes et al.,[13] who reported no significant impact of age or sex on resolution rates. In contrast, Batuecas-Caletrio et al.[10] found lower resolution rates among older patients, likely due to the absence of vestibular rehabilitation in their protocol. These variations suggest that cultural and lifestyle factors specific to the Thai population may influence recovery and warrant further investigation. In particular, beliefs about aging, strong family support, and balance-intensive occupations may affect adherence and perceived handicap. Moreover, psychological factors such as anxiety, emotional distress, and fear of falling may influence symptom perception and rehabilitation adherence, particularly among older adults and females. Addressing these factors may enhance treatment outcomes and reduce recurrence.[3,16]

Recent studies support the integration of CRP with vestibular rehabilitation, with reports of improved balance and gait in patients receiving individualized rehabilitation alongside CRP,[19] and enhanced dynamic balance in elderly patients with chronic BPPV.[23] A key finding of our study is that, while BPPV resolution rates are high, older adults and females experience greater dizziness-related handicaps, emphasizing the need to address quality of life alongside symptom resolution.

Clinical implications

Healthcare providers should emphasize quality of life assessments in older and female BPPV patients, extend follow-ups, and provide targeted education to enhance rehabilitation adherence. Routine DHI screening for all BPPV patients, with heightened attention to older adults and females experiencing greater residual handicap. Providers should counsel patients about potential demographic differences in recovery patterns while maintaining optimism about treatment effectiveness.

Limitations

Study design limitations: Selection bias due to single-center design may overestimate treatment effectiveness. Information bias from medical record review was minimized through standardized protocols. Short follow-up period limits assessment of long-term outcomes. The study's retrospective design, single-center scope, and short follow-up are key limitations. Furthermore, adherence to the home-based rehabilitation program was not formally monitored, which may represent a limitation as differential adherence could influence outcomes.

Generalizability: These findings may be most applicable to Southeast Asian healthcare settings with comparable patient demographics, healthcare infrastructure, and cultural contexts. Generalizability to other populations requires validation. Future research should use prospective, multi-center studies with extended follow-up to assess long-term outcomes and explore factors like comorbidities and socioeconomic status.

Future research directions

Given our retrospective design limitations, prospective randomized controlled trials should be conducted to: (1) compare CRP combined with home-based VR versus CRP alone, (2) investigate optimal rehabilitation protocols for different demographic groups, and (3) assess long-term outcomes including recurrence rates.

Conclusions

CRP combined with home-based vestibular rehabilitation is effective for BPPV across sex and age groups. However, older adults and females experience greater dizziness-related handicap, indicating the need for tailored treatment programs that address both physical and psychosocial factors.

Conflict of interest declaration

The authors declare no conflicts of interest.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript, including the writing, editing, or preparation of figures and tables, except for using Grammarly for basic grammar and spell-checking. All content was critically reviewed and edited by the authors.

Acknowledgment

We would like to acknowledge Trang Hospital for their support of this research.

Funding

No funding was received for this study.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author (Tidaporn Tairattanasuwan) on reasonable request.

Author contributions

Watcharin Tayati: conceptualization, methodology, investigation, data curation, software, writing-original draft,

Tidaporn Tairattanasuwan: supervision, software, validation, writing-review & editing.

References

1. Choi HG, Kim G, Kim BJ, Hong SK, Kim HJ, Lee HJ. How rare is benign paroxysmal positional vertigo in children? A review of 20 cases and their epidemiology. Int J Pediatr Otorhinolaryngol [Internet]. 2020 [cited 2025 Mar 11];132:110008. Available from: https://pubmed.ncbi.nlm.nih.gov/32240880/
2. Bhattacharyya N, Gubbels SP, Schwartz SR, Edlow JA, El-Kashlan H, Fife T, et al. Clinical practice guideline: benign paroxysmal positional vertigo (update). Otolaryngol Head Neck Surg [Internet]. 2017 [cited 2025 Mar 11];156(3 Suppl):S1–47. Available from: https://pubmed.ncbi.nlm.nih.gov/28248609/
3. Weidt S, Bruehl AB, Straumann D, Hegemann SC, Krautstrunk G, Rufer M. Health-related quality of life and emotional distress in patients with dizziness: a cross-sectional approach to disentangle their relationship. BMC Health Serv Res [Internet]. 2014 [cited 2025 Mar 11];14:317. https://pubmed.ncbi.nlm.nih.gov/25052136/
4. Whitney SL, Alghwiri AA, Alghadir A. Physical therapy for persons with vestibular disorders. Curr Opin Neurol [Internet]. 2015 [cited 2025 Mar 11];28(1):61-8. Available from: https://pubmed.ncbi.nlm.nih.gov/25514252/
5. Hoseinabadi R, Pourbakht A, Yazdani N, Kouhi A, Kamali M, Abdollahi FZ, et al. The effects of the vestibular rehabilitation on the benign paroxysmal positional vertigo recurrence rate in patients with otolith dysfunction. J Audiol Otol [Internet]. 2018 [cited 2025 Mar 11];22(4):204–8. Available from: https://pubmed.ncbi.nlm.nih.gov/30016856/
6. Zou TM, Chen JM, Zhou XW, Chen DP, Liu QL, Liu Z, et al. [The curative effect of manual reduction combined with vestibular rehabilitation exercise in the treatment of benign paroxysmal positional vertigo]. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi [Internet]. 2019 [cited 2025 Mar 11];33(11):1044–8. in Chinese. Available from: https://pubmed.ncbi.nlm.nih.gov/31914291/
7. Bressi F, Vella P, Casale M, Moffa A, Sabatino L, Lopez MA, et al. Vestibular rehabilitation in benign paroxysmal positional vertigo: reality or fiction? Int J Immunopathol Pharmacol [Internet]. 2017 [cited 2025 Mar 11];30(2):113–22. Available from: https://pubmed.ncbi.nlm.nih.gov/28485653/
8. Li D, Cheng D, Yang W, Chen T, Zhang D, Ren J, et al. Current therapies in patients with posterior semicircular canal BPPV: a systematic review and network meta-analysis. Otol Neurotol [Internet]. 2022 [cited 2025 Mar 11];43(4):421–8. Available from: https://pubmed.ncbi.nlm.nih.gov/34999620/
9. Luryi AL, Lawrence J, Bojrab DI, LaRouere M, Babu S, Zappia J, et al. Recurrence in benign paroxysmal positional vertigo: a large, single-institution study. Otol Neurotol [Internet]. 2018 [cited 2025 Mar 11];39(5):622–7. Available from: https://pubmed.ncbi.nlm.nih.gov/29649052/
10. Batuecas-Caletrio A, Trinidad-Ruiz G, Zschaeck C, del Pozo de Dios JC, de Toro Gil L, Martin-Sanchez V, et al. Benign paroxysmal positional vertigo in the elderly. Gerontology [Internet]. 2013 [cited 2025 Mar 11];59(5):408–12. Available from: https://pubmed.ncbi.nlm.nih.gov/29649052/
11. Babac S, Djeric D, Petrovic-Lazic M, Arsovic N, Mikic A. Why do treatment failure and recurrences of benign paroxysmal positional vertigo occur? Otol Neurotol [Internet]. 2014 [cited 2025 Mar 11];35(6):1105–10. Available from: https://pubmed.ncbi.nlm.nih.gov/24853239/
12. De Stefano A, Dispenza F, Suarez H, Perez-Fernandez N, Manrique-Huarte R, Ban JH, et al. A multicenter observational study on the role of comorbidities in the recurrent episodes of benign paroxysmal positional vertigo. Auris Nasus Larynx [Internet]. 2014 [cited 2025 Mar 11];41(1):31–6. Available from: https://pubmed.ncbi.nlm.nih.gov/23932347/
13. Bruintjes TD, Companjen J, van der Zaag-Loonen HJ, van Benthem PP. A randomised sham-controlled trial to assess the long-term effect of the Epley manoeuvre for treatment of posterior canal benign paroxysmal positional vertigo. Clin Otolaryngol [Internet]. 2014 [cited 2025 Mar 11];39(1):39–44. Available from: https://pubmed.ncbi.nlm.nih.gov/24438128/
14. Prokopakis EP, Chimona T, Tsagournisakis M, Christodoulou P, Hirsch BE, Lachanas VA, et al. Benign paroxysmal positional vertigo: 10-year experience in treating 592 patients with canalith repositioning procedure. Laryngoscope [Internet]. 2005 [cited 2025 Mar 11];115(9):1667–71. Available from: https://pubmed.ncbi.nlm.nih.gov/16148714/
15. Emasithi A, Pakdee S, Isaradisaikul SK, Uthaikhup S. Translation and validation of the Dizziness Handicap Inventory into Thai language. Otol Neurotol [Internet]. 2022 [cited 2025 Mar 11];43(2):e252–8. Available from: https://pubmed.ncbi.nlm.nih.gov/34711779/
16. Salvinelli F, Trivelli M, Casale M, Firrisi L, Di Peco V, D'Ascanio L, et al. Treatment of benign positional vertigo in the elderly: a randomized trial. Laryngoscope [Internet]. 2004 [cited 2025 Mar 11];114(5):827–31. Available from: https://pubmed.ncbi.nlm.nih.gov/15126738/

17. Lawson J, Johnson I, Bamiou DE, Newton JL. Benign paroxysmal positional vertigo: clinical characteristics of dizzy patients referred to a Falls and Syncope Unit. QJM [Internet]. 2005 [cited 2025 Mar 11];98(5):357–64. Available from: https://pubmed.ncbi.nlm.nih.gov/15820968/
18. Kitahara T, Shiozaki T, Hosoi H. Frailty of the vestibular system in the super-aging society. J Int Adv Otol [Internet]. 2024 [cited 2025 Mar 11];20(1):76–80. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10895879/
19. Se To PL, Singh DKA, Whitney SL. Effects of customized vestibular rehabilitation plus canalith repositioning maneuver on gait and balance in adults with benign paroxysmal positional vertigo: a randomized controlled trial. J Vestib Res [Internet]. 2021 [cited 2025 Mar 11];32(1):79–86. Available from: https://pubmed.ncbi.nlm.nih.gov/34151874/
20. Deems DA, Deems RO, O'Malley BW Jr. Managing challenges in an aging vestibular system: rehabilitation strategies normalize balance function in a cohort of patients up to 99 years. Ear Nose Throat J [Internet]. 2019 [cited 2025 Mar 11];98(1):37–43. Available from: https://pubmed.ncbi.nlm.nih.gov/30834792/
21. Caldas MA, Ganança CF, Ganança FF, Ganança MM, Caovilla HH. Clinical features of benign paroxysmal positional vertigo. Braz J Otorhinolaryngol [Internet]. 2009 [cited 2025 Mar 11];75(4):502–6. Available from: https://pubmed.ncbi.nlm.nih.gov/19784417/
22. De Moraes CG, Liebmann JM, Levin LA. Detection and measurement of clinically meaningful visual field progression in clinical trials for glaucoma. Prog Retin Eye Res [Internet]. 2017 [cited 2025 Mar 11];56:107–47. Available from: https://pubmed.ncbi.nlm.nih.gov/27773767/
23. Ribeiro KMOB, de Freitas RV, Ferreira LM, Deshpande N, Guerra RO. Effects of balance vestibular rehabilitation therapy in elderly with benign paroxysmal positional vertigo: a randomized controlled trial. Disabil Rehabil [Internet]. 2017 [cited 2025 Mar 11];39(12):1198–206. Available from: https://pubmed.ncbi.nlm.nih.gov/27340939/
24. Lacour M, Bernard-Demanze L. Interaction between vestibular compensation mechanisms and vestibular rehabilitation therapy: 10 recommendations for optimal functional recovery. Front Neurol [Internet]. 2015 [cited 2025 Mar 11];5:285. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC4285093/

Table S1: Estimated marginal means of post-treatment dizziness handicap inventory (DHI-Post) adjusted by covariates

Covariates	Adjusted mean DHI-post	Std. error	95% CI lower	95% CI upper	*p*-value
Sex					
• Female	4.59	0.20	4.20	4.97	< 0.01
• Male	1.90	0.37	1.17	2.64	
CRP Resolution					
• Resolved	2.36	0.29	1.79	2.92	0.02
• Not resolved	4.12	0.40	3.32	4.93	

Covariates appearing in the model are evaluated at the following value: Age = 63.76 years, CRP dy[9y]; :BPPV, paroxysmal positional vertigo

Table S2: Multiple linear regression coefficients predicting post-treatment DHI (DHI-post)

Variable	B (Unstandardized)	Std. Error	95% CI Lower	95% CI Upper	*p*-value
(Constant)	4.95	0.72	3.52	6.37	< 0.01
Age	-0.2	0.01	-0.04	0.00	0.10
Sex (Female)	2.52	0.55	1.43	3.60	< 0.01
Resolution (Yes)	-1.83	0.54	-2.90	-0.77	0.01

Dependent variable, DHI-post; sex coded as female = 1, male = 0; resolution coded as Yes = 1, No = 0
B, indicates unstandardized regression coefficients

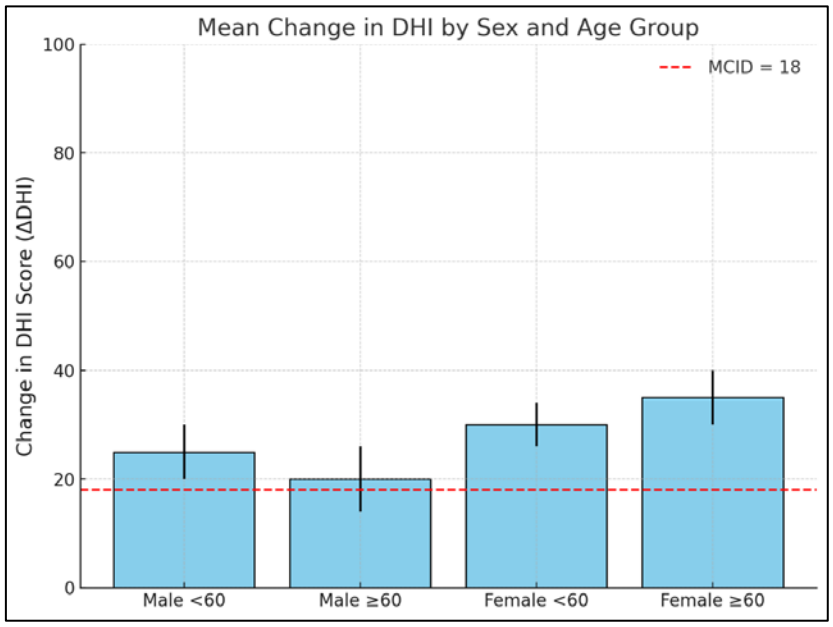
Table S3. Descriptive statistics and 95% confidence intervals of DHI improvement (**Δ**DHI) across age and sex

Group	N	Mean **Δ**DHI (SD)	95% CI
Male ≥ 60	10	14.30 (13.21)	(7.24, 21.36)
Female ≥ 60	18	20.83 (14.31)	(15.05, 26.60)
Male < 60	14	18.86 (16.41)	(10.06, 27.66)
Female < 60	36	24.06 (18.65)	(18.13, 29.99)

ΔDHI, difference in Dizziness Handicap Inventory scores between pre- and post-intervention;
SD, standard deviation. Higher scores indicate greater perceived improvement.

