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Dry Needling on the Infraspinus Latent and Active Myofascial Trigger Points in Older Adults With Nonspecific Shoulder Pain: A Randomized Clinical Trial

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ABSTRACT

Background and Purpose: Shoulder pain is a prevalent condition in older adults. Some authors associate nonspecific shoulder pain with myofascial trigger points (MTrPs) in the infraspinus muscle. Dry needling is recommended to relieve the MTrP pain of shoulders in the short term (<9 days). Active MTrPs dry needling improves shoulder pain and the irritability of the satellite MTrPs in the referred pain area. Nociceptive activity at a latent MTrP may influence motor activity and the sensitivity of MTrPs in distant muscles

at a similar segmental level. Therefore, this study aimed to evaluate dry needling on 1 latent MTrP, in conjunction with 1 active MTrP, in the infraspinus muscle of older adults with nonspecific shoulder pain.

Methods: A single-center, randomized, single-blinded, controlled study (NCT02032602) was carried out. Sixty-six patients aged 65 years and older with trigger points in the ipsilateral infraspinus of the painful shoulder were randomly assigned to (1) of (2) treatment groups. A session of dry needling on the infraspinus was performed in (1) the most hyperalgesic active and latent MTrP or (2) only the most hyperalgesic active MTrP. The Numeric Rating Scale, the pressure pain threshold (primary outcome) on the anterior deltoid and extensor carpi radialis brevis latent MTrPs, and grip strength were assessed before, after, and 1 week after the intervention.

Results: Statistically significant differences in the reduction of pain intensity ($P \leq .001$; $\eta^2 = 0.159$ - 0.269 ; $d = 1.017$ - 1.219) and the increase of pressure pain threshold ($P < .001$; $\eta^2 = 0.206$ - 0.481 ; $d = 0.870$ - 1.924) were found for the (1) treatment group immediately and 1 week postintervention. Nevertheless, no statistical significant differences were found in grip strength ($P > .05$; $\eta^2 = 0.006$ - 0.033 ; $d = 0.158$ - 0.368).

Conclusions: One dry needling intervention of the latent MTrP associated with the key active MTrP of the infraspinus reduces pain intensity and the irritability of the satellite MTrPs located in the referred pain area in the short term in older adults with nonspecific shoulder pain.

Key Words: aged, musculoskeletal pain, myofascial pain syndromes, shoulder pain, trigger points

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INTRODUCTION

Worldwide, one of the most important characteristics of society is the aging of the population. This factor has an impact on the level of health in this population and on the prevalence of chronic conditions.¹ In Spain, chronic pain is common in participants older than 65 years. Musculoskeletal pain, which is frequently found in joint areas, is more prevalent in older adults than in younger people.²⁻⁴ Regarding the pathologies in the locomotor system, lumbar, cervical, and shoulder pain are the most common conditions in primary care.⁵ Indeed, nonspecific

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shoulder pain shows a prevalence varying from 3% to 50.9% in the older adults.⁴ The degeneration associated with the aging process makes establishing an accurate diagnosis and determining the specific structures of the origin of shoulder pain difficult.⁶⁻⁸ All of this leads to a high cost for the Spanish public health service, which is associated with ineffective treatments (68.4%), and demonstrates a need for more evidence on physiotherapy interventions.⁹

Some authors associate nonspecific shoulder pain with myofascial pain syndrome (MPS) and myofascial trigger points (MTrPs) of the infraspinatus muscle are the most prevalent and the most reliable on palpation.¹⁰⁻¹² Based on MPS clinical activity, spontaneous and recognizable pain of active MTrPs distinguishes people with pain from participants with no pain, whereas latent MTrPs generate non-recognized local or referred pain upon stimulation.^{10,12-20} Nevertheless, both MTrPs are hyperirritable nodules in a taut band of skeletal muscle, associated with a characteristic nociceptive biochemical milieu near to the motor end-plate and related to sensitive, motor, and autonomic conditions.^{10,18,20} Depending on MPS primacy, the key MTrP is the primary hyperalgesic focus and satellite MTrPs are the secondary focus of hyperalgesia located in the referred pain area.^{10,16} Consequently, the treatment of the latent MTrP, associated with the key active MTrP, may reduce pain and irritability of the satellite MTrPs.^{14,16}

