The Effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) on Balance and Fall Risk in Older Adults: A Systematic Literature Review

[1]**Rheifani Salsabila Putri, [2]*Iman Santoso**
[1,2]Program Studi Fisioterapi, Program Pendidikan Vokasi, Universitas Indonesia
Email : imansantoso17@ui.ac.id*

ABSTRACT

Introduction: Proprioceptive Neuromuscular Facilitation (PNF) is an exercise method that focuses on improving neuromuscular control through proprioceptor stimulation. PNF is more commonly used in neurological therapy, but further research is needed regarding its ability to address musculoskeletal issues, such as balance and fall risk in the elderly. This study aims to review the PNF approach and analyse its effectiveness in improving balance and reducing the risk of falls in the elderly based on existing literature reviews. **Methods:** This study uses a simple literature review method. Data were collected through searches in research article databases such as Google Scholar, Crossref, ProQuest, PubMed, Science Direct, Scopus, and Semantic Scholar. Inclusion criteria for this article included studies published between 2015 and 2025, experimental research designs, and the application of Proprioceptive Neuromuscular Facilitation (PNF) in the elderly. **Results:** A review of six previous studies showed that PNF exercises had a positive effect on improving balance and reducing the risk of falls in the elderly. **Conclusion:** Proprioceptive Neuromuscular Facilitation (PNF) has been proven effective in improving balance and functional range associated with a reduced risk of falls in the elderly. With these benefits, PNF can be an important component of fall prevention programmes and improving the quality of life for the elderly.

Keywords: Proprioceptive Neuromuscular Facilitation, Balance, Fall Risk, Elderly.

INTRODUCTION

The increasing number of elderly people in various countries, including Indonesia, poses a major challenge in the field of health, especially due to the risk of falling (Burton et al., 2018). Data shows that falling is the leading cause of serious injury in the elderly, as it can have serious consequences such as broken bones and loss of mobility. It is important to seek interventions that can help reduce this risk, one of which is by improving balance (Mamani et al., 2019). Balance itself is a crucial factor that significantly influences the likelihood of someone falling.

Balance control involves the coordination of the musculoskeletal system, central nervous system, and the body's sensory system (Xing et al., 2023). If any of these systems are impaired, the risk of falls among the elderly can increase.

Compared to younger adults, the elderly tend to experience a decline in balance ability. This decline in balance is often accompanied by a fear or perception of falling. The decline in balance is generally caused by a reduction in the body's ability to sense position and movement (proprioception), muscle weakness, and decreased sensory function due to age-related factors (Chen & Qu, 2019; Song et al., 2021). As age increases, muscle mass also decreases and the body becomes less flexible, making it more difficult for the elderly to maintain stability while moving and avoid falls. Weakened muscles, particularly in the legs, along with reduced skin sensitivity and signals from the sensory system, make the elderly more prone to imbalance and falls (Song et al., 2021; Toosizadeh et al., 2018).

One of the most common health issues faced by the elderly is the risk of falling, experienced by approximately 30% to 50% of the elderly each year (Kumari et al., 2024). Falls can cause serious consequences, such as bruises, fractures, reduced quality of life, and even death (C. R. Da Silva et al., 2020). Approximately one in three elderly individuals aged 65 and above experience at least one fall per year (Ek et al., 2019). Research shows that the risk of falls in the elderly is associated with physical weakness and cognitive decline, which increase the likelihood of such incidents. A study in the United Kingdom found that poor balance and weak physical condition are the main factors contributing to falls, particularly among elderly women (Gale et al., 2016). Falls also increase the risk of complications such as psychological disorders, hospitalisation, the need for long-term care, and impose a significant economic burden. Therefore, effective physical intervention programmes are needed. Proprioceptive Neuromuscular Facilitation (PNF) exercises are one method that can be used, focusing on neuromuscular control through proprioceptive stimulation of muscles to stimulate muscle, joint, and nerve function, as well as sensory input from peripheral organs, thereby improving strength and body balance (Adler et al., 2007; Ek et al., 2019). This rehabilitation technique works by improving neuromuscular and proprioceptive function, making it a potential exercise option for reducing the risk of falls in the elderly (Attar et al., 2021).

