



Effect of Proprioceptive Neuromuscular Facilitation Exercises on Muscle Strength in Stroke Patients



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ABSTRACT

Aims Stroke is a localized and sudden neurological disorder in the brain that can decrease muscle strength. This study aimed to determine the effect of Proprioceptive Neuromuscular Facilitation exercises on the muscle strength of stroke patients.

Materials & Methods This pre-post clinical trial with a randomized control group was conducted in 2017-2018. Patients with stroke were referred to the Neurology Department of Shahid Beheshti Hospital in Yasuj City, Iran. Sixty eligible stroke patients were selected through convenience sampling and assigned to intervention and control groups using random block allocation. Data were collected through a muscle strength questionnaire at baseline, immediately post-intervention, and four weeks after the last intervention. Statistical analysis was performed using SPSS 21 software, employing Wilcoxon and Mann-Whitney U.

Findings There was no statistically significant difference in muscle strength between the research samples before and immediately after the intervention. However, one month after the intervention, a statistically significant difference was reported between the two groups ($p < 0.05$). The difference in the mean muscle strength was significant in the test group ($p = 0.001$).

Conclusion Implementing proprioceptive neuromuscular facilitation techniques improves muscle strength in stroke patients.

Keywords Proprioceptive Neuromuscular Facilitation; Muscle Strength; Stroke

CITATION LINKS

[1] Global, Regional, and Country-Specific Lifetime Risks of Stroke, 1990 and ... [2] A comparative analysis of machine learning classifiers for stroke prediction: A ... [3] Application of deep learning in detecting neurological disorders from magnetic resonance images: A survey on the detection of Alzheimer's disease, ... [4] Epidemiology of stroke in ... [5] Heart disease and stroke statistics-2017 update: A report from the American heart ... [6] Acute stroke and type 2 ... [7] Range of motion exercise to improve muscle strength among ... [8] Intensive therapy induces contralateral white matter changes in chronic stroke patients with Broca's ... [9] Effectiveness of Motor Interventions in Improving the Motor Abilities of Post-stroke Patients: A Systematic ... [10] Proprioceptive Neuromuscular Facilitation (PNF): Uts mechanism and effects on range of motion and ... [11] Effectiveness of the proprioceptive neuromuscular facilitation method on gait parameters in patients with stroke: A systematic ... [12] Effectiveness of Rhythmic Stabilization Technique (Pnf) with Conventional Physiotherapy in Osteoarthritis (Oa) ... [13] Effects of proprioceptive neuromuscular facilitation on balance, strength, and mobility of an older adult with chronic stroke: A ... [14] Effect of proprioceptive neuromuscular facilitation stretching on physical fitness: A critical ... [15] Effect of mirror therapy on walking ability in patients with ... [16] Comprehensive textbook of nursing ... [17] Duration of maintained hamstring flexibility after a one-time PNF-crca stretching protocol in ... [18] Comparison of Two different applications of proprioceptive neuromuscular facilitation techniques to increase upper-extremity muscle ... [19] Ischemic lesion volume correlation with functional outcome after PNF application in middle cerebral artery stroke ... [20] The effects of band exercise using proprioceptive neuromuscular facilitation on muscular strength in ... [21] Effectiveness of PNF stretching versus static stretching on pain and hamstring flexibility following moist heat in individuals ... [22] The comparison of neuromuscular facilitation exercises and traditional exercise therapy programs in the treating of patients with chronic ... [23] The immediate effect of diaphragm taping with breathing exercise on muscle tone and ... [24] Overflow using proprioceptive neuromuscular facilitation in post-stroke ... [25] Effects of aerobic physical exercise on neuroplasticity after stroke: ... [26] Effect of 8-week combined training (resistance and proprioceptive neuromuscular facilitation) on fatigue and quality of life in ... [27] Clinical evidence of exercise benefits for ...

Introduction

Stroke is one of the primary factors leading to disability, cognitive decline, and mortality worldwide [1]. This disease is considered the second leading cause of disability and the third leading cause of death [2]. According to the World Health Organization (WHO) report, every 4 to 5 minutes, one person dies due to a stroke [3]. The prevalence of this disease in Iran is reported as 283 cases per hundred thousand individuals [4]. Annually, more than 400 thousand individuals are discharged from hospitals following the occurrence of acute conditions of stroke, resulting in varying degrees of physical disorders and disabilities [5].

