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Effect of physical therapy intervention on thickness and ratio of the sternocleidomastoid muscle and head rotation angle in infants with congenital muscular torticollis

A randomized clinical trial (CONSORT)

Seonghyeok Song, MSc[a], Wonjeong Hwang, PhD[b], Seungwon Lee, PhD[c,*]

Abstract

Background: Early diagnosis as well as treatment is important in management of congenital muscular torticollis (CMT). The purpose of this study was to find an effective physical therapy modality to improve the sternocleidomastoid (SCM) muscle thickness, the ratio of the SCM muscle thickness on the affected side to that on the non-affected side (A/N ratio), and head rotation in infant under 3 months of age diagnosed with CMT.

Methods and analysis: A single-blind, randomized clinical trial was conducted. Participants were assigned in one of the 3 study groups through randomization. The treatment was performed 3 times a week for 30 minutes until the head tilt was ≤5 degrees. Group 1 was treated by handling for active or active-assist movement, group 2 was treated with passive stretching, and group 3 was treated with thermotherapy. For general characteristics, a χ^2 test and 1-way analysis of variance were used. Intragroup differences were analyzed using a paired *t* test, and intergroup differences were analyzed using an age-adjusted analysis of covariance.

Results: After the intervention, there was no significant difference between groups in terms of SCM thickness on the affected side and A/N ratio ($P > .05$). Degree of head rotation on the affected side showed significant differences between groups ($P < .05$), with Group 2 showing significantly better results than group 1 and group 3 ($P < .05$, both).

Conclusion: Passive stretching treatment was more effective than other treatments of this study for improvement in degree of head rotation in CMT infants under 3 months of age.

Trial registration: The trial is registered at the Institutional Review Board of Sahmyook University (IRB number, 2-7001793-AB-N-012019103HR) and the Clinical Research Information Service (CRiS; registry number, KCT0004862)

Abbreviations: A/N ratio = ratio of the thickness on the affected side to that on the non-affected side, CMT = congenital muscular torticollis, ROM = range of motion, SCM = sternocleidomastoid muscle.

Keywords: congenital muscular torticollis, handling, passive stretches, positioning, sternocleidomastoid muscle

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[a] Department of Physical Therapy, Graduate School of Sahmyook University, [b] Research Facility of Academy of Women's Health in Physical Therapy, [c] Department of Physical Therapy, College of Health and Welfare, Sahmyook University, Seoul, Republic of Korea.

[*] Correspondence: Seungwon Lee, Department of Physical Therapy, College of Health and Welfare, Sahmyook University, 815 Hwarang-ro, Nowon-gu, Seoul 01795, Republic of Korea (e-mail: swlee@syu.ac.kr).

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1. Introduction

Congenital muscular torticollis (CMT) is a musculoskeletal disease caused by shortening of the sternocleidomastoid (SCM) muscle and resulting in ipsilateral bending of the head and contralateral rotation of the chin.[1] As there is an imbalance in the muscles around the neck in torticollis, infants with CMT prefer unilateral use, and the normal developmental movements such as head control, rolling, reaching, sitting, crawling, and bilateral coordination skills are disrupted. In addition, CMT can cause facial asymmetry.[2,3]

It is already common knowledge that the age of diagnosis of CMT is low,[1,4,5] and some reported mean age at which CMT is diagnosed ranges from 1 to 2.3 to 4 months.[1,4,6] However, despite the emphasis on the importance of early treatment for CMT,[1,4,7–10] there are few studies on infant under 3 months of age who need early intervention.

Among various conservative therapies for CMT, passive stretching exercise is a general physical therapy[4,11,12] and an effective, stable treatment for patients younger than 1 year.[4] A study reported that 90% of CMT problems were managed by passive stretching, and only 10% of the cases needed surgical intervention.[13]

However, infants who receive passive stretching often cry during the therapy and refuse the treatment; this is observed more commonly in infants older than 3 to 4 months of age. Therefore a treatment that triggers active participation of an infant has recently been applied on the basis of the dynamic theories of motor control.[14] In other words, the treatment makes the infant's functional movement more natural through handling. In one study, there was no difference in the thickness of the SCM tumor and mean treatment duration between the manual stretching group and postural control group among infants younger than 6 months, indicating that postural control has a therapeutic effect.[9]

According to Yim et al,[15] 85% to 90% of infants with CMT visit a hospital before 3 months of age, and passive stretching is primarily used in these infants to stretch the shortened SCM muscle. However, a passive stretching treatment causes an infant to resist the therapist's hand, cry, or feel pain. Active or active-assist movement treatments can eliminate the risk of resistance, crying, pain, and soft tissue damage. In addition, infants can explore the environment and actively participate in the treatment, but only a few studies have been conducted on patients with CMT. In particular, studies on the effectiveness of treatment for younger infants have not been actively conducted.