Supplementary Figure S1. Mean change in dizziness handicap inventory (ΔDHI) scores stratified by sex and age group

This figure illustrates mean change in DHI scores across four age/gender subgroups. Error bars show the spread one standard deviation above and one standard deviation below the mean. The dashed red line marks the threshold of 18 points for clinically meaningful improvement.



Error bars indicate ±1 SD from the mean.
MCID, Minimally Clinically Important Difference for DHI, defined as 18 points; ΔDHI, Difference in DHI score between pre- and post-treatment;

Supplementary Table S5. Absolute risk (AR), absolute risk reduction (ARR), and relative risk (RR) for resolution of benign paroxysmal positional vertigo (BPPV) by age and gender subgroups

Subgroup	Total (n)	Resolved (n)	AR (%)	ARR (%)	RR	95% CI for RR
Age < 60 years	40	40	100.00	—	Reference	—
Age ≥ 60 years	38	36	94.70	5.30	0.95	0.90–1.00
Male	17	15	88.20	11.80	0.88	0.82–1.00
Female	61	61	100.00	0.00	1.00	—

Age < 60 years and female group served as reference groups, respectively. 95% confidence intervals (CI) calculated using the Katz method. All patients received canalith repositioning procedure (CRP) combined with home-based vestibular rehabilitation.

Original Article

The Effectiveness of Addition of Melodic Intonation Therapy on Language Ability in Stroke Patients with Broca's Aphasia: A Pilot Randomized Controlled Trial

Somjit Ruamsuk[1], Nicha Kripanan[1], Pornpat Thanasriseabwong[1], Jiratchaya Pinudom[2], Nattawut Foopong[2] and Patthamaphorn Jaiklom[3]

[1]Sirindhorn National Medical Rehabilitation Institute, Nonthaburi, [2]Vejjarak Lampang Hospital, Lampang, [3]Neurological Institute of Thailand, Bangkok, Thailand

ABSTRACT

Objectives: To evaluate the effectiveness of adding melodic intonation therapy (MIT) to conventional therapy in improving language abilities in Thai-speaking stroke patients with Broca's aphasia

Study design: A pilot randomized controlled trial

Setting: Three government hospitals in Thailand

Subjects: Eleven stroke survivors diagnosed with Broca's aphasia were enrolled in the study; eight completed the intervention and were analyzed.

Methods: Participants were randomly assigned to receive either conventional speech therapy or conven-tional therapy combined with MIT. Participants received three hours of therapy a week for eight weeks (two 30-minute sessions with a speech-language pathologist (SLP) and four 30-minute home-based sessions conducted by a caregiver). A blinded SLP assessed outcomes using the Thai adaptation of the Western Aphasia Battery (WAB) at baseline and three months post-baseline. Non-parametric tests (Wilcoxon Signed-Rank and Mann-Whitney U tests) were used due to the small sample size.

Results: The median age of participants was 56.5 years (IQR: 50.8-57.8) in the conventional group and 58.0 years (IQR: 33.5-67.5) in the conventional with MIT group. The median post-onset duration was longer in the conventional group (5.4 months, IQR: 2.4-9.8) compared to the MIT group (2.6 months, IQR: 1.0-4.6). Both groups showed improvements in fluency, comprehension, repetition, naming, and Aphasia Quotient (AQ). The MIT group demonstrated significantly greater gains in repetition and naming ($p < 0.05$).

Conclusions: The findings of this pilot study suggest that adding MIT to conventional therapy may enhance repetition and naming abilities in Thai-speaking individuals with Broca's aphasia. This finding supports the adaptation of MIT for tonal language contexts and highlights its potential in aphasia rehabilitation programs in Thailand. However, due to the limited sample size and statistical power, further research with larger samples is needed to confirm these findings.

Keywords: aphasia, speech therapy, stroke, rehabilitation

ASEAN J Rehabil Med. 2026; 36(1): 35-45.

Introduction

Stroke is a common condition worldwide. In 2021, stroke was the fourth leading cause of death globally.[1] In Thailand, according to a five-year report by the Department of Disease Control of the Ministry of Public Health, the number of stroke patients has steadily increased each year: from 2017 to 2021, the annual incidence of stroke per 100,000 population was 479, 534, 588, and 645, respectively. Similarly, the mortality rate per 100,000 population was recorded at 48, 47, 53, and 53, respectively. Additionally, approximately 30,000 people die from stroke annually, making it one of the leading causes of death in Thailand.[2] Stroke survivors often suffer from language and speech impairments, affecting approximately 4-20% of survivors.[3] Stroke-induced communication disorders are found in 15% of people under 65 years old and 43% of people over 85 years old.[4]

Patients with aphasia exhibit varying degrees of language and speech difficulties, depending on the location of brain damage, which impacts their daily communication. Aphasia can be classified into eight types: global aphasia, Broca's aphasia, isolation aphasia or transcortical mixed aphasia, transcortical motor aphasia, Wernicke's aphasia, transcortical sensory aphasia, conduction aphasia, and anomic aphasia.[5] Following a first stroke, the incidence rates of each type are as follows: global aphasia (32%), Broca's aphasia (12%), isolation aphasia (2%), transcortical motor aphasia (2%), Wernicke's aphasia (16%), transcortical sensory aphasia (7%), conduction aphasia (5%), and anomic aphasia (25%).[6] Broca's aphasia is caused by damage to the left hemisphere of the brain, with patients typically understanding speech well but struggling with word retrieval, sentence production, repetition, and sometimes reading and writing.[7,8]

Correspondence to: Nicha Kripanan, Speech-Language Pathologist; Sirindhorn National Medical Rehabilitation Institute, Nonthaburi 11000, Thailand; E-mail: slp.nicha@gmail.com

Received: May 1, 2025 Revised: July 5, 2025 Accepted: July 7, 2025

There are various methods of speech and language therapy (SLT) for patients with aphasia. These methods can be categorized based on the impairment: auditory comprehension SLT, word-finding SLT, repetition SLT, reading comprehension SLT, and writing SLT. Other approaches include functional SLT, phonological SLT, semantic SLT, constraint-induced aphasia therapy, multimodal therapy, conversational partner training SLT, and melodic intonation therapy (MIT).[9]

For patients with severe left hemisphere damage and non-fluent aphasia, traditional speech therapy alone often yields limited results because it depends on the impaired language network in the left hemisphere.[10] However, it has been reported that non-fluent aphasia patients can still sing,[11] leading to the development of MIT in 1973 by Albert et al.[12] MIT uses musical elements such as melody and rhythm to stimulate speech and improve communication, making it particularly beneficial for individuals with non-fluent aphasia, especially Broca's aphasia and apraxia of speech. MIT is a structured, hierarchical technique that begins with unison intoning of phrases and progresses to delayed repetition and spontaneous speech. Rhythmic left-hand tapping is used to support speech initiation through sensorimotor integration, leveraging preserved musical and prosodic abilities to enhance verbal output in individuals with severe non-fluent aphasia.[13,14]

Previous studies have shown that MIT is effective in tone-based languages such as Chinese,[15] suggesting its potential applicability to other tone-based Asian languages, including Thai. However, no prior studies have investigated the use of MIT in Thai individuals with aphasia. Therefore, the research team is interested in studying the effectiveness of adding MIT to conventional therapy in improving language abilities in patients with Broca's aphasia. The results will be used to develop a treatment model for hospitals across the nation.

Methods

Study design

This study is a randomized controlled trial (RCT) with a blinded outcome assessment, conducted in accordance with the CONSORT 2010 guidelines.[16]

The Human Research Ethics Committee of Sirindhorn National Medical Rehabilitation Institute (SNMRI) on December 23, 2020, Lampang Cancer Hospital (on behalf of Vejjarak Lampang Hospital or VJLH) on February 18, 2021, and Neurological Institute of Thailand (NIT) approved this study under approval numbers 64001, 40/2564-27/2666, and 031/2564 (project number 64016) on July 18, 2021, respectively. Informed consent was obtained from all participants. This study was registered with the Thai Clinical Trials Registry (TCTR20250411008). As participant recruitment did not progress as anticipated and the funding period concluded, the study was discontinued before reaching the intended sample size. All relevant IRBs were formally notified. Given the small number of enrolled participants and the discontinuation of recruitment, the study was conducted as a pilot trial to explore feasibility and inform the design of future larger-scale randomized trials.

Participants

The sample size calculation used the n4Studies application, employing the formula for testing two independent means (two-tailed test),[17] with the Aphasia Quotient (AQ) as the primary outcome variable. Estimates were based on previous studies reporting a mean of 18.7 (SD = 13.6) in group 1 and 6.1 (SD = 9.2) in group 2.[18] with an alpha of 0.05 and a beta of 0.20, the calculated sample size was 14 participants per group, increased by 5% to account for potential dropouts, for a total of 30 participants.

Inclusion criteria

1. First-time stroke confirmed by neuroimaging (CT or MRI).
2. Aged 20-70 years, with Thai as their primary language, and at least 6 years of education (starting from Year 1 of primary school) to reduce potential confounding from dementia and low educational level.[19]
3. SLP diagnosed Broca's aphasia using the Thai adaptation of the Western Aphasia Battery (WAB), based on an AQ of less than 94.7[20] and the following subtest score ranges: fluency 0-4, comprehension 4-10, repetition 0-7.9, naming 0-8.[21]
4. Able to cooperate during therapy without emotional disturbances affecting participation.[22]
5. Has a committed Thai caregiver, aged 20-60 years, who is literate and can assist with home practice for at least 30 minutes, four days a week, over eight weeks.[23]

Exclusion criteria

1. Presence of right hemisphere brain pathology as determined by CT or MRI.[24]
2. Presence of visual or hearing impairments affecting assessment and therapy, as determined from patient and caregiver history, since these sensory limitations could interfere with participants' ability to accurately perceive and respond to test stimuli, potentially confounding the results.
3. Patients receiving speech therapy at other hospitals during the study.
4. Presence of medical conditions such as heart disease, epilepsy, or dementia.
5. Inability to maintain the prescribed frequency or duration of home practice or failure to follow therapy instructions provided by the SLP.

Randomization

Randomization was conducted using a mixed-size block method. An independent SLP not involved in the study generated the allocation sequence using Microsoft Excel. The personnel responsible for enrolling participants and assigning them to intervention groups had no access to the allocation sequence. Assignments were sealed in opaque

envelopes to ensure allocation concealment. Participants were randomly assigned to the control or experimental group in a 1:1 ratio.

Intervention

Participants were randomly assigned to one of two groups: a conventional speech therapy group and a conventional therapy group combined with the MIT approach. Patients received eight weeks of treatment, comprising two sessions/week with SLP (30 minutes each) and four sessions/week at home with a caregiver (30 minutes each), totaling 3 hours per week.[23] Caregivers were instructed to support participants in continuing the activities practiced during in-clinic training and to document each home-based training session in a daily logbook. These records were used to verify participant adherence and monitor the fidelity of the intervention conducted at home. SLPs also used logbooks to document each therapy session conducted at the hospital, supporting fidelity monitoring across sites. Due to the nature of the intervention, blinding patients, caregivers, and SLPs delivering therapy was not feasible. No concomitant speech or language interventions were provided during the study period. No interim analyses or stopping guidelines were planned. A preparatory meeting and training session were held onsite with research teams from the three participating sites. Expert SLPs provided training and guidance on the implementation of the MIT technique. While the total therapy time was equal between groups, the strategies used to support speech production differed, consistent with the principles of each intervention.

Melodic intonation therapy (MIT)

Procedures for implementing MIT were based on established guidelines from Helm-Estabrooks et al. and Norton et al.[13,14] The therapy was designed for individuals with non-fluent aphasia and consisted of three hierarchical levels: elementary, intermediate, and advanced, progressing from two-syllable words to longer phrases. Each level included approximately 20 high-probability words or commonly used social phrases, presented with visual cues to support speech production. Phrases were intoned using two pitch levels based on natural prosody, with stressed syllables produced at a higher pitch and unstressed syllables at a lower pitch. Patients tapped their left hand once per syllable during intonation to support rhythm and motor planning. At each level, structured steps were followed, including humming, unison intoning, delayed repetition, and response to probe questions (e.g., "What did you say?"), with cueing gradually reduced. In later stages, speech-like intonation (Sprechgesang) was introduced and transitioned toward natural speech. Throughout all levels, activities and cueing strategies were adapted to match each individual's abilities and progress.

Conventional speech therapy

For conventional treatment, procedures followed the Guidelines for Assessment and Diagnosis of Disabilities under the Ministry of Social Development and Human Security.[25] The treatment aimed to improve basic communication skills, comprehension, and cognitive functions in individuals with Broca's aphasia. The intervention included communication and language-focused training, such as basic communication to express needs, auditory comprehension of words and conversations, and lexical retrieval of common items used in daily life. Cognitive stimulation targeted time, place, and person orientation, as well as memory, reasoning, and social interaction skills. Speech and articulation components included oral motor exercises to strengthen the speech organs, coordination training to improve articulator function, breathing exercises for voice control, and practice in producing vowels and simple words, as well as articulating consonants, vowels, and tones to enhance clarity and phonological accuracy. In addition, reading and writing tasks were simplified to match the patient's ability, and alternative communication strategies, such as picture-based tools, were introduced to support effective communication when verbal output was limited.[25]

Cueing protocol for conventional group

The conventional therapy group followed an additional cueing protocol to support participants in articulating target words. If a participant was unable to produce the target word within five seconds, the therapist provided a cue selected from the following types: (1) verbal associations, (2) written cues, (3) description of use, context of use, or function, (4) description of form, position in space, or outward characteristics, (5) gesture of action or function, (6) gesture of shape, location, or outward characteristics, (7) spelling or letter cues, and (8) production of the sound made by the object. The selection of cues depended on the nature of each target word, and therapists could combine two types of cues if a single method were insufficient. If the patient remained unable to respond within five seconds after cueing, the therapist then provided the initial sound of the word. If still unsuccessful after an additional five seconds, the initial syllable was given. Finally, if the patient continued to experience difficulty, the therapist produced the complete target word and prompted the patient to repeat it.[26,27] This cueing protocol was used only in the conventional group. It was not applied in the conventional manner with the MIT group, where target words were presented exclusively through structured MIT procedures.

