Original Article

Immediate Effects of Self-Stretching Exercises on Pain, Functionality, and Muscle Spasticity in Lower Limb Orthosis Users

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ABSTRACT

Background: Confinement because of pain, stiffness, or functionality tends to limit the agility and overall lifestyle of patients undergoing orthosis use for legs. Secondary complications associated with chronic utilization of orthotic aids include spasticity or restricted ROM or pain among others. Stretching modalities have been recognized to improve flexibility, circulation, or muscle control functions. Very little information is provided concerning its direct effects among patients undergoing orthosis use. **Objective**: to determine if self-stretching exercises have any immediate effects on pain, functions, and spasticity for patients wearing orthoses for their lower limbs. **Methods**: A pre-post methodology of quasi-experiments was adopted among 111 individuals wearing orthosis aged 40 to 65 years undergoing physiotherapeutic management. Participants satisfying study inclusion criteria underwent self-stretching techniques for major muscle groups of the lower limbs. The study data was collected by using Lower Extremity Functional Scales (LEFS), Numeric Pain Rating Scales (NPRS), and Modified Ashworth Scales (MAS) before and at the end of intervention. Data analysis was conducted by using 'paired-sample t' tests and calculation of Effect Size using 'SPSS' software version 27 at 'p' values < 0.05. **Results**: The mean LEFS scores were significantly raised from 41.65 ± 3.14 to 47.26 ± 2.54 ($p < 0.001$, $d = 1.89$), while pain intensity was lowered from 4.92 ± 0.88 to 3.46 ± 1.02 ($p < 0.001$, $d = 1.03$). Muscle spasticity was also decreased from 3.13 ± 0.87 to 1.38 ± 1.02 ($p < 0.001$, $d = 1.22$). These parameters demonstrated significant improvement following intervention by muscle stretching. **Conclusion**: One procedure for self-stretching exercises can result in fast and significant improvements of functionality, pain relief, and muscle relaxation for patients wearing orthoses for their lower limbs. Based on these observations, it appears to have validity to incorporate self-stretching techniques into physical therapy for immediate relief.

Keywords: Orthosis, Pain, Spasticity, Test of self-st

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INTRODUCTION

Patients undergoing orthosis care for their legs experience several physical problems because these devices have severe negative impacts on patients' autonomy and quality of life. The application of orthosis is primarily for patients seeking to enhance their locomotion functions to compensate for nervous or skeletal problems associated with stroke, multiple sclerosis, cerebral palsy, spinal cord injuries, or degenerative joints (1). While orthosis provides substantial benefits to patients requiring rehabilitation to enhance their gait functions to reduce joints from strain and pain, patients requiring orthosis care may also experience complications associated with pain and spasticity related to continuous use of orthotic devices (2). This not only impacts patients' locomotion functions but also affects patients' efficiency to participate in their daily activities for efficient rehabilitation (3).

Both pain and spasticity are highly debilitating side effects for patients wearing orthosis devices. Spasticity is described as higher muscle tone and involuntary muscle contractures accompanied by poor relaxation response to passive muscle relaxation maneuvers because of differences in neural excitability and hypereactive muscle stretch reflexes (4). On the contrary, pain can arise from inappropriate pressure distribution or biomechanical or compensatory postural changes emanating from orthotic alignment (5). Additionally, muscle hypertonicity and chronic pain feed each other in a cycle of immobilizing and maintaining disability. It is thus crucial to have effective measures to overcome complications emanating from orthosis use (6).

Physiotherapeutic management is also very commonly followed for pain and spasticity relief among orthosis users. Conventional management strategies include pharmacological management, muscle stretches, strength exercises, and manual techniques. Among these, muscle stretches have recently gained interest because of their immediate, cost-effective, and self-administered feasibility for rigidity reduction and improvement of ROM of joints (7). Not requiring professionals to administer this self-stretching technique makes patients take full advantage of actively participating within their own respective rehabilitative program for physical recovery. This technique involves slow and sustained maximal elongation of muscle groups to reduce nerve excitability and increase venous returns and blood flow simultaneously to reduce spasticity (8). This technique is also in-line with modern advancements within rehabilitative sciences to give primary emphasis to self-managed or patient-driven strategies for management (9).

