Case Report

Dry needling technique decreases spasticity and improves general functioning in incomplete spinal cord injury: A case report

Carlos Cruz-Montecinos [1,2,3], Rodrigo Núñez-Cortés[2,4], Trinidad Bruna-Melo[3], Claudio Tapia [5,2], Pablo Becerra[3], Nicolás Pavez[3], Sofía Pérez-Alenda [1]

[1]Department of Physiotherapy, University of Valencia, Valencia, Spain, [2]Laboratory of Clinical Biomechanics, Department of Physical Therapy, Faculty of Medicine, University of Chile, Santiago, Chile, [3]Biomechanics and Kinesiology Laboratory, Kinesiology Unit, San José Hospital, Santiago, Chile, [4]Service of Physical Therapy, Hospital Clínico La Florida, Santiago, Chile, [5]Universidad Tecnológica de Chile INACAP, Escuela Salud, Santiago, Chile

Context: Spasticity in neurological disorders (i.e. stroke patients and cerebral palsy) is positively improved by dry needling. However, reports are scarce regarding the potential effects of dry needling in reducing spasticity and improving functionality in patients with an incomplete spinal cord injury. The aim of this case report was to study the immediate, short-term effects of dry needling treatment (10 weeks) on spasticity, dynamic stability, walking velocity, self-independence, and pain in a single patient with an incomplete spinal cord injury.

Findings: The dry needling treatment resulted in immediate, short-time effects on basal spasticity in the upper (reduction from 2 to 0 point median) and lower (reduction from 2 to 0 point median) limbs, as measured by the modified Ashworth Scale. Dynamic-stability, assessed by trunk accelerometry, improved more than 50% (Root Mean Squared of acceleration, Root Mean Squared of Jerk and step variability), and gait speed improved by 24.7 s (i.e. time to walk 20 m). Self-independence and pain were respectively scored by the Spinal Cord Independence Measure (21 points improvement) and visual analog scale (4 points improvement).

Conclusions: This case report demonstrates that dry needling treatment can have positive effects on spasticity, dynamic stability, walking velocity, self-independence, and pain in patients with incomplete spinal cord injury. Further research is needed in a larger patient population to deeply understand the mechanism(s) associated with the obtained results and regarding the clinical significances of dry needling treatment for incomplete spinal cord injury.

Keywords: Spinal cord, Trigger point, Spasticity, Pain

Introduction

Chronic pain and spasticity are common clinical manifestations after spinal cord injury (SCI) that has negative impacts on quality of life.[1–3] While the experience of spasticity is highly individualized,[3] one in five patients will have ongoing functional limitations related to spasticity.[4] The commonly accepted definition of spasticity is "a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex."[5] However, this definition overlooks the contribution of viscoelastic properties of soft tissue to joint stiffness and the roles of proprioceptive and cutaneous sensory pathways.[6–8]

The primary focuses of multimodal treatment are to decrease spasticity to facilitate mobility[9,10] and reduce chronic complications (i.e. nociceptive pain).[11–13] Several studies have quantified the clinical effect of injecting the botulinum toxin on decreasing muscle spasticity.[14,15] Nevertheless, this medical treatment is expensive, and consensus is lacking in regards to dose, site of injection, and technique.[16]

One proposed alternative treatment to decrease spasticity in neurological disorders (i.e. stroke and cerebral palsy) is the dry needling technique (DNT).[17–23] DNT is a specialized intervention that uses a fine filiform needle to penetrate muscle directly at a myofascial

Correspondence to: Sofía Pérez-Alenda, Departamento de Fisioterapia, Universitat de València, C/ Gascó Oliag N°5, 46010 Valencia, Spain; Ph: +34 963983853. Email: Sofia.Perez-Alenda@uv.es

DOI 10.1080/10790268.2018.1533316

trigger point (MTrP).[24] Nevertheless, reports are scarce regarding the potential effect of DNT in reducing spasticity in an incomplete SCI (iSCI),[25] and the effect on functionality is not yet described. The hypothesized relation between DNT and decreased spasticity is established in prior research reporting a decrease in noise at the dysfunctional endplate,[26,27] restoration of muscle architecture,[20] contractile properties,[17] and a positive effect on regional brain activity.[19]

The MTrPs may be responsible for joint-range restrictions and alterations to muscle activation patterns.[28] Even a single session of DNT in the lower limbs could positively affect postural control, in addition to reducing spasticity[22,29] and pressure-pain sensitivity.[21,29] Due to spasticity, patients with iSCI present alterations in static and dynamic balance, with potential risks for falling.[30,31] Therefore, alternative, low-cost, and significantly impactful treatment strategies for improving gait control and functionality are an imperative need.

