Effect of Hand Splinting versus Stretching Exercises for Reducing Spasticity and Improving Hand Function in Poststroke Hemiplegia: A Comparative Interventional Study

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Abstract

Background: Hand splints are used to prevent muscular hyperactivity in adult poststroke patients. Reflex inhibitory splints may be used as an integrative treatment of poststroke upperlimb spasticity. Hand splints are used by occupational therapists as a method of reducing the increased muscle tone of the upper extremity following stroke. Muscle stretching is becoming a very common practice in the rehabilitative management of spasticity. It includes several types of muscle stretching such as passive stretching, active stretching and prolonged stretching, isotonic stretching, and isokinetic stretching. **Objectives:** The objective of this study was to study the difference between the effects of splinting and stretching in reducing spasticity and improving hand function in poststroke hemiplegia. **Study Design:** This was a two-arm comparative interventional study. **Methods:** A total of 30 poststroke hemiplegic patients fulfilling the inclusion criteria which mainly include patients having tone of the affected upper extremity at wrist and fingers ≥2, according to the Modified Modified Ashworth Scale (MMAS), having score ≥25 on Mini-Mental State Examination and having age between the age group of 35 and 65 years are enrolled for the study. Consecutive sampling was done by putting all odd number patients in the splinting group and all even number patients in the stretching group. Assessment tools and outcome measures were B and C subscales of Fugl-Meyer Assessment of Physical Performance for Upper Extremity and MMAS. The patients of the splinting group were given a resting hand splint to wear for 10–12 h continuously per day for 6 weeks. Stretching exercise using a prolonged slow stretch technique was carried out to patients of the stretching group. **Results:** The patients of splinting group showed more improvement in spasticity and hand function than stretching group with mean difference of 1, $P = 0.695$, and 95% confidence interval (CI) = −26.41-−22.39 for wrist flexor spasticity, for finger flexor spasticity mean difference was 4, $P = 0.143$, and 95% CI = −8.28-−5.42 and for hand function mean difference was 4, $P = 0.13$, and 95% CI = 14.62–20.47. **Conclusion:** There was the statistically nonsignificant difference between the efficacy of hand splinting and stretching exercises, in reducing spasticity and improving hand functions in poststroke hemiplegia. However, clinically, hand splinting is more beneficial than stretching exercises for the desired outcomes.

Key Words: Fugl-Meyer Assessment, Modified Modified Ashworth Scale, Resting Hand Splint, Treatment Modalities

INTRODUCTION

Hand splints are used to prevent muscular hyperactivity in adult poststroke patients. Hand splints are used by occupational therapists as a method to reduce spasticity of the upper extremity following stroke. There are numerous approaches to the manufacture of static splints that can be found in the literature such as Bobath's neurodevelopmental treatment (NDT) approach and rood sensorimotor splint.[1] Hand splints are used as a method of reducing the increased muscle tone of the upper extremity following stroke.[2]

Muscle stretching is becoming a very common practice in the rehabilitative management of spasticity. It includes several types of muscle stretching such as passive stretching, active

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stretching and prolonged stretching, isotonic stretching, and isokinetic stretching.[3] The effects of stretching on spasticity may be explained by a change in the excitability of motoneurons supplying the spastic muscle. A few studies have examined that the application of stretch decreased motor neuron excitability and may be beneficial to decrease spasticity.[4]

Two rationales have been used the following:
1. Biomechanical rationale suggested that prolonged stretch of the spastic muscle was altered to permit an increased range of motion and reduction of tone
2. Neurophysiologic rationale suggested that prolonged stretch in the fully elongated range may lead to stimulation of the neurotendinous spindle of the intrafusal fiber. This may inhibit the spastic muscle.[5]

The aim and objective of this study were to investigate the difference between the effects of hand splinting and stretching exercises, in reducing spasticity as well as improving hand functions in poststroke hemiplegia.