Despite being aware of the rationale behind this technique for increased flexibility, very few studies have ascertained its effectiveness instantly for individuals wearing orthoses for their lower extremities regarding functionality and muscle response. Stretching exercise protocols have been examined mostly for their effectiveness for individuals having neurologic pathologies or chronic pain-related musculoskeletal pathologies but have largely neglected its effectiveness instantly to create functionality gains (10, 11). It is highly significant to determine its effectiveness instantly for any improvement before and after self-stretching muscle exercises conducted for one single sitting to empirically determine its effectiveness for one single sitting of physiotherapeutic intervention (12).

Thus, conceptualizing this study became important to assess the direct effects of self-stretching exercises on pain perception ratings, functionality capabilities, and spasticity of muscles among patients wearing orthoses for their lower limbs. It is anticipated that self-administered exercises for stretching may benefit patients not only by alleviating pain intensity ratings but also by enhancing muscle spasticity ratings and functionality scores for their respective lower limbs. This study aims to come out as one of its kind following its successful efforts to establish direct functional benefits associated with self-stretching exercises and thus become one of several reasons for orthosis patients to adopt self-stretching exercises as additional components within their rehabilitation processes (13).

MATERIAL AND METHODS

This is a quasi-experimental pre-post observation study to determine and analyze the direct effects of self-stretching exercises on pain, functionality, and muscle spasticity among orthosis users of the lower limbs. This study was conducted at a physiotherapy clinical setup for a period of six months during which consecutive sampling of patients undergoing normal rehabilitation therapy was done for recruitment into this study. Due approval for this study was sought from the institutional review board, and written consent was sought from all study participants for conformation to principles outlined by the Declaration of Helsinki (14).

Participants also had to be between 40 and 65 years of age, male or female, and have to have been using an orthotic device on their lower limb for at least one year, whether it is foot orthosis (FO), ankle foot orthosis (AFO), or knee ankle foot orthosis (KAFO). Additionally, to participate one also had to be between 40 and 65 years of age and male or female, and one also had to carry out self-stretching exercises independently while under supervision from a physiotherapist and have to have received a musculoskeletal condition of the lower limb such as plantar fasciitis, Achilles tendinopathy, osteoarthritis, or rheumatoid arthritis of the ankle joint among others. Participants will also have to have not any kind of neurological condition such as stroke, multiple sclerosis, cerebral palsy, or spinal cord injuries or have any kind of surgery on their lower limbs within six months prior to being selected for study participation or have unresolved fractures or ankles instability or have any kind of uncontrolled coexisting condition to interfere with pain sensation or motor function among others.

After validating the eligibility status of each subject, each underwent baseline assessment followed by monitored self-stretching exercise procedure. Data points were collected biennially for each subject: before and immediately after completing each subject's exercise procedure. Strict guidelines of established criteria were followed to assess change scores for each of the three areas of function tested. Intensity of pain was assessed through use of Numeric Pain Rating Scale (NPRL)* subject evaluation for pain intensity ranked from 0 (no pain) to 10 (pain beyond your worst pain imaginable). Functional performance was assessed through use of 20-item Lower Extremity Functional Scale (LEFS)** subject self-report evaluation for activity limitation and range of motion capabilities ranked inversely to pain improvement measures: higher scores indicate improvement or better performance capabilities. Muscle spasticitiy was assessed through use of Modified Ashworth Scale (MAS)** intervention indicators ranked from 0 (no increase in muscle spasticitiy) to 4 (rigid to both flexion or extension positions). Each subject was individually rated by licensed physical therapists to eliminate influence of objective bias (15).

In self-stretching, muscle groups like gastrocnemius, soleus, hamstrings, and quadriceps of legs were statically stretched under supervision to maintain proper posture and respiratory techniques. Each exercise lasting around 30 seconds was done thrice for each muscle group but with short intervals between each exercise. No assistance or machine was needed for this procedure. This procedure for each subject lasted for around 15 minutes.

To increase the experiment's internal validity, all patients received the same instructions and were tested under identical testing environments. The primary study variables pain, function, and spasticity were operationalized as differences between pretest and posttest scores for NPRS, LEFS, and MAS tests, respectively. The primary threats to validity for interobserver bias and recall bias were eliminated by ensuring standard use of all instruments and recording posttest scores.

