

Effects of dry needling (DNHS technique) on the contractile properties of spastic muscles in a patient with stroke: a case report

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Dry needling for hypertonia and spasticity (DNHS) is a technique used for decreasing hypertonia and spasticity and for the improvement of function in patients with damage to the central nervous system. There is limited evidence supporting the effectiveness of this technique on the basis of objective assessments. The aim of the present case report was to quantify the effects of dry needling (DNHS technique) on the contractile properties of spastic muscles in an individual with stroke. The DNHS technique was applied to a 50-year-old male 2.5 years after stroke who had a complaint of spasticity. The treated muscles were biceps brachii, triceps brachii, rectus femoris, semitendinosus, biceps femoris, medial gastrocnemius, and lateral gastrocnemius. Tensiomyography was used to assess maximal displacement (D_m) of treated muscles. We performed a preintervention and postintervention measurement and a follow-up measurement 3 weeks after intervention. After the application of the DNHS technique, a decrease in the level of local muscle stiffness was observed for all muscles after intervention and at the 3-week follow-

up, quantified by an increase in D_m . The usefulness of tensiomyography for detecting changes in patients with spasticity correlated with clinical measures in this field requires further research to establish the reliability of the different parameters provided by the equipment. *International Journal of Rehabilitation Research* 00:000–000 Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.

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Introduction

Stroke is one of the most common causes of disability with respect to its impact on functional limitations (Ma *et al.*, 2014). Recent research shows that statistically and clinically meaningful differences in health-related quality of life exist between stroke survivors with and without spasticity (Gillard *et al.*, 2015).

Current pharmacological treatment options for patients with spasticity include specific treatment of dysfunctional motor endplates by the infiltration of botulinum toxin type A (Baker and Pereira, 2013), which acts by blocking the release of acetylcholine in the neuromuscular junction (Kuan *et al.*, 2002). However, this treatment is costly and can have negative long-term effects on the muscle (Mathevon *et al.*, 2015).

Nonpharmacological treatments for spasticity include acupuncture and dry needling, among others (Lim *et al.*, 2015). The dry needling for hypertonia and spasticity (DNHS) technique is a novel dry needling technique used clinically since 2004 for decreasing hypertonia and spasticity and for the improvement of function in patients with damage to the central nervous system (Gallego and del Moral, 2007). The technique follows specific diagnostic and application guidelines for the treatment of

patients with neurological lesions (Herrero *et al.*, 2015) and is based on the application of deep dry needling to the myofascial trigger points (MTrPs) of affected muscles using dry needling needles similar to those used in acupuncture (filiform and solid, non beveled needles) and without introducing any substance into the body. The irritability of an MTrP has been highly correlated with the prevalence of endplate noise in the MTrP region (Kuan *et al.*, 2007). In relation to this, the mechanism of action of dry needling is based on a mechanical disruption of the associated dysfunctional endplate zone. In addition, dry needling has been shown to enhance the blood flow and oxygen saturation in the stimulated region (Cagnie *et al.*, 2012). Despite its clinical use, available scientific evidence is limited, especially in terms of objective tone-related measurements, for which there is no evidence.

Tensiomyography (TMG) is an innovative and objective technological procedure for measuring the contractile properties of muscles that is fast gaining recognition in the field of sports medicine and rehabilitation (Alvarez-Diaz *et al.*, 2015). TMG allows us to obtain objective parameters such as the maximal radial muscle displacement (D_m) of assessed muscles, in response to an

electrical stimulus to the muscle belly, which is expressed in millimeters and is dependent on muscle elasticity. This parameter is advocated to provide a measure of muscle belly stiffness (Pisot *et al.*, 2008), capable of detecting changes in inherent muscle stiffness (Ditroilo *et al.*, 2011). Other authors have related changes of D_m to changes affecting muscle tone (Neamtu *et al.*, 2011). This parameter varies from one patient to another and according to each muscle group, as well as according to the morphofunctional characteristics and the circumstances in which these structures have been trained. Furthermore, D_m is the most commonly used TMG parameter in studies because of its high reliability and clarity of interpretation (Simunic, 2012).

Several authors have used TMG devices for the assessment of changes in the contractile properties of muscles in patients with central nervous system pathologies (Krizaj *et al.*, 2007; Neamtu *et al.*, 2011; Rodriguez-Ruiz *et al.*, 2014). To this effect, the TMG D_m parameter has been found to be highly sensitive to changes affecting the amplitude of muscular displacement in spastic muscles treated with botulinum toxin type A (Krizaj *et al.*, 2007). Furthermore, D_m parameter measurements at the level of the lower limb muscles of patients with multiple sclerosis have also shown the presence of increased stiffness in patients with gait disorders compared with those without gait disorders (Neamtu *et al.*, 2011).

