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## RESEARCH ARTICLE

### A Study on the Combined Effect of Dynamic Hand Splints and Proprioceptive Neuromuscular Facilitation in Improving Hand Function in Stroke Patients

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#### ABSTRACT

**Objectives:** Stroke is a major health concern in India and is associated with risk factors such as hypertension and diabetes. Dynamic Hand Splints (DHS) and Proprioceptive Neuromuscular Facilitation (PNF) may improve hand function and reduce spasticity. The aim of this study was to evaluate the effectiveness of combining DHS and PNF on the spastic hand in patients with hemiplegic stroke. **Methods:** A randomised controlled trial was conducted on 40 ischaemic hemiplegic stroke patients diagnosed with spastic hands. Participants were randomly allocated into two groups: Group A (20 patients) received DHS combined with PNF, while Group B (20 patients) received PNF. The study lasted for 6 weeks, with one session per day, 5 days a week. Pre- and post-treatment assessments included the Modified Ashworth Scale for spasticity and Fugl-Meyer Assessment for motor function. **Findings:** The baseline demographic and clinical characteristics were similar across both groups. In Group A, MAS scores decreased from  $2.85 \pm 0.74$  to  $1.25 \pm 0.78$  ( $p < 0.001$ ), and FMA scores increased from  $8.90 \pm 2.63$  to  $15.95 \pm 2.47$  ( $p < 0.001$ ). In Group B, MAS improved from  $2.95 \pm 0.87$  to  $1.80 \pm 0.83$  ( $p < 0.001$ ), and FMA scores rose from  $8.50 \pm 2.13$  to  $12.00 \pm 2.92$  ( $p < 0.001$ ). Group A showed significantly greater improvements in both MAS ( $p < 0.05$ ) and FMA ( $p < 0.05$ ) than Group B. **Novelty:** Combining DHS with PNF is more effective than PNF alone and could be incorporated in clinical practice to reduce spasticity and improve hand function in patients with hemiplegic stroke.

**Keywords:** Stroke; Dynamic Hand Splint; Proprioceptive Neuromuscular Facilitation; Spasticity; Hand Function

## 1 INTRODUCTION

Stroke is a major health concern in India, with a rising prevalence linked to various risk factors, including chronic diseases like diabetes, which can more than double the risk of stroke-related morbidity and mortality.<sup>1</sup> India witnesses approximately 1.8 million strokes annually, driven by common risk factors such as hypertension, diabetes, smoking, and physical inactivity, which are prevalent in the population.<sup>1</sup> The prevalence of stroke also varies significantly across different regions of India, and is influenced by socioeconomic conditions and access to healthcare. Diabetes plays a particularly significant role, with diabetic individuals facing more than twice the risk of stroke compared to non-diabetic individuals.<sup>1</sup> The presence of additional comorbidities, such as cardiovascular diseases, further increases the risk of stroke in these patients. While understanding stroke prevalence is crucial, it is equally important to address the broader public health context in

India, which includes improving healthcare infrastructure and implementing preventive measures to effectively tackle chronic diseases.

Stroke frequently results in upper limb impairments such as hand spasticity, which significantly affects patients' quality of life and their ability to perform daily activities. Recent studies have demonstrated the potential of dynamic hand splints and proprioceptive neuromuscular facilitation (PNF) techniques to improve hand function in stroke patients. Dynamic hand splints, in particular, have been shown to be more effective than traditional static splints, offering advantages such as reduced spasticity, a comfortable stretch, and enhanced hand performance.<sup>2</sup> In a study involving eight stroke patients, the use of a dynamic splint for at least three hours per day over four weeks resulted in significant improvements in hand function and a reduction in spasticity.<sup>2</sup>

PNF techniques have also been shown to be effective in improving various aspects of rehabilitation in stroke patients, including gait parameters, balance, and hand muscle strength. Studies have shown that PNF can enhance range of motion and athletic performance, particularly when applied consistently after exercise.<sup>3</sup> Additionally, PNF has been found to improve balance, strength, and mobility in older adults with chronic stroke.<sup>4,5</sup> Recent research also suggests that PNF significantly improves hand muscle strength, with a study reporting a p-value of 0.039 when compared to traditional strengthening exercises.<sup>6</sup> Furthermore, a case study demonstrated that PNF not only improved walking speed but also reduced discomfort in stroke patients, shows its role in enhancing overall functional mobility.<sup>7</sup>