Outcome measurements

SLPs conducted baseline assessments for participant eligibility at each site. Outcome assessments were conducted three months post-baseline by a blinded assessor who was not involved in the intervention. This SLP assessed participants onsite at one site and scored the others via video recordings.

The Thai adaptation of the Western Aphasia Battery (WAB)[20] was used as the primary outcome measure to assess language abilities in individuals with aphasia. This standardized tool quantifies severity and classifies aphasia subtypes based on four core domains: spontaneous speech, auditory

comprehension, repetition, and naming. The resulting AQ ranges from 0 to 100, with higher scores indicating better performance. The Thai version demonstrated strong content validity and excellent test-retest reliability (r = 0.99, p < 0.01), with an AQ cutoff of 94.7.[20]. Subtypes are classified using domain-specific cutoffs into eight standard types: Global, Broca's, Wernicke's, Conduction, Transcortical Motor, Transcortical Sensory, Isolation, and Anomic.[21] These criteria enable consistent classification, longitudinal tracking, and cross-linguistic comparisons, as the WAB has been widely translated and used internationally.[28]

While participants and the treating researchers were not blinded, the assessors were blinded to the treatment groups. The study employed a parallel-group design under a superiority framework to evaluate the effectiveness of adding Melodic Intonation Therapy to conventional therapy. Patients and members of the public were not involved in this research's design, conduct, reporting, or dissemination plans.

Statistical methods

Statistical analysis was performed using IBM SPSS Statistics for Mac, version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to report demographic information. The effectiveness of the intervention was assessed by comparing pre- and post-treatment results within each group and by comparing change scores between groups, using non-parametric tests (Wilcoxon Signed-Rank test, Mann-Whitney U test), based on data normality test results and the small sample size. All analyses were pre-specified in the study protocol based on participants who completed both baseline and post-treatment assessments. Participants who withdrew before completing the intervention and post-assessment were excluded from the analysis. No imputation for missing data, subgroup or sensitivity analyses, or ancillary analyses were conducted.

Results

Recruitment challenges limited the final sample size. Although 30 participants were initially planned, only 11 were enrolled, and eight were analyzed by per-protocol. The COVID-19 pandemic hindered recruitment, limited the number of eligible Broca's aphasia cases, and led to caregiver unavailability, staff constraints, and logistical barriers. As a result, the study proceeded as a pilot trial to assess feasibility.

This study includes data from 8 participants: seven from SNMRI and one from VJLH. No participants from NIT met the inclusion criteria. Participants were randomly assigned to the conventional therapy group (n = 4) or the conventional therapy combined with MIT group (n = 4). Participant flow reported following CONSORT guideline 2010[29], is shown in Figure 1.

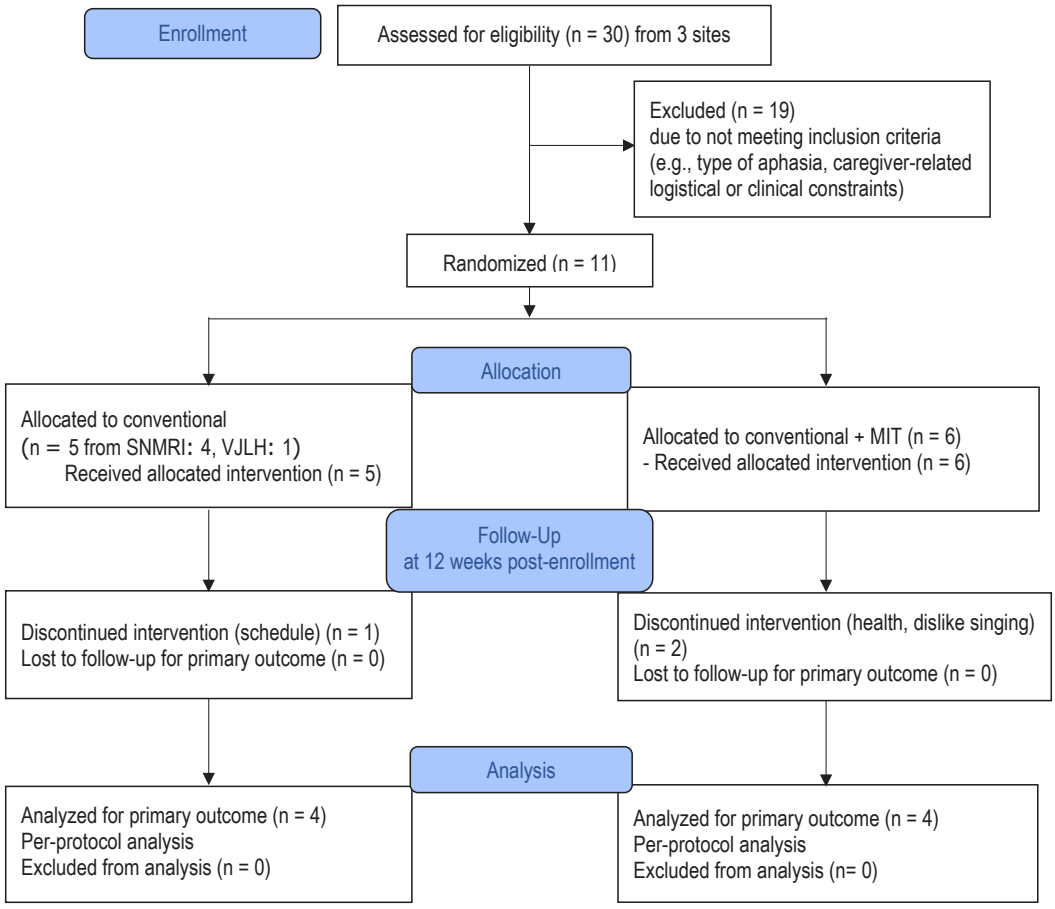


Figure 1. Participant flow diagram following CONSORT guidelines[29]

Normality of the data was assessed using the Shapiro-Wilk test due to the small sample size (n = 8). Several variables violated the assumption of normality, including years of education (p = 0.016), fluency change score (p = 0.013), baseline comprehension (p = 0.049), and post-treatment AQ (p = 0.030). As a result, non-parametric tests were employed for all subsequent within- and between-group comparisons.

The baseline demographic and clinical characteristics of the participants are presented in Table 1. The proportion of female participants was higher in the conventional with MIT group compared to the conventional group (83% vs. 60%), as was the proportion of participants with hemorrhagic stroke (50% vs. 40%). The median age of participants was 56.0 years (IQR: 48.5-57.5) in the conventional group and 57.5 years (IQR: 38.5-66.5) in the conventional with MIT group. The median years of education was higher in the conventional with MIT group (16.0 vs. 14.0 years). The median post-onset duration was longer in the conventional group (4.1 months, IQR: 1.1-8.7) than in the conventional with MIT group (2.4 months, IQR: 1.0-3.8). Baseline scores for fluency, comprehension, repetition, naming, and AQ were generally comparable between groups. Three participants who later withdrew had lower baseline scores and a shorter post-onset duration.

Between-group comparisons of baseline, post-treatment, and change scores were conducted using the Mann-Whitney U test with Monte Carlo simulation (Table 2), revealing no statistically significant differences between the conventional and conventional with MIT groups (p > 0.050), indicating baseline equivalence. Following treatment, the conventional with MIT group showed significantly greater improvement in repetition (p = 0.026, r = 0.837) and naming (p = 0.024, r = 0.816) compared to the conventional group. While both groups demonstrated improvements in other language domains and AQ scores, between-group differences in fluency, comprehension, and AQ change scores were not statistically significant.

Table 1. Baseline demographic and clinical characteristics of patients

Characteristics	Conventional (n = 5)	Conventional plus MIT (n = 6)
Gender		
Females (%)	3 (60)	5 (83)
Type of stroke		
Hemorrhage	2	3
Ischemic	3	3
Age (years)	56.0 (48.5, 57.5)	57.5 (38.5, 66.5)
Education (years)	14.0 (10.5, 16.0)	16.0 (8.3, 16.0)
Post-onset (months)	4.1 (1.1, 8.7)	2.4 (1.0, 3.8)
Fluency	2.0 (1.0, 2.5)	2.5 (0.8, 3.3)
Comprehension	4.9 (4.5, 6.4)	5.0 (4.4, 5.7)
Repetition	3.2 (2.0, 3.9)	3.1 (0.0, 5.1)
Naming	2.5 (1.7, 2.8)	0.3 (0.0, 2.3)
Aphasia quotient (AQ)	28.8 (27.7, 34.9)	26.2 (14.7, 36.7)

Values are presented as median (interquartile range). Education level (in years) is calculated starting from Year 1 of primary school

Table 2. Between-group comparison of baseline, post-treatment, and change scores in the conventional and conventional with MIT Groups

	Conventional (n = 4)	Conventional+MIT (n = 4)	p-value	Effect sizes
Fluency				
Baseline	2.0 (1.3, 2.8)	3.0 (0.8, 3.8)	0.515	-0.316
Post-treatment	3.0 (2.3, 4.5)	4.5 (3.3, 8.0)	0.285	-0.474
Change score (Δ)	1.0(1.0, 1.8)	3.0 (0.3, 5.0)	0.763	-0.164
Comprehension				
Baseline	4.9 (4.5, 7.0)	5.1 (4.5, 6.2)	0.973	-0.051
Post-treatment	7.1 (5.5, 8.5)	6.2 (5.5, 8.9)	1.000	0.000
Change score (Δ)	1.5 (0.4, 2.9)	0.6 (0.2, 3.9)	0.882	-0.102
Repetition				
Baseline	3.2 (1.7, 3.9)	4.5 (1.1, 6.1)	0.338	-0.408
Post-treatment	4.2 (3.5, 5.7)	7.6 (4.3, 9.3)	0.201	-0.510
Change score (Δ)	2.0 (0.6, 2.0)	3.3 (2.4, 3.8)	0.026*	-0.837
Naming				
Baseline	2.1 (1.6, 2.7)	0.9 (0.0, 3.4)	0.514	-0.258
Post-treatment	3.2 (1.9, 4.8)	6.0 (3.6, 8.0)	0.114	-0.612
Change score (Δ)	1.1 (0.2, 2.1)	4.1 (3.2, 6.1)	0.024*	-0.816
Aphasia quotient (AQ)				
Baseline	31.2 (28.0, 35.5)	31.6 (14.0, 42.0)	0.882	-0.102
Post-treatment	45.9 (36.3, 52.9)	53.3 (50.5, 82.2)	0.114	-0.612
Change score (Δ)	15.3 (7.0, 18.2)	34.3 (17.7, 46.4)	0.114	-0.612

Values are presented as median (interquartile range). *P*-values refer to between-group comparisons using the Mann-Whitney U Test with a Monte Carlo simulation.[30] Effect size (r) was calculated from Z scores using the formula r = Z/√N, where N is the total sample size[31] (0.2: small, 0.5: medium, 0.8 = large).[32] *p-values less than 0.05 were considered statistically significant

Table 3. Within group comparison of language outcomes at baseline and post-treatment in the conventional and conventional with MIT groups

	Baseline	Post-treatment	Change (Δ)	*p*-value	Effect sizes
Fluency					
Conventional (n = 4)	2.0 (1.3, 2.8)	3.0 (2.3, 4.5)	1.0 (1.0, 1.8)	0.127	-0.945
Conventional plus MIT (n = 4)	3.0 (0.8, 3.8)	4.5 (3.3, 8.0)	3.0 (0.3, 5.0)	0.249	-0.817
Comprehension					
Conventional (n=4)	4.9 (4.5, 7.0)	7.1 (5.5, 8.5)	1.5 (0.4, 2.9)	0.126	-0.913
Conventional plus MIT (n = 4)	5.1 (4.5, 6.2)	6.2 (5.5, 8.9)	0.6 (0.2, 3.9)	0.124	-0.913
Repetition					
Conventional (n=4)	3.2 (1.7, 3.9)	4.2 (3.5, 5.7)	2.0 (0.6, 2.0)	0.126	-0.945
Conventional plus MIT (n = 4)	4.5 (1.1, 6.1)	7.6 (4.3, 9.3)	3.3 (2.4, 3.8)	0.124	-0.913
Naming					
Conventional (n=4)	2.1 (1.6, 2.7)	3.2 (1.9, 4.8)	1.1 (0.2, 2.1)	0.126	-0.913
Conventional plus MIT (n = 4)	0.9 (0.0, 3.4)	6.0 (3.6, 8.0)	4.1 (3.2, 6.1)	0.124	-0.913
Aphasia quotient (AQ)					
Conventional (n=4)	31.2 (28.0, 35.5)	45.9 (36.3, 52.9)	15.3 (7.0, 18.2)	0.126	-0.913
Conventional plus MIT (n = 4)	31.6 (14.0, 42.0)	53.3 (50.5, 82.2)	34.3 (17.7, 46.4)	0.124	-0.913

Values are presented as median (interquartile range). *p*-values refer to within-group comparisons using the Wilcoxon Signed-Rank test with a Monte Carlo simulation.[30] Effect size (*r*) was calculated from Z scores using the formula $r = Z/\sqrt{N}$, where N is the total number of observations[31] (0.2 = small, 0.5 = medium, 0.8 = large).[32] *Statistical significance was set at $p < .05$.

Within-group comparisons of baseline and post-treatment were conducted using the Wilcoxon Signed-Rank test with a Monte Carlo simulation, as presented in Table 3. Both the conventional and the conventional with MIT groups showed improvements across all language domains. However, none of the within-group differences reached statistical significance ($p > 0.05$), possibly due to the small sample size (n = 4 per group).

Despite this, Table 3 shows that large effect sizes were observed in both groups. In the conventional with MIT group, effect sizes were slightly smaller for fluency ($r = 0.817$) and repetition ($r = 0.913$) compared to the conventional group ($r = 0.945$ for both outcomes). For other outcomes, the effect sizes were equal ($r = 0.913$ in both groups).

A post hoc power analysis was conducted using G*Power 3.1 for Mac (Heinrich Heine University, Düsseldorf, Germany) for the Wilcoxon-Mann-Whitney test. Based on the observed effect sizes of change scores in repetition ($r = 0.837$) and naming ($r = 0.816$) from the between-group comparison, with a sample size of 4 participants per group and a significance level of $\alpha = 0.05$ (two-tailed), the calculated statistical power was approximately 0.16. This low power may have contributed to the lack of statistically significant findings, despite the large observed effect sizes.

No harm or adverse events were monitored or observed during the trial.

Discussion

This pilot study found that adding MIT to conventional speech therapy led to greater improvements in repetition and naming abilities in Thai individuals with Broca's aphasia compared to conventional therapy alone. Although both groups showed progress in fluency, comprehension, repetition, and naming, statistically significant differences were observed specifically in repetition and naming. These findings suggest that MIT may be particularly beneficial in addressing specific language deficits commonly observed in non-fluent aphasia, such as difficulties with word retrieval and repetition.