Currently, conservative (myofascial manipulation, ischemic compression, laser therapy, and multimodal treatment) and invasive MTrP physiotherapy treatments are recommended for shoulder pain to reduce pain, increase range of motion, and improve function.²¹ On the one hand, trigger point dry needling (TrP-DN) is recommended to relieve the MTrP pain of shoulders in the short term (<9 days). On the contrary, lidocaine injections are more effective in the medium term (9-28 days).²² Indeed, latent TrP-DN may prevent the development of active MTrPs in the upper extremity and reduce their nociceptive input, normalize synaptic efficacy, and reduce central and peripheral sensitization in short-term shoulder pain.^{14-17,21-23} Finally, TrP-DN is associated with muscle regeneration and reinnervation.²⁴

The muscular tissue of older patients has degenerative features and multiple latent MTrPs that may require treatment to prevent chronic MPS.²⁵ Considering the chronic pain in older adults, invasive management techniques are proposed for myofascial pain treatment to improve quality of life and physical function.²⁶ Indeed, TrP-DN in older adults was shown to be effective in the reduction of pain for knee osteoarthritis and after total knee arthroplasty.^{13,27} Moreover, upper trapezius TrP-DN may be as useful as lidocaine injections for the treatment of cervical MPS in older patients.²⁸⁻³⁰ In addition, TrP-DN was shown to be better than a sham treatment for low back pain release.^{31,32} Nevertheless, more evidence is needed for nonspecific shoulder pain TrP-DN in this age group.¹⁴

Based on previous infraspinatus studies, TrP-DN produces segmental antinociceptive effects.¹⁵ On the one hand, active TrP-DN improves shoulder pain and the irritability of the satellite MTrP in the referred pain area.¹⁶ On the other hand, nociceptive activity at a latent trigger point (TrP) may influence motor activity and the sensitivity of TrPs in distant muscles at a similar segmental level.¹⁷ A prior pilot study has shown that infraspinatus latent TrP-DN, in conjunction with active TrP-DN, may reduce the mechanosensitivity of the distal musculature of the upper limb in older adults.¹⁴

Consequently, the aim is to demonstrate that only 1 intervention on one latent TrP-DN of the infraspinatus can improve motor function and reduce the nociceptive input, in nonspecific shoulder pain and in the satellite TrP located in the referred pain area in older adults, when added to the treatment of the key active TrP-DN.

METHODS

Study Design

This study is a single-center, randomized, single-blinded, controlled clinical trial. The CONSORT statement was followed. The CONSORT flow diagram and checklist were included. The Clinical Research Ethics Committee of the General Hospital from Segovia (10/2013) approved the study and was registered at Clinicaltrials.gov (NCT02032602).

Treatment groups (1) and (2) received active TrP-DN to demonstrate the effects of the addition of latent TrP-DN in the (1) treatment group.¹⁴ Moreover, TrP-DN shows difficulties in blinding patients due to the secondary local twitch responses (LTRs), referred pain, and postneedling pain. A true placebo control group only would be possible under anesthesia.¹³ Both groups were informed about this before signing the informed consent forms to satisfy the ethical requirements.

Participants

Sixty-six participants (23 men and 43 women) aged 65 years and older (18 participants aged from 65 to 70 years, 28 participants aged from 71 to 80 years, and 20 participants older than 80 years) with nonspecific shoulder pain were randomly recruited from a care center from January to July 2014.