Although there have been various studies discussing the effectiveness of PNF, there has been no systematic literature review that explicitly compares the dosage, techniques, measurement instruments, and short- and long-term effects of PNF on balance in the elderly. This serves as an important foundation for conducting a literature synthesis to obtain more precise recommendations for clinical practice. The purpose of this literature review is to provide a systematic and in-depth overview of the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) exercises in improving balance and reducing the risk of falls in the elderly. This review focuses on recent, relevant, and timely studies in the field of geriatric rehabilitation, aiming to summarise scientific findings, identify the mechanisms of action of PNF on balance function, and evaluate its impact on fall prevention. Through a critical assessment of the available evidence, this review is expected to provide scientific recommendations supporting the use of PNF as an effective intervention in rehabilitation programmes and fall risk prevention for the elderly population.

METHOD

The research used in this article is a systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which consists of four main stages: identification, screening, eligibility, and inclusion. During the identification stage, articles were systematically searched through several academic databases, including Google Scholar, Crossref, ProQuest, PubMed, Science Direct, Scopus, and Semantic Scholar, using the keywords 'PNF' or 'Proprioceptive Neuromuscular Facilitation,' 'balance,' and 'elderly.' Articles were selected based on inclusion and exclusion criteria.

The inclusion criteria of this study are categorized into five aspects. First, the population included in the selected studies consists of elderly people. Second, regarding the outcome, studies are included if they demonstrate that Proprioceptive Neuromuscular Facilitation (PNF) can improve balance in elderly individuals and/or decrease their risk of falling. Third, the research design must be experimental in nature. Fourth, only articles published in English and Indonesian are considered. Lastly, the year of publication must be between 2015 and 2025.

The exclusion criteria also consist of five aspects. First, studies that do not focus on elderly people are excluded. Second, articles in which PNF treatment does not show any improvement in balance and/or does not reduce the risk of falling in the elderly are not considered. Third, systematic reviews and literature reviews are excluded based on the research design. Fourth, articles written in languages other than English and Indonesian are not included. Finally, studies published before 2015 are excluded from the review.

A search using keywords yielded 1,580 articles. After screening according to the established inclusion and exclusion criteria, six articles were selected for review and analysis using a synthesis matrix (Figure 1).
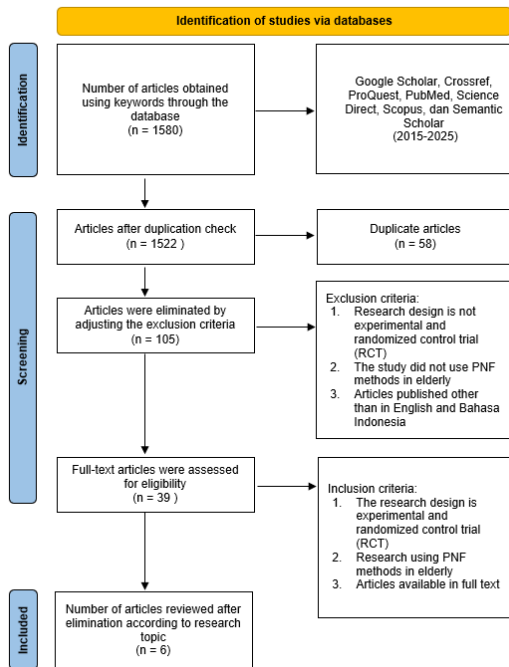