Dynamic hand splints, designed to facilitate movement and improve hand function, may work synergistically with PNF. This combination can address spasticity and improve motor control, leading to better rehabilitation outcomes. However, while PNF has shown promising results, some studies suggest that other interventions, such as therapy handball exercises, might provide superior improvements in motor dexterity.<sup>8</sup> This highlights the need for further research to identify the most effective combination of therapies for achieving optimal patient outcomes. Additionally, some researchers argue that the effectiveness of PNF may vary depending on individual patient conditions and the specific nature of their impairments, signifying the importance of tailoring rehabilitation approaches to meet each patient's unique needs.<sup>9,10</sup>

Given the individual benefits of dynamic hand splints and PNF techniques, combining these interventions may potentially yield synergistic effects in improving hand function and reducing spasticity in patients with hemiplegic stroke. The combination of dynamic hand splinting and PNF techniques presents an intriguing approach to address spasticity and improve hand function in patients with hemiplegic stroke. This study aimed to investigate the effectiveness of dynamic hand splints in combination with Proprioceptive Neuromuscular Facilitation techniques to reduce spasticity and improve hand function in patients with hemiplegic stroke.

## 2 METHODS

A convenient sampling technique was used to select participants for the study. Patients with hemiplegic stroke who met the inclusion and exclusion criteria were recruited from three different clinical settings: Sukino Health Care Pvt. Ltd., Hosur; Krupanidhi Physiotherapy Clinic, Bangalore; and Fortis Hospital, Bannerghatta, Bangalore. This study included 40 patients with ischaemic hemiplegic stroke diagnosed with spastic hands. Participants were randomly allocated into two groups: Group A (20 patients) received Dynamic Hand Splint treatment along with PNF, whereas

Group B (20 patients) served as the control group and received PNF interventions. The sample size was determined based on feasibility and previous studies that assessed similar interventions. The study lasted for 6 weeks, during which patients received one treatment session per day, 5 days a week. Each session included specific interventions for spasticity reduction and functional improvement in the affected hand.

## 3 RESULTS

In the present study, Table 1 presents the demographic characteristics of stroke patients with spastic hands in both Group A (Dynamic Hand Splint + Proprioceptive Neuromuscular Facilitation) and Group B (control group). The age range of participants in both groups was 35–50 years. The mean age in Group A was  $44.05 \pm 4.46$  years, while in Group B it was  $43.10 \pm 4.10$  years. The difference in the mean age between the two groups was statistically insignificant, as indicated by the unpaired t-test result ( $t = 1.366, p > 0.05$ ), suggesting that the age distribution was similar across both groups. Regarding gender distribution, Group A consisted of 13 males (65%) and 7 females (35%), whereas Group B had 11 males (55%) and 9 females (45%). The Chi-square test for gender distribution revealed no significant difference between the groups (chi-square = 0.417,  $df = 1, p > 0.05$ ), indicating that the gender ratio was comparable in both groups.

The distribution of patients with stroke based on the side affected by stroke was also similar between the two groups. In Group A, 11 patients (55%) had a left-sided stroke, and 9 patients (45%) had a right-sided stroke. In Group B, 12 patients (60%) had a left-sided stroke, and 8 patients (40%) had a right-sided stroke. The Chi-square test for the affected side showed no significant difference between the two groups (chi-square = 0.102,  $df = 1, p > 0.05$ ), suggesting that the side of stroke involvement was evenly distributed between the groups. The baseline demographic characteristics were comparable between Groups A and B, allowing for a fair comparison of the treatment effects on the spastic hand in patients with hemiplegic stroke.