Previous observations by SLPs indicate that patients with severe aphasia often demonstrate better articulatory muscle movement while singing compared to normal speech. This observation has led to the incorporation of music and singing into aphasia rehabilitation.[33] In 1973, Albert, Sparks, and Helm introduced MIT, a treatment that combines melody, rhythm, and speech to enhance articulation. The therapy follows a structured process, starting with patients singing simple phrases to a melody and gradually progressing to speaking without musical cues.[12] However, the majority of MIT literature comprises RCT studies focused on Western languages, with fewer studies examining East Asian languages such as Japanese and Chinese. Unlike Western languages, many East Asian languages, including Thai, are tonal, where differences in tone convey distinct meanings, necessitating more complex neural processing involving bilateral brain circuits.[34,35] A recent pilot study by Chen et al.[15] adapted MIT into a tone-rhythmic therapy (TRT) specifically for Mandarin, incorporating lexical tones and rhythmic patterns characteristic of the language. Six individuals with non-fluent aphasia, more than six months post-stroke, received TRT over six weeks, with five 50-minute sessions per week. Results showed improvements in speech and language skills that were sustained for up to six months. These findings highlight the potential of MIT-based approaches in tonal languages. While no adaptation was made, the present study applied MIT in a Thai-speaking population, another tonal language, providing foundational evidence for its feasibility and therapeutic benefit in this linguistic context.

Difficulty in recruitment for this study

The study aimed to recruit 30 patients across multiple sites but was able to enroll only 8 participants due to limited resources. Contributing factors included patients not meeting the inclusion criteria, a higher prevalence of global aphasia compared to Broca's aphasia, and reduced availability due to the COVID-19 pandemic. Emotional factors, including frustration and depression, also contributed to participant recruitment challenges or withdrawal, with depression rates as high as 40-60% among stroke survivors with aphasia.[36,37] Several patients withdrew due to health issues or discomfort with MIT training, and some caregivers did not meet the inclusion criteria. Additional barriers included travel, financial limitations, and staffing constraints, which impacted participation and follow-up opportunities.

Conducting research with aphasia patients in Thailand presented significant challenges, as the pool of eligible participants is smaller due to limited access to speech therapy services, further compounded by the pandemic. Caregiver involvement also proved challenging, as many struggled to commit to the at-home training. Some caregivers may not have been able to manage the demands of high-intensity therapy.[38] Caregivers frequently had to prioritize advocating for timely care and ensuring patient engagement in rehabilitation; balancing these responsibilities can be overwhelming.[39] Some caregivers believed that therapy should focus on the patient receiving treatment rather than on them receiving training.[40] These challenges suggest the need for hybrid teletherapy models when patients cannot attend sessions. Teletherapy can help address common barriers, including distance, travel costs, and time constraints.[41]

Expanding the inclusion criteria to encompass broader non-fluent aphasia may also increase the pool of eligible patients, as MIT has shown effectiveness in this condition.[35,42,43] In this study, only patients with Broca's aphasia were included to reduce heterogeneity in language profiles. However, as WAB does not detect apraxia of speech, which may co-occur with Broca's aphasia[44] and also benefits from MIT,[14,45] future studies should identify this subgroup to avoid potential bias.

Improvement of participants

Post-intervention WAB scores indicated significant improvements across all four subtests in both groups, consistent with the findings of Hough (2010), who implemented 3 hours of therapy per week over eight weeks[23], and Robey (1998), who reported that at least 2 hours per week yielded improvements.[46] Previous systematic reviews have raised unresolved questions regarding the optimal timing for starting MIT, particularly whether it should be initiated in the acute or chronic phase. The timing of therapy is closely linked to neural recovery and may result in different outcomes.[47] In this study, both groups had post-onset periods within six months, corresponding to the subacute or intermediate care phase. Notably, the conventional group with the MIT group had a shorter post-onset duration (median = 2.4 months, IQR: 1.0-3.8) compared to the conventional group (median = 4.1 months, IQR: 1.1-8.7). This difference may have favored treatment responsiveness in the MIT group due to spontaneous recovery, potentially confounding the results for some patients.[48] Future studies should match participants by post-onset time or include it as a covariate.

When comparing the groups, statistically significant improvements ($p < 0.05$) were observed in repetition and naming abilities in the experimental group compared to the control group. However, no significant differences were found in fluency or comprehension scores. This result is consistent with Lim et al. (2013), who found that adding MIT significantly improved verbal repetition and word retrieval.[18] Furthermore, systematic reviews[35,42] and meta-analysis[43,49] by Popescu, Haro-Martinez, and others have confirmed that MIT has the most potent effects on repetition tasks.

MIT is particularly beneficial for patients with left hemisphere damage who retain the right hemisphere's capacity for music. By activating the right hemisphere's auditory cortex for music processing and the right hemisphere's language motor areas, which correspond to the left hemisphere's Broca's area via the right arcuate fasciculus, MIT compensates for damaged areas and facilitates language output.[50] Degeneracy,[51] or the reorganization of language functions to the contralateral hemisphere, has also been observed in patients with brain tumors near Wernicke's area.[52] All participants in this study had left hemisphere brain damage, with an intact right hemisphere, making them well-suited for MIT. Other hypotheses explain why MIT is effective in treating non-fluent aphasia: MIT slows the rate of speech,[53] it prolongs the duration of syllables and introduces pauses between them,[24] and it incorporates left-hand tapping for each syllable, activating the right hemisphere, which controls both speech-related and arm movements,[54] all of which contribute to its success, particularly in enhancing the repetition and naming abilities observed in this study.

MIT is unsuitable for patients whose primary deficit is comprehension, such as those with Wernicke's aphasia, transcortical aphasia, conduction aphasia, or brain injuries affecting language comprehension.[22] In this study, both the control and experimental groups demonstrated significant improvements in comprehension, but no statistically significant differences were found between them. This result may be due to MIT's primary focus on enhancing expressive language. However, Morrow-Odom and Swann (2013) reported the effectiveness of MIT in a single case of global aphasia, where the patient received 2.5 hours of therapy per day, five days a week, for seven consecutive weeks. Post-therapy, the patient showed improvement in auditory comprehension, repetition, and sentence length, suggesting that MIT could also benefit global aphasia rehabilitation.[55] The lack of significant differences in fluency scores between the control and experimental groups in this study may be attributed to the

fact that most patients in both groups were still practicing at the word level, limiting gains in speech fluency.

In addition to statistical significance, improvements observed in the conventional group with the MIT group surpassed the minimal clinically important differences (MCID) as defined by Katz and Wertz.[56] Specifically, an increase of at least 5 points on the WAB AQ and at least 1 point on WAB subtests was considered clinically significant. Although the MIT group showed clinically significant gains in fluency, repetition, naming, and AQ, the improvement in auditory comprehension was smaller than in the conventional group. The median change in comprehension for the MIT group was only 0.6 points, falling below the 1-point MCID threshold. This change suggests that MIT, which primarily targets expressive language, may have limited effects on receptive abilities. These findings underscore the need for combined or tailored approaches and should be interpreted with caution, especially given the small sample size.

Treatment adherence

Although one participant in the conventional group discontinued due to scheduling difficulties, two participants in the experimental group also withdrew: one due to health issues requiring treatment at another hospital, and the other due to discomfort with singing. Despite these withdrawals, both patients and caregivers in both groups demonstrated excellent adherence to the therapy and home practice programs. This strong adherence contributed to statistically significant improvements in all domains of speech and language in both the control and experimental groups. The therapy program, comprising one hour of therapy with an SLP and two hours of home practice per week (a total of three hours weekly) over eight consecutive weeks, proved effective for all participants.

Applicability of MIT in the Thai context

In addition to the patient's preserved right hemisphere abilities, the successful application of MIT depends on the interest and comfort of the SLPs, patients, and caregivers in using melodic intonation and singing. SLPs must be trained in the technique, prepare target words, phrases, and sentences in advance, and be capable of teaching patients and, importantly, their caregivers how to practice MIT at home. Additionally, SLPs should carefully consider the meaning of words when sung, as tonal changes in the melody may confuse due to the tonal nature of the Thai language.

A post hoc power analysis indicated a statistical power of approximately 0.16 for detecting differences in repetition and naming scores between groups. This low power, due to the small sample size (n = 4 per group), suggests a risk of type II error, meaning that true effects may exist but were not detected. Therefore, the findings should be interpreted with caution, and future studies with larger sample sizes are warranted.

This feasibility study provides preliminary evidence supporting the benefit of adding MIT for Thai individuals with Broca's aphasia on repetition and naming abilities by engaging preserved right hemisphere functions. The limitations of this pilot study should also be noted. In addition to the small sample size, the exclusive inclusion of individuals with Broca's aphasia limits the generalizability of the findings. Therapy intensity was restricted to 3 hours per week,[18] comprising 1 hour provided by an SLP and 2 hours by caregivers, due to constraints of the existing service model, where typically only 30 minutes per week of professional therapy is available. Additionally, to minimize bias, a blinded SLP reviewed recorded sessions from the site where only one therapist provided treatment.

Future research should evaluate the effectiveness of MIT in other forms of non-fluent aphasia and apraxia of speech. Stratifying participants according to post-stroke onset phase (subacute vs. chronic)[47] could further clarify how timing affects recovery outcomes. Addressing these limitations through larger-scale studies would strengthen understanding of MIT's clinical utility across diverse patient populations.

Conclusions

This study found that both the experimental and control groups showed significant improvements in language and speech abilities, with the group receiving MIT alongside standard therapy demonstrating greater gains in verbal repetition and word retrieval ($p < 0.05$). As a pilot study, these findings are promising additions to speech-language rehabilitation in Thailand, but should be interpreted with caution and validated in larger-scale research.

Conflict of interest declaration

The authors declare that there is no conflict of interest.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript, including the writing, editing, or preparation of figures and tables, with the exception of Grammarly for basic spell-checking.

Acknowledgements

The research team gratefully acknowledges the financial support from the Institute of Medical Research and Technology Assessment, Department of Medical Services, Ministry of Public Health. We also would like to thank our colleagues at the Sirindhorn National Medical Rehabilitation Institute, the Neurological Institute of Thailand, and Vejjarak Lampang Hospital for their support in data collection, with special thanks to Dr. Sriwimol Manochiaopinij and Apinya Ueasiritanapaisan for their guidance on the Melodic Intonation Thera-

(MIT) method. We sincerely appreciate the commitment of the patients and their families, as well as the essential support of the following institutional leaders: Director, Deputy Director of Academic and Medical Affairs, and Chief of Rehabilitation Medicine of Sirindhorn National Medical Rehabilitation Institute, Director of Neurological Institute of Thailand, and Director of Vejjarak Lampang Hospital.

Funding

This research was funded by the Academic Support Fund of the Department of Medical Services, Ministry of Public Health, Thailand.

Data availability

The data supporting the findings of this study are available upon request from the corresponding author, Nicha Kripanan. The data are not publicly available due to ethical restrictions and the need to protect the privacy of research participants.

Author contributions

Somjit Ruamsuk: project administration, conceptualization, funding acquisition, resources, supervision, methodology, validation, writing-original draft preparation,

Nicha Kripanan: investigation, writing-original draft preparation, data curation, formal analysis, visualization,

Pornpat Thanasriseabwong: investigation, writing-original draft preparation,

Jiratchaya Pinudom: investigation, writing-review & editing,

Nattawut Foopong: investigation, writing-review & editing,

Patthamaphorn Jaiklom: investigation, writing-review & editing.

References

1. World Health Organization. The top 10 causes of death [Internet]. 2021 [cited 2024 Feb 1]. Available from: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death
2. Department of Disease Control, Ministry of Public Health. Stroke awareness campaign for World Stroke Day 2021: "Recognize the warning signs of stroke, every second counts" [Internet]. 2021 Oct 28 [cited 2024 Feb 1]. Available from: https://ddc.moph.go.th/brc/news.php?news=29284&deptcode=
3. Jariengprasert C. Speech therapy in cerebrovascular disease patient with communication problems. Vichaiyut Newsletter. 2005 [cited 2020 June 17].
4. Engelter ST, Gostynski M, Papa S, Frei M, Born C, Ajdacic-Gross V, et al. Epidemiology of aphasia attributable to first ischemic stroke: incidence, severity, fluency, etiology, and thrombolysis. Stroke. 2006 Jun [cited 2020 June 17];37(6):1379-84. doi: 10.1161/01.STR.0000221815.64093.8c. Epub 2006 May 11. PMID: 16690899
5. Ruamsuk S, Ngamsri A. The study of speech and language scores of Thai adaptation of Western Aphasia Battery in normal Thai participants aged 15-24 years old. J Dep Med Serv. 2015:40;66-79.
6. Pedersen PM, Vinter K, Olsen TS. Aphasia after stroke: type, severity and prognosis. The Copenhagen aphasia study. Cerebrovasc Dis. 2004 [cited 2020 June 17];17(1):35-43. doi: 10.1159/000073896. Epub 2003 Oct 3. PMID: 14530636.
7. Kelly H, Brady MC, Enderby P. Speech and language therapy for aphasia following stroke. Cochrane Database Syst Rev. 2010 May [cited 2020 June 17];(5):CD000425. doi: 10.1002/14651858.cd000425.pub2. PMID: 20464716.
8. Hillis AE. The 'standard' for poststroke aphasia recovery. Stroke. 2010 Jul[cited 2020 June 17];41(7):1316-7. doi: 10.1161/STROKEAHA.110.585364. Epub 2010 Jun 10. PMID: 20538691.
9. Brady M, Ali M, Vandenberg K, Williams L, Williams L, Abo M, et al. RELEASE: a protocol for a systematic review based, individual participant data, meta-and network meta-analysis, of complex speech-language therapy interventions for stroke-related aphasia. Aphasiology. 2020 Feb [cited 2020 June 17];34(2):137-157. doi: 10.1080/02687038.2019.1643003. PMID: 37560459; PMCID: PMC7614912.
10. Berthier ML, Pulvermüller F. Neuroscience insights improve neurorehabilitation of poststroke aphasia. Nat Rev Neurol. 2011 Feb [cited 2020 June 17];7(2):86-97. doi: 10.1038/nrneurol.2010.201. PMID: 21297651.
11. Marini A, Caltagirone C, Pasqualetti P, Carlomagno S. Patterns of language improvement in adults with non-chronic non-fluent aphasia after specific therapies. Aphasiology. 2007 [cited 2020 June 17];21(2):164-86. doi:10.1080/02687030600633799.
12. Albert ML, Sparks RW, Helm NA. Melodic intonation therapy for aphasia. Arch Neurol. 1973 Aug [cited 2020 June 17];29(2):130-1. doi: 10.1001/archneur.1973.00490260074018. PMID: 4717723.
13. Helm-Estabrooks N, Nicholas M, Morgan A. Melodic Intonation Therapy program. Austin, TX: PRO-ED Publishers; 1989.
14. Norton A, Zipse L, Marchina S, Schlaug G. Melodic intonation therapy: shared insights on how it is done and why it might help. Ann N Y Acad Sci. 2009 Jul [cited 2020 June 17];1169:431-6. doi: 10.1111/j.1749-6632.2009.04859.x. PMID: 19673819; PMCID: PMC2780359.
15. Chen W, Qian Q, van de Weijer J, Zhu S, Wang M. Adaptation of Melodic Intonation Therapy to a Tone Language: A Pilot Study of Tone-Rhythmic Therapy in Mandarin Chinese. Folia Phoniatr Logop. 2023 [cited 2024 Feb 1];75(2):104-116. doi: 10.1159/000527225. Epub 2022 Sep 27. PMID: 36167033.
16. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG; CONSORT. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. Int J Surg. 2012 [cited 2025 June 10];10(1):28-55. doi: 10.1016/j.ijsu.2011.10.001. Epub 2011 Oct 12. PMID: 22036893.
17. Ngamjarus C. n4Studies: Sample size calculation for an epidemiological study on a smart device. Siriraj Med J. 2016 [cited 2020 June 17];68(3):160-70.
18. Lim KB, Kim YK, Lee HJ, Yoo J, Hwang JY, Kim JA, Kim SK. The therapeutic effect of neurologic music therapy and speech language therapy in post-stroke aphasic patients. Ann Rehabil Med. 2013 Aug [cited 2020 June 17];37(4):556-62. doi: 10.5535/arm.2013.37.4.556. Epub 2013 Aug 26. PMID: 24020037; PMCID: PMC3764351.
19. The Committee Prepared the Preliminary Brain Test-Thai version. Mini Mental Examination Thai-2002 (MMSE-2002) [in Thai]. Nonthaburi: Institute of Geriatric Medicine, Department of Medical Services, Ministry of Public Health; 2002.
20. Teerapong W. The comparison of language abilities of Thai aphasic patients and Thai normal subjects by using Thai adaptation of Western Aphasia Battery [thesis]. Mahidol University; 2000.