The reduction in motor ability and pain are among this disorder's most common clinical symptoms [6], resulting from tissue damage in the brain. The decrease in muscular strength can be significant enough to impede the performance of daily activities. Therefore, professional, social, and quality-of-life activities will also be affected, leading to significant economic and social implications [7].

Clinical evidence indicates that physical activity after a stroke leads to motor improvement and structural changes in the brain [8]. Exercise interventions in the elderly have also successfully enhanced physical function and the exercises have a protective effect in alleviating functional limitations, including mobility, disability, and fall prevention. Therefore, researchers are striving to leverage exercise and rehabilitation activities to improve functional outcomes in stroke survivors [9]. Among suitable rehabilitation strategies in this context, incorporating stretching exercises is noteworthy to enhance the patient's muscle flexibility. Proprioceptive Neuromuscular Facilitation (PNF) exercises are a stretching method that improves muscles' elastic properties and positively affects both passive and active range of motion [10].

Results of the systematic review by Gunning and Uszynski have demonstrated that using the PNF method significantly improves walking outcome measures in stroke patients. Furthermore, these results indicated that groups undergoing treatment with PNF techniques showed significant improvement in outcome measures compared to groups receiving conventional physiotherapy treatment [11]. Jacob also indicated that PNF is significantly more effective than regular physiotherapy in reducing pain, increasing flexibility, and enhancing independence in functional mobility for patients with knee osteoarthritis [12].

Furthermore, the study by Cayco *et al.* demonstrated that PNF effectively improves balance, strength, and movement in patients with stroke [13]. Majhi, in their critical analysis study, concluded that despite reports of the positive impact of PNF on the strength, balance, and movement of individuals, some other studies have reported no effect or adverse effects. They

suggested further studies for more credible results [14].

Furthermore, considering that despite various research on the effects of PNF on other disorders and diseases, there is limited research on its impact on stroke patients, and sometimes these results are contradictory. Additionally, the review of existing literature indicates that local approaches have received less attention. Thus, this study aimed to investigate the effect of deep neuromuscular facilitation exercises on muscle strength in stroke patients.

Materials and Methods

Design and sampling

This pre-post clinical trial with a randomized control group was conducted in 2017-2018. Patients with stroke were referred to the Neurology Department of Shahid Beheshti Hospital in Yasuj City, Iran. The research sample included 60 patients who met criteria such as personal satisfaction and awareness for participation, a minimum of 4 months to 2 years since the onset of stroke, aged 60 to 90 years, absence of orthopedic and neurological diseases, ability to communicate, and muscle strength less than 3. Participants were selected using non-probability and convenience sampling methods and were randomly divided into 30 experimental and control groups based on block randomization. The required sample size was estimated to be 27 participants in each group using the Cohen formula for comparing the difference between the two means of the outcome variable score ($d = \mu_1 - \mu_2$) with a standard deviation of muscle strength of 1.05, according to a similar study [15] and considering a confidence level of 95%, a test power of 80%, and the maximum clinically significant difference (effect size). Finally, 30 participants in each group were determined based on the 10% statistical decline ($n=60$).

Instruments

The muscle strength of participants in both groups was assessed before the intervention using the Muscle Strength Measurement Questionnaire (MMT) in three parameters: muscle grade, percentage of normal muscle strength, and muscle scale, scored on a scale of 0-5. A score of 5 indicates complete contraction strength against gravity and resistance with natural muscle strength. A score of 4 indicates good muscle strength but not complete against gravity, with resistance being approximately average or partial weakness. A score of 3 indicates moderate weakness and sufficient muscle strength only against gravity. A score of 2 indicates the ability to move but unable to overcome gravity, signifying severe weakness. A score of 1 indicates minimal contractile strength (muscle contraction is weak but palpable, with no observable movement) or very severe weakness. A score of 0 indicates the absence of movement. Individuals with a muscle strength score

of three or fewer were included in the study. The reliability and validity of muscle strength measurement are confirmed in medical science reference books [16].

