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Efficacy of massage and stretching for controlling hamstring muscle spasticity in children with spastic diplegia cerebral palsy: A comparative study

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ABSTRACT

Background: Massage therapy is utilized to alleviate muscle spasticity in children with cerebral palsy, typically lasting at least 15 min per muscle group, which may result in lower family compliance with the home program. **Objective:** This study aimed to explore the impact of stretching alone or in combination with short-term massage on reducing hamstring muscle spasticity and enhancing knee range of motion (ROM) in children with spastic diplegia cerebral palsy. **Methods:** Twelve children diagnosed with spastic diplegia cerebral palsy (6–12 years old) were randomly divided into two groups: the first received massage and stretching exercises, and the second received stretching exercises only on the hamstring muscle. The Modified Ashworth Scale was used to measure the stiffness of the hamstring muscle, and the ROM of knee flexion was measured using a manual goniometer. ROM and modified Ashworth scale (MAS) were measured at baseline and after 1 and 2 weeks of treatment, respectively. Both legs of each participant received treatment for 2 weeks, with the duration of massage being 5 min and the duration of stretching being 30s with three repetitions. **Results:** Both methods reduced hamstring spasticity after two weeks; however, ROM improved after the first week and more significantly after the 2nd week. **Conclusion:** Stretching exercises, whether performed alone or in combination with short-term massage, have been found to be equally effective for treating spastic muscles. Although there was an improvement in spasticity after the first week of short-term massage, the difference was not statistically significant.

KEYWORDS

Spasticity, Cerebral palsy, Massage, Stretching Exercise, Physical Therapy, Rehabilitation.

1. INTRODUCTION

Cerebral palsy (CP) is a non-progressive disruption that occurs in the developing brain of the fetus or child. The incidence rate is approximately 3.4 per 1,000 live births which is considered the predominant motor impairment that may extend to cognitive and intellectual abilities (McIntyre et al., 2022). Brain lesions are the main and enduring condition, while orthopedic manifestations are secondary and gradually worsen (Hallman-Cooper et al., 2023). Their muscles frequently exhibit spasticity because of persistent activation of the central nervous system, resulting in continual contraction or hypertonicity of skeletal muscles (Bar-On et al., 2015). This condition of spasticity leads to tightening of muscles, which restricts walking and the ability to move joints and hinders the performance of voluntary movements required for everyday tasks (Ko et al., 2013; Cloodt et al., 2018; Skoutelis et al., 2020; Graham et al., 2021).

In the literature, there exist a multitude of recommended methodologies that can effectively treat or alleviate spasticity. These methods include pharmaceutical medications, physical interventions, and surgical operations that can be performed independently or in conjunction with one another (Sadowska et al., 2020). Nevertheless, there is currently no standard treatment strategy that effectively mitigates spasticity and its associated complications (Bingöl & Yılmaz, 2018). Various physical techniques have been employed to decrease spasticity, including therapeutic exercise, stretching, massage, and physical therapy modalities (Smith et al., 2012; Das & Ganesh, 2019).

Passive stretching is a commonly employed technique in patients with cerebral palsy to alleviate stiffness and spasticity, preserve ROM, and prevent joint contracture (Das & Ganesh, 2019; Fosdahl et al., 2019). Engaging in muscle stretching can induce several physiological changes. This results in an increase in the number of sarcomeres, which contributes to muscle elongation (Lieber & Friden, 2002). Furthermore, persistent stretching can lead to a durable alteration in fascial sheath length (Zhao et al., 2011). Stretching also produces glycosaminoglycans, gel-like molecules. This compound lubricates and loosens fascia fibers, preventing them from touching and adhering to the muscles, bones, and joints (Fede et al., 2018; Tohidnezhad et al., 2020). Various studies have indicated that the most effective stretching should be performed regularly, usually once or twice daily (Groppe et al., 2012; Theis et al., 2013). Stretching programs typically recommend engaging in a concise stretching routine that lasts for 30–60s (Stuberg et al., 2005). It has been found that a 30-second duration of static stretching for the hamstring muscles had better outcomes on 15s stretching and equivalent outcomes to a 60s or longer duration (Bandy & Iron, 1994; Groppe et al., 2012; Lee et al., 2020).