Therefore, the aim of this study was to identify an effective physical therapy method for CMT infant under 3 month of age among three treatments: handling for active or active-assist movement treatment, passive stretching treatment, and thermotherapy. We had the following hypothesis. First, the physical therapy method will affect the thickness of the affected side SCM muscle. Second, the ratio of SCM muscle thickness on the affected side to that on the nonaffected side (A/N ratio) will differ according to physical therapy method. Third, depending on the physical therapy method, the head rotation on the affected side will be impacted.

2. Methods

2.1. Study design and setting

This study was single-blind randomized clinical trial. The following criteria were used for site selection: should be a city rehabilitation center or hospital, must have physical therapists who can treat CMT patients professionally, should have outpatient treatment available for continuous physical therapy for CMT patients, and should treat at least 60 infants with CMT. On the basis of satisfying these criteria, a rehabilitation center in Yongin city in Korea was selected for this study (January to February 2020).

2.2. Participants

We screened 66 infants who decided to participate in this study. The eligible participants for inclusion were infants under 3 month of age who were diagnosed with CMT by a medical doctor and had a head tilt >15 degrees. Exclusion criteria were as follows: ocular torticollis, neurological complications, musculoskeletal disorders in the cervical spine, visual disorders, and auditory disorders.

2.3. Intervention

Each group received a 30-minute treatment, three times weekly, conducted by a physical therapist with ≥7 years of experience in manual therapy. In groups 1 and 2, with exercise as intervention, patients performed the same exercise for 15 minutes of the 30-minute treatment time. These exercises were conducted to control the infant's posture and use the major muscles according to the developmental stages, based on age-related reflex integration steps. Group 3 received only thermotherapy. The end point of each treatment was achievement of a symmetrical neck. The treatment was terminated when the head tilt measured by an arthrodial protractor was ≤5 degrees.[9]

For group 1, after 15 minutes of common initial exercise, 15 minutes of handling for active or active-assist treatment using positioning, eye tracking, tonic neck reflex, and righting reaction were performed to elongate the SCM on the affected side and strengthen the non-affected side by active movement or active-assistive movement through spontaneous heading toward environmental stimulation. For example, in infants aged 3 months or younger when active neck movement was impossible, passive stretching was not applied in the supine position; instead, the weight of the infant's head was slowly shifted to the affected hemi-occiput to enable head movement to the opposite side for midline positioning, and this position was maintained for seconds to induce reactions. In the developmental stage, infants who are stimulated by auditory stimuli more strongly than visual stimuli are continuously exposed to an environment in which their heads can move in response to auditory stimuli. Because the infant is unable to turn the head alone, a therapist continuously assists the infant to lift his or her buttocks, lengthen the shortened SCM muscle, and turn the head toward the sound or maintain the midline. By pulling the infant's arms forward for the pull-to-stand position, active contraction of both SCMs was promoted as the infant tucked his/her chin to raise the upper body. In the side-lying position, the SCM was elongated and induced to be in midline orientation by placing a towel underneath the infant's head or shoulders or by using the therapist's arm as support (Fig. 2). Subsequently, the SCM on the nonaffected side was strengthened by eye tracking, neck righting reaction, and postural control through toys and postural stimulation, and the SCM on the affected side was elongated (Fig. 3A and B). In cases in which the infant could move his/her head without assistance, various postures were actively tried to give him/her an opportunity to use the SCM. In the prone position, eye tracking was induced by using toys to promote neck control. By supporting the infant's weight using the therapist's forearm on the affected side, righting reaction on the neck and rolling were induced. In the sitting position, eye tracking using toys and righting reaction through weight shifting were induced (Fig. 4). In these ways, the therapist gave the infant opportunities to actively use the SCM by handling him/her in various positions.