The duration of stroke in both the groups ranged from 8 to 28 months. The mean duration of stroke in Group A was  $15.15 \pm 6.25$  months, while in Group B it was  $15.60 \pm 5.75$  months. The difference in the mean duration between the two groups was statistically insignificant ( $t = 0.237, p > 0.05$ ), indicating that the duration of stroke was comparable between the two groups. Patients were classified into two grades according to stroke severity: Grade 3 and Grade 4. In Group A 11 patients (55%) were categorised as Grade 3, while 9 patients (45%) were classified as Grade 4. In Group B, 10 patients (50%) were Grade 3 and 10 patients (50%) were Grade 4. The Chi-square test for the distribution of stroke grades revealed no significant difference between the two groups (chi-square = 0.100,  $df = 1, p > 0.05$ ), suggesting

**Table 1: Demographic Characteristics of Stroke Patients with Spastic Hand in Both Groups (Age, Gender, and Side Affected)**

Variables	Group A		Group B		Unpaired T-test / Chi-Square test
	Range	Mean ± SD	Range	Mean ± SD	
Age (years)	35 - 50	44.05 ± 4.46	35 - 50	43.10 ± 4.10	t=1.366, p>0.05
Male	13 (65%)		11 (55%)		Chi-Square value=0.417, df=1, p>0.05
Female	7 (35%)		9 (45%)		
Left side	11 (55%)		12 (60%)		Chi-Square value=0.102, df=1, p>0.05
Right side	9 (45%)		8 (40%)		

\*Significant (p<0.05)

that the severity of stroke was evenly distributed across both groups. These findings demonstrate that the baseline characteristics of stroke severity and duration were similar in both the groups (Table 2).

In Group A, the pre-test Modified Ashworth Scale (MAS) scores ranged from 2 to 4, with a mean of 2.85 ± 0.74. Following the intervention, MAS scores ranged from 0 to 3, with a mean of 1.25 ± 0.78. The Wilcoxon test revealed a significant improvement in MAS scores (Z = 4.053, p < 0.001), indicating a marked reduction in spasticity after treatment. Similarly, the pre-test Fugl-Meyer Assessment (FMA) scores in Group A ranged from 5 to 13, with a mean of 8.90 ± 2.63, while post-test scores ranged from 10 to 22, with a mean of 15.95 ± 2.47. This improvement was also significant (Z = 3.951, p < 0.001), suggesting notable recovery in motor function following the intervention.

In Group B, the pre-test MAS scores ranged from 1 to 4, with a mean of 2.95 ± 0.87, and post-test scores ranged from 0 to 3, with a mean of 1.80 ± 0.83. A significant reduction in spasticity was observed (Z = 3.272, p < 0.001). Regarding the FMA, Group B's pre-test scores ranged from 5 to 13, with a mean of 8.50 ± 2.13, and post-test scores ranged from 7 to 17, with a mean of 12.00 ± 2.92. This improvement was also statistically significant (Z = 3.948, p < 0.001), indicating improvement in motor function.

When comparing the pre- and post-test results between the two groups, no significant difference was found in the MAS pre-test scores (Z = 0.414, p > 0.05). However, Group A showed a significantly greater improvement in the post-test MAS scores than Group B (Z = 3.565, p < 0.05). For the FMA, no significant difference was observed in the pre-test scores between the groups (Z = 0.475, p > 0.05), but Group A demonstrated a significantly greater improvement in the post-test FMA scores than Group B (Z = 4.286, p < 0.05).

These results suggest that while both groups showed significant improvements in spasticity and motor function, Group A received a Dynamic Hand Splint along with PNF therapy, showing greater post-test improvements in both spasticity and motor function compared to the control group (Table 3).