Massage therapy has been shown to be effective in decreasing spastic muscles with or without other physical therapy techniques (Gracies, 2001). The main goal of massage of muscular tissue is to enhance its nutritive, pliable, and vital state, thereby allowing the muscle to function at its maximum capability (Prentice et al., 2005). Massage can stretch and break down constricted or adherent tissue (Mumford, 2007). Several studies have investigated the impact of massage treatment in children and adolescents with cerebral palsy. The researchers observed a significant decrease in spasticity levels, as assessed using the modified Ashworth scale (MAS) and Gross Motor Function Measure-66 (GMFM-66) (Wang et al., 2008). Different types of massage, including functional, Swedish, traditional, and deep friction massage, have been reported to effectively decrease muscular spasticity in children with CP (Bingöl et al., 2020). The massage session usually lasts for 15–30 min for a single muscle or muscle group (Macgregor et al., 2007; Rasool et al., 2017) which is considered a relatively long procedure for parents to adapt to home program exercises. Studies have shown that parental compliance according to the prescribed home regimen is approximately 40% (Chappell & Williams, 2002; Louka–Lazouri et al., 2020). The complexity and time required to perform the prescribed regimen are considered barriers for parents to perform home exercise programs (Gajdosik, 1991; Lillo-Navarro et al., 2015). It is important to keep in mind that long-term rehabilitation programs require simple and less time-consuming home program exercises for the parent or caregiver to achieve better compliance and outcomes (Gajdosik, 1991; Lillo-Navarro et al., 2019).

Therefore, incorporating a combination of stretching and massage techniques can provide optimal benefits for reducing spasticity and improving hamstring flexibility. The effective stretching time as reported 30s to 60s for a muscle or muscle group is considered a short time compared to massage sessions that range from 15 to 30 min. We do not know if shortening this time would be beneficial to spastic muscles, which may in turn increase family compliance in performing home exercise regimens for their children. The purpose of this study was to investigate the effects of short-term massage and static stretching on the hamstring muscles in children with diplegic CP. We hypothesized that incorporating static stretching and short-term massage would produce superior outcomes in reducing muscle spasticity and improving range of motion (ROM) in children compared to using static stretching of the hamstring muscles alone.

2. MATERIALS AND METHODS

2.1. Study design

This study used a pretest-posttest control experimental design.

2.2. Subjects

A sample 12 spastic diplegic children 7 males and 5 females aged 6-12 (9.6 ±1.6) years was recruited from a special needs school and CP center of the Cerebral Palsy Society in Amman, Jordan. The study participants showed mild to moderate spasticity, were able to communicate, had not undergone lower limb surgery within the 12 months prior to the study, did not have fixed contractures, had not received lower-limb botulinum toxin injections in the 6 months before the study, and were not undergoing pharmacological treatment for spasticity. This study did not include children with compound impairments, dyskinesia, dystonia, or inability to follow directions. The children and their parents/guardians provided written informed consent to participate in the study, in accordance with the Declaration of Helsinki. The Hashemite University Institutional Review Board authorized the study and consent forms. The participants were randomly divided into two groups. The massage group included 6 children (4 males and 2 females) with a mean age of 9.2±1.8 years. The second group, the stretch group (n=6, 3 males and 3 females), had a mean age of 10.3±1.2 years.

2.3. Procedures

Spasticity and ROM assessments were performed by experienced pediatric physiotherapists. They had more than five years of experience and were proficient in the routine use of a goniometer and MAS in their assessments. ROM and MAS measurements were performed on the left and right knees at baseline and at the end of the first and second week of treatment (Table 1). The therapists' intra- and inter-rater reliabilities were assessed using intraclass correlation coefficients (ICCs). The intra- and interrater reliabilities of the MAS had ICCs of 0.94 and 0.84, respectively. For the intra- and inter-rater reliabilities of knee ROM, the ICCs were 0.92 and 0.89, respectively. Three children with CP who were not involved in the study were included in the reliability study.