Inclusion criteria

The inclusion criteria were participants aged 65 years and older with unilateral nonspecific shoulder pain, including at least 4 MTrPs ipsilateral to the painful shoulder for both groups: 1 active MTrP in the infraspinatus, 1 latent MTrP in the infraspinatus, 1 latent MTrP in the anterior deltoid, and 1 latent MTrP in the extensor carpi radialis brevis.¹⁴

Exclusion criteria

The exclusion criteria were prior diagnoses or prescriptions in the medical record for myopathy or C₅₋₆ neuropathy, cognitive deficits, joint disorders (cervical spine, rotator-cuff tendon, or glenohumeral), surgeries (upper limb or cervical, in the past), conservative or invasive physical therapy (previous 6 months or during follow-up), infiltration (corticoid or local anesthetic during the previous year or follow-up), and use of medications (antiaggregant, anticoagulant, analgesic, or anti-inflammatory) or abusive substances (1 week previous to treatment or during follow-up).^{14-16,33}

Nonspecific shoulder pain diagnosis

Shoulder pain was considered if the origin of the symptoms was focused in the glenohumeral joint, with or without pain in the scapulothoracic, acromioclavicular, or sternoclavicular joints, according to the International Association for the Study of Pain criteria.³⁴ Nonspecific shoulder pain was taken into account if a previous diagnosis was not reported in the medical record, considering structural (impingement, tendinopathy, bursitis, tendon rupture, osteoarthritis, rheumatoid arthritis, instability, frozen shoulder, Milwaukee syndrome, etc), neurological (poststroke shoulder pain, complex regional pain syndrome, etc), visceral or red flag disorders.⁵

MTrPs diagnosis

According to the MPS evaluation,^{18,19} the active or latent MTrPs diagnosis was based on the key (palpable taut band, exquisite tender spot, patient's pain recognition, and painful limitation at full stretch) and confirmatory (1 visual or tactile LTR secondary to palpation or TrP-DN, and sensitivity upon compressing the sensitive knot) criteria proposed by Simons et al.^{10,20} An LTR was considered a rapid and nonvoluntary contraction of the taut band, including the sensitive knot, as a consequence of a spinal reflex.^{10,24,35} Active MTrPs generate spontaneous and recognizable pain, whereas latent MTrPs produce localized pain or unrecognizable referred pain.^{10,12-20}

Indeed, if more than 1 active MTrP was found in the infraspinatus muscle, the highest hyperalgesic active MTrP was considered to be the one that elicited the highest spontaneous and recognizable pain sensation in the Numeric Rating Scale (NRS) under the same palpation pressure. Moreover, if more than 1 latent MTrP was found in each muscle (infraspinatus, anterior deltoid, and extensor carpi radialis brevis), the highest hyperalgesic latent MTrP was considered to be the one that elicited the highest localized pain or unrecognizable referred pain sensation in the NRS under the same palpation pressure.¹⁴

This study was carried out by 2 specialized and experienced physiotherapists (5-6 years of experience and 20-30 hours per week of clinical practice) in MPS, which has shown good interexaminer reproducibility ($\kappa = 0.63$) in

the MTrPs manual palpation in relation to shoulder pain.³⁶ Before the outcomes measurements, physiotherapist 1 (J.M.M.) carried out the diagnosis of the most hyperalgesic active and latent MTrP in the infraspinatus muscle. Moreover, physiotherapist 2 (C.C.L.) identified the most hyperalgesic latent MTrP in each distal muscle of the upper extremity (anterior deltoid and extensor carpi radialis brevis).¹⁴

