Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 11, Issue, 02, pp. 44256-44260, February, 2021
https://doi.org/10.37118/ijdr.20975.02.2021

RESEARCH ARTICLE OPEN ACCESS

THE EFFECTS OF PASSIVE MANUAL STRETCHING IN LOWER LIMBS ON SPASTICITY AND RANGE OF MOTION IN CHILDREN WITH CEREBRAL PALSY

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ARTICLE INFO

Article History:
Received 20th December, 2020
Received in revised form
14th December, 2020
Accepted 28th January, 2021
Published online 24th February, 2021

Key Words:
Passive Stretching, Cerebral Palsy,
Muscle Spasticity,
Range of Motion.

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ABSTRACT

Introduction: Children with Cerebral Palsy often experience a disorder of the mechanism of reflex stretching, which have a devastating effect on the kinetic patterns. The purpose of this study was to identify the effect of six weeks passive manual stretching in lower limbs on spasticity and range of motion in children with cerebral palsy. **Methods:** The sample comprised 28 children with clinically diagnosed cerebral palsy divided into two groups: the control group [n=14; 12.31 mean age ± 2.25 st.deviation (SD)], which continued their normal routine of treatments, and the therapy group (n=14; 12.33 mean age ± 2.90 SD), which received an additional 2-month of passive manual stretching program on lower limbs. The spasticity was assessed with the use of the Modified Ashworth Scale (MAS) and Modified Tardieu Scale (MTS), and the range of motion with goniometer. **Results:** According tothe MAS and the MTS measurements, the therapy group presented a statistically significant improvement in most of the muscle groups in both limbs. Whereas the control group showed no statistically significant improvement in both scales. As far as the data of goniometry is concerned, the therapy group experienced statistically significant improvement compared to the control group. In total, a higher gain was observed in the right lower limb compared to the left. **Conclusion:** The above data is a bear statement that passive stretching improves spasticity and range of motion in lower limbs in children with CP and that stretching must be a fundamental part of the therapeutic protocol.

Citation: ***Trevlaki Evgenia, Georgiadou Athina, Trevlakis Emmanouil, Kapali Eleni, Papadopoulou Ourania, Baltatzi Georgia and Alexandra-Hristara Papadopoulou.*** "The effects of passive manual stretching in lower limbs on spasticity and range of motion in children with cerebral palsy", *International Journal of Development Research*, 11, (02), 44256-44260.

INTRODUCTION

Physiotherapy is a multidisciplinary science and one of its most important fields is pediatric neurological physiotherapy, which deals with neurological diseases of children. The prevention and cure of diseases, as well as the positive contribution to the health and happiness of the child, is fundamental for the modern social medicine and physiotherapeutic consciousness.

The physiotherapist, as a member of the treatment group, aims to reduce the deficits presented in motor control, improve the functionality and prevent any possible complications and distortions. There is no evidence that physiotherapy will correct the neurological deficit, but there is evidence that the treatment improves overall development.

Cerebral Palsy: Cerebral Palsy (CP) describes a group of disorders of evolution, movement and posture causing movement constraints due to non-progressive disorders in the developing embryonic or neonatal brain (Bax M. et al. 2005). It is the most prevalent chronic childhood motor disability, affecting 2–3 out of 1000 school aged children (Harvey S. et al. 2005). CP has an essential role in child neuropathology due to the severe decline it causes in mobility and the patient's independence from an early age.

Spasticity: It is fairly common for children with cerebral palsy to experience spasticity, especially in the lower limbs. While spasticity can affect the entire body, it is manifested with greater intensity in the lower limbs of children with bilateral involvement and in the upper limbs of children with unilateral involvement (L. Sakzewski et al. 2009). Moreover, the most frequently affected muscles are gastric-soleus, hamstrings, rectus femoris, adductors, and psoas in the lower limbs, and shoulder external rotators, elbow, wrist and finger flexors, and the elbow pronators in the upper limbs (K. Klingels et al. 2012) .Lastly, spasticity is thought to increase energy consumption during movement and interfere with voluntary control (J. R. Gage et al. 2009). The first official definition suggested that spasticity is a disorder of the motor mechanism characterized by an increase in tonal myotonic reflexes, which is proportional to the speed of movement and is accompanied by increased tendon reflexes, which is due to the hyperactivity of the myotactic reflexes and arises as a component of the upper motor neuron syndrome (Lance et al. 1980).