Hamstring muscle spasticity was evaluated in all patients using the MAS as defined by Bohannon & Smith (1987). The patient lay supine on the treatment table, and the therapist flexed the participant's hip to a 90 °angle, enabling the knee to fully flex under the influence of gravity. The therapist performed a quick knee extension by manipulating the ankle with one hand and stabilizing the thigh with the other hand. Afterward, the MAS was measured for one knee, and the same technique was replicated for the other knee. The MAS measures muscular tone, with a score of 0 indicating no increase in muscle tone and a score of 5 indicating rigidity in the region of concern, either in flexion or extension. The scoring for MAS was as follows: 0=0, 1=1, +1=2, 2=3, 3=4, and 4=5 (Dursun et al., 2021).

To measure knee ROM, each participant was positioned in a supine position on a treatment table, with natural resting lordosis of the spine and both hips completely extended. A marker was used to designate and assess knee flexion at three reference sites. The anatomical structures mentioned include the greater trochanter, the lateral condyle of the femur, and the lateral malleolus. Next, the hip and knee on the same side were flexed at a 90-degree angle. This was followed by extending and bending of the knee three times to alleviate any potential early muscle stiffness. Subsequently, the knee on the same side was straightened from 90 degrees until the point of maximum resistance was reached. Upon reaching the point of maximum knee extension, the pivot point of the goniometer was positioned directly above the lateral epicondyle of the femur. The fixed arm was then aligned with the femur and the greater trochanter, while the movable arm was aligned with the lateral malleolus. The measurement was taken in degrees by subtracting the obtained value from 90 degrees, and any missing degrees of full extension were recorded.

2.4. Intervention

During the massage session, each participant was placed in a prone lying posture with their knees slightly flexed at a 20-degree angle using a foot roll for support. Before performing massage, 5 mm of paraffin oil was applied to the back of the leg to minimize any friction that may cause skin damage. Subsequently, a series of Swedish massage techniques were executed for a duration of 5 min. The sequence comprises of three distinct timed strokes. The massage commenced with effleurage for 30s, followed by alternating between petrissage and friction for 2 minutes each, and concluded with another 30s of effleurage. Stretching of the hamstring muscle commenced after the completion of the massage session. The child was placed in a supine position with the opposite leg remaining parallel to the examination table. The therapist then flexed the hip joint to a right angle and extended the knee until the hamstring muscle was fully stretched, as indicated by the child's verbal or facial response, which was just below the threshold of discomfort. This process was maintained for a period of 30 seconds and was repeated three times, with a 15-second resting period between each repetition. The participants in the massage therapy group were provided with both massage therapy and stretching therapy, while the stretching therapy group was given only stretching therapy. Both groups received their respective treatments five times per week for a period of two weeks.

2.5. Statistical analysis

Data were analyzed using the statistical analysis software program SPSS v25 for Windows (SPSS Inc., Chicago, IL, USA). Descriptive values are presented as means ±standard deviation (M±SD).

Repeated measures ANOVA was used to compare the mean within subjects, and pairwise comparison was used to compare the mean within the group at baseline,1st week and 2nd weeks. To compare the differences between the two interventions, an independent t-test was used to compare the means of the massage and stretch groups. In addition, the side of the knees was used as a factor to examine the difference between the right and left knees in each group. A two-tailed value of $p< 0.05$ was considered statistically significant.

3. RESULTS

3.1. Range of Motion

An analysis of variance (ANOVA) repeated measurement test revealed a significant improvement in knee extension ROM in both groups over time ($p< 0.01$). Pairwise analysis revealed a statistically significant improvement in knee ROM after the first ($p<0.01$) and second ($p < 0.01$) weeks compared to the baseline measurement. Furthermore, the data indicated that the increase in ROM during the second week ($p<0.01$) was significantly greater than that observed in the first week. Both treatment methods showed similar effects on ROM improvement in both the knees.

3.2. Spasticity (MSA)

Repeated-measures ANOVA indicated that both groups showed a significant and consistent reduction in spasticity over time ($p< 0.01$). Pairwise analysis showed no statistically significant reduction in spasticity after the first week ($p>0.05$); however, spasticity was significantly decreased in the second week ($p< 0.01$) compared with baseline and the first week ($p< 0.01$).