METHODS

Study Design and Participants

A total of 30 poststroke hemiplegic patients of age 36–62 years were enrolled for the study. There were 11 males and 4 females in splinting group of age 40–61 years with a mean age of 48.60 years. There were 10 males and 5 females in a stretching group of age 36–62 years with mean age of 50.93 years. The study duration was of 8 months, and the research design was two-arm comparative interventional study. The study was conducted adhering to the principles of the Declaration of Helsinki, and written informed consent was sought from the patients.

Inclusion criteria comprised first poststroke adult hemiplegia, aged between 35 and 65 years, either right or left hemiplegia, muscle tone of the affected upper extremity at wrist and fingers ≥2 according to Modified Modified Ashworth Scale (MMAS).[6] Exclusion criteria comprised the presence of cognitive or perceptual impairments, any cutaneous or joint pathology or contractures, use of any antispastic medication, or hand splints before enrollment in the study.

Assessment and Outcome Measures

Mini-Mental State Examination[7] to rule out any cognitive or perceptual impairment. MMAS and B and C subscales of Fugl-Meyer Assessment of Physical Performance for Upper Extremity (FMA-UE [B and C])[8] were used as assessment tools as well as outcome measures for the study.

Procedure

A total of 30 patients fulfilling the inclusion criteria were enrolled in the study following written informed consent from the patients. Consecutive sampling was followed by recruiting all odd number patients in the splinting group and all even number patients in the stretching group.

Intervention

Designing and fabrication of resting hand splint for the splinting group were based on biomechanical principles and Bobath's principles. A static wrist-hand splint was fabricated of aluminum sheet padded with plastazote. In static resting wrist-hand splint, our main aim was to maintain all digits in extension at metacarpophalangeal, proximal, and distal interphalangeal joints, wrist in neutral or slight dorsiflexion with thumb in palmar abduction. The splint was designed to stabilize the proximal and distal interphalangeal joints based on Bobath's reflex inhibitory pattern. The forearm and wrist cuffs and Velcro straps were used to stabilize the forearm and wrist based on three-point pressure principle. The patients of the splinting group were given a resting hand splint to be worn for 10–12 h intermittently every day for 6 weeks. Splint wearing schedule was supervised by the researcher based on the interview with the patients' caregivers [Figure 1a].

Static stretching was carried for patients in stretching group 3–4 times a day and 5–6 days in a week for 6 weeks. Passive sustained stretching was carried out in a seated posture as per Bobath's reflex inhibitory pattern. The patient was positioned comfortably in a chair or a wheelchair, and the wrist joint was moved through a full range of motion by using a prolonged slow, sustained stretch technique to avoid eliciting a quick stretch reflex. The hand was held in the fully extended position or as much as possible (within patient's tolerable range and gradually advancing to full ranges over a couple of sessions) for approximately 60 s for each of five repetitions in each therapy session[9] [Figure 1b].

Data Analysis

The test parameters were compared before and after therapy. Statistical analyses were done using the statistical package for the social sciences version 16.0 package (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL, USA). Statistical tests were used with a level of significance set at $P < 0.05$ at the outset of the study. The raw scores of preintervention and postintervention of both the outcome measures (FMA-UE and MMAS) were calculated in both the groups. The changes in both outcome measures in splinting and stretching group were analyzed using the Wilcoxon signed-rank test. The Mann–Whitney U-test was used for analyzing the comparative efficacy between the groups.

RESULTS

Table 1 shows the results of Wilcoxon signed-rank test for

Figure 1: (a) Resting Hand Splint. (b) Stretching Exercises in Seated Posture
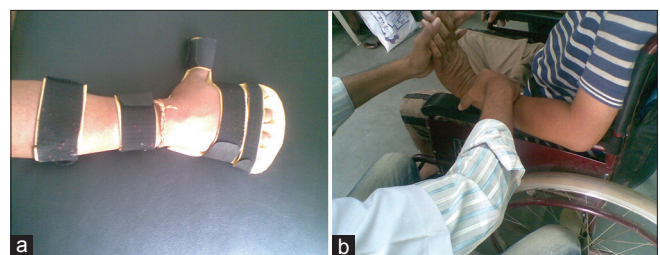
MMAS of wrist flexors and finger flexors and FMA-UE (B and C) scores of splinting and stretching groups, which indicates a significant improvement in both the groups.

