

Electrical stimulation in addition to passive stretch has a small effect on spasticity and contracture in children with cerebral palsy: a randomised within-participant controlled trial

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Question: Does electrical stimulation in addition to passive stretching reduce spasticity and contracture more than passive stretching alone in children with cerebral palsy? **Design:** Randomised within-participant controlled trial with concealed allocation, assessor blinding, and intention-to-treat analysis. **Participants:** Eleven (one dropout) children with cerebral palsy and bilateral knee flexor spasticity aged 13 years (SD 1). **Intervention:** One leg in each participant received the experimental intervention for four weeks which consisted of 30 min of electrical stimulation of the quadriceps 3 times per week and passive stretching of the hamstrings 5 times per week. The other leg received the control intervention for four weeks which consisted of passive stretching of the hamstrings 5 times per week. **Outcome measures:** Spasticity of the hamstrings was measured using the modified Ashworth scale. Contracture was measured as maximum passive knee extension using goniometry. **Results:** The mean difference in decrease in the modified Ashworth score due to the addition of electrical stimulation to the stretching regimen was 0.8 points (95% CI 0.1 to 1.5). The mean difference in increase in passive knee extension due to the addition of electrical stimulation to the stretching regimen was 4 degrees (95% CI 0 to 7). **Conclusion:** Electrical stimulation combined with passive stretching is marginally more effective than passive stretching alone for spastic limbs of children with cerebral palsy. [Khalili MA, Hajihassanie A (2008) Electrical stimulation in addition to passive stretch has a small effect on spasticity and contracture in children with cerebral palsy: a randomised within-participant controlled trial. *Australian Journal of Physiotherapy* 54: 185–189]

Key words: Electrical stimulation, Muscle spasticity, Cerebral palsy

Introduction

The relationship between spasticity, contracture, and activity is complex in children with cerebral palsy. Spasticity is 'a motor disorder characterised by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex' (Lance 1980, p. 485). Contracture is a loss of passive range of motion assessed by measuring maximum passive joint excursion (Horsley et al 2007, Harvey et al 2006, Refshauge et al 2006, Folpp et al 2006). Spasticity can lead to contracture (Farmer and James 2001, Tardieu et al 1982) and both spasticity and contracture can limit activity (Boyd and Ada 2008, Hoffer et al 1987). Currently, effective interventions for spasticity and contracture reduction are limited.

A systematic review of stretching for children with cerebral palsy identified three randomised trials of sustained stretches (Pin et al 2006). The data from these trials suggest that any effect of these stretching regimens on spasticity and contracture are limited. However, the effectiveness of a stretching procedure may be dependent on the frequency and duration of the applied stretch. A trial of serial casting applied for two weeks, albeit in patients with traumatic head injury not cerebral palsy, proved more effective in decreasing contracture (mean between-group difference 11

degrees; 95% CI 0 to 21 degrees) than 1 hour of stretching per day (Moseley et al 2008). However, the effects had all but disappeared two weeks later. Numerous other studies in adults with different neurological conditions suggest that stretching alone is of limited therapeutic benefit. This raises the question as to whether the effectiveness of stretch can be enhanced with electrical stimulation.

Electrical stimulation of the antagonistic muscles may improve the efficacy of stretching by providing an additional stretch to the agonistic muscles. It may also reciprocally inhibit the stretched muscle. Scheker and colleagues (1999) investigated electrical stimulation of the antagonists to upper limb muscles of children with cerebral palsy who were also receiving dynamic splinting. They demonstrated clinically-worthwhile improvements in the quality of upper limb movement. However, this was an uncontrolled trial. To our knowledge, electrical stimulation as an adjunct to stretching has not been investigated in a randomised controlled trial.

The research question therefore was:

When electrical stimulation is added to passive stretching, is it more effective than passive stretching alone for inducing short-term decreases in spasticity and contracture in adolescents with spastic cerebral palsy?