Figure 1. Prisma Flow Chart

RESULTS

Table 1. Research results in reviewed articles

Title	Year	Type of Research	Sample	Results
Effect of two exercise protocols on postural balance of elderly women: A Randomized Controlled Trial (Mesquita et al., 2015)	2015	Randomized Controlled Trial	63 womens were randomly divided into three groups: the proprioceptive neuromuscular facilitation group (PNFG), Pilates group (PG), and control group (CG). The inclusion and exclusion criteria were not explained in detail in the study.	After 4 weeks of training, static postural stability improved in the PNF group, based on stabilometric evaluations. Both the PNF and Pilates groups showed significant increases in dynamic balance, though no significant differences were observed between them.
Igor Almeida Silva, Jeffersob Roqrigues Amorim, Fabiana Teixeira de Carvalho, Laiana Sepulveda de Andrade Mesquita (I. A. Silva et al., 2017)	2017	Longitudinal, experimental study	20 womens aged from 65 to 80 years Inclusion criteira: a. Women between 65 to 85 years old b. Did not perform regular physical activity c. Agreed to participate in the study	After 4 weeks of PNF, older adults experienced reduced plantar support areas and significant improvements in both static and dynamic balance.
Christopher S. cayco, Edward James R. Gorgon, Rolando T. Lazaro (Cayco et al., 2019)	2019	Experimental study (case series)	4 older adults with chronic stroke. The inclusion criteria included older adults with a history of chronic stroke for more than six months, varying levels of stroke severity and characteristics, a high risk of falling based on initial balance assessments, and those who were medically stable and referred for physical therapy.	After 18 sessions of PNF intervention over 6 weeks (3 sessions per week, each lasting 1 hour), there was a significant improvement in balance, strength, and mobility in all participants. Proprioceptive Neuromuscular Facilitation (PNF) has been proven to be safe and effective in enhancing balance, strength, and mobility in older adults with chronic stroke.
Samed Solak, Hilal Yesil, Umit Dundar, Hasan Toktas, Murat Yesil, Murat Korkmaz (Solak et al., 2022)	2022	Randomized Control Trial	48 postmenopausal women The inclusion criteria were postmenopausal women aged 50 to 80 years who could walk independently.	After 4 weeks of PNF (5 sessions/week, 30 minutes each), the group showed significant improvements in all evaluation parameters. Both PNF and Frenkel exercises effectively enhanced balance, reduced fall risk, and

improved quality of life in postmenopausal women.

| V.Rajalaxmi, J.Arthi, G.Mohan Kumar, N.Muthukumaran, K.Balathandayutham, K. Sarasrwath, E. Kavitha (V et al., 2022) | 2022 | Experimental study design pre and post type | 50 Geriatric individuals were divided into two groups by a simple random sampling method. Group A (dual task exercise for 12 weeks/5 session per week) and Group B (PNF pattern exercise for 12 weeks/ 5 session per week).

The inclusion criteria were subjects aged 65 to 85 years of both sexes without orthopedic problems, with a Berg Balance Scale score of 20 to 40, a Falls Efficiency Scale score between 50 and 80, a Brief Cognitive Rating Scale score below 6, and a POMA (Performance-Oriented Mobility Assessment) score between 18 and 25. | The Dual Task Training and PNF exercise program, conducted for 12 weeks with 5 sessions per week, has been proven effective in improving balance and cognition in the elderly, based on pre- and post-test comparisons. |
| Jessica da Silva Lamp, Lucas Menghin Beraldo, Willian Vieira dos Santos, Leandro Giacometti da Silva, Eduardo Lusa Cadore, Caroline Pietta-Dias (Lamp et al., 2023) | 2023 | Randomized Control Trial | 70 womens aged 70 and over and then randomly allocated to three group using the Random Allocation Software: RS group (rhythmic stabilization), SR group (stabilizer reverseal), and CR group (control).

The inclusion criteria were women who did not engage in regular physical activity (≥150 minutes per week) and did not have low back pain, chronic labyrinthitis, central nervous system disorders, spinal cord abnormalities, peripheral nerve diseases, degenerative muscle disease, skeletal abnormalities or diseases, blindness, Parkinson's disease, or a history of stroke. | After one PNF session with Rhythmic Stabilization (RS) or Stabilizer Reversal (SR), elderly women showed improved Timed Up and Go (TUG) and Functional Reach Test (FRT) performance. RS also reduced Center of Pressure (COP) velocity and left foot pressure, enhancing static balance. Both PNF techniques effectively improve dynamic and static balance, lowering fall risk in older adults. |

Table 2. Appraisal Tools

No	Author & Year	Design	Clear Randomisation	Concealed Allocation	Blinding	Clear Inclusion Criteria	Objective & Valid Outcomes	Complete Follow-up	Appropriate Analysis	Assessment	Notes
1	Mesquita et al., 2015	RCT	Yes	Not specified	Not mentioned	Not specified	Yes	Yes	Yes	Moderate	No details on randomisation and blinding
2	Silva et al., 2017	Experiment	Not specified	None	No	Yes	Yes	Yes	Yes	Moderate	Not an RCT, moderate risk of bias
3	Cayco et al., 2019	Case study	Not relevant	Not relevant	No	Yes	Yes	Yes	Yes	High	Small sample size (n=4), non-RCT design
4	Solak et al., 2022	RCT	Yes	Not specified	No	Yes	Yes	Yes	Yes	Low	Design is quite robust
5	Rajalaxmi et al., 2022	Experiment	Yes	Not specified	No	Yes	Yes	Yes	Yes	Moderate	Does not mention allocation method
6	Lamp et al., 2023	RCT	Yes	Yes	No	Yes	Yes	Yes	Yes	Low	Methodology is quite clear and robust

