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EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) ON MUSCLE STRENGTH IN POST-STROKE PATIENTS

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ABSTRACT

Post-stroke rehabilitation often involves improving muscle strength and motor function to enhance the quality of life for stroke survivors. Proprioceptive Neuromuscular Facilitation (PNF) has emerged as an effective therapy in this context, particularly in enhancing muscle strength and upper limb function. PNF techniques use specific patterns of movement to activate proprioceptors and improve muscle coordination, which may aid in recovery for stroke patients. Despite its potential, limited research has evaluated its impact on muscle strength improvement, making this study significant.Research Objective: The primary aim of this study was to assess the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) in improving muscle strength in post-stroke patients, with a focus on the upper limbs. The research was conducted to evaluate the pre-test and post-test muscle strength scores, and to analyze the impact of PNF on muscle strength recovery.Research Methods: This research employed a pre-experimental design with a one-group pre-post test. A sample of 34 post-stroke patients was selected using purposive sampling from the Merdeka Health Center and 1 Ulu Palembang, South Sumatra, Indonesia. The intervention consisted of PNF exercises conducted three times a week for three months. Muscle strength was measured using a hand dynamometer both before and after the intervention. Statistical analysis using Cohen's d and paired t-tests was performed to evaluate the effectiveness of the intervention.Results: The results revealed a significant improvement in muscle strength after PNF intervention. The mean muscle strength score increased from 2.50 ± 0.570 (pre-test) to 3.64 ± 0.570 (post-test), with a difference of 1.14 ± 0.570. Cohen's d coefficient of 2 indicated a large effect size, confirming substantial improvement. The paired t-test yielded a p-value of 0.001, demonstrating that the changes were statistically significant.Conclusion: Proprioceptive Neuromuscular Facilitation (PNF) significantly improves muscle strength in post-stroke patients, particularly in the upper limbs.

Keywords: muscle strength; proprioceptive neuromuscular facilitation (pnf); post stroke

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INTRODUCTION

A stroke is a neurological disorder that occurs when blood flow to the brain is disrupted due to a blockage or rupture of blood vessels, this condition can lead to disability or even death. (Kemenkes RI, 2018). the incidence of stroke rises significantly with age, over 60% of strokes occur in people under the age of 70, and 16% affect those under 50 (World Stroke Organization, 2024). According to the World Health Organization, (2024) Stroke is one of the primary causes of 5 milion of death and 5 milion permanently disabled, loss of vision and/or speech, paralysis, confusion, and placing a burden on family and community (World Health Organization (WHO), 2024). Life after a stroke can be difficult, survivors need rehabilitation and support to regain independence and enhance their quality of life. Recovery varies widely among individuals, influenced by factors such as stroke severity, the brain region affected, and the speed of treatment received. Rehabilitation is essential in helping stroke survivors rebuild their strength and abilities (Association American Stroke, 2019)

Post-stroke rehabilitation is a vital part of recovery, focusing on maximizing independence and enhancing the quality of life for stroke survivors (Indarto, 2016). The rehabilitation approach is multidisciplinary, relying on a team of healthcare professionals who customize interventions to meet the unique needs of each patient, this tailored approach allows the patient to work toward functional recovery aligned with individual goals and capabilities, fostering a positive environment for long-term improvement (Simbolon et al., 2022).Early intervention is crucial such as rehabilitation often begins within 24 to 48 hours after the stroke until 6 weeks, once the patient is medically stable, as early mobilization significantly benefits recovery outcomes (Kemenkes RI, 2018). A coordinated multidisciplinary team, including physiatrists, physical therapists, occupational therapists, and speech-language pathologists, collaborates to assess progress and modify treatment plans regularly. Individualized rehabilitation plans assess physical, cognitive, and emotional needs, with clearly defined short- and long-term goals to enhance abilities like mobility, self-care, and communication. Continuous assessment allows for timely adjustments to rehabilitation strategies, ensuring that the patient's progress is optimized (Bantolo et al., 2022).