Method

Design

A randomised, within-participant controlled trial was conducted. Participants were recruited from adolescents with cerebral palsy at the Nursing Home of the Rehabilitation Centre of 12th Azar, Semnan, Iran. Baseline measures were collected before randomisation. One leg was randomised to either the experimental intervention or the control intervention by flipping a coin and the other leg was allocated the alternative intervention. The experimental intervention consisted of 30 min of electrical stimulation of the quadriceps 3 times per week and passive stretching of the hamstrings 5 times per week. The control intervention consisted of passive stretching of the hamstrings 5 times per week only. At the end of four weeks outcome measures were collected immediately after the last intervention by experienced therapists who were blinded to intervention allocation.

Participants

Residents of the Nursing Home of the Rehabilitation Centre of 12th Azar were included in the trial if they had cerebral palsy with spasticity affecting the knee flexors of both legs and were unable to walk independently. Residents were excluded if they did not have normal tactile and pain sensation, as determined by a consultant, or if informed consent could not be obtained.

Intervention

The experimental intervention consisted of 30 min of electrical stimulation of the quadriceps 3 times per week and passive stretching of the hamstrings 5 times per week. Participants were familiarised with the electrical stimulation before commencing the initial therapy session. A two-channel stimulator applied electrical stimulation to the antagonist muscle (quadriceps femoris) of the experimental leg. The frequency of stimulation was 30 Hz and the pulse width was 0.4 ms. The duty cycle was 4 s on and 4 s off with a ramp up of 0.5 s. The intensity was set as high as the participant would tolerate and to produce a visible contraction. During the application of the electrical stimulation the participant was positioned with the knee semi-flexed and the hamstring was not in the lengthened position as recommended by Benton (1981) to reduce the amount of stimulation required to attain a forceful contraction and therefore improve patient comfort. After the electrical stimulation, three brief stretches were applied to the hamstrings femoris. An assistant provided fixation while a physiotherapist applied a stretch for 30 s (Bandy and Irion 1994) with 1 min rest between the three stretches.

The control intervention consisted of passive stretching of the hamstrings 5 times per week. Neither the experimental or control legs received any other form of intervention during the four-week period.

Outcome measures

Spasticity of the hamstrings was measured using the modified Ashworth scale (Bohannon and Smith 1987). Participants were positioned in supine with the hip joint in 45 degrees of flexion. The knee was rapidly extended from 90 degrees of flexion towards full extension. The reliability of the Ashworth and modified Ashworth scales has been demonstrated (Sloan et al 1992, Gregson et al 1999, Benz et al 2005, and Zajicek et al 2003). It was administered by

Table 1. Participant characteristics.

Participant	Intervention leg		Age (yr)	Gender	Ambulation
	Exp	Con			
1	L	R	11.6	F	wheelchair
2	R	L	12.0	M	wheelchair
3	R	L	13.4	F	wheelchair
4	R	L	14.0	F	wheelchair
5	L	R	12.3	M	wheelchair
6	L	R	14.0	M	bed-ridden
7	L	R	13.0	F	wheelchair
8	L	R	11.6	M	crutch
9	R	L	14.0	F	wheelchair
10	R	L	12.3	F	bed-ridden
11	R	L	12.7	M	wheelchair

Exp = experimental group, Con = control group, R = right, L = left, M = male, F = female

the same therapist during pre- and post-intervention tests to reduce intra-test variability (Nuyens et al 1994).

Contracture was measured as maximum passive knee extension using goniometry according to Norkin and White (1995). The greater trochanter and the lateral epicondyle of the femur and lateral malleolus were palpated and served as landmarks during measurements. Participants were positioned in supine with the hip in 90 degrees of flexion. The knee was then passively extended to the point of maximal resistance. At this point, a second physiotherapist measured knee passive range of movement. In order to minimise error, the same two therapists took pre- and post-intervention goniometric measurements. The reliability of goniometers for measuring passive range of motion is fair to good (Hayes et al 2001, Gogia et al 1987).