#### 4 DISCUSSION

The study on the effectiveness of Dynamic Hand Splint combined with Proprioceptive Neuromuscular Facilitation (PNF) for spastic hands in hemiplegic stroke patients provides a basis for comparison with existing literature. The demographic characteristics of the study groups were comparable, allowing for a fair assessment of the treatment effects. This aligns with the findings of other studies that explored similar interventions, albeit with different methodologies and focus areas. The use of dynamic splints for post-stroke spasticity has been recognised; however, evidence of their effectiveness is limited. Properly designed dynamic splints can aid in functional recovery, though more research is needed to optimize their clinical utility.<sup>11</sup> PNF has been shown to improve functional mobility and upper limb function in stroke patients. Studies have demonstrated significant improvements in functional mobility when PNF is combined with other therapies, such as motor relearning<sup>12</sup> and constraint-induced movement therapy (CiMT).<sup>13</sup> A study comparing CiMT and PNF found both to be beneficial, with CiMT showing slightly better outcomes in upper limb function.<sup>13</sup> This suggests that although PNF is effective, its combination with other therapies might enhance the results. Another study shows the effectiveness of PNF in acute stroke patients, showing significant improvements in upper extremity function when initiated early.<sup>14</sup> The demographic characteristics in the present study, such as age and gender distribution, were similar to those in other studies, and the results were comparable across different research contexts.<sup>11,12</sup>

A study on the effectiveness of dynamic hand splints combined with PNF in hemiplegic stroke patients revealed comparable baseline characteristics in terms of stroke duration and severity across both groups. This finding aligns with recent literature, which shows the importance of understanding patient characteristics in rehabilitation outcomes. In the present study, the mean duration of stroke in Group A was 15.15 ± 6.25 months, while Group B had 15.60 ± 5.75 months, with no significant difference (t = 0.237, p > 0.05). The severity classification showed 55% of Group A in Grade 3 and 45% in Grade 4, while Group B had 50% in each grade, with no significant difference (chi-square = 0.100, df = 1, p > 0.05). Recent studies

**Table 2: Distribution of stroke patients with spastic hand according to stroke grade and duration in both groups**

Variables	Group A		Group B		Unpaired T-test / Chi-Square test
	Range	Mean ± SD	Range	Mean ± SD	
<b>Duration of stroke (Months)</b>	8 - 28	15.15 ± 6.25	8 - 28	15.60 ± 5.75	t=0.237, p>0.05
Grade 3	11 (55%)		10 (50%)		Chi-Square value=0.100, df=1, p>0.05
Grade 4	9 (45%)		10 (50%)		

\*Significant (p<0.05)

**Table 3: Comparison of MAS and FMA in Pre- and Post-Test in Group A and Group B**

Groups	Outcome	Pre-test		Post-test		Wilcoxon test	p-value
		Range	Mean ± SD	Range	Mean ± SD		
Group A	MAS	2-4	2.85±0.74	0-3	1.25±0.78	Z=4.053*	P<0.001
	FMA	5-13	8.90±2.63	10-22	15.95±2.47	Z=3.951*	P<0.001
Group B	MAS	1-4	2.95±0.87	0-3	1.80±0.83	Z=3.272*	P<0.001
	FMA	5-13	8.50±2.13	7-17	12.00±2.92	Z=3.948*	P<0.001

**Between-group comparison Mann-Whitney U test/unpaired t-test**

Groups	Outcome	Pre-test	Post-test
Group A	MAS	Z=0.414, p>0.05	Z=3.565, p<0.05*
Group B	FMA	Z=0.475, p>0.05	Z=4.286, p<0.05*

\*=Significant (p<0.05)

have highlighted variability in rehabilitation outcomes based on patient characteristics, suggesting that personalised interventions may yield better results.<sup>15</sup> Other studies, such as those on constraint-induced movement therapy, indicate that tailored approaches can significantly enhance motor recovery, encouraging the need for individualized treatment plans.<sup>16</sup> While the current study showed no significant differences in baseline characteristics, the broader literature suggests that understanding these factors is crucial for optimising rehabilitation strategies.

The present study showed significant improvements in the effectiveness of a Dynamic Hand Splint combined with PNF therapy for spastic hands in hemiplegic stroke patients with both spasticity and motor function. Group A exhibited a marked reduction in MAS scores and a notable increase in FMA scores post-intervention, outperforming Group B, which received PNF. This suggests that combination therapy is more effective than traditional methods. Group A showed significantly greater improvements in post-test MAS and FMA scores compared to Group B. In contrast, a study by Eghlidi et al. found no significant reduction in spasticity with splinting alone, indicating that the combination of dynamic splinting and PNF may be crucial for effective rehabilitation.<sup>17</sup> Dynamic splints have shown promise in reducing spasticity and improving hand function in patients with stroke. A study by Yang et al., indicated significant reductions in spasticity and enhancements in functional movements among users of a new dynamic splint.<sup>2</sup> The systematic review conducted by Kerr et al., found moderate evidence supporting dynamic splinting for improving hand