The aim of this case study was to study the immediate, short-term effects of DNT (10 weeks) on spasticity, dynamic stability, walking velocity, self-independence, and pain in a single patient with an iSCI.

Case presentation

The recruited patient (male, age: 47, height: 1.78 m, weight: 68 kg) presented a history of cervical-level surgery (six months prior to DNT) following a traumatic disk hernia, with compromised functionality of the right upper and lower limbs, neuropathic pain, spasticity, and difficulties performing independent gait.

Methods

Prior to DNT intervention, ethical approval was obtained from the Institutional Review Board, and the patient provided written informed consent. Thereafter, the patient underwent a 10-week DNT intervention.

Intervention

MTrPs were detected in the upper and lower limbs, as based on DNT criteria for spasticity: 1) Essential criteria: Restriction to passive stretching or triggering of myotatic reflex, taut muscle band with a hyperirritable nodular; and 2) Confirmatory criteria: visual or tactile identification of global or local twitch response when inserting the needle or by palpation for superficial muscle (note: can be very irritating and not sufficiently conclusive), and neural release (i.e immediate release from contraction).[18,23,32]

A single weekly session of DNT was administered with an acupuncture needle (0.30 × 50 mm; Huan Qiu, Suzhou, China). For each session, DNT was applied in the deltoid; biceps brachialis; wrist extensors and flexors; thenar muscles; vastus medialis; gastrocnemius medialis; and tibialis anterior.[33] Following local twitch responses (maximum three), the dry needle was left inserted for 15 minutes in each muscle.

Outcomes

Spasticity assessment

Spasticity for the upper and lower limbs was assessed before and after the first and last DNT sessions using the modified Ashworth Scale (MAS).[34–36]

Dynamic gait stability and walking assessment

Before and after the first and last DNT sessions, trunk acceleration was assessed at 800 Hz by a single triaxial accelerometer (X16-mini USB accelerometer, Gulf Coast Data Concepts, Waveland, MS, USA) located at the L3 level. The patient was asked to walk 20 m without a cane three times, with a 2-minute rest period between each repetition. Steps were detected by vertical acceleration, i.e. foot contact with the ground. Signals were processed according to previous reports on patient frailty.[37] The following variables were assessed: gait velocity (time in seconds to cover the distance of 20 m); step variability; root mean squared (RMS) of acceleration;[38,39] and RMS of lineal Jerk.[40] The RMS of acceleration was expressed as intensity during gait, with high values related to poorer trunk control.[38,39] RMS of Jerk was expressed as the smoothness of trunk control during gait, with lower values reflecting better trunk control.[40] All accelerometer data were analyzed in the Matlab software (MathWorks Inc, Natick, MA, USA).

Independence measure and pain assessment

Before and after the DNT program, independence was determined by the Spinal Cord Independence Measure,[41] and pain during daily activities (e.g. walking) was assessed through the Visual Analogue Scale (VAS).

Results

After the first DNT session, immediate effects on spasticity in the upper and lower limbs were assessed by the MAS. Reduced medians of 2 and 1 points on the MAS were observed in the upper and lower limb muscles, respectively. Walking velocity improved only 1.8 s; however, dynamic stability improved more than 50% (Table 2), as assessed by trunk accelerometry (i.e. less step variability, and lower RMS of acceleration and Jerk).

Major effects were observed at 10 weeks post-treatment, indicating that improvements due to DNT are

Table 1 Spasticity assessments before and after the first and the last dry needling technique session (10-week period).

	First session	First session	Final session	Final session
Modified Ashworth scale	Pre treatment	Post treatment	Pre treatment	Post treatment
Elbow flexors	4	1	2	0
Wrist flexors	2	0	1	0
Finger flexors	2	0	0	0
Knee flexors	1+	1	2	0
Knee extensors	3	1	2	0
Plantar flexors	2	2	1+	1+

accumulative. Spasticity in the upper and lower limb muscles reduced a median of 2 points on the MAS (Table 1). Dynamic-stability variables improved more than 50%. Gait speed improved by 24.7 s (i.e. time to walk 20 m). The Spinal Cord Independence Measure and VAS improved by 21 and 4 points, respectively (Table 2).