For group 2, after 15 minutes of common initial exercise, 15 minutes of passive stretching was performed. For this, in the supine position, lateral flexion and rotation were performed on the opposite side by the therapist for slow stretching of the shortened SCM. The stretch was maintained for 10 seconds at the end range of movement. Depending on the infant's age and condition, such as the level of crying, the stretch was conducted 10 to 20 times in one go and repeated after a 1-minute rest.

For group 3, on the affected SCM, therapeutic ultrasonography was performed at 3 MHz, 1 to 5 W/cm^2 with a 1-cm Doppler probe for 30 minutes at a time.[16]

All caregivers were educated on how to perform the good posture at home and monitored periodically every 2 weeks.

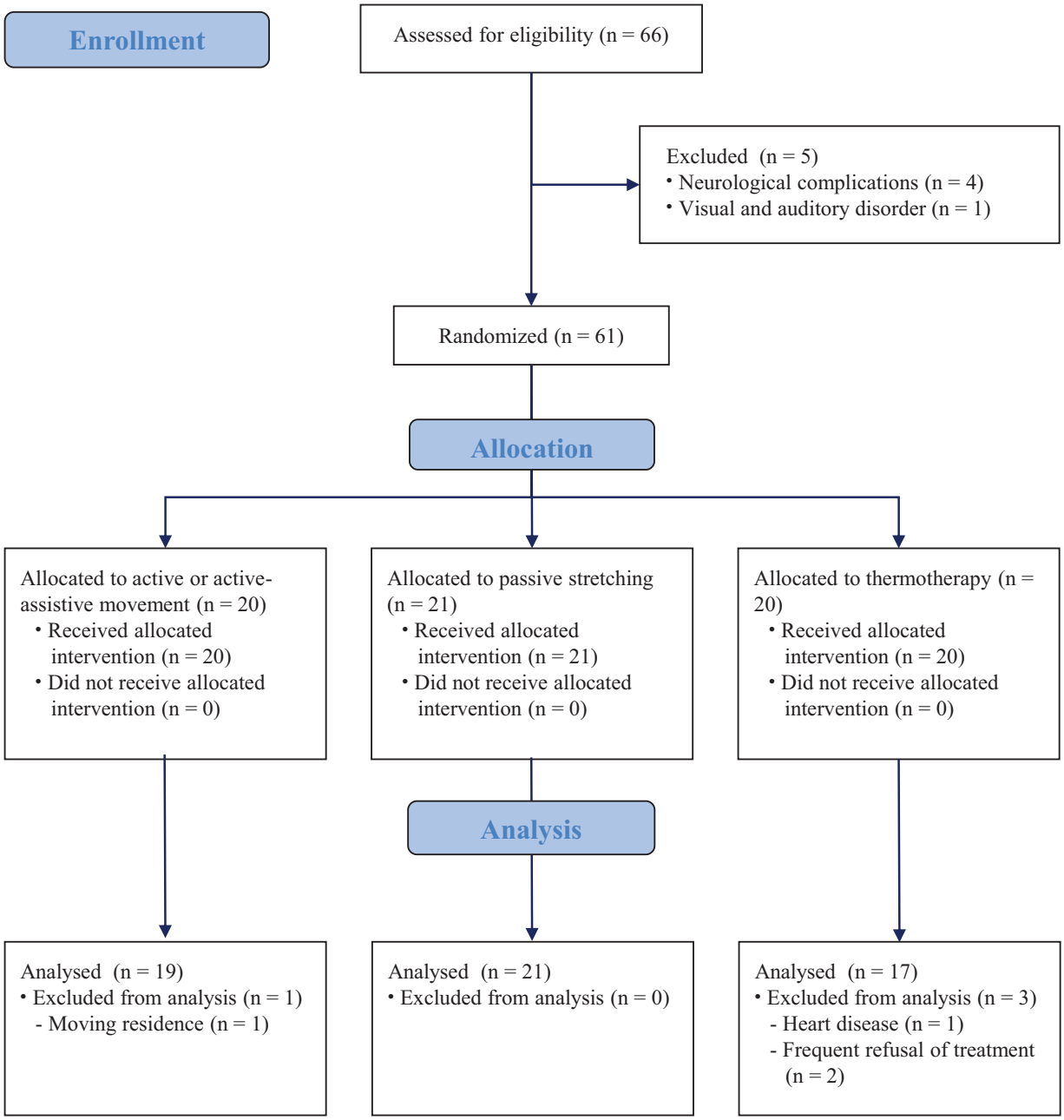

Figure 1. Flow diagram for patient enrollment.