Procedure

After obtaining approval from the Ethics Committee and registering in the clinical trial center, the purpose of the study was explained to the participants, and written informed consent was obtained. Emphasis was placed on voluntary withdrawal at any study stage and the confidentiality of information. No costs or harm were imposed on the patients, and the Helsinki Declaration principles were followed throughout the research process. Based on the protocol, the intervention was implemented for eight weeks, consisting of two sessions per week, each lasting 30 to 45 minutes (16 sessions over two months) in the experimental group. The control group did not receive any intervention and only received routine treatments.

For the implementation of PNF techniques, the following joint patterns were used:

1. Upper Limb Joint Patterns:

D1 Flexion Pattern: Flexion, abduction, external rotation (opening and closing of the elbow)

D1 Extension Pattern: Extension, adduction, internal rotation (opening and closing of the elbow)

D2 Flexion Pattern: Flexion, adduction, internal rotation (opening and closing of the elbow)

D2 Extension Pattern: Extension, abduction, external rotation (opening and closing of the elbow)

2. Lower Limb Joint Patterns (Subsequent Movements):

D1 Flexion Pattern: Flexion, abduction, external rotation (knee open and closed)

D1 Extension Pattern: Extension, adduction, internal rotation (knee open and closed)

D2 Flexion Pattern: Flexion, adduction, internal rotation (knee open and closed)

D2 Extension Pattern: Extension, abduction, external rotation (knee open and closed)

The researcher initially positioned the participant in a balanced posture; in this position, the muscles were stretched as much as possible. The exercises were performed in a way that initially involved a non-active or active stretch applied for 10 to 20 seconds, and the targeted muscle or muscles were gradually moved to the end of the range of motion. This position was maintained for moments. In the second stage, a contraction against the therapist's resistance was performed immediately or after a rest of about 2 to 3 seconds. This contraction can be isometric or static, or with less probability; it may be shortening and concentric. The duration of this contraction was 3 to 6 seconds. In this stage, the target muscle was gently relaxed through the "autogenic inhibition" or "reversed tension reflex" mechanism and was prepared for further stretching. In the third stage, the target muscle or muscles were stretched again to

reach a new point in the range of motion immediately or after a pause of about 2 to 3 seconds [17].

The muscle strength of the patients in both the test and control groups was assessed using the Muscle Strength Questionnaire administered by the researcher before starting the exercises, immediately, and four weeks after completing the last exercise session. The assistant researcher and statistical advisor were unaware of the sample grouping in the data analyst step.

Analysis Method

Data were analyzed using SPSS 21 software through descriptive statistics (tables and charts, central tendency indices, dispersion indices) and inferential statistical tests (Kolmogorov-Smirnov, Mann-Whitney, Wilcoxon) considering a 95% confidence level and $p < 0.05$.

Findings

There was no sample dropout ($n=60$) and no significant difference in sociodemographic parameters between the two patient groups ($p=0.1$). Both groups were in the 60 to 90 years age range. 56.7% of the research sample was male, and the rest were female. The majority of participants (35%) were unemployed. The majority (40%) had elementary education. 80% of the participants in the intervention group and 70% in the control group were residents of urban, and the rest were residents of villages. 30% of the intervention group and 23.3% of the control group were single. 70% of the intervention group and 76.7% of the control group were married or divorced. In both groups, 55% of the samples had a positive family history of stroke. 61.7% of the samples had a stroke in the right hemisphere and 38.3% in the left hemisphere. 61.7% had left-sided body paralysis, and 38.3% had right-sided paralysis.

There was no statistically significant difference in muscle strength between the research samples before and immediately after the intervention. However, one month after the intervention, a statistically significant difference was reported between the two groups (Table 1).

The difference in the mean muscle strength was significant in the test group ($p=0.001$; Table 2).