function and functional tasks.<sup>18</sup> PNF techniques stimulate motor activity and enhance neuromuscular control, which are crucial in hemiplegic patients. Research suggests that PNF can improve upper limb function and scapular alignment, contributing to better overall mobility.<sup>9</sup> Combining PNF with dynamic splinting may synergistically enhance rehabilitation outcomes by addressing both spasticity and functional deficits. The present study demonstrated the benefits of combined therapies and the combination of dynamic splints and PNF. Therefore, it is essential to consider individual patient variability and the need for tailored rehabilitation programs. Further research is warranted to establish standardised protocols and long-term efficacy of these interventions in diverse patient populations.

### 5 CONCLUSION

This study demonstrated that both Dynamic Hand Splint combined with PNF and standard therapy significantly improved spasticity and motor function in stroke patients with spastic hands. However, Group A, which received the combined intervention, showed greater post-test improvements in both spasticity, as measured by the Modified Ashworth Scale (MAS), and motor function, as assessed by the Fugl-Meyer Assessment (FMA), than the control group. These findings suggest that the combination of Dynamic Hand Splint and PNF therapy is more effective than PNF therapy alone and provides superior outcomes in reducing spasticity and improving hand function in hemiplegic stroke patients with spastic hands.

## REFERENCES

1. Misra P, Chakrabarti R. Introduction to Diabetes and Prevalence in India. In: Drug Discovery and Drug Development. Singapore. Springer. 2021;p. 159–163. Available from: [https://doi.org/10.1007/978-981-15-8002-4\\_6](https://doi.org/10.1007/978-981-15-8002-4_6).
2. Yang YS, Emzain ZF, Huang SC. Biomechanical Evaluation of Dynamic Splint Based on Pulley Rotation Design for Management of Hand Spasticity. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*. 2021;29:683–689. Available from: <https://dx.doi.org/10.1109/tnsre.2021.3068453>.
3. Hindle KB, Whitcomb TJ, Briggs WO, Hong J. Proprioceptive Neuromuscular Facilitation (PNF): Its Mechanisms and Effects on Range of Motion and Muscular Function. *Journal of Human Kinetics*. 2012;31:105–113. Available from: <https://dx.doi.org/10.2478/v10078-012-0011-y>.
4. Cayco CS, Gorgon EJ, Lazaro RT. Effects of proprioceptive neuromuscular facilitation on balance, strength, and mobility of an older adult with chronic stroke: A case report. *Journal of Bodywork and Movement Therapies*. 2017;21(4):767–774. Available from: <https://dx.doi.org/10.1016/j.jbmt.2016.10.008>.
5. Kofotolis N, Kellis E. Effects of Two 4-Week Proprioceptive Neuromuscular Facilitation Programs on Muscle Endurance, Flexibility, and Functional Performance in Women With Chronic Low Back Pain. *Physical Therapy*. 2006;86(7):1001–1012. Available from: <https://dx.doi.org/10.1093/ptj/86.7.1001>.
6. Nauko KY, Kadir S, Jusuf ML. Effectiveness of Proprioceptive Neuromuscular Facilitation and Strengthening Exercise towards Increasing Strength Stroke Patient's Hand Muscles at Tani Dan Nelayan Regional General Hospital. *International Journal of Medical Science and Clinical Research Studies*. 2024;04(06):1086–1092. Available from: <https://dx.doi.org/10.47191/ijmscrs/v4-i06-18>.
7. Lee S, Hong J, Kim J, Nam Y, Yu J. Effectiveness of Proprioceptive Neuromuscular Facilitation on Walking Speed, Discomfort, and Knee Extension in an Acute Stroke Patient: A Case Study. *South Eastern European Journal of Public Health*. 2024;XXV:64–68. Available from: <https://dx.doi.org/10.70135/seejph.vi.1305>.