Outcome Measures

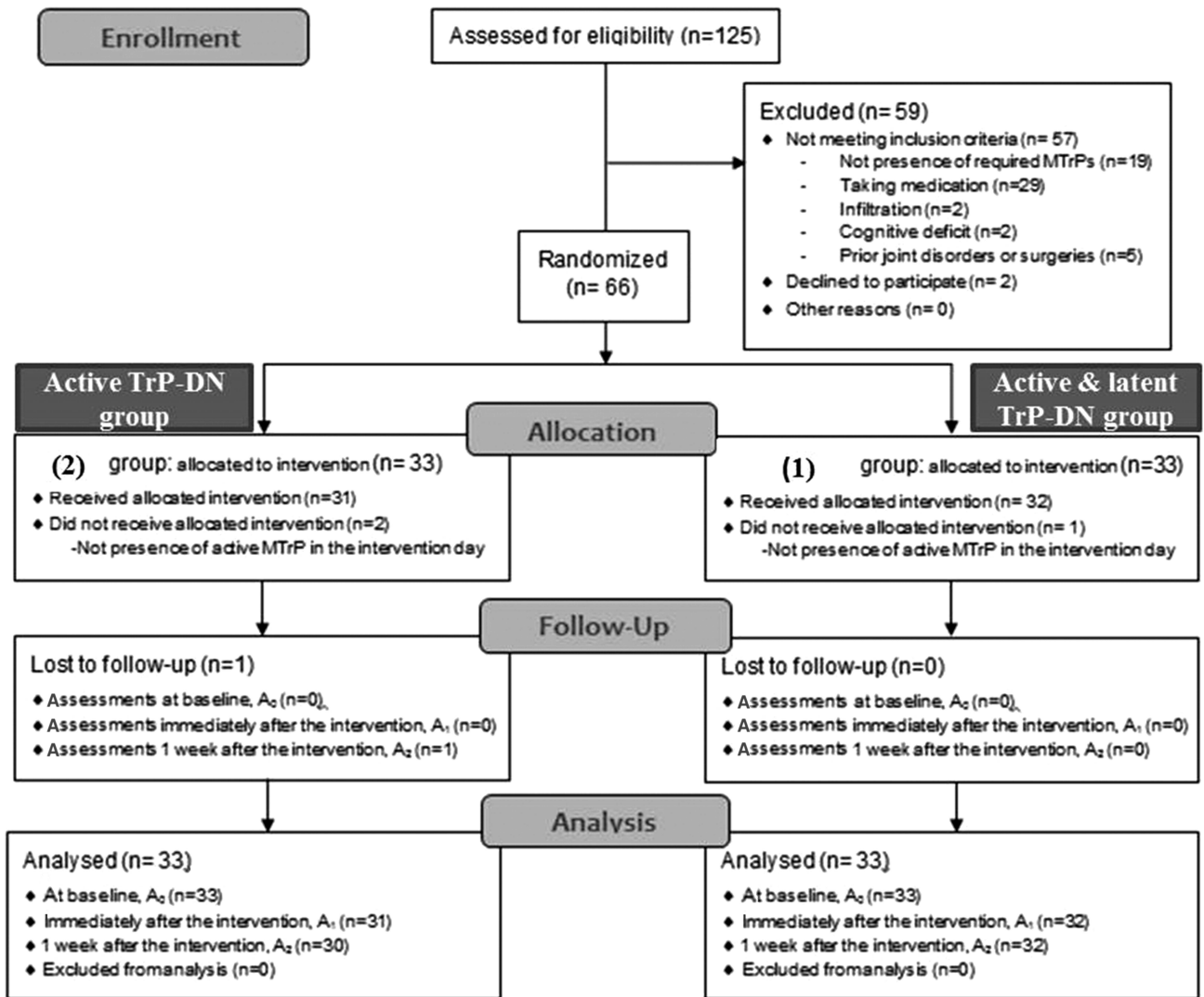
Physiotherapist 2 (C.C.L.), blinded to the patient group assignment, carried out all the assessments at baseline (A₀), after intervention (A₁) and 1 week after intervention (A₂). Sociodemographic data (age and sex) were collected before the intervention (A₀). The main outcomes pain intensity, pressure pain threshold (PPT), and grip strength were measured before TrP-DN (A₀) and in both posttreatment assessments (A₁ and A₂). Based on a previous pilot study, the PPT on the anterior deltoid latent MTrP was the primary outcome variable because it provided the highest sample size calculation.¹⁴

Pain intensity

Pain intensity was assessed using a NRS of 11 points (from 0, no pain, to 10, maximum pain). Patients determined their subjective pain intensity of the painful shoulder by pointing with 1 of their fingers to mark the level of pain on the scale. The NRS is recommended, reliable, and valid for use in older adults without cognitive impairment.^{37,38} Shoulder pain intensity has been related to latent and active TrP-DN in the ipsilateral infraspinatus.^{10,14,16,23}