21. Kertesz A, Poole E. The aphasia quotient: the taxonomic approach to measurement of aphasic disability. 1974. Can J Neurol Sci. 2004 May [cited 2020 June 17];31(2):175-84. doi: 10.1017/s0317167100120736. PMID: 15198441.
22. Helm-Estabrooks N, Albert M. Manual of aphasia and aphasia therapy. Austin, TX: PRO-ED Publishers; 2004.
23. Hough MS. Melodic intonation therapy and aphasia: another variation on a theme. Aphasiology. 2010 [cited 2020 June 17];24(6-8):775-86. doi:10.1080/02687030903501941.
24. Schlaug G, Marchina S, Norton A. From Singing to Speaking: Why Singing May Lead to Recovery of Expressive Language Function in Patients with Broca's Aphasia. Music Percept. 2008 Apr 1[cited 2020 June 17];25(4):315-323. doi: 10.1525/MP.2008.25.4.315. PMID: 21197418; PMCID: PMC3010734.
25. Sirindhorn National Medical Rehabilitation Institute. Guidelines for assessment and diagnosis of disabilities. Nonthaburi: Ministry of Social Development and Human Security; 2012.
26. Tompkins CA, Scharp VL, Marshall RC. Communicative value of self cues in aphasia: A re-evaluation. Aphasiology. 2006 Jul 1 [cited 2020 June 17];20(7):684-704. doi: 10.1080/02687030500334076. PMID: 20090926; PMCID: PMC2808031.
27. Best W, Greenwood A, Grassly J, Herbert R, Hickin J, Howard D. Aphasia rehabilitation: does generalisation from anomia therapy occur and is it predictable? A case series study. Cortex. 2013 Oct [cited 2020 June 17];49(9):2345-57. doi: 10.1016/j.cortex.2013.01.005. Epub 2013 Feb 4. PMID: 23608067.
28. Ivanova MV, Hallowell B. A tutorial on aphasia test development in any language: Key substantive and psychometric considerations. Aphasiology. 2013 Jan 1 [cited 2024 Feb 1];27(8):891-920. doi: 10.1080/02687038.2013.805728. PMID: 23976813; PMCID: PMC3747007.
29. Hopewell S, Chan AW, Collins GS, Hróbjartsson A, Moher D, Schulz KF, et al. CONSORT 2025 statement: updated guideline for reporting randomised trials. Lancet. 2025 [cited 2024 Feb 1]. doi:10.1016/S0140-6736(25)00672-5.
30. Mumby PJ. Statistical power of non-parametric tests: a quick guide for designing sampling strategies. Mar Pollut Bull. 2002 Jan [cited 2025 June 10];44(1):85-7. doi: 10.1016/s0025-326x(01)00097-2. PMID: 11883688.
31. Lenhard W, Lenhard A. Computation of effect sizes [Internet]. Psychometrica; 2022 [cited 2025 Jun 21]. Available from: https://www.psychometrica.de/effect_size.html. doi:10.13140/RG.2.2.17823.92329
32. Cohen J. Statistical Power Analysis for the Behavioral Science. 2nd ed. New York: Routledge; 1988.
33. Thaut MH, Hoemberg V. Handbook of neurologic music therapy. New York, NY: Oxford University Press; 2014.
34. Liang B, Du Y. The Functional Neuroanatomy of Lexical Tone Perception: An Activation Likelihood Estimation Meta-Analysis. Front Neurosci. 2018 Jul 24 [cited 2024 Feb 1];12:495. doi: 10.3389/fnins.2018.00495. PMID: 30087589; PMCID: PMC6066585.
35. Zhang X, Li J, Du Y. Melodic Intonation Therapy on Non-fluent Aphasia After Stroke: A Systematic Review and Analysis on Clinical Trials. Front Neurosci. 2022 Jan 27 [cited 2024 Feb 1];15:753356. doi: 10.3389/fnins.2021.753356. PMID: 35153655; PMCID: PMC8829877.
36. Ashaie SA, Hurwitz R, Cherney LR. Depression and Subthreshold Depression in Stroke-Related Aphasia. Arch Phys Med Rehabil. 2019 Jul [cited 2024 Feb 1];100(7):1294-1299. doi: 10.1016/j.apmr.2019.01.024. Epub 2019 Mar 2. PMID: 30831094.
37. Mitchell AJ, Sheth B, Gill J, Yadegarfar M, Stubbs B, Yadegarfar M, Meader N. Prevalence and predictors of post-stroke mood disorders: A meta-analysis and meta-regression of depression, anxiety and adjustment disorder. Gen Hosp Psychiatry. 2017 Jul [cited 2024 Feb 1];47:48-60. doi: 10.1016/j.genhosppsych.2017.04.001. Epub 2017 Apr 3. PMID: 28807138.
38. Brady MC, Kelly H, Godwin J, Enderby P, Campbell P. Speech and language therapy for aphasia following stroke. Cochrane Database Syst Rev. 2016 Jun 1 [cited 2020 June 17];2016(6):CD000425. doi: 10.1002/14651858.CD000425.pub4. PMID: 27245310; PMCID: PMC8078645.
39. Shafer JS, Shafer PR, Haley KL. Caregivers navigating rehabilitative care for people with aphasia after stroke: a multi-lens perspective. Int J Lang Commun Disord. 2019 Jul [cited 2020 June 17];54(4):634-644. doi: 10.1111/1460-6984.12467. Epub 2019 Mar 18. PMID: 30884057; PMCID: PMC6609487.
40. Johansson MB, Carlsson M, Sonnander K. Working with families of persons with aphasia: a survey of Swedish speech and language pathologists. Disabil Rehabil. 2011 [cited 2024 Feb 1];33(1):51-62. doi: 10.3109/09638288.2010.486465. Epub 2010 May 10. PMID: 20455706.
41. Hassan FH, Zakaria AS, Ahmad Rusli Y, Haris SM, Mohd Azraai H. Comparisons of Clients' and Caregivers' Satisfaction Across Conventional, Virtual, and Hybrid Speech-Language Therapy Services in Malaysia. Patient Prefer Adherence. 2023 Jul 19 [cited 2024 Feb 1];17:1731-1740. doi: 10.2147/PPA.S407347. PMID: 37492636; PMCID: PMC10363485.
42. Wanicharoen N, Boonrod V, Kalaysak T, Samueanjai S. A systematic review of melodic intonation therapy used by speech therapists on speech recovery for patients with non-fluent aphasia. J Assoc Med Sci. 2024 [cited 2024 Feb 1];57(3):212-20.
43. Haro-Martínez A, Pérez-Araujo CM, Sanchez-Caro JM, Fuentes B, Díez-Tejedor E. Melodic Intonation Therapy for Post-stroke Non-fluent Aphasia: Systematic Review and Meta-Analysis. Front Neurol. 2021 Aug 4 [cited 2024 Feb 1];12:700115. doi: 10.3389/fneur.2021.700115. PMID: 34421802; PMCID: PMC8371046.
44. Graff-Radford J, Jones DT, Strand EA, Rabinstein AA, Duffy JR, Josephs KA. The neuroanatomy of pure apraxia of speech in stroke. Brain Lang. 2014 Feb [cited 2025 June 10];129:43-6. doi: 10.1016/j.bandl.2014.01.004. Epub 2014 Feb 18. PMID: 24556336; PMCID: PMC4004427.
45. Slavin D, Fabus R. A Case Study Using a Multimodal Approach to Melodic Intonation Therapy. Am J Speech Lang Pathol. 2018 Nov 21 [cited 2025 June 10];27(4):1352-1362. doi: 10.1044/2018_AJSLP-17-0030. PMID: 30120439.
46. Robey RR. A meta-analysis of clinical outcomes in the treatment of aphasia. J Speech Lang Hear Res. 1998 Feb [cited 2020 June 17];41(1):172-87. doi: 10.1044/jslhr.4101.172. PMID: 9493743.
47. van der Meulen I, van de Sandt-Koenderman ME, Ribbers GM. Melodic Intonation Therapy: present controversies and future opportunities. Arch Phys Med Rehabil. 2012 Jan [cited 2020 June 17];93(1 Suppl):S46-52. doi: 10.1016/j.apmr.2011.05.029. PMID: 22202191.
48. Saur D, Lange R, Baumgaertner A, Schraknepper V, Willmes K, Rijntjes M, Weiller C. Dynamics of language reorganization after stroke. Brain. 2006 Jun [cited 2024 Feb 1];129(Pt 6):1371-84. doi: 10.1093/brain/awl090. Epub 2006 Apr 25. PMID: 16638796.
49. Popescu T, Stahl B, Wiernik BM, Haiduk F, Zemanek M, Helm H, Matzinger T, Beisteiner R, Fitch WT. Melodic Intonation Therapy for aphasia: A multi-level meta-analysis of randomized controlled trials and individual participant data. Ann N Y Acad Sci. 2022 Oct [cited 2024 Feb 1];1516(1):76-84. doi: 10.1111/nyas.14848. Epub

2022 Aug 2. PMID: 35918503; PMCID: PMC9804200.
50. Schlaug G, Marchina S, Norton A. Evidence for plasticity in white-matter tracts of patients with chronic Broca's aphasia undergoing intense intonation-based speech therapy. Ann N Y Acad Sci. 2009 Jul [cited 2025 June 10];1169:385-94. doi: 10.1111/j.1749-6632.2009.04587.x. PMID: 19673813; PMCID: PMC2777670.
51. Stefaniak JD, Halai AD, Lambon Ralph MA. The neural and neurocomputational bases of recovery from post-stroke aphasia. Nat Rev Neurol. 2020 Jan [cited 2025 June 10];16(1):43-55. doi: 10.1038/s41582-019-0282-1. Epub 2019 Nov 26. PMID: 31772339.
52. Kośla K, Pfajfer L, Bryszewski B, Jaskólski D, Stefańczyk L, Majos A. Functional rearrangement of language areas in patients with tumors of the central nervous system using functional magnetic resonance imaging. Pol J Radiol. 2012 Jul [cited 2025 June 10];77(3):39-45. doi: 10.12659/pjr.883373. PMID: 23049580; PMCID: PMC3447432.
53. Patel R, Connaghan KP, Campellone PJ. The effect of rate reduction on signaling prosodic contrasts in dysarthria. Folia Phoniatr Logop. 2013 [cited 2020 June 17];65(3):109-16. doi: 10.1159/000354422. Epub 2013 Nov 26. PMID: 24296946.
54. Gentilucci M, Dalla Volta R. Spoken language and arm gestures are controlled by the same motor control system. Q J Exp Psychol (Hove). 2008 Jun [cited 2020 June 17];61(6):944-57. doi: 10.1080/17470210701625683. PMID: 18470824.
55. Morrow-Odom KL, Swann AB. Effectiveness of melodic intonation therapy in a case of aphasia following right hemisphere stroke. Aphasiology. 2013 [cited 2020 June 17];27(11):1322-38. doi:10.1080/02687038.2013.817522.
56. Katz RC, Wertz RT. The efficacy of computer-provided reading treatment for chronic aphasic adults. J Speech Lang Hear Res. 1997 Jun [cited 2025 June 10];40(3):493-507. doi: 10.1044/jslhr.4003.493. PMID: 9210109.

Original Article

Assessment of Rehabilitation Medicine Education in Thai Undergraduate Medicine Curricula and its Relevance to General Practice: A Cross-Sectional Study

Kanokphol Supasirimontri[1], Phakamas Tanvijit[1], Phairin Laohasinnarong[2] and Cherdsak Iramaneerat[3]

[1]Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, [2]Rehabilitation Center, Chulabhorn Hospital, [3]Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

ABSTRACT

Objectives: To evaluate the content of rehabilitation medicine in undergraduate medicine curriculum and its relevance to general practice

Study design: Cross-sectional study

Setting: Department of Rehabilitation Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

Subjects: Medical graduates from the Faculty of Medicine Siriraj Hospital who practiced as general practitioners and graduated between 2018 and 2020

Methods: A total of 842 medical graduates were surveyed using a structured questionnaire consisting of three sections: basic characteristics information, rehabilitation medicine content aligned with the Medical Competency Assessment Criteria for National License 2012, and recommendations for teaching and learning management. Participants rated the content using a four-point Likert scale based on frequency and criticality. Frequency was defined as the frequency with which each topic was applied in general practice, while criticality referred to the importance of each topic in its clinical practice. Data were analyzed using the Rasch rating scale model, a psychometric approach that applied the logistic regression technique to transform ordinal ratings into an interval scale. The level of the variable is on the logit scale, and the measurement unit is referred to as a logit.