Table 3. Exercise Dosage

Study	Exercise (PNF technique)	Dose
(Mesquita *et al.*, 2015)	Rhythmic stabilisation techniques, hold-relax techniques, and PNF-based balance exercises	3 times a week, for 10 weeks. Each session lasts 50 minutes.
(Silva *et al.,* 2017)	Contract-relax techniques for diagonal movement patterns and active stretching	2 times a week, for 8 weeks. Each session lasts 45 minutes.
(Cayco *et al.*, 2019)	Hold-relax techniques combining isometric movements, PNF-based strength exercises	3 times a week, for 6 weeks. Each session lasts 60 minutes.
(Solak *et al.*, 2022)	Hold-relax techniques, combining isometric movements, diagonal PNF patterns (D1 & D2)	3 times a week, for 8 weeks. Each session lasts 50 minutes.
(Rajalaxmi *et al.*, 2022)	Diagonal movement patterns above and below, PNF-based balance exercises	3 times a week, for 6 weeks. Each session lasts 60 minutes.
(Lamp *et al.*, 2023)	Contract-relax technique, rhythmic stabilisation, and proprioceptive exercises	2 times a week, for 6 weeks. Each session lasts 45 minutes.

DISSCUSION
PNF dosage

Based on 6 articles selected from 7 databases, namely Google Scholar, Crossref, ProQuest, PubMed, Science Direct, Scopus, and Semantic Scholar, the administration of Proprioceptive Neuromuscular Facilitation (PNF) exercises in various studies showed variations (Table 4). The PNF exercises applied include rhythmic stabilisation techniques, stabiliser reversal, and functional movement exercises focused on improving balance and mobility. Additionally, some studies compared PNF with other methods, such as dual-task exercises, cognitive therapy, and home-based exercises, to enhance effectiveness in reducing the risk of falls, improving postural stability, and enhancing quality of life in the elderly.

The studies analysed in this review used a variety of measurement tools to assess balance and fall risk, reflecting significant methodological heterogeneity. The following are some of the instruments used:
  a. Berg Balance Scale (BBS): this tool assesses functional ability to maintain balance during static and dynamic activities.
  b. Timed Up and Go (TUG) and Functional Reach Test (FRT): both assess speed and stability during mobilisation and forward reach.
  c. Stabilometry: evaluates postural stability using a centre of pressure measurement device.
  d. Plantar support area: results are measured based on plantar support area and static-dynamic balance.
  e. Performance-Oriented Mobility Assessment (POMA) and Falls Efficacy Scale (FES): Used as a complement to BBS, to assess the efficiency and confidence of the elderly in performing activities without falling.

Although all tools have validity in a clinical context, differences in the type and sensitivity of each instrument can affect the interpretation of results across studies. Therefore, standardisation of outcome instrument use in further research is needed to facilitate evidence synthesis and implementation in clinical practice.

The effectiveness of PNF on balance and fall risk in the elderly

The results of the studies analysed are generally consistent with the basic theory of PNF, which states that proprioceptive stimulation can improve neuromuscular control and body balance through reflex activation and increased postural awareness (Adler et al., 2007; Hindle et al., 2012). Techniques such as rhythmic stabilisation and diagonal pattern movement have been shown to have positive effects on static and dynamic balance, particularly in older adults with impaired sensory function. Proprioceptive Neuromuscular Facilitation (PNF) helps the body recognise its position and movement by stimulating receptors in muscles, tendons, and joints (Hindle et al., 2012; Kumar & George, 2024). In the elderly, this exercise can improve balance by stimulating the body's sensory system, particularly proprioception, which is the body's ability to be aware of its position and movement (Ferlinc et al., 2019). As age increases, this ability tends to decline. PNF exercises also involve diagonal movement patterns that train coordination between muscles and the sensory system, thereby making the body more stable and improving balance (Nguyen et al., 2022). PNF works in various ways, such as reducing muscle tension (known as autogenic inhibition), relaxing one side of the muscle to allow the other side to function better (reciprocal inhibition), and gradually reducing muscle stiffness (stress relaxation) (Hindle et al., 2012). Additionally, this technique influences pain perception through the gate control theory, which indirectly helps the body move better and more balanced, making PNF exercises beneficial for improving body control and balance, especially in the elderly (Beckers & Buck, 2021; Hindle et al., 2012).