Discussion

In this case report, DNT improved measures of muscle spasticity, dynamic gait stability, pain, and daily independence in a patient with iSCI. The present findings align with previous reports on DNT applied in patients with neurological disorders with spasticity,[17–23,25] in addition to complementing the first report in two patients with iSCI by Fresno *et al.*[25]

The mechanism(s) that may explain the obtained results are not fully understood. However, some peripheral and central hypotheses can be established. Since there is a non-linear relationship between scoring of the MAS and α motor neuron excitability,[42] decreased spasticity, as determined MAS scoring, could be related to muscle thixotropy and muscle contractures. The muscle stiffness could increase spasticity, with a consequent increase in sensory input from muscle spindles.[8] Mechanical stimulation through DNT may inhibit spontaneous electrical activity in MTrPs by reducing the availability of acetylcholine in the motor endplate,[27] thereby restoring muscle architecture[20] and the contractile properties of hypertonic muscles.[17]

The effects of DNT on sensorimotor coordination might also be explained by changes in the frontal and prefrontal regions of the brain. In particular, a previous report in two chronic-stroke patients reported changes in the alpha waves of these brain regions.[19] Positive effects in functional walking capacity following DNT have also been reported in chronic-stroke patients.[20] Patients with iSCI have fewer muscle synergies during gait than healthy subjects and, on the affected side, muscle organizations related to functional walking (i.e. speed, cadence) are the most impacted.[43] MTrPs are associated with increased antagonistic muscle activity during agonist muscle contraction,[44] with final effects on intermuscular coordination.[28] It is possible that the presently observed improvements in walking outcomes (i.e. dynamic stability and walking speed) could be related to a regulation of muscle stiffness and a better modulation of the local/descendent pathways at the spinal level; all of which might positively impact the organization of muscle synergies during gait.

In turn, the presently observed positive effects on pain (i.e. VAS) could be related to improved independence. Neuropathic pain notably impacts the quality of life for iSCI patients,[1] in addition to being interrelated with spasticity.[12] DNT is commonly used to treat pain in chronic neuromusculoskeletal conditions,[45,46] and a positive effect of DNT in pressure-pain sensitivity has been reported in stroke patients.[21,29]

Also worth noting is that DNT has fewer adverse effects (e.g. soreness)[47] than botulinum toxin treatment, the side-effects of which include an allergic reaction,[48]

Table 2 Functional and clinical variables assessed before the first and after the last dry needling technique session (10-week period). Values reflect the mean of three tests.

Variables	First session Pre treatment	First session Post treatment	Final session Pre treatment	Final session Post treatment	% change	% CV
VAS (points)	6	–	2	–	−66.6	–
SCIM (points)	69	–	90	–	+30.4	–
Walking 20 m (seconds)	54.8	53.0	31.2	30.1	−45.1	15.7
Step variability (%)	40.0	18.7	8.0	5.5	−86.3	16.2
RMS of acceleration (m/s^2)	4.8	2.1	3.5	2.4	−50.0	23.4
RMS of Jerk (m/s^3)	18.9	8.7	11.5	8.2	−56.7	12.4

VAS, visual analog scale; SCIM, spinal cord independence Measure; RMS, root mean squared sum of the three axes (X,Y,Z). Jerk sum of the three axes (X,Y,Z). % Change, percent difference between the basal condition (i.e. first session) and post-treatment condition (i.e. final session). % CV, coefficient of variation. Walking 20 m, step variability, RMS of acceleration and jerk are expressed as the mean of three measurements.

muscle weakness,[49] and anaphylaxis.[50] Further recent evidence in an animal model indicates that administration of the botulinum toxin increases intramuscular connective tissues, meaning that the botulinum toxin could be increasing rather than decreasing stiffness.[51]

Finally, DNT represents a possible economic alternative for decreasing spasticity and pain and improving functionality in iSCI. However, future studies are needed to determine the clinical and functional effects of dry needling in a large population of patients with iSCI.