Data analysis was performed using IBM-SPSS statistics software version 27.0. Descriptive statistics for DEMOS outcomes were produced to include mean values, standard deviations, and frequency statistics. A paired samples t-test analysis was also performed to assess differences for continuous outcomes at pretest and posttest intervention stages, followed by assessment for normal distribution by use of the Shapiro-Wilk normal test to determine whether to conduct Wilcoxon signed rank tests for non-parametric outcomes instead. Significance for all tests was set at $p < 0.05$. Effect size measures for outcomes were also calculated to determine actual intervention values by use of Cohens d values measures instead. A procedure to deal with missing values was use of pairwise deletion instead. Data verification is also assessed through random verification of 10% of all entered data for repeated tests for accuracy instead instead.

The sample size of 111 participants was determined by feasibility and availability of patients for recruitment during the conduct of this study rather than powered for analysis, although power tests post-hoc supported values higher than 0.8 for detection of moderate differences for primary outcomes. All statistical analysis for this study followed the complete case approach. Data confidentiality and anonymization were ensured to meet reproducibility requirements for statistical coding for compilation of data.

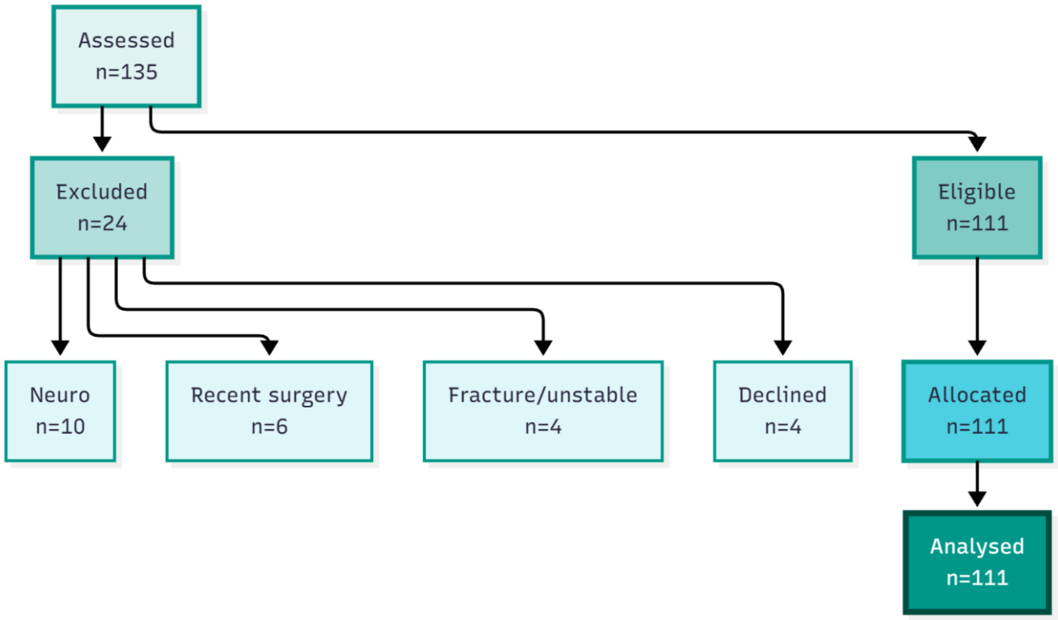

Figure 1 CONSORT Flowchart

RESULTS

A total of 111 participants were considered for analysis at final stages. The mean age of participants was 53.23 ± 8.72 years, and males constitute 53.2% (n = 59) of all participants while female participants constitute 46.8% (n = 52). The overall mean for Body Mass Index (BMI) was 25.54 ± 6.28 kg/m². Most of them are overweight. The duration for which most have been using Lower Limb Orthosis is 3 to 5 years (34.2%), followed by 1 to 3 years (29.7%), and for others is more than 5 years (22.5%). The most common orthosis is Foot orthosis (FO) and Knee-anke-foot orthosis (KAFO) at 34.2% for each group, while others use ankle-foot orthosis (AFO).