Graph 1 shows that there is a significant improvement in MMAS of wrist flexors and finger flexors in both the splinting and stretching groups.

Graph 2 shows that there is a significant improvement in FMA-UE (B and C) scores of both the splinting and stretching groups.

Table 2 shows the results of the Mann–Whitney U-test for MMAS of wrist flexors and finger flexors and FMA-UE (B and C) scores of splinting and stretching groups, which indicates there is no statistically significant difference of improvement between splinting and stretching groups.

Graph 1: The Mean Score Changes in Modified Modified Ashworth Scale Score within the Groups. MMAS: Modified Modified Ashworth Scale, WF: Wrist flexors, FF: Finger flexors
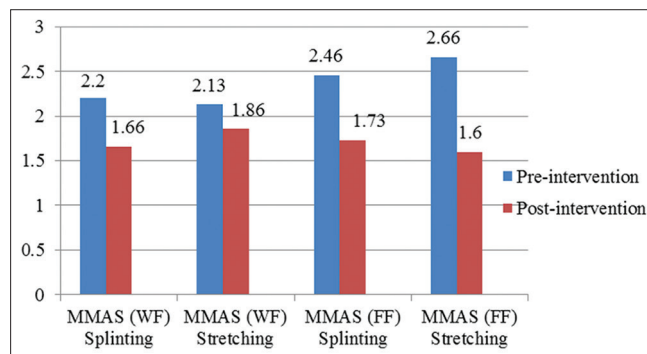
MMAS: Modified Modified Ashworth Scale, WF: Wrist flexors, FF: Finger flexors

Discussion

The present study was designed to compare the two treatment modalities, i.e., hand splinting and stretching exercises for reducing spasticity and improving hand function in poststroke hemiplegia, to find the effects of these modalities on spasticity of wrist flexors and finger flexors and improvement in hand function in stroke survivors.

Effect on Spasticity

The result of the outcome measure used for the spasticity of wrist flexors, i.e., MMAS scores showed that there is a significant reduction in the spasticity in splinting and stretching groups (within the groups). This result finding is consistent with the previous study done by Pizzi et al., 2005[10] where

Graph 2: The Mean Score Changes in B and C subscales of Fugl-Meyer Assessment of Physical Performance For Upper Extremity within the Groups. FMA-UE (B and C): B and C Subscales of Fugl-Meyer Assessment of Physical Performance for Upper Extremity
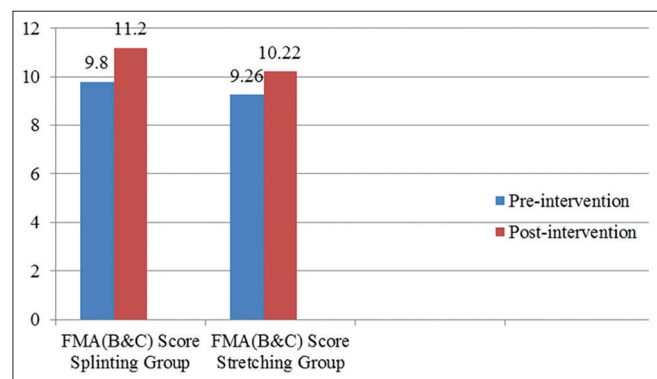

Table 1: The Results of Wilcoxon Signed-Rank Test for Modified Ashworth Scale and B and C Subscales of Fugl-Meyer Assessment of Physical Performance for Upper Extremity within the Groups