2.4. Outcome measurements

The primary outcomes of measurements were SCM muscle thickness and SCM A/N ratio. Diagnostic ultrasonography is a primary evaluation tool used to measure muscle thickness safely and easily in infants with CMT.[17–19] The thickness of the SCM muscle was measured by a medical doctor using diagnostic ultrasonography (E-CUBE 11, Alpinion Medical Systems Co., Ltd., Seoul, Korea). For the measurement, the infant's neck was rotated 45 degrees to the opposite side with a thin pillow placed underneath the infant's shoulders while in the supine position; this movement led to elongation of the SCM muscle.[16,20] The thickness of the SCM muscle was measured at the thickest point between the superficial surface and the deep aponeurosis, by placing the Doppler probe on the middle of the muscle at a right angle. The ratio of the SCM thickness was the ratio of the thickness on the affected side to that on the nonaffected side.[16] There is a correlation between the SCM muscle thickness and SCM A/N ratio during the rehabilitation period.[21]

The secondary outcome of measurement is neck functional status from passive range of motion (ROM). In multiple studies, rotation and lateral flexion have been used to determine the neck functional status of torticollis.[16,22,23] To measure the ROM of the neck, the infants were placed in the supine position while the caregivers held the shoulders, whereby the passive ROM was measured by performing head rotation using an arthrodial protractor. Head tilt was measured with arthrodial protractor.

Figure 2. Handling an infant in the side-lying position.

Figure 3. Handling an infant through various methods. (A) Handling an infant in the side-lying position using a toy for eye tracking, (B) handling an infant in the side-lying position using a book for eye tracking.

Figure 4. Handling an infant through righting reaction in the sitting position.

Infants was placed in a supine position on the table, and the therapist stabilized infant's shoulder and measures the tilted angle of the head.[18,20] Measurements were taken before intervention and at the end of treatment.

2.5. Sample size

The sample size was calculated using a repeated measures design formula considering 2 factors: group and time. This study set the 0.25 effect size and 80% power ($\alpha = 0.05$) in 3 groups using G-power software (version 3.1.9.6 for Mac), resulting in a total of 54 participants. We selected participants with a total of 60 more, considering to account the 10% dropouts.

2.6. Randomization and blinding

A total of 61 eligible infants whose caregivers understood the aim of this study and agreed to provide written consent were participated. Informed consent was obtained from the caregiver of the patients for participation in the study and the publication of this case report details. The participants were randomly

Table 1

General patient characteristics.

Variables	Group 1	Group 2	Group 3	χ^2/F
Sex (M/F)	10/9	8/13	9/8	0.563
Age, days	59.32 ± 20.35	77.52 ± 18.83	74.59 ± 11.26	6.021*
A-SCM, mm	1.79 ± 0.29	1.77 ± 0.29	1.82 ± 0.27	0.161
A/N ratio	6.64 ± 0.94	6.14 ± 1.70	5.77 ± 1.75	1.500
Rotation, degree	49.47 ± 5.24	49.29 ± 3.64	51.76 ± 3.51	1.934

Values are presented as mean ± standard deviation.

A-SCM = sternocleidomastoid muscle thickness on the affected side, A/N ratio = ratio of the sternocleidomastoid muscle thickness on the affected side to the non-affected side, rotation = degree of head rotation on the affected side.

* $P < .01$.

allocated to 3 groups in a 1:1:1 ratio. Blocked randomization sequence was computer-generated by a researcher who was not involved in recruitment or assessment. The patients were allocated to group 1 (handling for active or active-assist movement treatment, 20 patients), group 2 (passive stretching treatment, 21 patients), and group 3 (thermotherapy, 20 patients). However, 1 patient in group 1 and 3 in group 3 dropped out due to moving residence, heart disease, and frequent refusal of treatment. Accordingly, the statistical analysis included 57 patients (Fig. 1). Baseline and follow-up assessments were completed by blinded researcher.