Study aim

The aim of the present case report was to objectively quantify the effects of the DNHS technique on muscle contraction properties in an individual with stroke on the basis of the TMG D_m parameter.

Methods

Patient

This descriptive case study is based on the case of a male patient aged 50 years old who had suffered a left-sided stroke 2.5 years earlier. The patient complained of spasticity associated with a right-sided hemiplegia. He had received dry needling treatment (DNHS) in the past, with good results, and was currently undergoing private physiotherapy treatments, as well as performing an exercise routine at home, although he reported few improvements with his current treatment. The patient presented marked spasticity in both the upper and the lower limbs: the upper limb presented with internal rotation of the shoulder, accompanied by elbow, wrist, and finger flexion; in terms of the lower limb and its functionality, the patient was able to walk unsupported using a marked hemiplegic gait pattern characterized by knee extension, drop-foot (ankle plantar flexion), and hip circumduction. He had a good level of cognitive function, screened by the mini-mental state exam. The patient was informed of the study aims and characteristics and enrolled voluntarily. Informed consent was obtained from

the patient before commencing the study. The study protocol was approved by the Ethical Committee of the Instituto Aragonés de Ciencias de la Salud [CEICA], Act No 17/2014 (Zaragoza, Spain).

Intervention

The DNHS technique was applied for one session by a physiotherapist specialized in the technique. Dry needling needles measuring 0.25×25 and 0.25×40 mm were used with a guide tube according to the depth of the muscles to be treated.

The following muscles were selected on the right (hemiplegic) side for treatment and assessment: (i) biceps brachii (BB), (ii) triceps brachii (TB), (iii) rectus femoris (RF), (iv) semitendinosus (ST), (v) biceps femoris (BF), (vi) medial gastrocnemius (MG), and (vii) lateral gastrocnemius (LG). The selection criteria of the muscles were two-fold: (i) muscles presenting spasticity and (ii) superficial muscles that allowed for measurement with the TMG technology.

The DNHS technique was applied on the MTrPs of the previously cited muscles according to a series of published essential and confirmatory diagnostic criteria and application guidelines (Gallego and del Moral, 2007; Herrero *et al.*, 2015). The intensity of the application was adjusted according to the patient's tolerance; this was monitored by the physiotherapist throughout the session by asking for regular verbal feedback. Furthermore, the patient was advised to say 'stop' if at any point he needed a break. Local twitch responses were obtained for every muscle treated to verify the correct placement of the needle into the MTrP (Hong, 1994; Simons *et al.*, 1999).

Signal recording

A TMG device was used (TMG North America) to assess changes in the contractile properties of the treated muscles. The equipment provides an electrical stimulus to the muscle belly and assesses skeletal muscle displacement and low-frequency lateral oscillations of active skeletal muscle fibers during twitch contractions with a linear displacement sensor measure the muscle radial displacement (contractile properties of transverse muscle sections) (Dahmane *et al.*, 2005).

Electrical stimulation was provided by a TMG-S1 electrostimulator (Furlan & Co. Ltd.) using 5×5 cm platinum-type electrodes. The stimulation pulse was 1 ms, whereas increasing electrical current intensities were used, ranging between 10 and 65 mA. A G40, RLS Inc. sensor, placed central to the muscle belly and perpendicular to the skin surface overlying the muscle, was used for the detection of the muscular response to the electrical stimulus. Correct sensor placement was ensured on the basis of anatomical references and adjusted according to the patient's individual muscle length and dimensions using visual inspection and

AQ3

AQ4

palpation. Once the sensors were in place, measurements were taken to calculate the distance from the nearest anatomical references to improve the reliability of sensor placements between measurements. This sensor exerts a 0.7 N/mm^2 pressure on the contact surface, known as pretension (Dahmane *et al.*, 2001), and serves to increase the response to the applied electrical stimulus. The TMG recordings in terms of displacement were then received by a Matlab Compiler Toolbox at a 1 kHz frequency. Two supramaximal responses were stored and the mean was calculated.

Measurement procedure

Two weeks before commencing the protocol, a one-day training session was carried out to ensure that both the researchers and the patient were familiar with the equipment. To ensure standardization of the procedure, all measurements were performed under the same conditions (same room and appointment schedule) by an independent assessor with previous experience in TMG assessments.