The potential impact of knee side, either left or right, in conjunction with the time variable was investigated by using a repeated-measures analysis of variance. The findings of the analysis did not reveal any notable interactions between the time variable and knee side in either group. In both groups, the knees exhibited considerable improvement over time, and there was no statistically significant discrepancy in range of motion or muscle tone between the right and left sides for both the massage ($p=0.4$) and stretch ($p=0.1$) groups. Additionally, the independent t-test did not reveal any statistically significant differences ($p>0.05$) in ROM or MAS scores for muscle tone between the two groups after the first and second week. Therefore, we repeated the analysis previously performed to use the average ROM and MAS score of both knees and reached the same conclusion.

Table 1. Baseline information of the participants

	Male	Female	N	Age (M±SD)
Participants	7	5	12	9.8±1.6
Massage Group	4	2	6	9.2±1.8
Stretching Group	3	3	6	10.3±1.2

N: number, **M±SD**: mean ± standard deviation

Table 2. The mean and the standard deviation of Modified Ashworth Scale (MAS) of the left and right knees

Group	Left Knee						Right Knee						Average MAS					
	BL		W1		W2		BL		W1		W2		BL		W1		W2	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Massage group	2.8	0.4	2.3	0.5	1.3*	0.5	2.5	0.5	2.2	0.4	1.7*	0.5	2.7	0.5	2.3	0.5	1.5*	0.5
Stretching group	2.5	0.5	2.5	0.5	1.7*	0.5	2.7	0.5	2.5	0.5	2.2*	1.0	2.6	0.5	2.5	0.5	1.9*	0.8

M: mean, **SD**: standard deviation, **BL**: baseline, **W1**: after one week, **W2**: after two weeks.

* Significantly different compared to the baseline and the first week measurements.

Table 3. The mean and the standard deviation of the range of motion (ROM) of the left and right knees

Group	Left Knee						Right Knee						Average ROM					
	BL		W1		W2		BL		W1		W2		BL		W1		W2	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Massage group	23.8	7.7	21.5*	7.3	16.2**	7	25.5	6.7	23.3*	6.6	19.2**	6.0	24.7	7.0	22.4*	6.7	17.7**	6.4
Stretching group	19.2	7	17.2*	5.9	15.8**	5.6	20.3	7.9	18.8*	7.7	18.0**	7.2	19.8	7.1	18.0*	6.6	16.9**	6.2

M: mean, SD: standard deviation, BL: baseline, W1: after one week, W2: after two weeks.

* Significantly different compared to the baseline measurement.