Post-stroke patients often experience muscle weakness and communication disorders, which are primary indicators of their condition. Muscle weakness, or hemiparesis, occurs in approximately 70-80% of stroke patients and may affect one side of the body, including either the arm or leg. This weakness is due to damage to the central nervous system, which disrupts motor control and blood flow to the muscles (Setiyawan et al., 2019).One effective technique used in post-stroke rehabilitation is Proprioceptive Neuromuscular Facilitation (PNF). PNF focuses on improving motor control, coordination, and strength by using repeated patterns of movement that mimic natural motions. By activating muscle receptors and stimulating the neuromuscular system, PNF helps retrain the brain's control over the muscles, facilitating improved functional movement. Incorporating PNF into a comprehensive stroke rehabilitation plan allows therapists to work on balance, flexibility, and motor skills with greater precision, offering benefits to patients by increasing their mobility and reducing spasticity (Berampu & Sembiring, 2022) .

Proprioceptive Neuromuscular Facilitation (PNF) therapy has been shown to enhance muscle strength in post-stroke patients through several mechanisms. First, PNF works by activating stronger muscle groups to stimulate weaker muscles, a technique similar to "timing for emphasis." This method encourages the dominant muscles to aid in stretching and strengthening the less active ones, allowing the patient to progressively regain muscle control. Studies indicate that this emphasis on coordination through strong muscle groups helps support weaker areas, which is crucial for stroke patients experiencing hemiparesis or significant muscle weakness. Research also supports the benefit of PNF in reinforcing this interaction between muscle groups, thereby enhancing the therapeutic process for improved strength and control (Akbulut & Agopyan, 2015). PNF therapy also contributes significantly to flexibility and coordination in stroke patients by using complex movement patterns that engage multiple muscle groups simultaneously. This coordinated approach improves motor coordination and enhances muscle flexibility, which is vital for patients with limited mobility post-stroke. For example, patients performing structured movement patterns under PNF have shown improvements in joint flexibility, which aids in smoother motor function and helps reduce stiffness (Anas et al, 2021).

Supported by research conducted by Hendrik et al., (2018) on the effect of PNF training on improving lower limb muscle endurance in post-stroke patients at Salewangang Maros General Hospital, the results showed that applying PNF twice a week for four weeks led to an average increase in half squat endurance after intervention to 141.60 ± 21.28 seconds, with an average difference of 63.50 ± 22.09 seconds compared to before the intervention et al., 2018).PNF therapy's impact extends beyond muscle strengthening to include improved functional motor abilities, helping patients recover motor skills necessary for daily activities. Increases in functional activity levels, such as enhanced Barthel Index scores, have been reported following several PNF sessions, indicating a positive effect on independence in daily tasks. Moreover, comparative studies show that while PNF may be as effective as Active-Assistive ROM exercises in strengthening muscles (Tiwow et al., 2022), it provides additional benefits in coordination and motor skills, particularly for post-stroke patients. These findings underscore the role of PNF therapy not only in restoring muscle strength but also in promoting overall motor function and independence, supporting a return to daily activities with greater ease (Borges et al., 2018).

Based on the encouraging findings from previous studies on the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) in improving muscle strength and endurance in post-stroke patients, this research aims to explore PNF intervention to specifically assess and enhance muscle strength among stroke survivors. By building on evidence that highlights PNF's potential in promoting motor recovery and functional gains, this study seeks to provide further validation and insights into PNF as a targeted rehabilitation strategy for post-stroke muscle weakness.

METHOD

The type of research used is a *Pre-Experimental Design*, specifically employing a *One Group Pre-Posttest Design*. The intervention provided is Proprioceptive Neuromuscular Facilitation (PNF) training, with the outcome measured being the change in muscle strength among post-stroke patients.The study population consists of post-stroke patients within the Merdeka and 1 Ulu Palembang Public Health Center working areas in South Sumatra, Indonesia. The sample size is calculated using the following formula sample size calculation for comparing two means in a one-group pre-posttest design, according by Simbolon et al., (2022). The result suggests a minimum of 34 samples are required. *Purposive sampling* was employed, meaning samples were chosen at random among the population according to the researcher's specific criteria. Inclusion Criteria: 1)Post-stroke patients with a non-hemorrhagic stroke, < 3 months post-stroke; 2)Willingness to participate and sign informed consent; 3)Presence of spasticity and inability to walk independently; 4)First occurrence of non-hemorrhagic stroke; 5)No severe comorbidities that interfere with participation. Ability to understand and follow basic instructions for exercises. The procedure involves measuring muscle strength before and after the intervention a Hand Dynamometer (CAMRY) is used to assess hand grip strength in kilograms, with measurements recorded in an observation sheet for non-hemorrhagic stroke patients.Participants engage in a preliminary warm-up exercise for 10-15 minutes, followed by PNF exercises comprising three movements. Each movement lasts 30 seconds with a 10-second relaxation period between movements. The intervention dosage is set at once per day, three times per week, over a period of three months (Leksonowati et al., 2022).