Pressure pain threshold

Pressure pain threshold was measured with an analogue pressure algometer (Mechanical algometer, FDK/FDN series Force Dial, Wagner Instruments, 1217 Greenwich, CT 06836; 0-10 kg/cm²), which has shown reliability, reproducibility, and sensitivity for assessing the effects of latent and active MTrPs treatment in upper-extremities MPS.³⁹⁻⁴² Ipsilateral to the painful shoulder PPT for the most hyperalgesic latent MTrP of each muscle was determined in the extensor carpi radialis brevis and anterior deltoid. The reasons for the PPT assessments in these muscles (satellite latent MTrPs) were their location in the referred pain pattern of the infraspinatus (key active MTrP) and their neurological connection (C₆ segmental level).²³⁻²⁶ Previously, both the physiotherapist 2 and the patient carried out contralateral training to recognize the PPT. An average value of 3 repeated measurements within an interval of 30 to 60 seconds were used for analysis data. The patient was placed in supine decubitus and the forearm being supported on the patient's abdomen, following prior studies.^{14,17}



TrP-DN= Trigger point dry needling

Figure 1. Consort flow diagram.

Grip strength

The maximum grip strength (isometric muscular force in manual pressure) was measured with a hydraulic manual analogical dynamometer (Hydraulic hand dynamometer, JAMAR, Sammons Preston Rolyan, 4 Sammons Court Bolingbrook, IL 60440; 0-90 kg), which has shown validity, reproducibility, and reliability in different elderly groups,⁴³ and might be a complementary tool for assessing the effects of short-term invasive treatment in the upper-extremities MPS.⁴⁴ The motor activity of the latent MTrPs in the extensor carpi radialis brevis has been associated to latent MTrPs in the infraspinatus muscle. Furthermore, age-related motor changes of the upper extremities are not statistically significant after the age of 60 years.⁴⁵ Based on prior studies, a single measurement was performed after an interval of 5 to 10 seconds.^{14,43}

Interventions

Before the outcome measurements, the patients were randomly assigned into 2 groups by opaque closed letter envelopes, the (1) treatment group (n = 33) or the (2) treatment group (n = 33), and were assigned a code (01-66) in order to blind the patient assignment to the treatment group. Physiotherapist 1 (J.M.M.) carried out all the TrP-DN interventions on the infraspinatus muscle.

Treatment groups

Only one session of a TrP-DN intervention on the ipsilateral infraspinatus muscle of the painful shoulder using Hong's fast-in and fast-out technique with multiple rapid needle insertion was applied following previous recommendations.^{10,16,35} Each subject of the (1) treatment group received the same TrP-DN procedure in 2 MTrPs: the most

Table 1. Baseline Characteristics (A₀) and Homogeneity of the Sample According to the Intervention Group