In 2003, the North American Task Force for Childhood Motor Disorders suggested that spasticity should be redefined as "a velocity dependent increase in hypertonia with a catch when a threshold is exceeded" (T. D. Sanger et al. 2003) .Although hypertonia is a common clinical term, the inability of clinical scales to differentiate between the neural and nonneural components of increased resistance has led to the terms "spasticity" and "hypertonia" often being used interchangeably (S. Malhotra et al. 2009). In 2005, the SPASM (European Thematic Network to Develop Standardized Measures of Spasticity) suggested that the term "spasticity" should reflect a more clinical reality and for this reason the term "disturbed sensory-mobility control, coming from the upper motor neuron syndrome, presented as intermittent or persistent muscle activation. Assuming that all involuntary activities involve reflexes, spasticity is the intermittent or persistent involuntary hyperactivity of skeletal muscles associated with upper motor neuron syndrome" (Pandyan et al. 2005). Another reason for the lack of agreement and on-going debate surrounding the definition of spasticity is the emerging evidence that spasticity is manifested differently in an active versus passive muscle (V. Dietz et al. 2007). The main metric used in literature to quantify spasticity has been the hyperreflexia or hypertonia when the muscle is at rest, apart from the definition provided by the SPASM consortium. The former definition is, in part, a reflection of feasibility, since testing muscle tone during active movement is technically very challenging.

Stretching: With the term Stretching we describe any therapeutic manipulation designed to elongate short pathological structures of soft tissues in order to increase the range of motion (Hong J et. al.2019). The term "muscular stretching" is used to describe a set of manipulations that temporarily increase the range of motion of a joint" (P Akpinar et al. 2017). Stretches generally concentrate on increasing the length of the myotatic unit that increases the distance between the origin and the insertion of the muscle. In stretching the muscle tension is inversely related to length: decreased muscle tension is associated with increased muscle length, while increased muscle tension is associated with decreased muscle length. Inevitably, muscle stretching applies tension to other structures, such as the synovial bursal and the fascia, which consist of different tissues from the muscles and have different industrial properties.

Historical background: Considerable efforts have been made in the past to investigate the effects of stretching in the human body. Based on past literature, statistically significant positive results from the application of stretching programs were reported (T. D. Sangeret al. 2003, S. Malhotraet al. 2009, A. D. Pandyan et al. 2005). Studies often followed a treatment protocol of 8-10 repetitions and had an average duration of 5.4 weeks at a frequency of 2.4 times a week. Many researches have been conducted that compares the different types of stretching, as well as their effects on increasing flexibility, reducing spasticity, increasing joint movement, preventing injuries, and improving patient mobility. Specifically, these studies were divided according to each stretching method used: isotonic stretching program, functional stretching exercises, isokinetic stretching program, isometric stretching program and mixed stretching patterns. Throughout literature there have been several reviews of the effects of passive stretching on patients with CP (V. Dietz et al. 2007, Hong J et al 2019, P. Akpinar et al 2017, McPherson JJ. et al. 1984, Tremblay F. et al. 1991, O'Dwayer N. et al. 1994). Each of the aforementioned works have applied passive stretching combined with other methods (i.e. positioning) in order to evaluate improvement in range of motion and spasticity. As a result, the exclusive impact of passive stretching on patients with CP is not clear. The current work is an effort to quantify the contribution of passive stretching on the rehabilitation of these patients.

MATERIAL AND METHODS

Design: The study has a non-randomized, single-blinded controlled design and the study protocol was approved by the committee of the Pediatric Physical Therapy master of Alexander Technological Educational Institute of Thessaloniki.

Setting: The assessments and interventions took place in a Special Elementary School in Thessaloniki, from which most of the children with cerebral palsy were included. The Special School cooperates with ELEPAP - Rehabilitation for The Disabled, a rehabilitation center with 6 branches throughout Greece and more than 80 years of history, that supports the development of children with physical disabilities and developmental difficulties and at the same time provides support to their families.