8. Tongpangmeren, Baruah TS, Dihidar N, Paul M, Dutta A. Evaluation of Proprioceptive Neuromuscular Facilitation (PNF) and Therapy Hand Ball to Improve Motor Dexterity in Post-Stroke Patients. *International Journal of Life Science and Pharma Research*. 2023;13(6):468–481. Available from: <https://dx.doi.org/10.22376/ijlpr.2023.13.6.1468-1481>.
9. Saklecha A, Quershi MI, Raghuvver R, Harjpal P, Raghuvver P, Harjpal. Efficacy of scapular and upper limb proprioceptive neuromuscular facilitation techniques on scapular alignment, upper limb function, and gait in subacute stroke: a randomized controlled trial protocol. *F1000Research*. 2023;12:1–13. Available from: <https://doi.org/10.12688/f1000research.138133.1>.
10. Susilo T, Agustin L. Effectiveness of Proprioceptive Neuromuscular Facilitation in Improving Walking Quality in Post-Stroke Patients at Haji General Hospital Medan. *Jurnal Keperawatan dan Fisioterapi*. 2024;7(1):47–53. Available from: <https://doi.org/10.35451/jkf.v7i1.2155>.
11. Bianca C, Machuki JO, Chen W, Zhang M, Shang K. A dynamic splint for the treatment of spasticity of the hand after stroke? Recognition of its design, functionality and limitations: A narrative review article. *Journal of Neurology and Neurorehabilitation Research*. 2018;03(02):1–7. Available from: <https://dx.doi.org/10.35841/neurology-neurorehabilitation.3.2.1-5>.
12. Agarwal K. Effectiveness Motor Re-Learning along with Proprioceptive Neuromuscular Facilitation on Improving Functional Mobility in Subjects with Chronic Stroke. *International Journal of Science and Research (IJSR)*. 2023;12(8):252–257. Available from: <https://www.ijsr.net/archive/v12i8/SR23731101958.pdf>.
13. Abba MA, Muhammad AS, Badaru UM, Abdullahi A. Comparative effect of constraint-induced movement therapy and proprioceptive neuromuscular facilitation on upper limb function of chronic stroke survivors. *Physiotherapy Quarterly*. 2020;28(1):1–5. Available from: <https://dx.doi.org/10.5114/pq.2020.89809>.
14. Chaturvedi P, Singh AK, Kulshreshtha D, Maurya PK, Thacker AK. Abstract 102: Effects of Proprioceptive Neuromuscular Facilitation Exercises on Upper Extremity Function in the Patients With Acute Stroke. *Circulation: Cardiovascular Quality and Outcomes*. 2016;9(suppl\_2):102–102. Available from: [https://dx.doi.org/10.1161/circoutcomes.9.suppl\\_2.102](https://dx.doi.org/10.1161/circoutcomes.9.suppl_2.102).
15. Coscia M, Wessel MJ, Chaudary U, del R Millán J, Micera S, Guggisberg A, et al. Neurotechnology-aided interventions for upper limb motor rehabilitation in severe chronic stroke. *Brain*. 2019;142(8):2182–2197. Available from: <https://dx.doi.org/10.1093/brain/awz181>.
16. Diwan SJ, Shah P, Bansal AB. Effectiveness of distributed form of constraint induced movement therapy to improve functional outcome in chronic hemiparesis patients. *International Journal of Research in Medical Sciences*. 2017;2(4):1423–1430. Available from: <https://dx.doi.org/10.5455/2320-6012.ijrms20141134>.
17. Eghlidi J, Elyaspour D, Tabatabaee SM, Jamehbozorgi AA, Farshchi F, Heidari M. Comparison of the effect of dynamic and static splints on wrist spasticity in post-stroke patients. *Journal of Rafsanjan University of Medical Sciences*. 2011;10(1):35–45. Available from: <https://doi.org/10.29252/jrums.10.1.35>.
18. Kerr L, Vanessa D Jewell, Jensen L. Stretching and Splinting Interventions for Poststroke Spasticity, Hand Function, and Functional Tasks: A Systematic Review. *The American Journal of Occupational Therapy*. 2020;74(5):7405205050p1–7405205050p15. Available from: <https://dx.doi.org/10.5014/ajot.2020.029454>.