Combined arm stretch positioning and neuromuscular electrical stimulation during rehabilitation does not improve range of motion, shoulder pain or function in patients after stroke: a randomised trial

Lex D de Jong[1,2], Pieter U Dijkstra[2,3], Johan Gerritsen[4], Alexander CH Geurts[5] and Klaas Postema[2]

[1]School of Physiotherapy, Hanze University of Applied Sciences, Groningen, [2]Department of Rehabilitation Medicine, University of Groningen, University Medical Center Groningen, Groningen, [3]Department of Oral and Maxillofacial Surgery, University of Groningen, University Medical Center Groningen, [4]ViaReva, Center for Rehabilitation, Apeldoorn, [5]Department of Rehabilitation, Radboud University Nijmegen Medical Center, Nijmegen The Netherlands

Question: Does static stretch positioning combined with simultaneous neuromuscular electrical stimulation (NMES) in the subacute phase after stroke have beneficial effects on basic arm body functions and activities? **Design**: Multicentre randomised trial with concealed allocation, assessor blinding, and intention-to-treat analysis. **Participants**: Forty-six people in the subacute phase after stroke with severe arm motor deficits (initial Fugl-Meyer Assessment arm score ≤ 18). **Intervention**: In addition to conventional stroke rehabilitation, participants in the experimental group received arm stretch positioning combined with motor amplitude NMES for two 45-minute sessions a day, five days a week, for eight weeks. Control participants received sham arm positioning (ie, no stretch) and sham NMES (ie, transcutaneous electrical nerve stimulation with no motor effect) to the forearm only, at a similar frequency and duration. **Outcome measures**: The primary outcome measures were passive range of arm motion and the presence of pain in the hemiplegic shoulder. Secondary outcome measures were severity of shoulder pain, restrictions in performance of activities of daily living, hypertonia, spasticity, motor control and shoulder subluxation. Outcomes were assessed at baseline, mid-treatment, at the end of the treatment period (8 weeks) and at follow-up (20 weeks). **Results**: Multilevel regression analysis showed no significant group effects nor significant time × group interactions on any of the passive range of arm motions. The relative risk of shoulder pain in the experimental group was non-significant at 1.44 (95% CI 0.80 to 2.62). **Conclusion**: In people with poor arm motor control in the subacute phase after stroke, static stretch positioning combined with simultaneous NMES has no statistically significant effects on range of motion, shoulder pain, basic arm function, or activities of daily living. **Trial registration**: NTR1748. **[de Jong LD, Dijkstra PU, Gerritsen J, Geurts ACH, Postema K (2013) Combined arm stretch positioning and neuromuscular electrical stimulation during rehabilitation does not improve range of motion, shoulder pain or function in patients after stroke: a randomised trial. *Journal of Physiotherapy* 59: 245–254]**

Keywords: Stroke, Upper extremity, Muscle stretching exercises, Electrical stimulation, Activities of daily living, Randomized controlled trial

Introduction

Annually, 15 million people worldwide suffer a stroke (Mackay and Mensah 2004). About 77–81% of stroke survivors show a motor deficit of the extremities (Barker and Mullooly 1997). In almost 66% of patients with an initial paralysis, the affected arm remains inactive and immobilised due to a lack of return of motor function after six months (Sunderland et al 1989, Wade et al 1983). Over time, the central nervous system as well as muscle tissue of the arm adapt to this state of inactivity, often resulting in residual impairments such as hypertonia (de Jong et al 2011, van Kuijk et al 2007), spasticity (O'Dwyer et al 1996) or contractures (Kwah et al 2012, O'Dwyer et al 1996, Pandyan et al 2003). In turn, these secondary impairments are associated with hemiplegic shoulder pain (Aras et al 2004, Roosink et al 2011) and restrictions in performance of activities of daily living (Lindgren et al 2007, Lundström et al 2008).

Several interventions improve arm function after stroke and prevent secondary impairments, eg, bilateral arm training (Coupar et al 2010) or constraint-induced movement therapy (Sirtori et al 2009). However, these interventions are not suitable for people with severe motor deficits because they require 'active' residual arm motor capacity. For these people 'passive' interventions may be needed to prevent secondary impairments and optimise long-term handling

What is already known on this topic: Contracture of muscles in the arm after stroke is common. Stretch alone does not typically produce clinically important reductions in contracture in people with neurological conditions. Hypertonia may limit the application of stretch and therefore its potential benefits.

What this study adds: In people with poor arm motor control after stroke, static arm positioning to stretch muscles prone to contracture combined with neuromuscular stimulation of the antagonist muscles did not have significant benefits with respect to range of motion, shoulder pain, performance of activities of daily living, hypertonia, spasticity, motor control or shoulder subluxation.

and assistive use of the affected arm. It is also important to elicit muscle activity if at all possible, and to improve arm function. To prevent the loss of passive range of joint motion as a result of contracture of at-risk muscles in the shoulder (eg, internal rotators, adductors) and forearm (eg, pronators, wrist and finger flexors) in particular, the application of arm stretch positioning alongside regular physiotherapy was deemed important (Ada and Canning 1990), especially because contractures are associated with shoulder pain (Aras et al 2004, de Jong et al 2007, Wanklyn et al 1996). However, in general, passive stretch does not produce clinically important changes in joint range of motion, pain, spasticity, or activity limitations (Katalinic et al 2011). One explanation for the lack of effect of passive stretch of the shoulder muscles could be the inadequate duration of stretch, with clinical trials using a dose of 20 or 30 minutes only (Borisova and Bohannon 2009). However, it is questionable whether stretch of the shoulder muscles for much more than 60 minutes per day during intensive rehabilitation programs is feasible (Turton and Britton 2005).