PNF exercises have been proven to improve balance, enhance mobility, and reduce the risk of falls in the elderly (Cayco et al., 2019; Lamp et al., 2023; Solak et al., 2022). Several experimental studies and randomised controlled trials in the table support these findings, such as the study by Solak et al. (2022), which showed that postmenopausal women who participated in PNF exercises for four weeks experienced significant improvements in balance, fall prevention, and quality of life (Solak et al., 2022). These results are consistent with other studies indicating that PNF techniques, involving

rhythmic stabilisation and dynamic balance exercises, can improve postural control and reduce the risk of falls, particularly in vulnerable or high-risk groups. Additionally, Cayco et al. (2019) found that chronic stroke participants who underwent 18 PNF sessions over six weeks experienced significant improvements in balance, strength, and mobility (Cayco et al., 2019). PNF also plays a role in reducing the risk of falls in the elderly by improving balance and body movement functions, while promoting independence in performing daily activities, which is an important aspect in maintaining quality of life (Nguyen et al., 2022). These results confirm the flexibility of PNF in addressing various deficits associated with ageing and neurological conditions (Cayco et al., 2019; Nguyen et al., 2022).

However, there are variations in the magnitude of the effect and duration of influence between studies. For example, a study by Lamp et al. (2023) showed that a single session of PNF training also provided benefits for the elderly (Lamp et al., 2023). In that study, elderly women who participated in a single session of rhythmic stabilisation (RS) or stabiliser reversal (SR) training experienced improved mobility based on the results of the Timed Up and Go (TUG) and Functional Reach Test (FRT). Additionally, there was a decrease in centre of pressure (COP) movement speed and pressure on the left foot, indicating improved static balance (García-Flores et al., 2016; Lamp et al., 2023). PNF training can strengthen muscles, particularly lower body muscles such as the hips and legs, which are important for maintaining balance and reducing the risk of falls (García-Flores et al., 2016). Meanwhile, studies by Silva et al. and Mesquita et al. highlight the need for repeated exercises over several weeks. This suggests that responses to PNF may vary individually, depending on initial physical condition, age, and the type of technique used. Although not contradictory to theory, these findings indicate that exercise intensity and dosage should be personalised.

PNF training is not only beneficial physically but also has positive effects on the psychological well-being of the elderly (Lee & Bae, 2021; Nguyen et al., 2022). The fear of falling, which often discourages the elderly from moving, can be reduced because this training enhances self-confidence by simultaneously stimulating muscles and nerves, thereby helping the elderly feel safer and more comfortable during activities (Kumari et al., 2024; Lee & Bae, 2021). Research shows that PNF is effective in reducing the number of falls, increasing satisfaction, and supporting the elderly to remain active and independent (Lee & Bae, 2021; Nguyen et al., 2022). Therefore, PNF not only improves physical health but also contributes to an overall improvement in the quality of life of the elderly (Kumar & George, 2024; Xiong et al., 2024).

Differences in results across studies in this review appear to be influenced by natural variations in intervention approaches, including differences in PNF techniques used, exercise duration and frequency, and participant characteristics. From a methodological perspective, study design also plays a role. Studies using a pre-post approach without a control group may show larger effects compared to randomised controlled trials (RCTs), which are more stringent in controlling variables. These differences are not shortcomings but reflect the diversity of scientific approaches used to explore the benefits of PNF. These findings underscore the importance of aligning methodology and reporting interventions in future studies to strengthen external validity and facilitate the application of results in geriatric physiotherapy practice.