Conclusions

In conclusion, important immediate, short-term positive effects were observed in spasticity of the upper and lower limbs, dynamic stability, walking velocity, self-independence, and pain following DNT in one iSCI patient. Further research is needed in a larger patient population to deeply understand the mechanism(s) associated with DNT results and in regards to the clinical significances of DNT in iSCI patients.

Disclaimer statements

Contributors All authors have contributed significantly to the design, analysis and writing of this manuscript. The contents represent original work and have not been published elsewhere.

Funding statement None.

Declaration of interest The authors stated that they had no interests, which might be perceived as posing a conflict or bias.

Ethics approval The Institutional Review Board for the study site reviewed and approved this project.

Supplemental data

Supplemental data for this article can be accessed http://dx.doi.org/10.1080/10790268.2018.1533316.

ORCID

Carlos Cruz-Montecinos http://orcid.org/0000-0002-3835-3368
Claudio Tapia http://orcid.org/0000-0001-7313-2483
Sofía Pérez-Alenda http://orcid.org/0000-0002-0841-5767

References

1 Andresen SR, Biering-Sorensen F, Hagen EM, Nielsen JF, Bach FW, Finnerup NB. Pain, spasticity and quality of life in individuals with traumatic spinal cord injury in Denmark. Spinal Cord 2016;54(11):973–9.
2 Westerkam D, Saunders LL, Krause JS. Association of spasticity and life satisfaction after spinal cord injury. Spinal Cord 2011;49(9):990–4.
3 McKay WB, Sweatman WM, Field-Fote EC. The experience of spasticity after spinal cord injury: perceived characteristics and impact on daily life. Spinal Cord 2018;56(5):478–86.
4 Holtz KA, Lipson R, Noonan VK, Kwon BK, Mills PB. Prevalence and effect of problematic spasticity after traumatic spinal cord injury. Arch Phys Med Rehab 2017;98(6):1132–8.
5 Lance JW. Symposium synopsis. In: Feldman RG, Young PR, Koella WP, (eds.) Spasticity: Disordered Motor Control. Chicago, IL: Yearbook Medical Publishers; 1980; p. 485–94.
6 Van den Noort JC, Bar-On L, Aertbelien E, Bonikowski M, Braendvik SM, Brostrom EW, *et al.* European consensus on the concepts and measurement of the pathophysiological neuromuscular responses to passive muscle stretch. Eur J Neurol 2017;24(7):981–e38.
7 Akpinar P, Atici A, Ozkan FU, Aktas I, Kulcu DG, Sari A, *et al.* Reliability of the modified Ashworth scale and modified Tardieu scale in patients with spinal cord injuries. Spinal Cord 2017;55(10):944–9.
8 Kuo C-L, Hu G-C. Post-stroke spasticity: a review of epidemiology, pathophysiology, and treatments. Int J Gerontol 2018;10:1016.
9 Cardenas D. Spinal Cord Injury Rehabilitation, an Issue of Physical Medicine and Rehabilitation Clinics of North America, E-Book. Philadelphia: Elsevier Health Sciences; 2014.
10 Sisto SA, Druin E, Sliwinski MM. Spinal Cord Injuries-E-Book: Management and Rehabilitation. Philadelphia: Elsevier Health Sciences; 2008.
11 Burke D, Fullen BM, Stokes D, Lennon O. Neuropathic pain prevalence following spinal cord injury: a systematic review and meta-analysis. Eur J Pain 2017;21(1):29–44.
12 Finnerup NB. Neuropathic pain and spasticity: intricate consequences of spinal cord injury. Spinal Cord 2017;55:1046–50.
13 Sezer N, Akkuş S, Uğurlu FG. Chronic complications of spinal cord injury. World J Orthopedics 2015;6(1):24.
14 Baba Y, Osborne MD, Wszolek ZK, Kwolek A, Druzbicki M. Treatment of spasticity with botulinum toxin. Ortop Traumatol Rehabil 2004;6(5):665–72.
15 Lester J, Alvarez-Resendiz GE, Klériga E, Videgaray F, Zambito G. Treatment with Botulinum toxin for refractory fever caused by severe spasticity: a case series. Neurol Ther 2018;7(1):1–5.
16 Chan AK, Finlayson H, Mills PB. Does the method of botulinum neurotoxin injection for limb spasticity affect outcomes? A systematic review. Clin Rehabil 2017;31(6):713–21.
17 Calvo S, Quintero I, Herrero P. Effects of dry needling (DNHS technique) on the contractile properties of spastic muscles in a patient with stroke: a case report. Int J Rehabil Res 2016;39(4):372–6.
18 Gallego PH, del Moral OM. A case study looking at the effectiveness of deep dry needling for the management of hypertonia. J Musculoskelet Pain 2007;15(2):55–60.
19 Calvo S, Navarro J, Herrero P, Del Moral R, De Diego C, Marijuán PC. Electroencephalographic changes after application of dry needling [DNHS© technique] in two patients with chronic stroke. Myopain 2015;23(3-4):112–7.
20 Hadi S, Khadijeh O, Hadian M, Niloofar AY, Olyaei G, Hossein B, *et al.* The effect of dry needling on spasticity, gait and muscle architecture in patients with chronic stroke: A case series study. Top Stroke Rehabil 2018;23:1–7.
21 Mendigutia-Gómez A, Martín-Hernández C, Salom-Moreno J, Fernández-de-las-Peñas C. Effect of dry needling on spasticity, shoulder range of motion, and pressure pain sensitivity in patients with stroke: A crossover study. J Manip Physiol Ther 2016;39(5):348–58.
22 Fakhari Z, Ansari NN, Naghdi S, Mansouri K, Radinmehr H. A single group, pretest-posttest clinical trial for the effects of dry needling on wrist flexors spasticity after stroke. NeuroRehabilitation 2017;40(3):325–36.
23 Herrero Gallego P, Mayoral del Moral O, Calvo Carrión S. Utilización de la técnica DNHS© (dry needling for hypertonia and spasticity) en el tratamiento de la hipertonía, la espasticidad y otras alteraciones y disfunciones del movimiento de origen central. Fisioterapia 2011;33(5):189–91.
24 Dommerholt J, Mayoral del Moral O, Gröbli C. Trigger point dry needling. J Man Manip Ther 2006;14(4):70E–87E.
25 Fresno M, Mediavilla P, Mayoral O. Dry needling of miofascial trigger points for hypertonia spastica in incomplete spinal cord injuries. J Musculoskelet Pain 2004;12(Suppl 9):75 [abstract].