2.7. Ethics

This protocol was approved by the Institutional Review Board of Sahmyook University on March 13, 2020 (IRB number, 2-7001793-AB-N-012019103HR) of Korea and registered in the Clinical Research Information Service (CRiS) (registry number, KCT0004862) on March 25, 2020. The study was conducted in accordance with the ethical standards formulated in the Declaration of Helsinki, 1964.

2.8. Statistical analysis

In this study, the χ^2 test and 1-way analysis of variance were used to analyze the patients' general characteristics (n = 57). Post-hoc analysis was performed using Bonferroni correction. Intragroup differences were analyzed using the paired *t* test, and intergroup differences were analyzed using age-adjusted analysis of covariance. A Pearson correlation analysis was performed to analyze the correlation between treatment duration and the variables.

Statistical analyses were performed using SPSS version 21.0 (IBM Corp., Armonk, NY). Statistical significance was set at $P < .05$.

3. Results

3.1. General patient characteristics

The average age of patients was 59.32 ± 20.35 days in group 1 (n = 19), 77.52 ± 18.83 days in group 2 (n = 21), and 74.59 ± 11.26 days in group 3 (n = 17). The average SCM muscle thickness on the affected side was 1.79 ± 0.29 mm in group 1, 1.77 ± 0.29 mm in group 2, and 1.82 ± 0.27 mm in group 3. The average A/N ratio was 6.64 ± 0.94 in group 1, 6.14 ± 1.70 in group 2, and 5.77 ± 1.75 in group 3. The average rotation degree of head rotation on the affected side was 49.47 ± 5.24 in group 1, 49.29 ± 3.64 in group 2, and 51.76 ± 3.51 in group 3. There were no intergroup differences in general characteristics except for age (Table 1).

3.2. Comparison of treatment effects within and between the groups

There were significant differences between before and after treatment measurements within all groups ($P < .05$). There was no significant difference between the groups in SCM muscle thickness on the affected side and A/N ratio after intervention ($P > .05$). However, there was a significant difference between the groups in degree of head rotation on the affected side ($P < .05$). The changes in degree of head rotation on the affected side after intervention were −20.00 ± 9.00 in group 1, −25.71 ± 4.27 in group 2, and −15.00 ± 4.33 in group 3. That was a significant difference in head rotation between groups 1 and 2 and groups 2 and 3 ($P < .05$, both), but not between groups 1 and 3 (Table 2).

3.3. Correlation between treatment duration and variables

The duration of treatment was correlated with age ($r = -0.325$, $P < .05$) and SCM muscle thickness on the affected side ($r = 0.310$, $P < .05$).

4. Discussion

Physical therapy interventions applied to infants with CMT under 3 months of age have been shown to be effective in SCM muscle thickness on the affected side, SCM A/N ratio, and head rotation on the affected side. Although there were no differences in the SCM thickness and the SCM A/N ratio in the group comparison of the intervention effects, the head rotation showed that passive stretching was more effective than the other 2 interventions.

A previous study, as a result of handling of and providing active strength exercise treatment to infants at a mean age of 4.5 months, treatment time affected the muscle function scale score in affected and contralateral side.[24] Like the previous study, in this study, handling for active or active-assist treatment was performed, allowing the infants to move themselves to strengthen their muscles, and infants in the active or active-assist movement treatment group showed positive improvement in the SCM muscle thickness on the affected side, A/N ratio, and head rotation. This treatment facilitates infants' active exploration of the environment, without restricting or resisting their movements.[14,25] The handling principle of Tscharnuter Akademie for Motor Organization is not about emphasizing artificial movements; instead, it is about performing functional tasks in a natural environment. A case report applying this principle demonstrated the therapeutic effect of active ROM exercise in an infant with CMT.[14] Balancing between the SCM on the affected side and the nonaffected side enables infants to control their neck. In the

Table 2

Intragroup and intergroup comparisons after the intervention.

Variables	Group 1	Group 2	Group 3	*F*	η_p^2
A-SCM, mm	−0.12 ± 0.11	−0.13 ± 0.11	−0.09 ± 0.11	0.636	0.023
t	−4.738**	−5.393**	−3.392*		
A/N ratio	5.18 ± 1.18	4.86 ± 1.51	4.03 ± 1.78	2.072	0.073
t	21.718**	12.370**	9.273**		
Rotation, degree	−20.00 ± 9.00	−25.71 ± 4.27	−15.00 ± 4.33	13.904** Group 1 <group 2 Group 2 > group 3	0.344
t	−9.713**	−27.611**	−14.283**		

Values are presented as mean ± standard deviation and the difference change values between pre-test and post-test.