**Significantly different compared to baseline and first week.

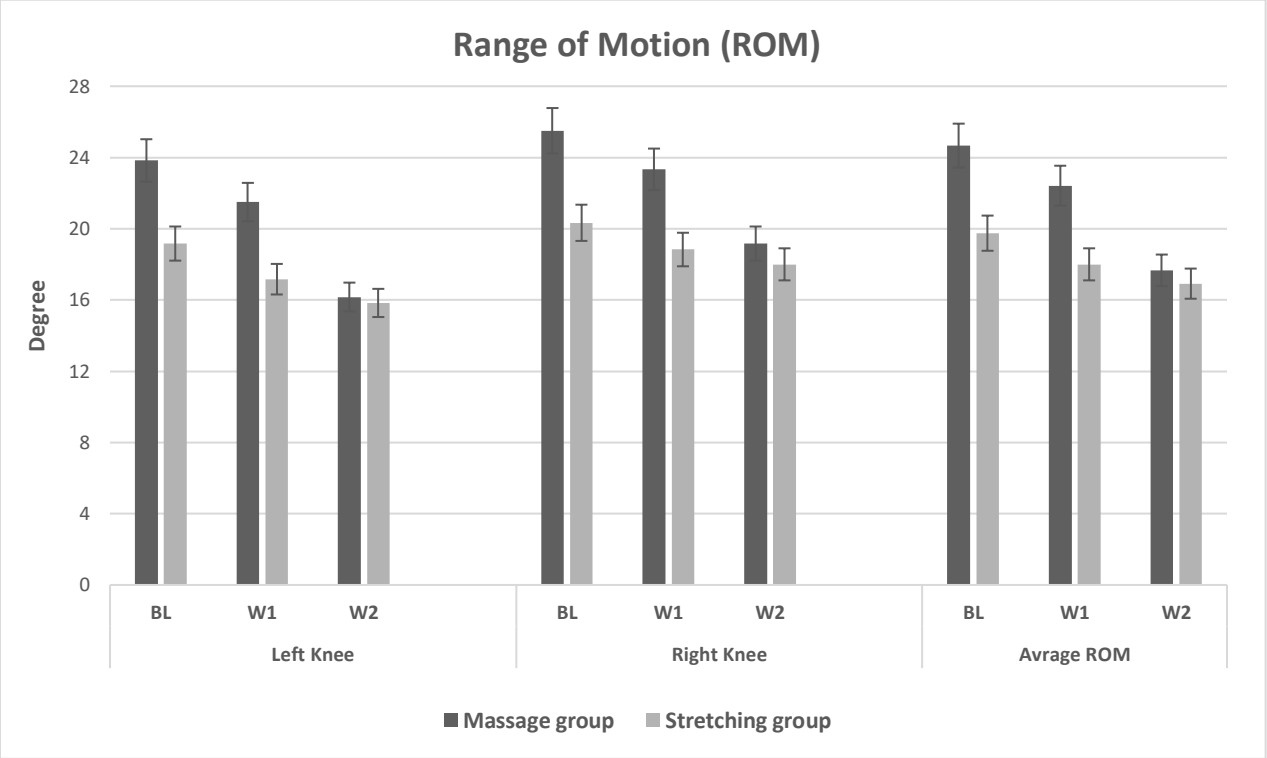

Figure 1. Mean values of missing range of motion for the right and left knees and the average of both knees at baseline (BL), after week one (W1), and after week two (W2)