People with severe motor deficits after stroke have a higher risk of developing increased resistance to passive muscle stretch (hypertonia) and spasticity of the muscles responsible for an antigravity posture (de Jong et al 2011, Kwah et al 2012, Urban et al 2010). These muscles are also at risk of developing contracture. As a result, the passive range of the hemiplegic shoulder (exteral rotation, flexion and abduction), elbow (extension), forearm (supination) and wrist (extension) can become restricted.

Stretching hypertonic muscles is difficult when they are not sufficiently relaxed. Cyclic neuromuscular electrical stimulation (NMES) (Chae et al 2008), another example of a 'passive' intervention, can not only be used to improve pain-free range of passive humeral lateral rotation (Price and Pandyan 2000), but also to reduce muscle resistance (King 1996) and glenohumeral subluxation (Pomeroy et al 2006, Price and Pandyan 2000). From these results we hypothesised that NMES of selected arm muscles opposite to muscles that are prone to the development of spasticity and contracture might facilitate static arm stretching both through reciprocal inhibition ('relaxation') of antagonist muscles (Alfieri 1982, Dewald et al 1996, Fujiwara et al 2009) and the imposed (cyclic) stretch caused by motor amplitude NMES. Consequently, static arm stretch positioning combined with NMES could potentially result in larger improvements of arm passive range of motion and less (severe) shoulder pain compared to NMES or static stretching alone. From these hypotheses we developed the following research questions:

1. Does eight weeks of combined static arm stretch positioning with simultaneous NMES prevent the loss of shoulder passive range of motion and the occurrence of shoulder pain more than sham stretch positioning with simultaneous sham NMES (ie, transcutaneous electrical stimulation, TENS) in the subacute phase of stroke?
2. Does the experimental intervention have any additional effects on timing and severity of shoulder pain, restrictions in daily basic arm activities, resistance to passive stretch (hypertonia) and spasticity, arm motor control, and the degree of shoulder subluxation?

Method

Design

A multicentre, assessor-blinded, randomised controlled trial was conducted. After inclusion, participants were randomised in blocks of four (2:2 allocation ratio) in two strata (Fugl-Meyer Assessment arm score 0–11 points and 12–18 points) at each treatment centre. Opaque, sealed envelopes containing details of group allocation were prepared by the main co-ordinator (LDdJ) before trial commencement. After a local trial co-ordinator had determined eligibility and obtained a patient's consent, the main co-ordinator was contacted by phone. He instructed an independent person to draw an envelope blindfolded and to communicate the result back to the local trial co-ordinator. The local trial co-ordinator then made arrangements for the baseline measurement after which the allocated intervention was initiated. Mid-treatment, end-treatment, and follow-up measurements took place at 4, 8, and 20 weeks after baseline measurement by two independent assessors (physiotherapists), who were unaware of group allocation and not involved in the treatment of participants. To keep the assessors blinded, participants were reminded before each measurement not to reveal the nature of their treatment. Participants were considered to be unaware of group allocation because they were informed about the existence of two intervention groups but not about the study hypothesis. The participants' and assessors' beliefs regarding allocation were checked at the eight-week (ie, end of treatment) assessment using a three-point nominal scale (*I suspect allocation to experimental/control group, I have no clue of group allocation*). All investigators, staff, and participants were kept blinded with regard to the outcome measurements.

Participants

Between August 2008 and September 2010, consecutive newly admitted patients on the neurological units of three rehabilitation centres in the Netherlands (Beetsterzwaag, Doorn, and Zwolle) were approached for participation. Willing patients were initially screened by a physician for the following inclusion criteria: first-ever or recurrent stroke (except subarachnoid haemorrhages) between two and eight weeks poststroke; age > 18 years; paralysis or severe paresis of the affected arm scoring 1–3 on the recovery stages of Brunnstrom (1970); and no planned date of discharge within four weeks. Subsequently, a local trial co-ordinator excluded patients with: contraindications for electrical stimulation (eg, metal implants, cardiac pacemaker); pre-existing impairments of the affected arm (pre-existing contracture was not an exclusion criterion); severe cognitive deficits and/or severe language comprehension difficulties, defined as < 3/4 correct verbal responses and/or < 3 correct visual graphic rating scale scores on the AbilityQ (Turner-Stokes and Rusconi 2003); and moderate to good arm motor control (> 18 points on the Fugl-Meyer Assessment arm score).

Interventions

All participants received multidisciplinary stroke rehabilitation, ie, daily training in activities of daily living by rehabilitation nurses, occupational therapists, physiotherapists, and speech therapists. These interventions were not standardised, but generally administered in a way that was consistent with the recommendations of