Data analysis

The effect of the addition of electrical stimulation to a regimen of stretching was examined using the mean (95% CI) between-group difference in pre-to-post intervention change of the modified Ashworth scale for spasticity and in passive knee extension for contracture. Only observed differences consistent with the direction specified by our hypothesis were tested for their statistical significance using a one-tailed t-test for range of motion measures and the Wilcoxon signed rank test for the modified Ashworth Scale scores.

Results

Flow of participants through the trial

Eleven participants (6 female) were recruited from March 2004 to September 2004. Their mean age was 12.8 years (SD 0.9, range 11.6 to 14.0). See Table 1 for individual participant characteristics. Due to the limited number of patients at our centre, we were unable to recruit a greater sample size. Six participants had their right leg allocated to the experimental condition and their left leg to the control condition while the other five participants had the reverse allocation. After three sessions of intervention, one participant dropped out of the study due to discharge from the nursing home at the request of his family (Figure 1).

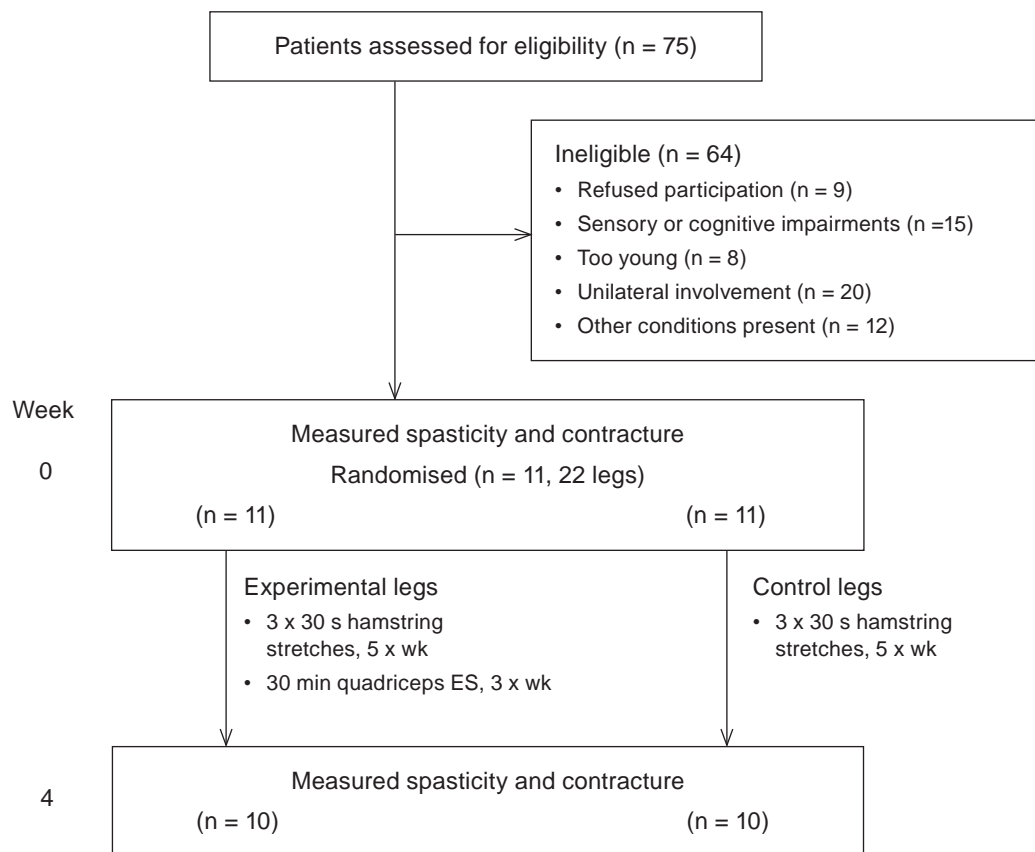


Figure 1. Design and flow of participants through the trial.

Table 2: Mean (SD) score, mean (SD) difference within interventions, and mean (95% CI) difference between interventions.