Participants: The inclusion criteria were as follows: patients of both sex, 8 to 18 years old, with clinical diagnosis of CP, spasticity in both lower limbs [Modified Ashworth Scale (MAS)>0] and to attend all interventions. The exclusion criteria were: unstable seizures, severe adverse drug events, hospitalization during the trial, non-adherence to the study protocol (n=1) and changes to the medical treatment or surgical procedure for spasticity up to 6 months prior to the study. After applying the exclusion criteria, 28 children [14 males; 14 females; 12.3 mean age; St. Deviation (SD) 2.16] were enrolled and written informed consent was given by the parents. The subjects maintained level V (n=18), level IV (n=2), level II (n=4) and level I (n=4) of the Gross Motor Function Classification System (GMFCS). The total sample were divided in two groups, the control group [n=14; 12.31 mean age; 2.25 SD) and the therapy group [n=14; 12.33 mean age; 2.90 SD]. There was no significant difference between the two groups in terms of age. Such matching is a convenient method for minimizing confounding in case-control studies as it balances the clinical characteristics of the two groups (Hong J. et al. 2019).

Outcome measures: The data were collected in each of the participants by a specific physical therapist of the special school. The physical therapist who performed the intervention was different from the one that performed the measurements, thus, ensuring a non-biased research. Various personal characteristics were measured once at baseline, such as age, gender, gross motor function differences, etc. There were two assessments pursed pre- and post- intervention sessions. Both the assessments were accomplished into two weeks period and measured spasticity and range of motion of the lower limbs.The Spasticity was measured with the use of the Modified Ashworth (MAS) and the Modified Tardieu Scale (MTS) (P Akpinar et al. 2017). Whereas the Range of Motion was assessed with the use of goniometer, with a standardized protocol for goniometric positioning and procedures (AkmerMutl, 2007).

Intervention: Stretching program. The therapy group followed a 6-week stretching program, twice per week. Each intervention lasted for 30 – 40 minutes.

The intervention was additional to any other therapies the child received and was explicitly designed to stretch all the muscles of the lower limbs passively. The interventions were held individually in each child and included 8 passive stretches for lower limbs. Each stretch performed thrice and was comprised of 45 seconds repetitions followed by 15 seconds rest periods. The stretches were executed mostly in a supine position, but also in prone and slope position if possible, at a physical therapy mat on the ground.

RESULTS

The statistical analysis of the measurements was done by the Paired t-test and the Related samples Wilcoxon signed Rank test on SPSS, measured the results of manual passive stretching on spasticity and on range of motion in lower limbs of the subjects of this study. Initially, a test of normality was conducted that divided the pairs in two groups based on their distribution. The group whose pairs followed normal distribution was analyzed with the Paired sample t-test, which is a parametric test, while the second group, whose pairs did not follow a normal distribution, with the non-parametric Related samples Wilcoxon signed Rank test. The results of the statistical analysis, based on the three scales: MAS, MTS and Goniometry, are demonstrated below.

Data analysis of MAS: The MAS was utilized in order to evaluate the spasticity in lower limbs. Specifically, the joints of the hip, knee and the ankle were measured based on their performance on 8 movements. Each movement was evaluated for both the right and left limb. As shown in Tables 2 and 3, the therapy group demonstrated a significantly positive effect on spasticity in most of the joint's movements. Concerning the hip joint, the measurements revealed statistical significance on the right and left hip flexion, the right hip extension, the right hip abduction $t(12)= 2{,}229$ ($p< 0{,}05$) and the left hip abduction $t(12)=2{,}229$ ($p< 0{,}05$). As far as the knee joint is concerned, the right and left knee extension showed statistically significant improvement. Finally, for the ankle joint, the right ankle flexion and the right ankle extension was statistically significantly higher after the stretching intervention. On the other hand, in the control group the tests revealed that the statistical importance of the results was higher than 0.05 (Table 2 and 3). So there was no significant improvement in the lower limbs.