Results: The response rate was 24.2%. According to the model, the frequency scores ranged from -3.31 to 3.05 logits, and the criticalities ranged from -2.12 to 2.44 logits. Integrating these two factors determined the "relevance," representing the extent to which topics in the rehabilitation curriculum for medical graduates were relevant in their experience, with values ranging from -5.43 to 5.49 logits. The five most relevant topics covered were stroke (5.49 logits), pressure ulcers (4.68 logits), osteoarthritis (4.38 logits), diabetic foot ulcers (4.33 logits), and chronic obstructive sleep apnea (4.19 logits), respectively.

Conclusions: Stroke rehabilitation, pressure ulcers, and osteoarthritis were identified as the most relevant topics in rehabilitation medicine for general practice. Therefore, teaching management should consider the appropriate teaching hours and assessments.

Keywords: rehabilitation medicine, undergraduate medical education, program evaluation

ASEAN J Rehabil Med. 2026; 36(1): 46-55.

Introduction

Rehabilitation medicine aims to improve functional capacity and quality of life for patients with physical disabilities or impairments. These conditions impact the spinal cord, brain, nerves, joints, bones, muscles, ligaments, and tendons.[1,2] According to the report, in 2022[3], sixteen percent of people globally suffered from a major disability and required rehabilitation services.

Currently, changes in physical fitness, lifestyle, and sociodemographic patterns, such as the growing prevalence of noncommunicable diseases and an aging population, are contributing to a rapid increase in the number of people experiencing functional loss.[4] Similarly, the number of elderly individuals and persons with disabilities in Thailand, as in many places globally, is projected to increase.[5,6] Changes in public health problems, societal needs, and advancements in medical technologies prompt the need for improvements in medical knowledge and clinical practice.[7] As a result, medical schools and educational institutions need to develop and update medical curriculums in response to the changes in societal demands and provide learning strategies and assessment practices to develop medical students' skills so they will have sufficient knowledge and capabilities to become competent doctors able to deal both with patients and with such future disruptions that may arise. Therefore, the appropriate course content is a key component of the curriculum[8] and should be evaluated to determine its relevance to current societal needs, i.e., the topics covered.[9]

Correspondence to: Phakamas Tanvijit, MD, FRCPhysiatrT; Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Wanglang Road, Bangkok Noi, Bangkok 10700, Thailand; Email: phakamas.tan@mahidol.ac.th

Received: Mar 12, 2025 Revised: May 15, 2025 Accepted: Oct 9, 2025

The Faculty of Medicine Siriraj Hospital, Mahidol University, offers a six-year Doctor of Medicine Program. Within this curriculum, the Department of Rehabilitation Medicine provides learning experiences and knowledge in rehabilitation medicine to fifth-year medical students over a two-week duration. The course is designed to equip students with the essential knowledge related to functional impairments caused by common medical conditions. Course content is structured according to the Medical Competency Assessment Criteria for National License 2012[10], which categorizes learning into three groups based on symptoms, conditions, or diseases.

Group 1: Diseases/ symptoms/ emergency conditions in which the mechanism or disease must be understood. General practitioners (GPs) should be able to make an initial diagnosis and provide timely, appropriate treatment and management tailored to the specific situation.

Group 2: Diseases/ symptoms/ conditions in which the mechanism or disease must be understood. GPs should be capable of diagnosing, treating, and managing patients independently, including rehabilitation, health promotion, and disease prevention. In cases where the conditions are severe or too complex, GPs should manage the immediate problems and refer the patients to a specialist. Examples of such conditions include soft-tissue rheumatism, osteoarthritis, degenerative diseases of the spine, atelectasis, and lower respiratory tract infections.

Group 3: Diseases/ symptoms/ conditions in which the mechanism or disease must be understood. GPs should be able to perform differential diagnosis and understand the principles of patient care and management, including addressing immediate issues, making appropriate referral decisions, and providing rehabilitation, health promotion, and disease prevention. Examples of such conditions are peripheral nerve entrapment, such as carpal tunnel syndrome; motor impairments like hemiplegia, paraplegia, and tetraplegia; and cerebral palsy.

Rehabilitation medicine encompasses content from both groups 2 and 3, resulting in a wide range of topics that span multiple organ systems.

According to previous studies[11,12], rehabilitation medicine course content in Thailand has not been evaluated since 2006. Previous assessments identified standard procedures such as disability certification, therapeutic exercises, and bed positioning, as well as prevalent conditions like cerebrovascular diseases, musculoskeletal pain, and fractures of the extremities. Based on the previous article in China[13], the categories of rehabilitation therapy education included junior college, undergraduate, master's, and doctoral levels. The goals of the undergraduate curriculum were to develop knowledge of Chinese medicine, rehabilitation medicine techniques and technology, and work skills. In the USA, one medical school implemented a two-week musculoskeletal rehabilitation rotation to enhance clinical experiences for medical students.[14] While another medical school offered a two-week rehabilitation medicine course, including general lectures and clinical rotations alongside a physiatrist and a resident, to enhance the medical students' understanding of rehabilitation medicine.[15]

The rehabilitation medicine course has not been formally evaluated in terms of its content or alignment with the Medical Competency Assessment Criteria for the National License 2012.[10,16] The hypothesis is that the course content provides a comprehensive overview of common rehabilitation issues that medical students may encounter in clinical practice. However, some topics may be of limited relevance to GPs. Previous studies[17,18] have evaluated medical curricula by assessing the frequency of use and criticality of each topic in clinical settings. One study[19] utilized feedback from final-year medical students to evaluate preclinical content within these two domains and analyzed the results using the Rasch rating scale model to determine clinical relevance.[19] Gathering opinions from medical graduates working in diverse healthcare settings can further highlight which topics are most applicable in real-world practice. Therefore, this study aimed to explore the experiences and opinions of medical graduates from the Faculty of Medicine, Siriraj Hospital, regarding the relevance and appropriateness of the content for the rehabilitation medicine course in relation to the Medical Competency Assessment Criteria for the National License 2012. The findings could serve as a valuable resource for future revisions of the undergraduate rehabilitation medicine curriculum.

Methods

Study design

This study employed a cross-sectional design, utilizing both paper and online questionnaires as primary research instruments. The protocol for this study was approved by the Siriraj Institutional Review Board on August 17, 2020 (COA: Si 693/2020). This study was reported by the STROBE guidelines for observational studies.

Setting

This study was conducted at the Department of Rehabilitation Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand.

Participants

A total of 842 medical graduates from the Faculty of Medicine at Siriraj Hospital, with graduation years from 2018 to 2020, were invited to participate in the study. Participants were asked to complete questionnaires from September to December 2020, excluding those who had expressed an unwillingness to participate. Based on a sample size calculation of[20], the author set a 95% confidence interval, a margin of error of 7%, and an expected proportion of 0.5 in the population.[21] A minimum of 196 participants was required. Considering the anticipated dropout rate for survey study[22], at least 784 participants were expected to complete the questionnaire.[23]

As a result, all 842 medical graduates from three graduation years were provided with the questionnaire.

Outcomes measurements

A questionnaire was developed consisting of three parts, as described below.

The first part covered the variables of baseline characteristics, including graduation year, gender, age, total grade point average (GPAX), grade for the rehabilitation medicine element, types of current hospital workplace and medical field, number of hospital beds, number of physiatrist physicians in their workplace, interest in the medical field in the future, and experience in elective rehabilitation medicine.

The second part focused on the rehabilitation medicine course content domain, covering 93 topics. Of these, 58 topics pertained to medical conditions that required rehabilitation, and 35 topics focused on skills and modalities used in rehabilitation. The topics were based on the Medical Competency Assessment Criteria for National License 2012[10] and were validated by two physiatrists and one medical education specialist. Participants rated each item based on two aspects: "frequency" and "criticality," using a four-point Likert scale. Frequency referred to the number of times they applied specific knowledge in their practical experience, with the scores being 1: "never or rarely used the knowledge"; 2: "used the knowledge in a few cases"; 3: "used the knowledge sometimes"; and 4: "used the knowledge very often," respectively. In terms of criticality, this referred to the importance of each topic in their clinical practice, with the scores being 1: "unimportant," 2: "somewhat important," 3: "moderately important," and 4: "very important," respectively.

The third part of the questionnaire invited participants to offer suggestions for the teaching and learning management of rehabilitation medicine, including the appropriate class year and duration to study rehabilitation medicine, as well as open-ended suggestions for improving the course.

Statistical methods

The internal consistency reliability of the questionnaire was evaluated using Cronbach's alpha (Cα).

The usefulness of the rehabilitation medicine course content in the undergraduate medical curriculum for actual practice was analyzed using the Rasch rating scale model.[24,25] This model is a class of psychometric models that employs a logistic regression technique to transform ordinal ratings into an interval scale.[26] The key variables in considering the course content are frequency and criticality, and they are originally ordinal scales. The author aimed to transform the ordinal scale into the interval scale for mathematically analyzing the measures and investigating the relationships. The level of the variable is the logit scale, and the measurement unit is called logits.[26,27] This model allows for the comparison the obtained values. For example, the two logits are twice as much as the one logit. One logit plus two logits equal three logits. Moreover, the Rasch Rating Scale Model is capable of handling missing data without removing participants' responses entirely.

After analyzing by using the Rasch rating scale model, the sum of frequency and criticality gives the "relevance", which represents the relevant level of each topic in actual rehabilitation practice based on the GPs' experience.

For the descriptive statistics, categorical data, including the respondents' basic characteristics, were reported in terms of frequency and percentage. Numerical data, including logits of frequency, criticality, and relevance, were reported in terms of the mean and standard deviation.

The mean score for the "relevance" (on the logits scale) was compared based on each participant's characteristics using the independent samples t-test for two-group variables and one-way ANOVA for three-group variables.

Descriptive and inferential statistics analyses were performed using Statistical Package for the Social Sciences (SPSS) for Windows 18.0. The statistical significance level was considered as $p < 0.05$. The Rasch measurements were performed using WINSTEPS, a Rasch analysis and measurement software.

Additionally, open-ended suggestions for improving the course from the medical graduates were analyzed by a qualitative method.

Results

Basic characteristics of respondents

Overall, 204 respondents completed and returned the questionnaire (204/842, 24.2%), of whom 175 (85.8%) graduated in 2020. The mean age of the respondents was 24.6 years old, and 107 (52.5%) were male. The mean total grade point was 3.50 out of 4.00. The respondent cohort comprises 49 doctors working at a university hospital, 76 doctors working at a tertiary care hospital with a medical education center or a tertiary care hospital, and 79 doctors working at a secondary care hospital, community hospital, or other settings. Other characteristics were presented in terms of frequency in Table 1.

Reliability of questionnaire

Cronbach's alpha for the frequency domain in the questionnaire was 0.97. Cronbach's alpha for the criticality domain in the questionnaire was 0.98.

Frequency, criticality, and relevance of the course content in rehabilitation medicine

Frequency: The frequency scores of 93 topics that medical graduates applied during their general practitioner experience ranged from -3.31 logits to 3.05 logits, with a mean of 0 logits and a standard deviation of 1.29 logits. The five most frequent medical conditions requiring rehabilitation were stroke (3.05 logits), pressure ulcers (2.75 logits), chronic obstructive pulmonary disease (COPD) (2.62 logits), osteoarthritis (2.61 logits), and muscle strain (2.52 logits). Additionally, the

Table 1. Basic characteristics of the respondents

Basic characteristics	n (%)
Graduation year (n = 204)	
2020	175 (85.8)
2019	14 (6.9)
2018	15 (7.3)
Gender (n = 204)	
Male	107 (52.5)
Female	97 (47.5)
GPAX (n = 187)	
3.50-4.00	112 (59.9)
2.50-3.49	75 (40.1)
Grade in rehabilitation medicine (n = 186)	
A	117 (62.9)
B+, B, C+, and C	69 (37.1)
Types of current hospital workplace (n = 204)	
University hospital	49 (24.0)
Tertiary care hospital with a medical education center, tertiary care hospital alone	76 (37.3)
Secondary care hospital, community hospital, or other	79 (38.7)
Types of working[#] (n = 202)	
GP	132 (65.3)
GP with a special track	70 (34.7)
Field of interest (n = 190)	
Rehabilitation medicine	23 (12.1)
Other fields	167 (87.9)
Number of beds in the hospital (n = 202)	
< 500 beds	83 (41.1)
≥ 500 beds	119 (58.9)
Physiatrist in hospital (n = 202)	
Yes	157 (77.7)
Experience with elective rehabilitation medicine (n = 200)	
Yes	35 (17.5)

[#]Types of working

GP, general practitioner, GP with special track = general practitioner whose track involves the CPIRD (Collaborative Project to Increase the Production of Rural Doctors), or a specific track, including preclinical internship or internship in a specific ward in a university hospital; GPAX, total grade point average

five most frequent skills and modalities utilized in rehabilitation included the use of a walker (0.90 logits), use of axillary crutches (0.87 logits), advice on caring for pressure ulcers (0.64 logits), use of a lumbar support brace (0.41 logits), and teaching stretching exercises for the neck and shoulder muscles (0.39 logits).

Criticality: Among the 93 topics that medical graduates rated as important in terms of the course content they utilized during their general practitioner experience, the criticality scores ranged from -2.12 logits to 2.44 logits, with a mean of 0 logits and a standard deviation of 1.00 logits. The five most critical medical conditions requiring rehabilitation were stroke (2.44 logits), diabetic foot ulcers (1.96 logits), pressure ulcers (1.93 logits), traumatic brain injury (1.84 logits), and osteoarthritis (1.77 logits). Additionally, the five most critical skills and modalities needed in rehabilitation medicine in practice were disability certification (0.63 logits), advice on caring for pressure ulcers (0.51 logits), swallowing assessment (0.30 logits), and teaching stretching exercises for the neck and shoulder muscles and how to use a walker (0.26 logits).

Relevance: Of the 93 topics considered necessary course content based on general practitioners' experience, their relevance scores ranged from -5.43 logits to 5.49 logits, with a mean of 0 logits and a standard deviation of 2.25 logits. The ten most relevant medical conditions requiring rehabilitation were stroke (5.49 logits), pressure ulcers (4.68 logits), osteoarthritis (4.38 logits), diabetic foot ulcers (4.33 logits), COPD (4.19 logits), traumatic brain injury (3.86 logits), pneumonia (3.85 logits), gouty arthritis (3.78 logits), myofascial pain syndrome (3.69 logits), and muscle strains (3.61 logits), respectively, as shown in Table 2.

The five most relevant skills and modalities in rehabilitation practice were the use of a walker (1.16 logits), advice on caring for pressure ulcers (1.15 logits), the use of axillary crutches (1.10 logits), teaching/ providing advice on stretching exercises for the neck and shoulder muscles (0.65 logits), and teaching stretching exercises for the back muscles (0.44 logits), respectively, as shown in Table 3.