The measurements were performed according to the protocol described by the TMG manufacturer both for the patient position and for the placement of the TMG device. The patient setup and sensor placement for each of the muscles are described in Table 1. Figure 1 shows the basic setup for the semitendinosus muscle assessment, which was adapted to suit each of the different muscles measured. A coresearcher provided support when necessary to avoid involuntary movements while measurements were being taken.

The patient was measured three times: before intervention (M1), after intervention (M2), and at a follow-up assessment 3 weeks after the DNHS intervention (M3). Data were processed as follows: (i) treatment effect: intrasession changes after treatment with DNHS (M2–M1) and (ii) changes maintained at follow-up (M3–M1).

For all muscles, the postintervention measurements were performed 1 min and 50 s after the application of the DNHS technique. Also, the intensity of the electrical stimulus applied for the measurements was always the same.

Results

Table 2 shows all the raw data obtained for the D_m parameter classified by muscle, specifying the pre-intervention measurement (M1), the postintervention measurement (M2), and the measurement at the 3-week follow-up (M3). An increase in the D_m parameter was observed in all muscles both at the postintervention measurement as well as at follow-up. No adverse effects were reported in association with the dry needling intervention, the intensity of which was well tolerated by the patient. He described a feeling of heaviness immediately after the dry needling intervention in the lower limb, which improved over a period of several hours. Furthermore, he reported improved performance during his home exercise routine. Overall, the patient perceived more notable improvements in the upper limb than the lower limb and was particularly satisfied with the results of the former. The patient expressed interest in repeating the intervention in the future.

Discussion

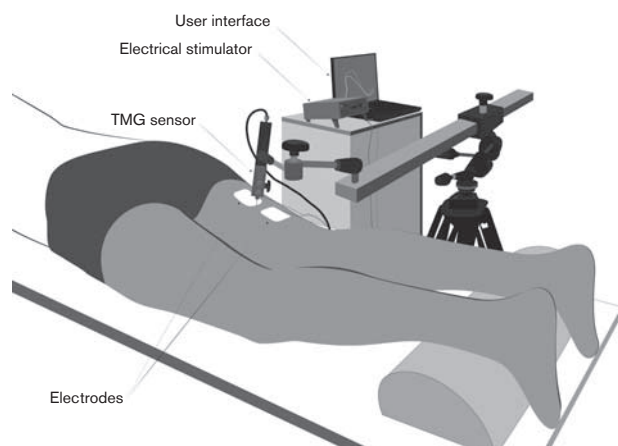
This study aimed to objectively analyze TMG parameter changes associated with the dry needling treatment (DNHS technique) of spastic muscles in an individual with stroke. The D_m parameter was selected for its superior between-day reliability, with a reported ICC ranging between 0.98 and 0.99, depending on the assessed muscles (Simunic, 2012). Low values of the D_m parameter have been attributed to muscle and tendon stiffness (Pisot *et al.*, 2008; Ditroilo *et al.*, 2011) as well as being related to high tone (Neamtu *et al.*, 2011), together with the opposite situation, that is, high values of D_m are related to lower muscle stiffness and lower tone states. It is worth highlighting that we found that the D_m parameter of all muscles under study increased both immediately after the DNHS intervention and at follow-up. This supports findings obtained by Ansari *et al.* (2015), who applied dry needling to the upper limb muscles of a patient with chronic stroke. The authors of this study reported a decrease in spasticity, measured using the Modified Ashworth Scale (a decrease of 1 point for both supination and finger extension passive stretching), the $H_{\max}/M_{\max}$ ratio (decreasing from 0.39 to 0.29 immediately after dry needling), and range of motion (the range of supination increased from 30° to 75° immediately after

Table 1 Patient position and tensiomyography sensor placement for the muscles under study

	Patient position	Sensor placement ^a
Biceps brachii	Seated, elbow flexed 90, neutral pronosupination	11.5 cm from elbow crease
Triceps brachii	Seated, elbow flexed 90, neutral pronosupination	22.5 cm proximal to the olecranon
Rectus femoris	Supine, bolster under the patient's feet	22 cm proximal to the superior pole of the patella
Semitendinosus	Prone, bolster under the patient's feet	18.5 proximal to the popliteal crease
Biceps femoris	Prone, bolster under the patient's feet	18.5 proximal to the popliteal crease
Lateral gastrocnemius	Prone, bolster under the patient's feet	34.7 cm proximal to the calcaneus
Medial gastrocnemius	Prone, bolster under the patient's feet	34.3 cm proximal to the calcaneus

^aSensor placement was central to the muscle belly and perpendicular to the skin surface overlying the muscle. Each individual muscle was assessed to determine optimal sensor placement.