Outcome	Interventions				Difference within interventions		Difference between interventions
	Pre-test		Post-test		Post- minus pre-test		Post- minus pre-test
	Exp (n = 11)	Con (n = 11)	Exp (n = 10)	Con (n = 10)	Exp	Con	Exp minus con
Spasticity MAS (0 to 4)	4.1 (0.7)	4.1 (0.7)	2.0 (0.7)	2.9 (1.2)	2.0 (0.9)	1.2 (0.6)	0.8 (0.1 to 1.5)
Contracture Max passive knee ext (deg)	33 (6)	29 (8)	19 (7)	18 (7)	13 (5)	9 (3)	4 (0 to 7)

Exp = Experimental, Con = Control, deg = degrees, MAS = Modified Ashworth Scale

Compliance with trial method

All experimental legs received electrical stimulation and stretching at all scheduled sessions and all control legs received stretching at all scheduled sessions.

Effect of intervention

Intervention data at two measurement times (Week 0 and 4) as well as within- and between-intervention data are presented in Table 2, while individual data are presented in Table 3 (see eAddendum for Table 3). The mean decrease in the modified Ashworth score in the experimental group

was 2.0 points (SD 0.9), while in the control group it was 1.2 points (SD 0.6). The mean difference in decrease in the modified Ashworth score due to the addition of electrical stimulation to the stretching regimen was 0.8 points (95% CI 0.1 to 1.5, $p = 0.046$).

The mean increase in passive knee extension in the experimental group was 13 degrees (SD 5), while in the control group it was 9 degrees (SD 3). The mean difference in increase in passive knee extension due to the addition of electrical stimulation to the stretching regimen was 4 degrees (95% CI 0 to 7, $p = 0.04$).

Discussion

The results of this study identified a statistically significant effect of electrical stimulation in addition to passive stretch on spasticity and contracture over passive stretching alone. The mechanisms by which electrical stimulation might bring about the improvements were not examined in this study. It has been suggested that electrical stimulation may reduce the resistance to passive extension (Scheker et al 1999), reduce oedema (Pandyen et al 1996), or reduce hypertonicity (Shindo and Jones 1987) – any or all of which may affect passive range of motion. These findings support the work of Pandyan and colleagues (1997) who employed electrical stimulation to the wrist extensors of hemiplegic patients and reported an increase in range of motion and a decrease in hypertonia.

We nominated 1 point on the Ashworth scale as a minimum clinically-worthwhile between-group difference in spasticity. The low end of the 95% CI indicates that it may not be worthwhile but the high end indicates that electrical stimulation may be worthwhile. Similarly, the 95% CI for maximum passive knee extension spanned our nominated minimum-clinically worthwhile difference of 5 degrees. A larger sample size is required to attain more precision around these estimates.

The marginal size of the effect may be due to the short duration and relatively low-intensity regimen we investigated. It is reasonable to consider that the effect might reach clinical significance if it were applied with a more intensive regimen, as occurs with regimens of stretching alone (eg, Moseley et al 2008). Therefore, clinicians should note that although the effect is real, the benefit is unlikely to be clinically worthwhile at the regimen we describe. Researchers may also note that investigation of a more intensive regimen of stretching with electrical stimulation of the antagonists is warranted.

There were several limitations of the study, including that therapists and patients were not blinded, that the sample size was small, and that the modified Ashworth Scale is not an optimal measure of spasticity (Patrick and Ada 2006). Also, the lack of a standardised force when measuring contracture means that the changes observed in passive knee extension may not solely reflect changes in muscle length, but also increased tolerance to stretch (Folpp et al 2006) and difference in the force applied during measurement. Finally, because the final outcome measurement occurred immediately after the last intervention session, the large within-intervention differences are likely to be the result of transient changes of muscle extensibility but the between-intervention differences are still likely to be because of the electrical stimulation.

In conclusion, electrical stimulation in addition to passive stretch had statistically significantly greater effects on spasticity and passive range of motion than passive stretching alone. However, further research is required to determine whether these effects are clinically worthwhile or could be increased with a more intensive regimen.

eAddenda: Table 3 available at www.physiotherapy.asn.au/AJP

Ethics: The Ethics Committee of Semnan University of Medical Sciences approved this study. Informed consent was gained from the participants' families before data collection began.

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