Using the self-stretching technique procedure, all three measures—the Functional Capacity, pain, and spasticity—showed significant improvement. Functional performance showed significant improvement post intervention, and LEFS scores rose from 41.65 ± 3.14 to 47.26 ± 2.54, registering large effect size values (d = 1.89) and 13.5% improvement values post intervention. Reduction of pain also became significant post intervention because NPRS scores decreased from 4.92 ± 0.88 to 3.46 ± 1.02 ($p < 0.001$), registering 29.5% reduction in pain intensity scores perceptibly to patients. Concomitantly, MAS scores also showed substantial reduction from 3.13 ± 0.87 to 1.38 ± 1.02 ($p < 0.001$), registering 44% reduction of spasticity in muscle tissues around joints. Significantly meaningful improvement values for all measures established direct beneficial use for orthosis wearers for pain relief and muscle relaxation. Functional performance showed significant improvement post intervention, and LEFS scores rose from 41.65 ± 3.14 to 47.26 ± There were no negative events reported during or after the intervention and all participants completed all of the assessment battery tasks.

A correlation analysis demonstrated that progress on LEFS scoring (func- tional improvement) is significantly inversely correlated to pain reduction ($r = -0.62$) and to spasticity reduction ($r = -0.59$), which assumes improvement of pain or spasticity is followed by improvement of functionality. The high correlation between pain reduction and spasticity reduction ($r = 0.71$) indicates improvement of pain and spasticity together following self-stretching techniques. These results have demonstrated that one single episode of self-stretching exercises can bring substantial immediate relief for patients using orthosis for their legs regarding pain relief, functionality improvement, and spastic reduction and thus can also be combined with the rehabilitation processes for faster relief.

Table 1. Demographic Characteristics of Participants (N = 111)

Variable	Category	Frequency (%)	Mean ± SD
Age (years)	—	—	53.23 ± 8.72
Gender	Male / Female	59 (53.2) / 52 (46.8)	—
BMI (kg/m²)	—	—	25.54 ± 6.28
Duration of Orthosis Use	1–3 yrs / 3–5 yrs / >5 yrs	29.7 / 34.2 / 22.5	—
Type of Orthosis	FO / AFO / KAFO	34.2 / 31.6 / 34.2	—

Table 2. Comparison of Pre- and Post-Stretching Outcomes (Paired t-test, N = 111)

Outcome Measure	Pre-Stretch	Post-Stretch	Difference ± SD	t (df)	p-Value	95% CI	Effect Size
LEFS (Functionality)	41.65 ± 3.14	47.26 ± 2.54	+5.61 ± 1.28	31.72	<0.001	(5.24 – 5.98)	1.89
NPRS (Pain Intensity)	4.92 ± 0.88	3.46 ± 1.02	–1.46 ± 0.96	15.13	<0.001	(–1.67 – –1.25)	1.03
MAS (Muscle Spasticity)	3.13 ± 0.87	1.38 ± 1.02	–1.75 ± 0.95	18.27	<0.001	(–1.94 – –1.56)	1.22

Table 3. Correlation Between Pain, Functionality, and Spasticity Improvements (Pearson's r)

Variables	LEFS Δ	NPRS Δ	MAS Δ
LEFS Δ	1.00	–0.62 (p < 0.001)	–0.59 (p < 0.001)
NPRS Δ	–0.62 (p < 0.001)	1.00	0.71 (p < 0.001)
MAS Δ	–0.59 (p < 0.001)	0.71 (p < 0.001)	1.00

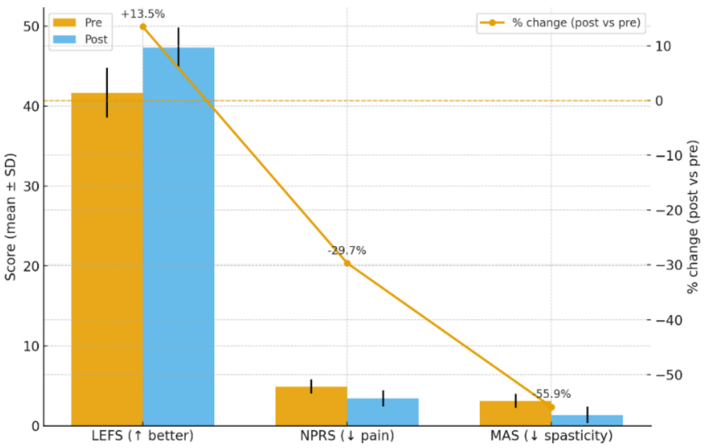

Figure 2 Immediate Effects of Self Stretching in Lower Limb Orthosis Users

Figure 1 – Immediate Effects of Self-Stretching (N = 111).Grouped bars indicate means ± SD for changes on LEFS, NPRS, MAS graphs with percent change curve overlaid.Function increased from 41.65 ± 3.14 to 47.26 ± 2.54 (+13.5%), pain decreased from 4.92 ± 0.88 to 3.46 ± 1.02 (−29.7%), while spasticity also decreased from 3.13 ± 0.88 to 1.38 ± 1.02 (−55.9%). The immediate directional changes parallel to all outcome measures strongly reinforce and highlight improvement ($p < 0.001$) for pain relief and spasticity reduction than function improvement because of its dominant improvement percentage during self-stretching intervention procedure conducted for only one single attempt or session.