Fig. 1



Experimental setup for tensiomyography assessment of the semitendinosus muscle. TMG, tensiomyography.

Table 2 Results according to changes in the D_m parameter for all muscles

	D_m				
	M1	M2	M3	M2–M1 (treatment effect)	M3–M1 (follow-up)
BB	6.53	9.1	6.97	2.57	0.44
TB	2.14	3.78	2.21	1.64	0.07
RF	11.53	12.25	11.64	0.72	0.11
BF	12.49	13.35	17.52	0.86	5.03
ST	17.07	17.47	17.11	0.4	0.04
MG	3.37	5.3	5	1.93	1.63
LG	2.62	2.63	5.52	0.01	2.9

BB, biceps brachii; BF, biceps femoris; D_m , maximal displacement; LG, lateral gastrocnemius; M1, preintervention measurement; M2, postintervention measurement; M3, follow-up measurement 21 days postintervention; MG, medial gastrocnemius; RF, rectus femoris; ST, semitendinosus; TB, triceps brachii.

dry needling). We sought to elicit LTRs during the dry needling intervention as this has been shown to improve the effectiveness of the same (Hong, 1994). Local twitch responses are considered to be involuntary spinal reflexes (Hsieh *et al.*, 2011), and their achievement has been related to the modulation of the myotatic reflex (Gallego and del Moral, 2007) and a decrease in stiffness that is quantifiable by sonoelastography (Maher *et al.*, 2013). On the basis of these studies, our findings of an increase in the D_m parameter after treatment correlate with the dry needling literature.

These findings must be considered in relation to the TMG measurement error to determine the extent of changes and whether these can be considered as real changes in values. As there are no published values on the minimal clinically important difference, we based our calculations on the smallest real difference (SRD), with the objective of determining whether the treatment effect found may be associated with the equipment measurement error. The data used to calculate the SRD

were obtained from Simunic (2012) in a study carried out on a healthy sample as we could not find published data based on patients with spasticity. Considering that the SEM for the D_m parameter ranges between 0.17 and 0.43, the SRD was calculated, as a result of which we determined that this would range from 0.80 to 1.28. Therefore, and considering the more conservative values, a change greater than 1.28 in D_m after the DNHS intervention was considered to be the smallest real difference not derived from measurement error. Because of this, the changes observed in our study may be considered real changes in values for all muscles at after intervention, except for RF, ST, and LG. In terms of the effects at follow-up, no real changes were maintained for the D_m parameter in the case of the RF, ST, and TB muscles, whereas other muscles such as BF and LG continued to improve and changes can be considered real at follow-up.

Study limitations

Because of the lack of reference values in the magnitude of minimal clinically important difference in patients with spasticity, no definitive conclusions can be obtained. Also, although assessments were carried out in a standardized manner to preserve the measurement conditions, the influence of previous movement experience was not controlled for, which may have influenced the results at follow-up measurements. As this is a case report, no cause–effect relationships can be supported. Further studies are required with larger sample sizes to help identify possible response patterns and the duration of the effects. Tensiomyography can potentially be a valuable tool for measuring the magnitude and duration of dry needling effects; however, reliability values in spastic muscles are needed to facilitate data interpretation.

Another important limitation is that the reported effects cannot be restricted to the mechanical effect of the needle in the MTrP; therefore, further studies comparing dry needling and acupuncture would be necessary to differentiate between the local and the indirect effects of this therapeutic modality.

Conclusion

This is the first controlled experimental study to use TMG to assess the effects of dry needling (DNHS technique). Indeed, to our knowledge, this is the first study to use TMG for the assessment of any dry needling technique. The use of TMG has shown changes in the D_m parameter that appear to be reliable in patients with stroke. It is worth highlighting that this measurement represents maximal muscle displacement, which is associated with local muscle stiffness. However, D_m cannot be directly related with the measurement of spasticity as this is indeed a complex syndrome in itself.

Further studies are needed with larger samples of patients with spasticity to obtain reference TMG values

as well as to determine the minimal changes that can be detected with TMG with respect to the application of DNHS. Besides, future studies analyzing the correlation between TMG values and clinical measurements would help clinicians to objectively register changes after treatment and over time. Similarly, further research into the types of muscle responses and the duration of their effects is required to support or refute clinical findings in certain muscle groups that respond differently immediately after treatment compared with the follow-up after treatment with DNHS.

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Conflicts of interest

Pablo Herrero owns the register of DNHS mark. For the remaining authors there are no conflicts of interest.

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