Data analyses of MTS: The MTS was utilized in order to evaluate the spasticity in lower limbs. Moreover, the joints of the hip, knee and the ankle were measured based on their performance on 8 movements in 2 velocities. Each movement was evaluated for both the right and the left limb. Furthermore, it was shown that the intervention had a positive statistically significant effect on the spasticity of the subjects. As demonstrated in tables 2 and 4, the therapy group presented improvement on the left and right hip flexion in velocity 1, the right hip extension in velocity 1, the right hip adduction in velocity 2, the left hip adduction in velocity 1 and the right hip abduction in velocity 1. As far as the knee joint is concerned the measurements revealed statistically significant improvement in the right and left knee flexion in velocity 1 and 2. At last, the evaluation of the ankle joint showed statistically significant improvement in the right ankle flexion in velocity 1 and 2, the left ankle flexion in velocity 1 and 2, the right ankle extension in velocity 1 and 2, and the left ankle extension in velocity 2. On the contrary, the Wilcoxon Signed-Ranks Test for the control group indicated that the statistical importance of the results was higher than 0.05. So there was no significant improvement in the lower limbs.

Data analyses of Goniometry: The Goniometry was utilized in order to evaluate the range of motion in lower limbs. In more detail, the joints of the hip, knee and the ankle were measured based on their performance on 10 movements; each movement was evaluated for both the right and the left limb. Concerning the therapy group, the report in APA A Wilcoxon Signed-Ranks Test and the Paired t-test indicated that the median pre- and post- test ranks showed statistically significant improvement (Table 2 and 4).

Table 1. Distribution of children in subgroups depending on gender, age and type of cerebral palsy

		Type of Cerebral Palsy			Sum
		Spastic Quadriplegia	Paraplegia	Diplegia	
Gender	Boys	10	3	1	14
	Girls	12	2	0	14
Age	Under 13 years old	10	3	1	14
	Over 13 years old	12	2	0	14
	Sum	22	5	1	28

As far as the hip joint is concerned the right and left hip abduction, and the right and left hip extension showed a significant gain. Moreover, the measurements of the knee joint reveal significant improvement in the right and left knee flexion. Last but not least, the ankle joint showed significant development only in the left ankle flexion. Meanwhile, in the control group only the left ankle flexion $t(11)= -2{,}402$ ($p= 0{,}035< 0{,}05$) presented significant improvement (Table 2).

DISCUSSION

There is a rudimentary understanding of the mechanisms of contractures in muscle with spasticity. Ideally our clinical decisions should be guided by good scientific inquiry (Thamar J. et al 2008). There is a need for laboratory research into the mechanisms of muscle contracture to provide additional information about the theoretical assumptions that guide physical therapy interventions for children with CP. Clinical evaluation of the effects of stretching techniques is also needed because existing research evidence is not adequate to support or refute the effectiveness of stretching as a management strategy. Pediatric physical therapists have a lot to contribute due to their essential role. The overall purpose of this study was to examine the mechanical adaptations resulting from a 2-months manual passive stretching program of the lower limbs in children with CP. According to the spasticity, the results showed a big difference between the two groups. The MAS presented no improvement of the spasticity at the control group. Meanwhile, the therapy group showed statistically significant improvement in both limbs at the hip flexion, the hip abduction, the knee extension, the right hip extension and the right ankle extension and flexion.

The MTS measurements in the therapy group showed statistical improvement on velocity 1 in the left and right hip flexion, the right hip extension and hip abduction, the left hip adduction, the right and left knee flexion, the right and left ankle flexion and the right ankle extension. As far as the velocity 2 is concerned the results presented a significant improvement in the right hip adduction, the right and left knee flexion, the right and the left ankle flexion, and the left and right ankle extension. Whereas the control group presented no improvement of the spasticity. The goniometry measurements also showed a big difference between the two groups. The therapy group presented statistically significant improvement in both limbs at the hip abduction, hip extension, knee flexion and the left ankle flexion. However, the control group showed a significant improvement only in the left ankle flexion. The primary outcome of this research is that the therapy group experienced a huge improvement in spasticity and range of motion after the 2-months intervention, whereas the control group, that received no intervention and continued the routine of treatments, showed no statistically significant improvement in both scales. This led us to the conclusion that passive stretching has an important role in reducing spasticity and increasing the range of motion of lower limbs in children with CP. The secondary outcome concerns some patterns that were noted through the research measurements. From the first evaluation of spasticity was observed that the hip extensors, the hip adductors, the knee extensors, and the ankle extensors presented high levels of spasticity. The results of the first evaluation are totally compatible with K. Klingels, I. Demeyere, E. Jaspers et al. (2012) research findings. So, in general children with CP tend to present more spasticity in these group muscles. As it was expected the first evaluation of range of motion showed an inverse proportion of range of motion and spasticity.