Sociodemographic Data and Main Outcomes	Mean (SD) or Number (%)		P
	(1) Active and Latent TrP-DN Group (n = 33)	(2) Active TrP-DN Group (n = 33)	
Sex (%), n = 66 (100%)	33 (100)	33 (100)	.606 ^a
Men, n = 23 (34.8%)	10 (30.3)	13 (39.4)	
Women, n = 43 (65.2%)	23 (69.7)	20 (60.6)	
Age, y	75.35 (6.97)	76.74 (8.20)	.461 ^b /.453 ^c
Subjects from 65 to 70 y, n = 18 (27.3%)	9 (27.3)	9 (27.3)	.214 ^d
Subjects from 71 to 80 y, n = 28 (42.4%)	17 (51.5)	11 (33.3)	
Subjects > 80 y, n = 20 (30.3%)	7 (21.2)	13 (39.4)	
Pain intensity	5.24 (1.70)	4.55 (1.66)	.096 ^b /.113 ^c
Men	5.00 (1.70)	4.08 (1.50)	.181 ^b /.218 ^c
Women	5.35 (1.72)	4.85 (1.72)	.350 ^b /.364 ^c
65-70 y	4.78 (1.56)	5.11 (2.09)	.707 ^b /.857 ^c
71-80 y	5.29 (1.83)	4.36 (0.92)	.088 ^b /.244 ^c
>80 y	5.71 (1.60)	4.31 (1.84)	.107 ^b /.087 ^c
Anterior deltoid PPT, kg/cm ²	2.59 (0.60)	2.43 (0.58)	.276 ^b /.326 ^c
Men	2.95 (0.56)	2.54 (0.65)	.131 ^b /.172 ^c
Women	2.44 (0.56)	2.36 (0.54)	.647 ^b /.733 ^c
65-70 y	2.64 (0.56)	2.38 (0.60)	.365 ^b /.479 ^c
71-80 y	2.63 (0.62)	2.56 (0.71)	.772 ^b /.742 ^c
>80 y	2.44 (0.67)	2.36 (0.49)	.763 ^b /.968 ^c
Extensor carpi radialis brevis, kg/cm ²	2.19 (0.56)	2.21 (0.66)	.887 ^b /.949 ^c
Men	2.55 (0.76)	2.27 (0.79)	.399 ^b /.306 ^c
Women	2.44 (0.56)	2.36 (0.54)	.342 ^b /.428 ^c
65-70 y	2.02 (0.43)	2.08 (0.67)	.829 ^b /.895 ^c
71-80 y	2.29 (0.47)	2.35 (0.63)	.788 ^b /.869 ^c
>80 y	2.17 (0.87)	2.19 (0.71)	.956 ^b /.751 ^c
Grip strength, kg	19.71 (10.92)	21.86 (11.03)	.429 ^b /.314 ^c
Men	32.00 (9.92)	32.23 (7.98)	.951 ^b /.950 ^c
Women	14.37 (5.89)	15.12 (6.58)	.694 ^b /.608 ^c
65-70 y	27.56 (12.46)	24.67 (8.05)	.566 ^b /.658 ^c
71-80 y	19.59 (7.34)	24.59 (10.59)	.149 ^b /.220 ^c
>80 y	9.93 (9.00)	17.61 (12.54)	.170 ^b /.153 ^c

Abbreviations: PPT, pressure pain threshold; TrP-DN, trigger point dry needling.
^aFisher exact test.
^bStudent *t* test for independent samples.
^cMann-Whitney test.
^dPearson chi-square test.

hyperalgesic active MTrP plus the most hyperalgesic latent MTrP, both of them located on the infraspinatus muscle. Each subject of the (2) treatment group received the same TrP-DN intervention in only the most hyperalgesic active MTrP on the infraspinatus.¹⁴

Procedure for both treatment groups

The patient was placed in contralateral decubitus to the painful shoulder. A headless 0.32×40-mm needle (Stainless

steel, Agupunt A1041P, 158 Caspe, Barcelona, Spain 08013) was fixed between the fingers of the nondominant hand and inserted perpendicular to the scapula toward the MTrP. By means of metacarpophalangeal flexion extension of the first to second fingers of the dominant hand, the area was probed in different directions until presence of 1-LTR, a pain response and, usually, the referred pain pattern of the MTrP were obtained.^{10,14} The penetration depth was different according to the subject.¹⁵ TrP-DN was

Table 2. Effectiveness in the Active and Latent TrP-DN Group (1) Between the Assessments

Main Outcomes	Mean (SD)			Repeated-Measures ANOVA, <i>P</i> Value ^a	Friedman Test, <i>P</i>	Related Samples Student's <i>t</i> Test ^b Wilcoxon Test ^c (<i>P</i> (Reduction or Increase n/N))		
	A ₀ (n = 33)	A ₁ (n = 32)	A ₂ (n = 32)			A ₁ - A ₀	A ₂ - A ₀	A ₂ - A ₁
Pain intensity	5.28 (1.71)	3.03 (1.51)	1.91 (1.40)	<.001	<.001	<.001 ^b <.001 ^c (↓28/32)	<.001 ^b <.001 ^c (↓32/32)	<.001 ^b <.001 ^c (↓22/32)
Anterior deltoid PPT, kg/cm ²	2.58 (0.61)	3.35 (0.64)	3.39 (0.59)	<.001	<.001	<.001 ^b <.001 ^c (↑30/32)	<.001 ^b <.001 ^c (30/32)	.692 ^b .477 ^c (↑18/32)
Extensor carpi radialis brevis, kg/cm ²	2.16 (0.55)	3.28 (0.85)	3.26 (0.74)	<.001	<.001	<.001 ^b <.001 ^c (↑30/32)	<.001 ^b <.001 ^c (↑31/32)	.789 ^b .653 ^c (↑12/32)
Grip strength, kg	19.27 (10.78)	20.31 (11.52)	20.42 (11.07)	.048	.145	.060 ^b .103 ^c (↑17/32)	.006 ^b .007 ^c (↑19/32)	.839 ^b .990 ^c (↑11/32)