RESULT

Tabel 1 The majority of participants in the study are in the 45-54 age range, accounting for 44.11% (15 participants) of the total sample. This is followed by the 35-44 age group, which makes up 26.47% (9 participants) of the total. Most participants are female, comprising

97.06% (33 participants) of the total sample, with only 2.94% (1 participant) being male. In terms of educational background, the largest group is those with a Senior High School (SMA) education, representing 67.64% (23 participants) of the sample. Junior High School (SMP) graduates make up 20.58% (7 participants), while those with a University (PT) education constitute 11.76% (4 participants). This demographic distribution highlights the predominance of middle-aged, female participants with a high school education in the study.

Tabel 1.
Distribution of Respondents

Variable		f	%
Age	35-44	9	26.47
	45-54	15	44.11
	55-64	6	17.64
	65-74	3	8.82
	> 74	1	2.94
	Total	34	100
Sex	Laki-Laki	1	2.94
	Perempuan	33	97.06
Education	SMP	7	20.58
	SMA	23	67.64
	PT	4	11.76
Occupation	Unemployed	31	91.18
	Tradesman	1	2.94
	Laborer	1	2.94
	Other	1	2.94

Table 2.
Analysis of The Effect PNF On Muscle Strength Post-Stroke Patients

Pre-Test		Post-Test		Selisih		Cohen's d Coefficient	p-Value
Min / Max	M ±SD	Min / Max	M ± SD	Min / Max	M ± SD		
1 / 4	2.50 ± 0.570	2 / 5	3.64 ±0.570	1 / 2	1.14 ± 0.570	2	0.001

*Paired t-Test

Table 2, the results of the pre-test and post-test show a significant improvement in the measured outcome, with the pre-test having a mean score of 2.50 ± 0.570 (ranging from 1 to 4) and the post-test showing a mean score of 3.64 ± 0.570 (ranging from 2 to 5). The difference between the pre-test and post-test means is 1.14 ± 0.570, indicating a notable improvement. The Cohen's d coefficient of 2 suggests a large effect size, demonstrating a substantial change due to the intervention. Additionally, the p-value of 0.001, derived from a paired t-test, confirms that this improvement is statistically significant, indicating that the observed change is unlikely to have occurred by chance.

DISCUSSION

Based on Table 1, the majority of respondents (44.11%) are aged 45-54 years, with 15 participants in this age group. While this finding may not align directly with data from the American Heart Association or RISKESDAS regarding overall stroke prevalence, it provides insight into the outcomes following stroke. The data suggests that survival rates among patients aged 65 and older following a stroke are significantly lower. This aligns with findings from the American Heart Association (AHA), which reports that individuals aged 85 and older face a stroke mortality risk 13 times higher than those aged 75-84, and those in the 75-84 age group have a risk three times higher than younger patients. This is why the majority of respondents in this study are aged 45-54, a group that is also commonly involved in post-stroke care and follow-up, according to RISKESDAS data (RISKESDAS, 2018; Tsao et al., 2023).

Unemployment is associated with a higher risk of stroke, particularly among middle-aged adults, and also influences how well individuals adhere to stroke rehabilitation. This relationship is influenced by several factors, including the health risks linked to unemployment and the dynamics of rehabilitation. In terms of health risks, studies show that voluntary unemployment increases the risk of stroke by 92%, mainly due to associated health problems like hypertension, diabetes, and obesity (Błaż et al., 2022). Furthermore, involuntary unemployment has been linked to more frequent self-reported stroke-like symptoms, which suggests that individuals without work may become more aware of their health issues. Regarding rehabilitation adherence, unemployed individuals may have more time available for rehabilitation, which could lead to better participation in recovery programs, however, plays a critical role while unemployment may reduce distractions, it can also provide the motivation for recovery due to the lack of job-related stressors. the downside of unemployment is that it can lead to social isolation and economic stress, factors that might hinder the recovery process (Cisek et al., 2024).