Table 2. Paired Samples Test (normal distribution)

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
A.	MAS (Therapy group)								
Pair 1	R hip abduction pre-post	,88462	1,43111	,39692	,01980	1,74943	2,229	12	,046
Pair 2	L hip abduction pre-post	,88462	1,43111	,39692	,01980	1,74943	2,229	12	,046
Pair 3	R knee flexion pre-post	,07692	,34437	,09551	-,13118	,28502	,805	12	,436
Pair 4	L knee flexion pre-post	,11538	,29957	,08309	-,06565	,29641	1,389	12	,190
B.	MAS (Control group)								
Pair 1	R hip flexion pre-post	,15000	,42906	,12386	-,12261	,42261	1,211	11	,251
Pair 2	R hip abduction pre-post	,15000	,42906	,12386	-,12261	,42261	1,211	11	,251
Pair 3	L hip abduction pre-post	,15000	,42906	,12386	-,12261	,42261	1,211	11	,251
Pair 4	R knee extension pre-post	2,04167	6,30461	1,81998	-1,96409	6,04742	1,122	11	,286
Pair 5	L knee extension pre-post	,22667	,49377	,14254	-,08706	,54039	1,590	11	,140
C.	MTS (Therapy group)								
Pair 1	R hip flexion U1 pre-post	,76923	1,09193	,30285	,10939	1,42908	2,540	12	,026
Pair 2	R hip abduction U1 pre-post	,30769	,48038	,13323	,01740	,59799	2,309	12	,040
Pair 3	R hip abduction U2 pre-post	,23077	,43853	,12163	-,03423	,49577	1,897	12	,082
Pair 4	L hip abduction U1 pre-post	,46154	,66023	,18311	,06257	,86051	2,521	12	,027
Pair 5	L hip abduction U2 pre-post	,38462	,65044	,18040	-,00844	,77767	2,132	12	,054
Pair 6	L hip adduction U1 pre-post	,53846	,51887	,14391	,22491	,85201	3,742	12	,003
Pair 7	L knee flexion U2 pre-post	,61538	,86972	,24122	,08982	1,14095	2,551	12	,025
D.	Goniometry (Therapy group)								
Pair 1	R hip extension pre-post	-5,00000	5,64076	1,62835	-8,58397	-1,41603	-3,071	11	,011
Pair 2	L hip extension pre-post	-6,40000	6,39033	1,84473	-10,46022	-2,33978	-3,469	11	,005
E.	Goniometry (Control group)								
Pair 1	R hip flexion pre-post	-,16667	,57735	,16667	-,53350	,20016	-1,000	11	,339
Pair 2	L hip flexion pre-post	,00000	,85280	,24618	-,54185	,54185	,000	11	1,000
Pair 3	R knee flexion pre-post	,18167	,57496	,16598	-,18365	,54698	1,095	11	,297
Pair 5	L ankle flexion pre-post	-,90917	1,31111	,37848	-1,74221	-,07613	-2,402	11	,035

Table 3. Hypothesis Test Summary in MAS by Related Samples Wilcoxon Signed Rank Test

Therapygroup		Controlgroup	
Pairs	Sig	Pairs	Sig
R hip flexion pre-post	0,017	L hip flexion pre–post	0,102
L hip flexion pre-post	0,027	R hip extension pre-post	0,102
R hip extension pre–post	0,041	L hip extension pre–post	0,102
L hip extension pre-post	0,216	R hip adduction pre–post	0,102
R hip adduction pre-post	0,066	L hip adduction pre–post	0,102
L hip adduction pre-post	0,066	R knee flexion pre–post	0,109
R knee extension pre-post	0,024	L knee flexion pre–post	1
L knee extension pre-post	0,015	R ankle flexion pre–post	0,18
R ankle flexion pre-post	0,024	L ankle flexion pre–post	0,18
L ankle flexion pre-post	0,059	R ankle extension pre-post	0,102
R ankle extension pre-post	0,027	L ankle extension pre–post	0,102
L ankle extension pre-post	0,068		

Table 4. Hypothesis Test Summary in Therapy group, by Related Samples Wilcoxon Signed Rank Test