Table 2. Ten most common medical conditions requiring rehabilitation that are relevant for medical students to study in rehabilitation medicine

Rank	Topic	Relevance	Frequency	Criticality
		Logits	Logits	Logits
1	Stroke	5.49	3.05	2.44
2	Pressure ulcers	4.68	2.75	1.93
3	Osteoarthritis	4.38	2.61	1.77
4	Diabetic foot ulcers	4.33	2.37	1.96
5	Chronic obstructive pulmonary disease (COPD)	4.19	2.62	1.57
6	Traumatic brain injury	3.86	2.02	1.84
7	Pneumonia	3.85	2.19	1.66
8	Gouty arthritis	3.78	2.24	1.54
9	Myofascial pain syndrome	3.69	2.21	1.48
10	Muscle strains	3.61	2.52	1.09

Table 3. The five most relevant skills and modalities needed in rehabilitation

Rank	Topic	Relevance	Frequency	Criticality
		Logits	Logits	Logits
1	Use of a walker	1.16	0.90	0.26
2	Advice on caring for pressure ulcers	1.15	0.64	0.51
3	Use of axillary crutches	1.10	0.87	0.23
4	Teaching/Providing advice on stretching exercises for the neck and shoulder muscles	0.65	0.39	0.26
5	Teaching/Providing advice on stretching exercises for the back muscles	0.44	0.23	0.21

Conversely, the five least relevant medical conditions requiring rehabilitation were myelitis (-3.08 logits), sciatic nerve injury (-3.12 logits), common peroneal nerve injury (-3.31 logits), lumbosacral plexus injury (-3.39 logits), and poliomyelitis (-5.43 logits), respectively; In contrast, the five least relevant skills and modalities in rehabilitation were ultrasound (-3.02 logits), a below-knee prosthesis (-3.07 logits), an above-knee prosthesis (-3.22 logits), paraffin (-3.92 logits), and short wave diathermy (-3.97 logits), respectively.

Basic characteristics of the medical graduates who rated the relevance of specific rehabilitation medicine course content for actual clinical practice (relevance)

According to the basic characteristics of the medical graduate respondents, their scores for rating the necessity of the rehabilitation medicine course content for different aspects (relevance) ranged from -1.13 to 13.18 logits, with a mean of 3.91 logits and a standard deviation of 2.47 logits. The mean scores for rating the relevance of the course content by respondents who received higher grades in rehabilitation medicine (mean = 4.18, SD = 2.41) were better than those who graduated with a lower grade (mean = 3.43, SD = 2.50), $p = 0.046$. However, there were no significant differences in ratings based on other respondent characteristics, as shown in Table 4.

Suggestions for improving the rehabilitation course

Most medical graduates suggested that the fifth-class year of the medical program (93.2%) and a two-week teaching block (65.4%) were appropriate for gaining sufficient learning experience in rehabilitation medicine. At the same time, 17.6% and 14.7% of participants rated a three-week and four-week teaching block, respectively, as suitable for learning management.

From the open-ended suggestions, the results demonstrated that there were two major themes in the comments of medical graduates regarding improvements to the rehabilitation course in Doctor of Medicine Programs: learning experience (n = 15) and the use of media for education (n = 13).

Regarding the learning experience, integration with other departments and teaching in ambulatory care settings were suggested (n = 4), while other responders suggested traditional lectures should not be used (n = 2). Additionally, other participants thought rehabilitation advice, such as education in chronic diseases and practical points for consideration in rehabilitation settings for GPs, should be focused on (n = 9). Many also thought that technology-enhanced learning should be applied, such as the use of online resources (n = 8) and multimedia content and tools, including appropriate exercises for common diseases (n = 5).

Discussion

In this study, medical graduates from the Faculty of Medicine Siriraj Hospital, Mahidol University, reflected on their experiences as general practitioners (GPs) and considered the appropriate course content needed to address rehabilitation medicine and practice in Doctor of Medicine programs. The results of this study were consistent with those of previous studies in Thailand. Stroke and musculoskeletal conditions were the medical conditions for which medical graduates rated rehabilitation as the most helpful treatment, particularly Thai medical graduates who graduated between 2002 and 2004 from the Faculty of Medicine, Naresuan University.[11] Additionally, advice on caring for pressure ulcers was a commonly utilized skill in rehabilitation practice among physicians in Thai community hospitals.[12]

Stroke is prevalent in Thailand and many other parts of the world, representing a significant health burden to both individuals and society.[28,29] Stroke rehabilitation is crucial for enhancing the quality of life of stroke patients and for reducing their physical impairment and levels of functional dependency.[30] Interestingly, diabetic foot ulcers were also identified as a highly relevant topic. According to a previous study based on a multicenter registry in Thailand, the prevalence of diabetic foot ulcers in diabetic patients was 5.9%.[31] Thus, proper footwear is essential for preventing diabetic foot ulcers and their recurrence[32], and providing appropriate footwear and advice is an important aspect of the rehabilitation field. Additionally, COPD was also reported to be highly relevant in the experiences of many general practitioners. Previous literature has demonstrated that COPD is prevalent in Thailand[33] and represents both a health burden and an economic burden to patients in Thailand.[34] Therefore, pulmonary rehabilitation is crucial for improving patients' physical

Table 4. Different characteristics of the medical graduate respondents and their effects on their rating of the relevance of different rehabilitation medicine course contents for use in clinical practice

Basic characteristics	Mean (SD), logits	*p*-value
Graduation year		
2020	4.03 (2.56)	0.210
2019	3.21 (1.29)	
2018	3.12 (1.95)	
Gender		
Male	3.65 (2.26)	0.120
Female	4.19 (2.66)	
GPAX		
3.50-4.00	4.15 (2.49)	0.089
2.50-3.49	3.52 (2.42)	
Grade in rehabilitation medicine		
A	4.18 (2.41)	0.046
B+, B, C+, and C	3.43 (2.50)	
Types of current hospital workplace		
University hospital	3.83 (2.57)	0.930
Tertiary care hospital with a medical education center and tertiary care hospital alone	3.88 (2.55)	
Secondary care hospitals, community hospitals, and others	3.99 (2.34)	
Types of working[#]		
GP	3.65 (2.31)	0.055
GP with a special track	4.35 (2.71)	
Field of interest		
Rehabilitation medicine	3.58 (1.78)	0.52
Other fields	3.93 (2.58)	
Number of beds in hospital		
< 500 beds	3.94 (2.36)	0.83
≥ 500 beds	3.86 (2.56)	
Physiatrist in hospital?		
Yes	3.95 (2.52)	0.57
Experience with elective rehabilitation medicine?		
Yes	4.41 (2.85)	0.18

[#] Types of working: GP, general practitioner; GP with special track, general practitioner whose track involves the CPIRD (Collaborative Project to Increase Production of Rural Doctor), or a specific track including preclinical internship or internship in a specific ward in a university hospital

function and alleviating respiratory symptoms.[35]

Nevertheless, the present study revealed that the topics of below-knee prostheses and above-knee prostheses for general practice were of interest, given the decreasing number of amputee patients in recent years.[36] This trend might be attributed to advancements in medical knowledge and technology, as well as an increase in highly skilled vascular surgeons and orthopedic physicians over the past decade.[37]

The Medical Council of Thailand outlines broad rehabilitation competencies but provides limited guidance on disease-specific aspects. Given the short duration of rehabilitation rotations, curricula must focus on high-yield, practical topics that are relevant to the field of rehabilitation. Therefore, the rehabilitation medicine course for medical students was developed based on the Medical Council's standards, along with feedback from faculty seminars, the educational committee, and stakeholders.[12,38,39] This resulted in variations in topic selection and in allocated teaching hours across different institutions. Although our study did not directly measure teaching hours or the assessment weighting for each topic, the findings offered valuable insights to inform curriculum planning. Specifically, topics identified as highly relevant to general practice, such as stroke, pressure ulcers, diabetic foot ulcers, COPD, and musculoskeletal conditions, should be prioritized. Suppose any of these topics are currently underrepresented in teaching time or assessments. In that case, curriculum developers should consider adjusting the content accordingly to reflect their clinical importance and relevance to future practice. Specifically, we recommend emphasizing stroke rehabilitation, particularly in the acute care setting. Integration with internal medicine teaching, along with a focus on acute stroke rehabilitation, may enhance learning outcomes. For COPD, we recommend supplementing traditional content with online platforms and case-based discussions to reinforce

learning and enhance patient outcomes. Diabetic foot ulcers are already addressed within internal medicine; however, rehabilitation teaching should focus on reinforcing the importance of screening and interdisciplinary care. Musculoskeletal (MSK) pain, which was also rated highly in relevance, could benefit from expanded teaching time and diverse instructional strategies such as flipped classrooms, case-based discussions, simulations, and outpatient clinical exposure.[14] Skills-based assessment using Objective Structured Clinical Examinations (OSCEs) may also be appropriate, particularly for exercises and patient advice. In contrast, topics such as physical modalities and lower-limb prosthetics may be deprioritized if time is limited. Focus can instead be placed on the pre-prosthetic phase, including stump care and exercises, which align with the practical competencies required by the Medical Council's standards. Physical modalities might be incorporated into MSK teaching and outpatient clinics, where their use is most relevant.

Interestingly, respondents with higher grades in rehabilitation medicine gave higher ratings for the necessity of rehabilitation medicine course content, which was similar to a previous study that found a moderate positive correlation between practical scores and attitudes toward rehabilitation medicine among medical students.[40] However, other characteristics of the respondents did not affect the medical graduates' ratings of the rehabilitation medicine course content. A previous study found that neither gender nor academic level had a significant effect on the attitude of medical graduates and medical students toward rehabilitation medicine.[41]

Moreover, most medical graduates agreed that it was best to study rehabilitation medicine in the fifth-class year over two weeks. According to previous studies, an appropriate learning management approach with a two-week course dedicated to rehabilitation medicine can help medical students acquire sufficient knowledge in rehabilitation medicine[42] and improve their understanding of the rehabilitation field.[43] However, about one-third of participants suggested that rehabilitation medicine rotation should be managed over three or four weeks. This result was consistent with a previous study in a Thai Tertiary care hospital with a medical education center in the Northern area, which found that four-week rotations were considered appropriate for learning management according to students' opinions.[44] Extending the course duration from two weeks to four weeks would be highly challenging, as it would impact the overall curriculum structure. A feasible approach would be to encourage students to select rehabilitation medicine as an elective course or online platform.[44,45] Some medical graduates suggested that teachers should improve the learning experiences and use multimedia to support education in this area in future courses. Current learners might prefer further technological integration in their classrooms due to possible disruptions in education, such as those caused by the recent COVID-19 pandemic.[46] In previous studies, medical students in Croatia suggested that rehabilitation medicine courses should include more practical activities.[47] Meanwhile, medical students in the USA were impressed with the workshop format for teaching musculoskeletal diseases, physical examination, and clinical integration.[38]

This study offers valuable insights for evaluating and developing course content in rehabilitation medicine. However, the use of this information should be carefully considered, taking into account the context of each country and advancements in medicine and technology. Additionally, there are several limitations to note in this study. First, there was a low response rate, especially among medical graduates from the 2018-2019 graduation years, who predominantly worked in community hospitals. Therefore, the information might not reflect the opinions of general practitioners in community hospitals. Second, medical graduates who graduated in 2020 were surveyed when they had only limited experience as general practitioners, having worked for around four to six months, and they might not have encountered patients with certain medical conditions requiring rehabilitation in real-life settings. Third, most respondents were from the 2020 graduate year and had better GPAs and grades in rehabilitation medicine, which may represent a selection bias. Fourth, this study surveyed medical graduates from a single institute, which limits its ability to generalize the results to other institutions due to potential differences in learning experiences. Fifth, the inclusion of multiple topics in the questionnaire may have contributed to respondent fatigue, potentially affecting the accuracy of some responses.

Conclusions

Stroke rehabilitation, pressure ulcers, osteoarthritis, diabetic foot ulcers, and COPD were the most relevant contents. However, poliomyelitis, short-wave diathermy, paraffin, lumbosacral plexus injury, and common peroneal nerve injury were the least relevant contents. Most medical graduates suggested that the fifth year of the medical program, along with a two-week teaching rotation, was suitable for gaining a learning experience in rehabilitation medicine. The novel learning experience and the use of media for education were important concepts for enhancing the rehabilitation course.

Conflicts of interest declaration

The authors confirm that there is no conflict of interest related to the manuscript.

Generative AI declaration

The authors confirm that the following large language models (LLMs) or artificial intelligence (AI) tools were used in the preparation of this manuscript: ChatGPT for language editing and improving readability, and Grammarly for grammar correction. All generated content was critically reviewed and edited by the authors.

Acknowledgements

None.

Funding

This study was supported by an educational research grant from the Faculty of Medicine Siriraj Hospital, Mahidol University (Funding Number: R016461003). The funder had no role in the design or analysis of the study and was not granted access to any participant information. This part of this research was presented at the 53rd Annual Meeting of the Japan Society for Medical Education.

Data availability

The data that support the findings of this study are available from the corresponding author, Phakamas Tanvijit, upon reasonable request.

Author contributions

Kanokphol Supasirimontri: conceptualization, data curation, funding acquisition, investigation, methodology, visualization, writing-original manuscript preparation,

Phairin Laohasinnarong: methodology, formal analysis, validation,

Cherdsak Iramaneerat: conceptualization, methodology, formal analysis, validation,

Phakamas Tanvijit: conceptualization, methodology, formal analysis, supervision, validation, writing-review & editing.

All authors read and approved the final manuscript.