26 Cagnie B, Dewitte V, Barbe T, Timmermans F, Delrue N, Meeus M. Physiologic effects of dry needling. Curr Pain Headache Rep 2013;17(8):348.

27 Chen J-T, Chung K-C, Hou C-R, Kuan T-S, Chen S-M, Hong C-Z. Inhibitory effect of dry needling on the spontaneous electrical activity recorded from myofascial trigger spots of rabbit skeletal muscle. Am J Phys Med Rehab 2001;80(10):729–35.

28 Lucas KR, Polus BI, Rich PA. Latent myofascial trigger points: their effects on muscle activation and movement efficiency. J Bodyw Mov Ther 2004;8(3):160–6.

29 Salom-Moreno J, Sánchez-Mila Z, Ortega-Santiago R, Palacios-Ceña M, Truyol-Domínguez S, Fernández-de-las-Peñas C. Changes in spasticity, widespread pressure pain sensitivity, and baropodometry after the application of dry needling in patients who have had a stroke: a randomized controlled trial. J Manip Physiol Ther 2014;37(8):569–79.

30 Brotherton SS, Krause JS, Nietert PJ. Falls in individuals with incomplete spinal cord injury. Spinal Cord 2007;45(1):37–40.

31 Sadeghi M, Mclvor J, Finlayson H, Sawatzky B. Static standing, dynamic standing and spasticity in individuals with spinal cord injury. Spinal Cord 2016;54(5):376–82.

32 Herrero P, Calvo S, Ortiz M. Dry needling for hypertonia and spasticity (DNHS). Advanced techniques in musculoskeletal Medicine & Physiotherapy Using Minimally Invasive Therapies. London, UK: Churchill-Livingston, Elsevier; 2015.

33 Hong C-Z. Considerations and recommendations regarding myofascial trigger point injection. J Musculoskelet Pain 1994;2(1): 29–59.