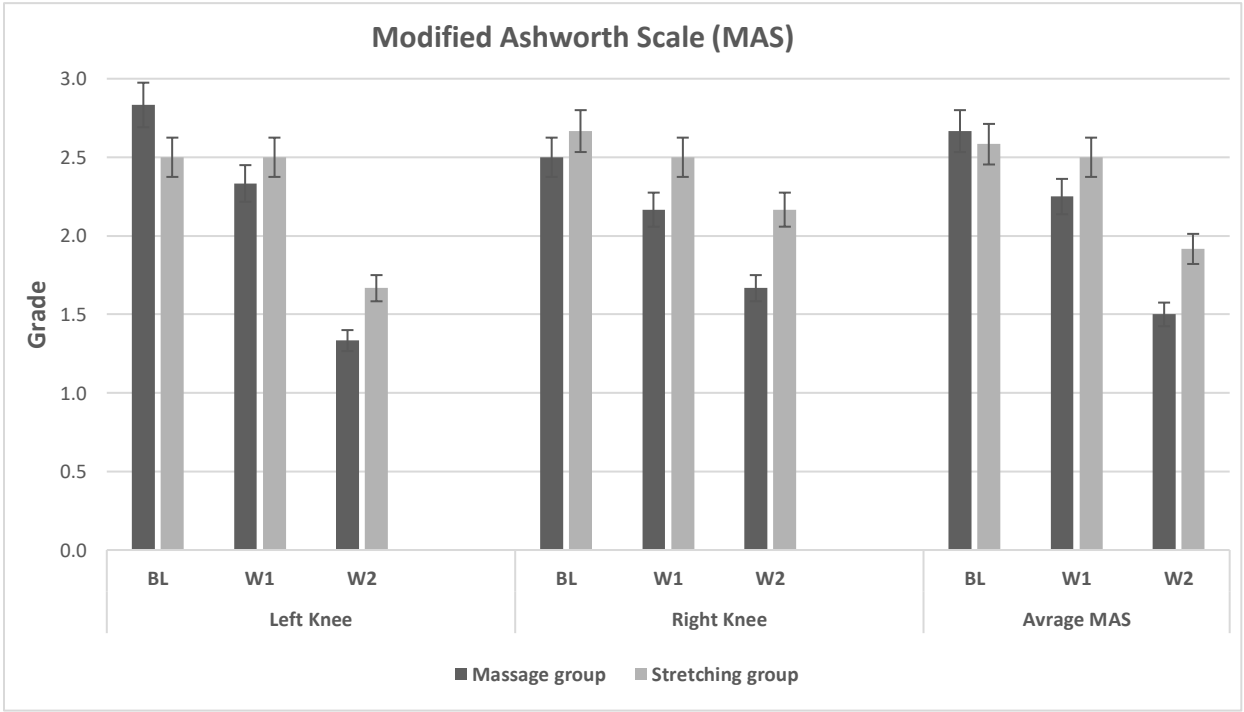

Figure 2. The bars represent the mean values of the Modified Ashworth Scale (MAS) for both the right and left thighs, and the average mean values for both thighs at baseline (BL), after week one (W1), and after week two (W2)

4. DISCUSSION

The aim of this study was to determine whether children diagnosed with diplegic cerebral palsy could benefit from combining two therapeutic techniques to successfully decrease hamstring spasticity and reduce treatment duration. In order to improve the knee's ROM and decrease spasticity in the hamstring, we suggested that a combination of passive stretching, and a brief 5-minute massage would be more advantageous than performing stretching exercises alone. Our findings indicate that short-term massage therapy does not offer any greater benefits in terms of reducing muscle spasticity compared to stretching alone, contrary to our initial hypothesis. A 15–45 min massage effectively reduced muscular stiffness, according to previous research (Macgregor et al., 2007; Wang et al., 2008). This is the amount of time that needs to pass before each set of spastic muscles in a child with CP can be treated. However, this may pose a challenge for the patient's family or caregivers to adhere to the prescribed home program (Gajdosik, 1991; Lillo-Navarro et al., 2019).

Aside from the treatment duration, the intensity of massage is regarded as a critical component of its efficacy. Van Pelt et al. (2021) observed that a massage with a fixed frequency and duration at a force of 4N had more beneficial effects on the muscles of rats than those massaged with a force of 1.4N, which was ineffective, or 11N, which caused muscle injury. To surmount the shielding effects of the extracellular matrix, which are heightened in the spastic muscles of children with CP, this type of force is required to reach myofibers (Van Pelt et al., 2021; Konno et al., 2022). In the previously mentioned research, a mechanism was specifically designed to precisely regulate the force applied. This mechanism was used in the study, and the massage pressure applied was enough to cause skin blanching without causing discomfort. Massage therapy is considered a valuable aid in physiotherapy, in addition to conventional physiotherapy and professional rehabilitation, according to a study by Moyer et al. (2004).

Muscle tightness is attributed to a reduction in the muscle's elongation capacity, which subsequently diminishes the ROM of the joint on which the muscle acts (Akinpelu et al., 2005). Stretching exercises are without a doubt one of the most effective treatment modalities for spasticity (Bandy & Iron, 1994; Gracies, 2001; Stecco et al., 2021). Nevertheless, when integrated with additional physical therapy modalities, such as electrical stimulation (Greve et al., 2022), diathermy (Almalty et al., 2023; Picelli et al., 2023), heat (Lee & Ng, 2008), and cryotherapy (Garcia et al., 2019) would augment the effectiveness of passive stretching exercises in the treatment of spastic muscles. Furthermore, in line with previous investigations, static stretching lasting only 30s yielded a noteworthy enhancement in ROM and spasticity, thereby demonstrating that stretching routines do not

require extended periods of time (Groppe et al., 2012). Furthermore, Farrow et al. (2023) found that a 15-second static stretching exercise decreased the stiffness of the hamstring muscles in both young and elderly individuals without any health issues. However, for those with spastic CP muscles, a 15-second stretching exercise was not as beneficial as a 30-second (Lee et al., 2020). The stretching duration used in this study, which was 30s, was regarded as a suitable standard time. This is because the relaxation of muscle stress occurs within the first 20s (McNair et al., 2000; Duong et al., 2001). To prevent related deformities in spastic infants such as increased thoracic kyphosis, decreased lumbar lordosis, posterior pelvic tilt, and knee flexion posture, it is important to focus on reducing hamstring tightness (McCarthy & Betz, 2000).