Intergroup comparisons were analyzed by age-adjusted values.

A-SCM = sternocleidomastoid muscle thickness on the affected side, A/N ratio = ratio of the sternocleidomastoid muscle thickness on the affected side to the non-affected side; rotation = degree of head rotation on the affected side.

* $P < .05$.

** $P < .001$.

prone position, infants can elongate the SCM through a play intervention, and in a side-lying position, the SCM can be strengthened in the same way.

In this study, although the infants were crying during passive stretching, the positive effects were similar to the observations of previous studies about the SCM muscle thickness on the affected side, SCM A/N ratio, and head rotation in the passive stretching treatment group. Although passive stretching is an effective therapy for CMT,[4,12,26] both active and passive stretching exercises are highly effective and currently applied as physical therapy for CMT.[8] A CMT group that received stretching treatment more than the other group demonstrated improvement in head tilt, ROM of the neck, and thickness ratio of the SCM, indicating the positive effect of stretching treatment.[27] Cheng et al[4] reported that although passive and active stretching has a favorable effect on increasing ROM of the neck, passive stretching can lead to soft tissue injury. Infants express their discomfort by resisting the therapist's hands or crying, when they feel pain and distress during passive stretching. In particular, since infants older than 3 months who can move voluntarily may more extremely resist the treatment, long-term, low-intensity stretching rather than a compulsory approach has been reported to be useful.[28]

In one study, postural control and manual stretching intervention were performed in infants under 6 months of age. There were no significant differences between the groups in the treatment duration and thickness of SCM tumors between the 2 groups after intervention.[9] Moreover, it was found that the thickness of SCM tumors and head tilt affected the duration of treatment.[9] In this study, there were no significant differences in SCM muscle thickness on the affected side and A/N ratio between groups after intervention, and the difference between groups showed significance only for head rotation. Passive stretching showed a better improvement in head rotation than the other groups.

Some studies stated that neck rotation rather than lateral flexion is a more important factor for rehabilitation.[4] In addition, it has been reported that more restriction on neck rotation leads to a longer treatment duration.[29] Although cervical rotation and side-bending were strongly correlated, only cervical rotation showed an association with rehabilitation time.[12] In another study, no correlation was observed between cervical rotation and side-bending, although the SCM thickness and SCM A/N ratio showed an association with rehabilitation time.[21] However, in another study, the SCM thickness and ratio demonstrated no correlation with the treatment duration.[16] In this study, head rotation correlated with treatment duration and was used as a function variable, and the treatment duration showed a significant correlation with age and SCM muscle thickness on the affected side.

There are several limitations to this study. The symmetrical adjustment of active and passive postures is critical for infants with CMT. It is necessary to induce symmetry by using infants' active movements using positioning or a play intervention. Hence, parents' education is crucial, and it has been reported that consistently implemented home programs are needed for education on handling and positioning.[30] However, in this study, the same home program was offered in each group to exclude the instruction for passive stretching. Therefore, any biases that could affect the results were eliminated in advance. Other limitations of this study were its small sample size, which resulted in a lower statistical power, and absence of a continuous follow-up, leading to the lack of data on long-term treatment effects. As the study variables were limited to muscle thickness and head rotation, changes in other functions were not studied. Future research should include a large sample size, and further studies need to confirm the persistence of the treatment effect over time.

In conclusion, this study shows that compared to other treatments, passive stretching is a more effective treatment for improving head rotation in CMT infants <3 month of age.

Author contributions

Conceptualization: Seungwon Lee.
Data curation: Seonghyeok Song and Wonjeong Hwang.
Formal analysis: Seungwon Lee.
Investigation: Seonghyeok Song and Wonjeong Hwang.
Methodology: Seonghyeok Song and Seungwon Lee.
Project administration: Seonghyeok Song and Wonjeong Hwang.
Resources: Seonghyeok Song.
Supervision: Seungwon Lee.
Validation: Seungwon Lee.
Visualization: Seonghyeok Song and Wonjeong Hwang.
Writing – original draft: Seonghyeok Song.
Writing – review & editing: Seungwon Lee.

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