Effectiveness of various PNF techniques

The most commonly used techniques in PNF exercises are hold-relax, contract-relax, diagonal patterns (D1 & D2 patterns), and proprioceptive exercises. The hold-relax technique is used to improve muscle flexibility and joint range of motion (Mesquita et al., 2015; Nguyen et al., 2022). This technique works by optimising the muscle relaxation reflex mechanism, enabling muscles to function more effectively in supporting body posture. Additionally, exercises using rhythmic stabilisation techniques, as applied in the study by Lamp et al. (2023), have been shown to improve balance by strengthening core muscles and enhancing postural awareness (Lamp et al., 2023). Rhythmic stabilisation allows the body to develop isometric control, which is crucial for the

elderly in maintaining balance and preventing falls (Lamp et al., 2023).

Another study by Solak et al. (2022) compared PNF exercises with aerobic exercises (Solak et al., 2022). The results showed that PNF exercises were more effective in improving balance and reducing fear of falling compared to aerobic exercises. This indicates that exercises based on movement control and proprioceptive stimulation are more effective in improving postural stability than cardiorespiratory exercises alone.

Optimal duration and frequency of PNF exercises

Research by Mesquita et al. (2015) implemented PNF exercises for 4 weeks and found that static postural stability improved in the PNF group based on stabilometry evaluation . In the study by Silva et al. (2017), the exercise dose was 4 weeks of PNF exercises (15). The results showed a decrease in plantar support area and an improvement in static and dynamic balance in the elderly. The study by Cayco et al. (2019) was conducted on individuals with chronic stroke . PNF was administered for 6 weeks, with a frequency of 3 sessions per week, each lasting 1 hour. After the intervention, there was a significant improvement in balance, strength, and mobility, indicating that PNF is effective for stroke patient rehabilitation. In the study by Solak et al. (2022), PNF was administered for 4 weeks with 5 sessions per week, each lasting 30 minutes. Research shows that PNF can improve balance, reduce the risk of falls, and improve quality of life in postmenopausal women. A study by Rajalaxmi et al. (2022) compared PNF exercises with dual-task exercises in the elderly. The exercises were conducted over 12 weeks, with 5 sessions per week. The results showed that both methods were effective in improving balance and cognition, but PNF was more focused on movement patterns and motor control . Meanwhile, a study by Lamp et al. (2023) evaluated the effects of Rhythmic Stabilisation (RS) and Stabiliser Reversal (SR) techniques in a single PNF exercise session. The RS technique showed a reduction in centre of pressure speed and left foot pressure, which positively impacted static balance. Overall, both techniques were effective in improving static and

dynamic balance and helping to reduce the risk of falls in the elderly.

Results from various studies indicate that PNF training significantly improves balance and reduces the risk of falls in the elderly. Although there are variations in exercise techniques and duration, generally, PNF performed for at least 4 weeks with a frequency of 3 to 5 times per week has been proven to yield the most effective results. This review was conducted using six articles that met the inclusion criteria, which, although limited in number, still provide a representative overview of the diversity of PNF exercise approaches in the elderly population. Variations in intervention methods, exercise frequency, and evaluation instruments reflect the complexity of existing research designs, presenting both strengths and challenges in synthesising results. Additionally, most of the accessible literature is written in English or Indonesian, so there is a possibility that some relevant studies in other languages may not have been included in this review.

CONCLUSION

Based on a review of several studies, Proprioceptive Neuromuscular Facilitation (PNF) has been proven effective as a method for improving balance and reducing the risk of falls in the elderly, both in the short and long term. Its ability to improve static and dynamic balance, strengthen muscles, and enhance mobility makes PNF an effective choice in geriatric physical therapy programmes. In addition to its physical benefits, PNF also contributes to improving the quality of life for the elderly. Therefore, based on the results of this literature synthesis, the application of Proprioceptive Neuromuscular Facilitation (PNF) exercises in a clinical setting is highly recommended as one of the approaches supporting the safety, bodily function, and overall well-being of the elderly. Although the findings from the six studies reviewed provide consistent results regarding the effectiveness of PNF, further research is still needed to refine the technique and expand its application context in various clinical conditions. Further research is recommended to adopt a more standardised design, both in terms of intervention techniques, exercise dosage, and balance measurement instruments, to enhance the consistency and comparability of results. In

addition to focusing on physical aspects, exploring the impact of PNF on psychosocial dimensions and long-term quality of life in the elderly is also important to provide a more comprehensive understanding of the benefits of this intervention.