In ModifiedTardieuScale		In Goniometry	
Pairs	Sig	Pairs	Sig
R hip flexion U2 pre-post	0,046	R hip flexion pre-post	0,929
L hip flexion U1 pre-post	0,007	L hip flexion pre-post	0,225
L hip flexion U2 pre-post	0,083	R hip abduction pre-post	0,008
R hip extension U1 pre-post	0,008	L hip abduction pre-post	0,011
R hip extension U2 pre-post	0,414	R hip adduction pre-post	0,130
L hip extension U1 pre-post	0,08	L hip adduction pre-post	0,092
L hip extension U2 pre-post	0,257	R hip lateral rotation pre-post	0,107
R hip adduction U2 pre-post	0,046	L hip lateral rotation pre-post	0,383
L hip adduction U2 pre-post	0,083	R hip medial rotation pre-post	0,937
R knee flexion U1 pre-post	0,023	L hip medial rotation pre-post	0,154
R knee flexion U2 pre-post	0,084	R knee flexion pre-post	0,013
L knee flexion U1 pre-post	0,015	L knee flexion pre-post	0,005
R knee extension U1 pre-post	0,527	R knee extension pre-post	0,107
R knee extension U2 pre-post	0,655	L knee extension pre-post	0,204
L knee extension U1 pre-post	0,429	R ankle flexion pre-post	0,075
L knee extension U2 pre-post	0,705	L ankle flexion pre-post	0,05
R ankle flexion U1 pre-post	0,034	R ankle extension pre-post	0,074
R ankle flexion U2 pre-post	0,025	L ankle extension pre-post	0,312
L ankle flexion U1 pre-post	0,039		
L ankle flexion U2 pre-post	0,034		
R ankle extension U1 pre-post	0,028		
R ankle extension U2 pre-post	0,031		
L ankle extension U1 pre-post	0,117		
L ankle extension U2 pre-post	0,010		

The muscles that present more spasticity obstructthe antagonist muscles function and reduce the range of the antagonist's muscle motion. So the movements that presented more range of motion was the hip extension, the hip adduction, the knee extension and the ankle extension. This fact must be taken into consideration in order to create a preventive way of treatment. Also, as it was expected the velocity 1 showed higher improvement. These results underpin the inversely proportional amounts correlation of spasticity and velocity. Last but not least, the improvement of spasticity was almost twice as high in the right limb, whereas the improvement of range of motion was silty higher in the left limb. The results of this study do not contradict with the historical background on passive stretching in children with CP. Only 3 studies have been conducted on this specific subject thatdates to 1990 (McPherson JJ.et al. 1984, Tremblay F. et al. 1991, O'Dwayer N. et al. 1994). It must be noted, that since then physical therapy techniques has evolved. As far as the results of the literature is concerned, only 2 of the studies showed a decrease in muscle tone, while the other one showed no statistically significant results. In general, studies often followed a treatment protocol of 8-10 repetitions and had an average duration of 5.4 weeks at a frequency of 2.4 times a week (Lesley Wiart et al. 2008, Tamis Pin et al. 2006, Thamar et al 2008). Finally, the literature on the effects of passive stretching on children with CP is more than incomplete. Thus, the importance of this study as well as the necessity of further research are highlighted.

Suggestions

Based on the results of the present study, it is proposed to:

- Initiation of a stretching program in every specialized school.
- Establishment of a preventive protocol of stretching in ever physical therapy in children with CP.
- Implementation of daily physical therapy to improvethe quality of life of children with mobility difficulties.
- Training parents in stretching techniques.

CONCLUSION

The findings demonstrate that six weeks of passive stretching showed a statistically significant improvement between the pre- and post-treatment evaluations of the therapy group compared to the control group. This indicates that passive stretching improves spasticity and range of motion in children with CP. The above results do not contradict the results of previous researches.

Limitation of research: As with the majority of studies, the design of the current study is subject to limitations. The limiting factor of this study is the duration of the intervention. Since this study included a 2-months intervention of stretching in children with CP, the ability to generalize the results is limited.

Implications for further research: It would be of great interest to study the effect of passive stretching in a larger sample of patients over a more extended period and the way they affect the daily activities of the participants.

Conflict of interest: The author declares that she had no competing interests.

Acknowledgments: We also wish to thank all the children and their parents for their participation in this project.

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