According to current understanding, a considerable amount of passive stiffness within a muscle bundle is attributed to the thickening of collagen fibers and the reduction in the quantity of sarcomeres, concurrent with an increase in their length (Konno et al., 2022). These changes in muscle affect can be mitigated by stretching and massaging. To date, no study has revealed the superiority of the current approaches used for the treatment of spasticity. Thus, there is still no standard treatment approach for decreasing the severity of spasticity and muscle stiffness (Sadowska et al., 2020). Despite the ongoing debate around passive stretching in academic literature, it remains the most practical and efficient therapy for treating spastic muscles (Bryant et al., 2023; Zaidi et al., 2023). Moreover, studies have indicated that the effectiveness of stretching is not only confined to the limb being stretched, but it also enhances the ROM in the opposite limb52. There is some debate over the efficacy of stretching exercises, which may produce only modest improvements (Akinpelu et al., 2005). The results of this study demonstrated a superior outcome in regard to ROM and MAS by the end of the second week. Despite not showing statistical significance after the first week, the MAS measurements in the massage group were lower than those in the stretching group (Table 2). It is important to note that applying classic passive stretch exercises to muscles with spasticity may cause discomfort or pain (Wallen et al., 2013). Therefore, it is recommended to use stretch exercises combined with massage therapy when treating spastic muscles (Moyer et al., 2004).

The results of our investigation raise questions about the cause of the apparent increase in ROM after one week of treatment, whereas the reduction in spasticity exhibited only marginal improvement and lacked statistical significance. The improved flexibility of non-contractile tissues of the knee joint may be responsible for this improvement. Nevertheless, there is a complex interaction between various factors that can potentially result in the formation of joint contractures. This condition may arise due to tightness in the muscles, fascial contraction, and capsuloligamentous structures of the joint (Page,

2012). Hence, passive stretching exerts tension on all of these components, comprising diverse tissues and distinct biomechanical characteristics. Passive stretching can alter the composition of collagen and glycosaminoglycans (GAGs) in the extracellular matrix at cellular level (Abusharkh et al., 2021). In addition, there is a decrease in the levels of soluble transforming growth factor β1, which plays a role in stimulating the production of collagen and proteins in the extracellular matrix (Bouffard et al., 2008). However, Zaidi et al. (2023) have demonstrated that static stretching of the hamstring muscle for 80s leads to both immediate and long-term improvements in knee ROM. According to Brusco et al., an immediate or short-term increase in ROM can be linked to an increase in stretch tolerance, which reduces the feeling of stiffness in the patient's muscles and joints. Owing to the complicated relationship between contractile and non-contractile tissues at the biomechanical and molecular levels, it is challenging to provide a specific explanation for why ROM improves faster than spasticity.

5. CONCLUSIONS

Our investigation revealed that there was no statistically significant difference between doing a 5-minute massage with stretching and employing stretching for 30s three times daily in terms of enhancing knee ROM and reducing stiffness in the hamstring muscle. Nevertheless, to enhance patient comfort, we suggest utilizing this combined approach of massage and stretching. By effectively managing hamstring muscle spasticity within a short timeframe, we provide valuable insights for further investigation into the potential effects of shorter treatment durations on various aspects of family psychological support. This research may enhance family motivation and compliance in sustaining treatment for children with cerebral palsy.

The investigation's brief duration of two weeks and the modest sample sizes in both groups presented limitations to the study. It does, however, offer scientific proof that affordable and simple methods can improve the care of children with spastic diplegia. Subsequent studies ought to investigate these effects in further detail by expanding the sample sizes, prolonging the durations, and integrating a range of factors, including variations in gender-specific flexibility. Ultimately, a more thorough examination of the data around contractile tissue flexibility and massage, as well as the potential impact of the family's involvement in the program, may prove beneficial.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to the study's design, data collection, analysis, interpretation, and manuscript preparation. All authors reviewed and approved the final version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available on request from the corresponding author.

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