ACKNOWLEDGEMENT

REFERENCES

Adler, S. S., Beckers, D., & Buck, M. (2007). *PNF in Practice: An Illustrated Guide*. Springer Berlin Heidelberg. https://books.google.co.id/books?id=NYvQeja_UGwC

Attar, M., Alsinnari, Y. M., Alqarni, M. S., Bukhari, Z. M., Alzahrani, A., Abukhodair, A. W., Qadi, A., Alotibi, M., & Jastaniah, N. A. (2021). Common Types of Falls in the Elderly Population, Their Associated Risk Factors and Prevention in a Tertiary Care Center. *Cureus*, *13*(5), e14863. https://doi.org/10.7759/cureus.14863

Beckers, D., & Buck. (2021). *PNF in Practice*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-61818-9

Burton, E., Lewin, G., O'Connell, H., & Hill, K. D. (2018). Falls prevention in community care: 10 years on. *Clinical Interventions in Aging*, *13*, 261–269. https://doi.org/10.2147/CIA.S153687

Cayco, C. S., Gorgon, E. J. R., & Lazaro, R. T. (2019). Proprioceptive neuromuscular facilitation to improve motor outcomes in older adults with chronic stroke. *Neurosciences (Riyadh, Saudi Arabia)*, *24*(1), 53–60.

https://doi.org/10.17712/nsj.2019.1.20180322

Chen, X., & Qu, X. (2019). Age-Related Differences in the Relationships Between Lower-Limb Joint Proprioception and Postural Balance. *Human Factors*, *61*(5), 702–711. https://doi.org/10.1177/0018720818795064

Da Silva, C. R., Magalhães, L. F. R., Chaves, F. M. G., Vieira, E. C. do N., Adames, A. P. R., & Brauns, I. da S. D. (2020). Effects of aquatic physiotherapy versus conventional physical therapy on the risk of fall in the elderly: a randomized clinical trial. *Fisioterapia Brasil*, *21*(3), 253–264. https://doi.org/10.33233/fb.v21i3.3459

Ek, S., Rizzuto, D., Fratiglioni, L., Calderón-Larrañaga, A., Johnell, K., Sjöberg, L., Xu, W., & Welmer, A.-K. (2019). Risk Factors for Injurious Falls in Older Adults: The Role of Sex and Length of Follow-Up. *Journal of the American Geriatrics Society*, *67*(2), 246–253. https://doi.org/10.1111/jgs.15657

Ferlinc, A., Fabiani, E., Velnar, T., & Gradisnik, L. (2019). The Importance and Role of Proprioception in the Elderly: a Short Review. *Materia Socio-Medica*, *31*(3), 219–221. https://doi.org/10.5455/msm.2019.31.219-221

Gale, C. R., Cooper, C., & Aihie Sayer, A. (2016). Prevalence and risk factors for falls in older men and women: The English Longitudinal Study of Ageing. *Age and Ageing*, *45*(6), 789–794. https://doi.org/10.1093/ageing/afw129

García-Flores, F. I., Rivera-Cisneros, A. E., Sánchez-González, J. M., Guardado-Mendoza, R., & Torres-Gutiérrez, J. L. (2016). [Correlation between gait speed and muscular strength with balance for reducing falls among elderly]. *Cirugia y cirujanos*, *84*(5), 392–397. https://doi.org/10.1016/j.circir.2015.12.005

Hindle, K., Whitcomb, T., Briggs, W., & Hong, J. (2012). Proprioceptive neuromuscular facilitation (PNF): Its mechanisms and

effects on range of motion and muscular function. *Journal of Human Kinetics*, *31*(1), 105–113. https://doi.org/10.2478/v10078-012-0011-y

Kumar, S., & George, C. M. (2024). Effects of Head and Neck pattern of PNF combined with conventional balance training in older adults with balance impairment - A Randomized control Trial. *Journal of Bodywork and Movement Therapies*, *40*, 552–556. https://doi.org/10.1016/j.jbmt.2024.02.008

Kumari, R., Chaudhary, V., & Sharma, S. (2024). "Comparison Of Pelvic PNF And Lower Limb Strengthening Protocol For Prevention Of Fall In Post Menopausal Women." *Journal of Advanced Zoology*, *45*(01), 624–630. https://doi.org/10.53555/jaz.v45i1.3520