Outcome measures	Groups	Mean rank	Z (two-tailed)	P (two-tailed)	95% CI
MMAS (wrist flexors)	Splinting	6	−3.317	0.001	−0.26-−0.20
	Stretching	5.50	−3.162	0.002	
MMAS (finger flexors)	Splinting	4.50	−2.828	0.005	−0.05-−0.04
	Stretching	2.50	−2.000	0.046	
FMA (B and C)	Splinting	6.50	−3.140	0.002	0.16-0.21
	Stretching	7	−3.419	0.001	

MMAS: Modified Modified Ashworth Scale, FMA-UE (B and C): B and C subscales of Fugl-Meyer Assessment of physical performance for Upper Extremity, CI: Confidence interval

Table 2: The Results of Mann-Whitney U-Test for Modified Modified Ashworth Scale and B and C Subscales of Fugl-Meyer Assessment of Physical Performance for Upper Extremity between the Groups

Outcome measures	Groups	Mean rank	Sum of rank	U	P	95% CI
MMAS (wrist flexors)	Splinting	16.00	240.00	105.00	0.695	−26.41-−22.39
	Stretching	15.00	225.00			
MMAS (finger flexors)	Splinting	17.50	262.50	82.50	0.143	−8.28-−5.42
	Stretching	13.50	202.50			
FMA-UE (B and C)	Splinting	17.73	266.00	79	0.130	14.62-20.47
	Stretching	13.27	199.00			

MMAS: Modified Modified Ashworth Scale, FMA-UE (B and C): B and C subscales of the Fugl-Meyer Assessment of physical performance for Upper Extremity, CI: Confidence interval

a significant improvement of wrist passive range of motion with greater change in extension than flexion, and reduction of spasticity, pain, and spasm was observed.

This result finding is also consistent with the previous study done by Mortenson and Eng 2003[11] where stretching was used in spasticity to normalize muscle tone, to maintain or increase soft-tissue extensibility, to reduce pain, and to improve function.

This result finding is also consistent with the previous study done by Rose et al. 1987[12] where 30 patients with spastic wrist flexors resulting from a diagnosed stroke not more than 6 months' poststroke. Participants were randomly assigned to either of two experimental groups (predominantly dorsal or predominantly volar static orthosis) or to the control group (no orthosis). The patients in the intervention groups had significant increases in the passive range of wrist extension and a decrease in hypertonicity compared with the control group.

The result of MMAS score at wrist flexors between the groups statistical analysis using the Mann–Whitney U-test showed that there is no significant difference in improvement between the splinting and stretching groups.

Although the splinting group participants showed more improvement than the stretching group and this improvement in MMAS score between the splinting and stretching groups may be due to the effect of resting hand splint for longer time, which maintains proper alignment and proper positioning of the wrist and hand.

This result finding is also consistent with the previous study done by Katalini et al., 2011[13] where the immediate effects of stretch on spasticity were investigated by pooling the data from four studies. The long-term effects of stretch on spasticity were investigated by pooling the data from two studies. No study measured the short-term effects of stretch on spasticity. The results of this review indicate that stretch does not have clinically important effects on joint mobility in people with or at risk of contractures. There is little or no effect of stretch on pain, spasticity, or activity limitation in people with neurological conditions.

The result of the outcome measure used for the spasticity of finger flexors, i.e., MMAS score showed that there is a significant reduction in the spasticity in splinting and stretching groups (within the groups). This result finding is consistent with the previous study done by Adrienne and Manigandan 2011,[14] hand-splint prescription following stroke was found to be a common practice among occupational therapists who perceive splints to be quite effective. A custom-made, volar forearm-based wrist-hand splint is the preferred splint among therapists to achieve a number of clinical aims such as improving range of motion, stretching soft-tissue contractures, and reducing spasticity in the upper extremity. This result finding is also consistent with the previous study done by Langlois et al., 1991,[2] where nine adults with hemiplegia with a finger spreader splint and found that the spasticity was reduced. Prolong stretch resulted in a significant reduction in spastic hypertonus in wrist and finger flexors. The mechanism

leads to beneficial effects due to stretch receptor fatigue or adaptation to the new extended position.