34 Bohannon RW, Smith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. Phys Ther 1987;67(2):206–7.

35 Ghotbi N, Ansari NN, Naghdi S, Hasson S, Jamshidpour B, Amiri S. Inter-rater reliability of the modified modified Ashworth scale in assessing lower limb muscle spasticity. Brain Injury 2009;23(10): 815–9.

36 Naghdi S, Nakhostin Ansari N, Azarnia S, Kazemnejad A. Interrater reliability of the modified modified Ashworth scale (MMAS) for patients with wrist flexor muscle spasticity. Physiother Theor Pract 2008;24(5):372–9.

37 Martínez-Ramírez A, Martinikorena I, Gómez M, Lecumberri P, Millor N, Rodríguez-Mañas L, *et al.* Frailty assessment based on trunk kinematic parameters during walking. J Neuroeng Rehabil 2015;12(1):48.

38 Haas B, Bergström E, Jamous A, Bennie A. The inter rater reliability of the original and of the modified Ashworth scale for the assessment of spasticity in patients with spinal cord injury. Spinal Cord 1996;34(9):560–4.

39 Wada O, Asai T, Hiyama Y, Nitta S, Mizuno K. Root mean square of lower trunk acceleration during walking in patients with unilateral total hip replacement. Gait Posture 2017;58:19–22.

40 Brodie MA, Menz HB, Lord SR. Age-associated changes in head jerk while walking reveal altered dynamic stability in older people. Exp Brain Res 2014;232(1):51–60.

41 Zarco-Periñan MJ, Barrera-Chacón MJ, García-Obrero I, Mendez-Ferrer JB, Alarcon LE, Echevarria-Ruiz de Vargas C. development of the Spanish version of the spinal cord independence measure version III: cross-cultural adaptation and reliability and validity study. Disabi Rehabil 2014;36(19):1644–51.

42 Bakheit A, Maynard V, Curnow J, Hudson N, Kodapala S. The relation between Ashworth scale scores and the excitability of the α motor neurones in patients with post-stroke muscle spasticity. J Neurol Neurosurg Psychiat 2003;74(5):646–8.

43 Pérez-Nombela S, Barroso F, Torricelli D, de Los Reyes-Guzmán A, Del-Ama A, Gómez-Soriano J, *et al*. Modular control of gait after incomplete spinal cord injury: differences between sides. Spinal Cord 2017;55(1):79–86.

44 Ibarra JM, Ge H-Y, Wang C, Vizcaíno VM, Graven-Nielsen T, Arendt-Nielsen L. Latent myofascial trigger points are associated with an increased antagonistic muscle activity during agonist muscle contraction. J Pain 2011;12(12):1282–8.

45 Mayoral O, Salvat I, Martín MT, Martín S, Santiago J, Cotarelo J, *et al.* Efficacy of myofascial trigger point dry needling in the prevention of pain after total knee arthroplasty: a randomized, double-blinded, placebo-controlled trial. Evid-Based Compl Alt Med 2013;2013:1–8.

46 Núñez-Cortés R, Cruz-Montecinos C, Vásquez-Rosel Á, Paredes-Molina O, Cuesta-Vargas A. Dry needling combined with physical therapy in patients with chronic postsurgical pain following total knee arthroplasty: a case series. J Orthop Sport Phys 2017;47(3): 209–16.

47 Martín-Pintado-Zugasti A, del Moral OM, Gerwin RD, Fernández-Carnero J. Post-needling soreness after myofascial trigger point dry needling: current status and future research. J Bodyw Mov Ther 2018(29).

48 Careta MF, Delgado L, Patriota R. Report of allergic reaction after application of botulinum toxin. Aesthet Surg J 2015;35(5): NP102–NP5.

49 Gracies J-M, Brashear A, Jech R, McAllister P, Banach M, Valkovic P, *et al*. Safety and efficacy of abobotulinumtoxinA for hemiparesis in adults with upper limb spasticity after stroke or traumatic brain injury: a double-blind randomised controlled trial. Lancet Neurol 2015;14(10):992–1001.

50 Moon I, Chang S, Kim S. First case of anaphylaxis after botulinum toxin type A injection. Clin Exp Dermatol 2017;42(7): 760–2.

51 Yucesoy CA, Ateş F. BTX-A has notable effects contradicting some treatment aims in the rat triceps surae compartment, which are not confined to the muscles injected. J Biomech 2018; 66:78–85.