Lamp, J., Beraldo, L., Santos, V., Giacometti, da, Cadore, E., & Dias, C. (2023). Cute effects of different proprioceptive neuromuscular facilitation stabilization techniques on the balance of elderly women. *Journal of Bodywork and Movement Therapies*, *35*. https://doi.org/10.1016/j.jbmt.2023.04.054

Lee, D., & Bae, Y. (2021). Short-Term Effect of Kinesio Taping of Lower-Leg Proprioceptive Neuromuscular Facilitation Pattern on Gait Parameter and Dynamic Balance in Chronic Stroke with Foot Drop. *Healthcare (Basel, Switzerland)*, *9*(3). https://doi.org/10.3390/healthcare9030271

Mamani, A. R. N., Reiners, A. A. O., Azevedo, R. C. de S., Vechia, A. D. R. D., Segri, N. J., & Cardoso, J. D. C. (2019). Elderly caregiver: knowledge, attitudes and practices about falls and its prevention. *Revista Brasileira de Enfermagem*, *72*(suppl 2), 119–126. https://doi.org/10.1590/0034-7167-2018-0276

Mesquita, L. S. de A., de Carvalho, F. T., Freire, L. S. de A., Neto, O. P., & Zângaro, R. A. (2015). Effects of two exercise protocols on postural balance of elderly women: a randomized controlled trial. *BMC Geriatrics*, *15*, 61.

https://doi.org/10.1186/s12877-015-0059-3

Nguyen, P. T., Chou, L.-W., & Hsieh, Y.-L. (2022). Proprioceptive Neuromuscular Facilitation-Based Physical Therapy on the Improvement of Balance and Gait in Patients with Chronic Stroke: A Systematic Review and Meta-Analysis. *Life (Basel, Switzerland)*, *12*(6). https://doi.org/10.3390/life12060882

Silva, I. A., Amorim, J. R., Carvalho, F. T. de, & Mesquita, L. S. de A. (2017). Efeito de um protocolo de Facilitação Neuromuscular Proprioceptiva (FNP) no equilíbrio postural de idosas. *Fisioterapia e Pesquisa*, *24*(1), 62–67. https://doi.org/10.1590/1809-2950/16636724012017

Solak, S., Yeşil, H., Dündar, Ü., Toktaş, H., Yeşil, M., & Korkmaz, M. (2022). Evaluation of Balance Exercises on Balance, Fall Risk, and Quality of Life in Postmenopausal Women. *Turk Osteoporoz Dergisi*, *28*(1), 32–40. https://doi.org/10.4274/tod.galenos.2021.85866

Song, Q., Zhang, X., Mao, M., Sun, W., Zhang, C., Chen, Y., & Li, L. (2021). Relationship of proprioception, cutaneous sensitivity, and muscle strength with the balance control among older adults. *Journal of Sport and Health Science*, *10*(5), 585–593. https://doi.org/10.1016/j.jshs.2021.07.005

Toosizadeh, N., Ehsani, H., Miramonte, M., & Mohler, J. (2018). Proprioceptive impairments in high fall risk older adults: the effect of mechanical calf vibration on postural balance. *Biomedical Engineering Online*, *17*(1), 51. https://doi.org/10.1186/s12938-018-0482-8

V, R., Arthi, J., Kumar, G. M., N, M., K, B., K, S., & Kavitha, E. (2022). Effects of Dual Task Training Versus PNF Pattern on Balance and Cognition in Geriatric Population. *International Journal of Life Science and Pharma Research*, *12*(4), 1–7. https://doi.org/10.22376/ijpbs/lpr.2022.12.4.11-7

Xing, L., Bao, Y., Wang, B., Shi, M., Wei, Y.,

Huang, X., Dai, Y., Shi, H., Gai, X., Luo, Q., Yin, Y., & Qin, D. (2023). Falls caused by balance disorders in the elderly with multiple systems involved: Pathogenic mechanisms and treatment strategies. *Frontiers in Neurology*, *14*, 1128092. https://doi.org/10.3389/fneur.2023.112809 2

Xiong, X., Zang, J., Zhu, C., Wei, W., Wang, P., Wang, J., & Gao, Q. (2024). Effects of Proprioceptive Neuromuscular Facilitation Technique on Balance Function and Muscle Health in Older Adults With High Fall Risk. *Journal of Gerontological Nursing*, *50*(8), 37–44. https://doi.org/10.3928/00989134-20240702-03