References

1. American Academy of Physical Medicine and Rehabilitation. About Physical Medicine & Rehabilitation [Internet]. Rosemont (IL): American Academy of Physical Medicine and Rehabilitation; [cited 2025 Apr 12]. Available from: https://www.aapmr.org/about-physiatry/about-physical-medicine-rehabilitation
2. Tederko P, Krasuski M, Denes Z, Moslavac S, Likarevic I. What medical doctors and medical students know about physical medicine and rehabilitation: a survey from Central Europe. Eur J Phys Rehabil Med [Internet]. 2015 Dec 1 [cited 2024 July 9];52(5):597-605. Available from: https://pubmed.ncbi.nlm.nih.gov/26629844/
3. World Health Organization. Global report on health equity for persons with disabilities [Internet]. Geneva (CH): World Health Organization; 2022 Dec 2 [cited 2025 Apr 12]. Available from: https://www.who.int/publications/i/item/9789240063600
4. Cieza A. Rehabilitation the health strategy of the 21st century, really?. Arch Phys Med Rehabil [Internet]. 2019 Nov 1 [cited 2024 July 9];100(11):2212-4. Available from: https://pubmed.ncbi.nlm.nih.gov/31128114/ doi: 10.1016/j.apmr.2019.05.019
5. Foundation of Thai Gerontology Research and Development Institute (TGRI). Situation of the Thai elderly 2018 [Internet]. Nakhon Pathom: Foundation of Thai Gerontology Research and Development Institute (TGRI); 2019 [cited 2024 July 9]. Available from: https://www.dop.go.th/download/knowledge/th1610945020-322_0.pdf
6. National Statistical Office. The 2017 Disability Survey [Internet]. Bangkok: National Statistical Office of Thailand; 2017 [cited 2024 July 9]. Available from: http://www.nso.go.th/sites/2014en/Survey/social/SocialSecurity/Disabilitysurvey/2017/Full_Report.pdf
7. Mcleod P, Steinert Y. Twelve tips for curriculum renewal. Med Teach [Internet]. 2015 Mar [cited 2024 July 9];37(3):232-8. Available from: https://pubmed.ncbi.nlm.nih.gov/25010218/ doi: 10.3109/0142159X.2014.932898
8. Harden RM. AMEE Guide No. 21: Curriculum mapping: a tool for transparent and authentic teaching and learning. Med Teach [Internet]. 2001 Jan 1 [cited 2024 July 9];23(2):123-37. Available from: https://pubmed.ncbi.nlm.nih.gov/11371288/ doi: 10.1080/01421590120036547
9. Cook DA. Twelve tips for evaluating educational programs. Med Teach [Internet]. 2010 [cited 2024 July 9];32(4):296-301. Available from: https://pubmed.ncbi.nlm.nih.gov/20353325/ doi: 10.3109/01421590903480121
10. The Medical Council of Thailand. Medical Competency Assessment Criteria for National License 2012 [Internet]. Bangkok: The Medical Council of Thailand; 2012 [cited 2024 July 9]. Available from: http://www.tmc.or.th/download/medical2555.pdf
11. Wannapira P, Wannapira W, Jariya Y, Pannarunothai S. Practice assessment on Physical Medicine and Rehabilitation among graduates. J Thai Rehabil [Internet]. 2006 [cited 2024 July 9];16(2):60-66. Available from: https://www.rehabmed.or.th/main/wp-content/uploads/2015/01/L-225.pdf
12. Tongprasert S, Kovindha A. The Study on Implementation of Rehabilitation Medicine by Primary Care Physicians at District Hospitals in Thailand. J Thai Rehabil Med [Internet]. 2013 [cited 2024 July 9];23(2):51-56. Available from: https://www.rehabmed.or.th/main/wp-content/uploads/2015/01/L-357.pdf
13. Sun S, Lin X, Ouyang X, Cai W, Gao Q, Guo P, Li Z, Ji L, Dong Z, Jing Q, Zhang J. Education and development of rehabilitation therapy in China under the background of aging. Front Public Health [Internet]. 2022 Dec 7 [cited 2025 Apr 12];10:1000048. Available from:https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.1000048/full doi: 10.3389/fpubh.2022.1000048
14. Laskowski ER, Moutvic M, Smith J, Newcomer-Aney K, Showalter CJ. Integration of physical medicine and rehabilitation into a medical school curriculum: musculoskeletal evaluation and rehabilitation. Am J Phys Med Rehabil [Internet]. 2000 Nov 1 [cited 2025 Apr 12];79(6):551-7. Available from: https://pubmed.ncbi.nlm.nih.gov/11083306/ doi: 10.1097/00002060-200011000-00014
15. Kirshblum SC, Delisa JA, Campagnolo DL. Mandatory clerkship in physical medicine and rehabilitation: effect on medical students' knowledge of physiatry. Arch Phys Med Rehabil [Internet]. 1998 Jan 1 [cited 2025 Apr 12];79(1):10-3. Available from: https://pubmed.ncbi.nlm.nih.gov/9440409/ doi: 10.1016/s0003-9993(98)90199-x.
16. The Medical Council of Thailand. Medical Competency Assessment Criteria for National License 2012 (No.2) [Internet]. Bangkok: The Medical Council of Thailand; 2012 [cited 2025 Apr 12]. Available from: https://www.tmc.or.th/pdf/MCACNL2012-2-2563.pdf
17. Chiniara G, Cole G, Brisbin K, Huffman D, Cragg B, Lamacchia M, et al. Simulation in healthcare: a taxonomy and a conceptual framework for instructional design and media selection. Med Teac [Internet]. 2013 [cited 2025 Apr 12];35(8):e1380-e95. Available from: https://pubmed.ncbi.nlm.nih.gov/23121247/ doi:10.3109/0142159X.2012.733451
18. Supasirimontri K, Triloga N, Harnphadungkit K. Clinical Competency Needs of Physiatrists in Thailand: A Cross-Sectional study. ASEAN J Rehabil Med [internet]. 2025 Jan. 10 [cited 2025 Apr. 12];35(1):35. available from: https://he01.tci-thaijo.org/index.php/

aseanjrm/article/view/272468
19. Iramaneerat C, Tewsikhares P, Pinchoo P. The evaluation of preclinical curriculum content of a doctor of medicine program. Paper presented at: Annual meeting of the International Association for Medical Education (AMEE), 2008 Sep; Prague, Czech Republic
20. Cochran WG. Sampling techniques. 3rd ed. New York: John Wiley & Sons; 1977.
21. Al-Subaihi AA. Sample size determination. Influencing factors and calculation strategies for survey research. Saudi Med J [Internet]. 2003 Apr [cited 2025 Apr 12];24(4):323-30. Available from: https://pubmed.ncbi.nlm.nih.gov/12754527/
22. Hoerger M. Participant dropout as a function of survey length in Internet-mediated university studies: Implications for study design and voluntary participation in psychological research. Cyberpsychol Behav Soc Network [Internet]. 2010 Dec 1 [cited 2025 Apr 12];13(6):697-700. Available from: https://pubmed.ncbi.nlm.nih.gov/21142995/ doi: 10.1089/cyber.2009.0445
23. In J, Kang H, Kim JH, Kim TK, Ahn EJ, Lee DK, Lee S, Park JH. Tips for troublesome sample-size calculation. Korean J Anesthesiol [Internet]. 2020 Apr 1 [cited 2025 Apr 12];73(2):114-20. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7113158/ doi: 10.4097/kja.19497
24. Andrich D. Application of a psychometric rating model to ordered categories which are scored with successive integers. Appl Psychol Meas [Internet]. 1978 [cited 2024 July 9]. Oct;2(4):581-94. Available from: https://journals.sagepub.com/doi/10.1177/014662167800200413 doi: 10.1177/014662167800200413
25. Andrich D. A rating formulation for ordered response categories. Psychometrika [Internet]. 1978 Dec [cited 2024 July 9];43:561-73. Available from: https://link.springer.com/article/10.1007/BF02293814
26. Wright BD, Mok MM. An overview of the family of Rasch measurement models. Introduction to Rasch measurement. 2004 [cited 2024 July 9]:1-24. Available from: http://jampress.org/irmch1.pdf
27. Sumintono B. Rasch Model Measurements as Tools in Assesment for Learning. In1st International Conference on Education Innovation (ICEI 2017) [Internet] 2018 Feb (pp. 38-42) [cited 2024 July 9]. Atlantis Press. Available from: https://www.atlantis-press.com/proceedings/icei-17/25892886
28. Feigin VL, Stark BA, Johnson CO, Roth GA, Bisignano C, Abady GG, Abbasifard M, Abbasi-Kangevari M, Abd-Allah F, Abedi V, Abualhasan A. Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol [Internet]. 2021 Oct 1 [cited 2024 July 9];20(10):795-820. Available from: https://www.thelancet.com/article/S1474-4422(21)00252-0/fulltext doi: 10.1016/S1474-4422(21)00252-0
29. Suwanwela NC. Stroke epidemiology in Thailand. J Stroke [Internet]. 2014 Jan [cited 2024 July 9];16(1):1. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC3961816/ doi: 10.5853/jos.2014.16.1.1
30. Pattanasuwanna P, Kuptniratsaikul V. Inpatient rehabilitation outcomes in patients with stroke at Thailand's largest tertiary referral center: a 5-year retrospective study. J Sci Res Stud [Internet]. 2017 [cited 2024 July 9];4(8):208-16. Available from: https://www.academia.edu/64687660/Inpatient_rehabilitation_outcomes_in_patients_with_stroke_at_Thailand_s_largest_tertiary_referral_center_A_5_year_retrospective_study
31. Rawdaree P, Ngarmukos C, Deerochanawong C, Suwanwalaikorn S, Chetthakul T, Krittiyawong S, Benjasuratwong Y, Bunnag P, Kosachunhanun N, Plengvidhya N, Leelawatana R. Thailand diabetes registry (TDR) project: clinical status and long term vascular complications in diabetic patients. J Med Assoc Thai [Internet]. 2006 Aug 1 [cited 2024 July 9];89(Suppl 1):S1-9. Available from: https://pubmed.ncbi.nlm.nih.gov/17717877/
32. Sukthomya S, Ehara Y, Srisawasdi G, Suwannakin A, Katsuhira J. Foot problems, footwear habits and indoor footwear design preferences of the diabetic population in Thailand. Niigata Journal of Health and Welfare [Internet]. 2020 [cited 2024 July 9];20(2):85-112. Available from: https://www.jstage.jst.go.jp/article/niigatajohewe/20/2/20_85/_html/-char/en doi: 10.34540/niigatajohewe.20.2_85
33. Adeloye D, Song P, Zhu Y, Campbell H, Sheikh A, Rudan I. Global, regional, and national prevalence of, and risk factors for, chronic obstructive pulmonary disease (COPD) in 2019: a systematic review and modelling analysis. Lancet Respir Med [Internet]. 2022 May 1 [cited 2024 July 9];10(5):447-58. Available from: https://www.thelancet.com/article/S2213-2600(21)00511-7/fulltext doi: 10.1016/S2213-2600(21)00511-7
34. Thanaviratananich S, Cho SH, Ghoshal AG, Muttalif AR, Lin HC, Pothirat C, Chuaychoo B, Aeumjaturapat S, Bagga S, Faruqi R, Sajjan S. Burden of respiratory disease in Thailand: results from the APBORD observational study. Medicine [Internet]. 2016 Jul [cited 2024 July 9];95(28). Available from: https://pubmed.ncbi.nlm.nih.gov/27428193/ doi: 10.1097/MD.0000000000004090
35. Zhang H, Hu D, Xu Y, Wu L, Lou L. Effect of pulmonary rehabilitation in patients with chronic obstructive pulmonary disease: a systematic review and meta-analysis of randomized controlled trials. Ann Med [Internet]. 2022 Dec 31 [cited 2024 July 9];54(1):262-73. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC8765243/ doi: 10.1080/07853890.2021.1999494
36. Goodney PP, Tarulli M, Faerber AE, Schanzer A, Zwolak RM. Fifteen-year trends in lower limb amputation, revascularization, and preventive measures among medicare patients. JAMA Surg [Internet]. 2015 Jan 1 [cited 2025 Apr 12];150(1):84-6. Available from: https://jamanetwork.com/journals/jamasurgery/fullarticle/1921806 doi: 10.1001/jamasurg.2014.1007
37. The Medical Council of Thailand. Information about doctors who have received approval letters and certificates from the Medical Council (by branch) [Internet]. 2022 [cited 2024 July 9]. Available from: https://www.tmc.or.th/pdf/tmc-stat-29-12-22-05-.pdf
38. Saleh K, Messner R, Axtell S, Harris I, Mahowald ML. Development and evaluation of an integrated musculoskeletal disease course for medical students. J Bone Joint Surg Am [Internet]. 2004 Aug 1 [cited 2024 July 9];86(8):1653-8. Available from: https://pubmed.ncbi.nlm.nih.gov/15292412/ doi: 10.2106/00004623-200408000-00008
39. Hettle M, Braddom RL. Curriculum needs in physical medicine and rehabilitation for primary care physicians. Results of a survey. Am J Phys Med Rehabil [Internet]. 1995 Jul 1 [cited 2024 July 9];74(4):271-5. Available from: https://pubmed.ncbi.nlm.nih.gov/7632383/ doi: 10.1097/00002060-199507000-00003
40. Razavi SZ, Azadvari M, Hosseini M, Dehgolan SR, Maghbouli N. Evaluation of physical medicine and rehabilitation course for undergraduate medical students: A mixed-methods study. J Educ Health Promot [Internet].2021 [cited 2024 July 9];10. Available from: https://pubmed.ncbi.nlm.nih.gov/34084795/ doi: 10.4103/jehp.jehp_713_20
41. Khosrawi S, Ramezanian H, Mollabashi R. Survey of medical students' attitude and knowledge toward physical medicine and rehabilitation in Isfahan University of Medical Sciences. J Educ Health Promot [Internet]. 2018 [cited 2024 July 9];7. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5903171/ doi: 10.4103/

jehp.jehp_180_16
42. Faulk CE, Mali J, Mendoza PM, Musick D, Sembrano R. Impact of a required fourth-year medical student rotation in physical medicine and rehabilitation. Am J Phys Med & Rehabil [Internet]. 2012 May 1 [cited 2024 July 9];91(5):442-8. Available from: https://pubmed.ncbi.nlm.nih.gov/22377823/ doi: 10.1097/PHM.0b013e31824ad41c
43. Kirshblum SC, Delisa JA, Campagnolo DI. Mandatory clerkship in physical medicine and rehabilitation: effect on medical students' knowledge of physiatry. Arch Phys Med Rehabil [Internet].1998 Jan 1 [cited 2024 July 9];79(1):10-3. Available from: https://pubmed.ncbi.nlm.nih.gov/9440409/ doi: 10.1016/s0003-9993(98)90199-x
44. Teeraleekul W. Rehabilitation Medicine Practice in Graduates from Medical Education Center, Sunpasitthiprasong Hospital. Sanpasit Med J [Internet]. Aug 2021 [cited 2025 Apr 12];35(3):125-3. available at: https://he02.tci-thaijo.org/index.php/sanpasit_medjournal/article/view/252541
45. Reza Raissi G, Vahdatpour B, Ashraf A, Mansouri K. Integrating physical medicine and rehabilitation into the curriculum of Iranian medical students. Disabil Rehabil [Internet]. 2006 Jan 1 [cited 2025 Apr 12];28(1):67-70. Available from: https://pubmed.ncbi.nlm.nih.gov/16393835/ doi: 10.1080/09638280500116834
46. Plochocki JH. Several ways generation Z may shape the medical school landscape. J Med Educ Curric Dev [Internet]. 2019 Oct [cited 2024 July 9];6:2382120519884325. Available from: https://pubmed.ncbi.nlm.nih.gov/31701014/ doi: 10.1177/2382120519884325
47. Vlak T, Boban M, Franulovic-Golja N, Eldar R. Teaching disability and rehabilitation medicine at the Medical School in Split, Croatia. Croat Med J [Internet]. 2004 Feb 1 [cited 2024 July 9];45(1):99-102. Available from: https://pubmed.ncbi.nlm.nih.gov/14968462/