Table 1. Comparison (Mann-Whitney U) of muscle strength mean scores before and after intervention in test and control groups

Parameter	Experimental group	Control group	p-Value
Muscle grade			
Before	1.0±9.7	2.0±2.1	0.2
After	2.0±8.7	2.0±4.8	0.1
One month after	3.0±3.8	2.1±4.0	0.001
Percentage of Normalcy			
Before	12.0±28.3	13.0±31.4	0.4
After	19.0±45.0	37.1±5.3	0.1
One month after	59.2±5.2	37.2±8.4	0.001
Scale			
Before	2.0±1.4	2.0±2.6	0.5
After	2.0±7.6	2.0±4.6	0.5
One month after	3.0±4.7	2.0±6.8	0.001

Table 2. Comparing (Wilcoxon test) differences in muscle strength before and after the intervention in the experimental and control group

Parameter	T3-T2		T3-T1		T2-T1	
	p-Value	Difference	p-Value	Difference	p-Value	Difference
Experimental						
Muscle grade	0.001	0.5	0.001	1.4	0.001	0.9
Percentage of Normalcy	0.001	14.5	0.001	31.5	0.001	17
Scale	0.001	0.7	0.001	1.3	0.001	0.6
Control						
Muscle grade	0.999	0	0.2	0.2	0.05	0.2
Percentage of Normalcy	0.9	0.3	0.06	6.8	0.007	6.5
Scale	0.2	0.2	0.05	0.4	0.1	0.2

Discussion

Stroke is a common neurological disorder that can significantly impact the quality of life of affected individuals due to functional impairments. This study investigated the effect of neuromuscular facilitation exercises on stroke patients' muscle strength.

The results indicated no statistically significant difference in muscle strength (muscle grade, percentage of normalcy, and muscle scale) among stroke patients before the intervention. Furthermore, findings revealed no statistically significant differences immediately after the intervention in the muscle strength parameters based on manual measurements. It is possible that excessive fatigue immediately after exercise and quick muscle assessment without sufficient rest opportunities could contribute to this observation. However, a statistically significant difference was observed between the two groups one month after the intervention. This implies that muscle strength in all three parameters showed an increasing trend in the intervention group one month after the intervention, suggesting a potential rehabilitation effect. Tonak *et al.* have demonstrated that Proprioceptive Neuromuscular Facilitation increases muscle strength in the arm and forearm in studied samples. Chaturvedi & Tyagi's study also emphasized the improvement in the condition of stroke patients after performing PNF exercises [19].

Additionally, the current study's findings align with the results of other research studies. For instance, improvement in muscle strength, flexibility, and balance, as observed in the study by Rhyu *et al.* [20]. Similar improvements in hamstring flexibility compared to static stretching with moist heat were reported in the research conducted by Meena and colleagues [21]. Furthermore, Rezasoltani *et al.* [22] demonstrated increased muscle strength and reduced pain. Wang *et al.* also indicated a decrease in the average muscle tone and stiffness in the lower limbs of chronic stroke patients, although this change was deemed insignificant [23]. Oliveira *et al.* also suggest a positive impact of PNF on muscle activity in patients with hemiplegia after a stroke [24].

Exercise can enhance brain function and reduce nerve damage. Additionally, it can modify the excitability of neurons and neurotrophic factors in neural networks after a stroke, consequently influencing neural plasticity [25]. On the other hand,

alterations in the connection between motor neurons lead to increased coordination and recruitment of motor units, enhancing force production and stable force application. The result is an improvement in muscle strength [26]. Therefore, stretching exercises can improve stroke patients' muscle weakness, walking ability, and overall performance [27].

This study also has limitations, such as not examining the long-term sustainability of the exercise effects. It would be beneficial to address this aspect in future research endeavors. One of the strengths of this research is its effort to propose an empowering solution for stroke patients to control and manage the symptoms of the disease. As improving muscle strength and daily life activities is a primary goal in controlling stroke, it is recommended that healthcare professionals, especially nurses, focus on various approaches, including neuromuscular facilitation exercises, in the care and management of physical issues in stroke patients. Since these exercises are non-invasive, cost-effective, and free of side effects, nurses can take effective steps by performing and teaching these techniques to stroke patients, enhancing their overall health. Thus, the results of this study can be employed as a complementary and non-pharmacological intervention in the rehabilitation or disability management process for stroke patients.

Conclusion

Neuromuscular facilitation exercises improve stroke patients' muscle strength. Based on these results, enhancing muscle strength in the daily activities of stroke patients leads to overall improvement.

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Ethical Permissions: This study was approved by the Ethics Committee of the Yasuj University of Medical Sciences (IR.YUUMS.REC.1395.9). It was also registered on the Clinical Trials website (IRCT2016043027676N1).

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Parandvar Y (Fourth Author), Assistant Researcher/Methodologist/Introduction Writer/ Discussion Writer (32%)

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