The result of MMAS score of finger flexors between the group statistical analysis using the Mann–Whitney U-test showed that there is no significant difference in improvement between the splinting and stretching groups.

Although the splinting group participants showed more improvement than the stretching group and this improvement in MMAS score between the splinting and stretching groups may be due to the effect of resting hand splint for longer time, which maintains proper alignment and proper positioning of the hand. This result finding is also consistent with the previous study done by Langlois et al., 1991[2] where nine adults with hemiplegia with a finger-spreader splint and found that spasticity reduced more in the group who had wearing scheduled for 22 h a day, as compared to the group who had 6 h a day wearing schedule and 12 h a day wearing schedule. Since, in this study, splint-wearing schedule was 12 h considering the feasibility of the participants such as routine conventional therapy, their engagement in activities of daily living (ADL). This could have caused no significant difference between the two groups.

This result finding is also consistent with the previous meta-analysis done by Foley et al., 2010[15] in which six randomized controlled trials were identified examining the benefit of splinting. Most of the studies failed to support the benefit of splinting in reducing spasticity of avoiding contracture. It has been suggested that short treatment periods, generally 4–6 weeks and underpowered studies may have contributed to the negative findings. In the same way, in this study, the protocol of wearing splint was also only 6 weeks which could cause the impact of splinting less effective.

Effect on Hand Function

The result of outcome measure used for measuring the effect on hand function, FMA-UE (B and C) showed significant improvement in hand function in splinting and stretching groups using the Wilcoxon signed-rank test for within the group statistical analysis.

This result finding is consistent with the previous study done by Pitts and O'Brien 2008[16] where custom splints were applied to maximize functional outcomes by keeping peripheral muscles and joint systems at a functional length.

This result finding is consistent with the previous study done by Mortenson and Eng 2003[11] where stretching was used in spasticity to normalize muscle tone, to maintain or increase soft-tissue extensibility, to reduce pain, and to improve function.

The statistical analysis between the splinting and stretching groups using the Mann–Whitney U-test for FMA-UE (B and C) showed that there is no significant difference in improvement in hand function.

This result finding is consistent with the previous study done by Shamili et al. 2010[17] where the aim of this study was to compare the effects of using splint or botulinum toxin injection

on spasticity, range of motion, and upper extremity function in which as a result all outcome measures improved in each group; however, the differences between two groups were not significant.

This result finding is also consistent with the previous study done by Barnes, 1998[18] where the application of splints and casts can prevent the formation of contractures in the spastic limb, and serial casting can improve the range of movement in a joint and thus hand functions also improved.

From previous studies and the current result, it can be hypothesized that due to the application of resting hand splint or muscle stretching in stroke survivors, there is a significant reduction of the spasticity which in turn improves the hand function but without any significant difference.

CONCLUSION

This study concluded that both hand splinting and stretching exercises are effective in reducing spasticity and improving hand functions in poststroke hemiplegia. However, the recovery of splinting group patients was clinically better than the stretching group, although the difference was statistically not significant.

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Nil.

Conflicts of Interest
There are no conflicts of interest.

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Parliamentary Bulletin Part-II

No. 58452   **Wednesday, January 2, 2019**   **Bill Office**

Reference of the Bill to the Department-related Parliamentary Standing Committee

Members are informed that the Chairman, Rajya Sabha on 2ⁿᵈ January, 2019, has referred the Allied and Healthcare Professions Bill, 2018, as introduced in the Rajya Sabha and pending therein, to the Department-related Parliamentary Standing Committee on Health and Family Welfare, for examination and report within three months.

Desh Deepak Verma
Secretary-General