Based on Table 2, data from the pre-test and post-test indicate a significant improvement in muscle strength following Proprioceptive Neuromuscular Facilitation (PNF) therapy. The pre-test had a mean score of 2.50 ± 0.570, ranging from 1 to 4, while the post-test mean score increased to 3.64 ± 0.570, with values ranging from 2 to 5. The difference of 1.14 ± 0.570 reflects a clear enhancement in strength. The large effect size, indicated by Cohen's d coefficient of 2, further confirms the substantial impact of PNF on muscle strength. Additionally, the p-value of 0.001, derived from a paired t-test, demonstrates that this improvement is statistically significant, supporting the effectiveness of PNF in stroke rehabilitation. Proprioceptive Neuromuscular Facilitation (PNF) is widely regarded as a powerful rehabilitation approach for enhancing muscle strength, particularly beneficial for post-stroke patients. This method emphasizes improving motor skills, especially in the upper limbs, by engaging specific movement patterns that activate proprioceptive pathways (Perdani & Rahayu, 2021). By doing so, PNF significantly contributes to muscle strength enhancement, promotes functional independence, and supports overall motor recovery in individuals with neurological conditions such as stroke (Borges et al., 2018). Several studies have consistently demonstrated the effectiveness of PNF in improving muscle strength and motor function in post-stroke patients. A systematic review of relevant studies found that four out of five trials indicated statistically significant improvements in upper limb motor ability after PNF interventions, as measured by standardized assessments like the Arm Motor Ability Test and the Fugl-Meyer Assessment (Kaminska & Sargsjane, 2019). These findings suggest that PNF exercises effectively enhance both strength and functional movements in patients recovering from stroke. Furthermore, a case report of a 50-year-old male with left hemiplegia showed significant improvements in muscle strength in both the upper and lower limbs after just four weeks of PNF-focused physiotherapy (Chitra & Joshi, 2017)

In addition to improving muscle strength, PNF has been shown to enhance other aspects of motor ability in hemiparetic patients. A comparative study found that while PNF exercises were effective at increasing muscle strength, they were not significantly more effective than Active-Assistive Range of Motion (ROM) exercises (Tiwow et al., 2022). This suggests that while PNF is beneficial, its impact on muscle strength may vary and might not outperform other rehabilitation techniques in all cases (Akbulut & Agopyan, 2015).PNF works by enhancing both the sensory and motor systems through its structured techniques. One of the key mechanisms of PNF is its ability to increase central arousal and volitional movements, thereby improving the active capacity of affected muscles (Nikolova et al., 2022), by using specific movement patterns, PNF stimulates proprioceptors in the muscles and joints, which leads to better muscle recruitment and motor control. These repetitive patterns facilitate motor recovery by retraining the nervous system and strengthening the connection between the brain and muscles (Sudaryanto & Anshar, 2018; Yuli Yanti & Aktifah, 2021).

Further studies have shown that combining PNF with neuromuscular functional electrical stimulation (NMFES) can have even more significant effects on muscle strength and spasticity reduction in post-stroke patients (Priestnall et al., 2020). This combination technique enhances the effects of PNF by adding an electrical component that directly stimulates the muscles, improving the recovery process. The synergy between PNF and NMFES underscores the potential of multifaceted approaches in stroke rehabilitation.While PNF has shown significant benefits in improving muscle strength and recovery, some studies suggest that its effectiveness may not always surpass other rehabilitation techniques. This indicates the importance of individualized treatment approaches based on each patient's unique needs, for instance, while PNF is highly effective for certain patients, others may respond better to alternative therapies like Active-Assistive ROM exercises or functional electrical stimulation without PNF. Personalization of rehabilitation strategies ensures that patients receive the most appropriate and effective care tailored to their condition and recovery goals.

CONCLUSION

In conclusion, overall Proprioceptive Neuromuscular Facilitation (PNF) is an effective intervention for improving muscle strength in post-stroke patients. The data from the pre-test and post-test revealed a significant increase in muscle strength, as evidenced by a substantial improvement in the mean scores, with a Cohen’s d coefficient indicating a large effect size. The statistically significant effectiveness post-stroke patients. However, it is important to note that while PNF shows considerable benefits, individual factors such as age, stroke severity, and adherence to rehabilitation may also influence outcomes, highlighting the need for personalized treatment approaches. Overall, PNF contributes positively to post-stroke rehabilitation, particularly in enhancing motor abilities and muscle strength, aligning with findings from various studies on its therapeutic benefits

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