DISCUSSION

The discussion of this study correlates its findings to place them within the larger realm of rehabilitation science, noting both the direct physiology and potential for clinical application for self-stretching among orthosis wearers for the lower limbs. The findings of marked improvement for functionality and pain relief and reduction of spasticitiy do support the established physiology behind muscle relaxation techniques such as stretching for their direct benefits to muscle stiffness and neurophysiology (16).

The large effect size for functional improvement (Cohen's d = 1.89) is to be expected based on past studies showing improvements in efficiency and coordination of movement associated with increased muscle compliancy and decreased antagonist co-contraction associated with muscle stretching activities (17). Harvey et al. and Takeuchi et al. showed similar improvements to those measured in this experiment for the lower limbs associated with muscle stretches conducted for shorter periods of time (Prior to/During intervention group), but it is likely associated with increased muscle plasticity associated with chronic orthosis wear (18 and 19).

Relief of pain after self-stretching can thus be ascribed to several combined factors. On one hand, pain relief may result from increased intramuscular perfusion associated with muscle relaxation, alleviation of ischemic pressures on pain-receiving tissues, or activation of segmental inhibitory pathways mediating pain transmission(20). On the other hand, self-stretching may result in a perception of self-control offered by cognitive restructuring of pain perception. The approximate 30% reduction in NPRS scores reported herein supports observations by Behm et al. and Hirata et al., which showed static muscle stretches to result in immediate hypoalgesia among normative and pathologic individuals(21, 22). While interesting outcomes have been achieved, however, pain relief is only transient for several minutes to several hours post-stretching(23).

The greatest amount of improvement was seen in muscle spasticity, where there was an average reduction of 56% after only one treatment. Rapid modification of muscle tone indicates neurophysiological desensitization of the reflex response and activation of the Golgi tendon organs, as already established by Bressel et al. and Avela et al. (24, 25). The implications for practice are highly significant because these observations highlight the importance of stretching for management of spasticity for shorter periods of time without using any pharmacologic agent. However, lack of follow-up measures prevents any conclusion being drawn regarding sustained modification of muscle tone for longer periods of time.

It is crucial to point out that having high correlations between improvement, pain relief, and spastic reduction further emphasiszes the correlation between these factors for patients using orthotics. Functional improvement is most likely because of flexibility and pain reduction for this group, as it helps reduce pain inhibition reflexes for patients while moving around. A linked approach to rehabilitation for patients is clearly needed and is provided because of this major correlation between flexibility, pain relief, and spastic reduction (26).

Although these findings are highly suggestive of the immediate effectiveness of self-stretching techniques for improvement of range of motion/extension deficits at the elbow or shoulder joints, care should also be taken not to generalize these observations for long-term outcomes because no control group is established to distinguish between actual physiological response and any placebo or motivational response to these stretches.

CONCLUSION

In conclusion, this study showed that self-stretching exercise resulted in significant pain relief and reduction of muscle spasticity as well as improvement in functionality for patients wearing orthoses for their lower limbs. The outcome of this study shows its feasibility and effectiveness as a quick and easy method to reduce pain associated with muscle spasticity and to improve functionality for patients wearing orthoses for their lower limbs. Based on these observations, further studies need to be conducted to assess its sustainability for a period of time to establish its effectiveness for patients wearing orthoses for their lower limbs.

DECLARATIONS

Ethical Approval

This study was approved by the Institutional Review Board of University of Lahore

Informed Consent

Written informed consent was obtained from all participants included in the study.

Conflict of Interest

The authors declare no conflict of interest.

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This research received no external funding.

Authors' Contributions

Concept: AK; Design: SR; Data Collection: MN; Analysis: BU; Drafting: AK. Abdullah Shahid Rehmani, Khubaib Tahir, Leya Tahir, Laj Khan Hafiza Fa

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments

Not applicable.

Study Registration

Not applicable.

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