Abbreviations: A₀, assessment at baseline; A₁, assessment immediately postintervention; A₂, assessment 1 week postintervention; ANOVA, analysis of variance; PPT, pressure pain threshold; TrP-DN, trigger point dry needling; ↓, reduction; ↑, increase.
^aConsidering the significance of the Greenhouse-Geisser test.
^{b,c} According to the *P* values obtained by the Bonferroni correction (*P* < .05/3; significance < .017).

performed with multiple needle insertion therapy for MTrP inactivation until reaching LTR exhaustion.^{10,14,35} TrP-DN lasted 1 to 2 minutes.^{14,15} Finally, hemostasis was applied for 1 minute.^{10,14}

Intraexaminer Reliability for the MTrP Localization Procedure

Ipsilateral to the painful shoulder, an intraexaminer reliability study of the procedure for the MTrPs detection was carried out in 42 older adults with nonspecific shoulder pain.

Physiotherapist 1 intraexaminer reliability in the MTrPs of treatment

Physiotherapist 1 (J.M.M.) identified the infraspinatus MTrPs at the same position described for TrP-DN.^{10,14} The most hyperalgesic active MTrP was marked with a grid that had 4 perpendicular lines. The most hyperalgesic latent MTrP was marked with a grid that had 2 perpendicular lines.¹⁴ The distance (cm) from each MTrP was measured with respect to the superior-internal angle of the scapula at 2 different moments with an interval of 1 hour.

Table 3. Effectiveness in the Active TrP-DN Group (2) Between the Assessments

Main Outcomes	Mean (SD)			Repeated-Measures ANOVA ^a	Friedman Test, <i>P</i>	Related Samples Student's <i>t</i> Test ^b Wilcoxon Test ^c (<i>P</i> (Reduction or Increase, n/N))		
	A ₀ (n = 33)	A ₁ (n = 31)	A ₂ (n = 30)			A ₁ - A ₀	A ₂ - A ₀	A ₂ - A ₁
Pain intensity	4.33 (1.49)	3.13 (1.61)	2.60 (1.63)	<.001	<.001	<.001 ^b <.001 ^c (↓23/31)	<.001 ^b <.001 ^c (↓25/30)	.003 ^b .005 ^c (↓12/30)
Anterior deltoid PPT, kg/cm ²	2.48 (0.59)	2.82 (0.60)	2.73 (0.57)	<.001	<.001	<.001 ^b <.001 ^c (↑28/31)	.001 ^b <.001 ^c (↑24/30)	.075 ^b .047 ^c (↑9/27)
Extensor carpi radialis brevis, kg/cm ²	2.25 (0.66)	2.55 (0.66)	2.36 (0.56)	<.001	<.001	<.001 ^b <.001 ^c (↑25/31)	0.096 ^b 0.006 ^c (↑23/30)	0.001 ^b 0.002 ^c (↑8/30)
Grip strength, kg	21.66 (11.19)	22.18 (10.06)	23.80 (12.15)	.010	.045	.370 ^b .243 ^c (↑16/31)	.001 ^b .001 ^c (↑18/30)	.551 ^b .179 ^c (↑15/30)

Abbreviations: A₀, assessment at baseline; A₁, assessment immediately postintervention; A₂, assessment 1 week postintervention; ANOVA, analysis of variance; PPT, pressure pain threshold; TrP-DN, trigger point dry needling; ↓, reduction; ↑, increase.
^aConsidering the significance of the Greenhouse-Geisser test.
^{b,c} According to the *P* values obtained by the Bonferroni correction (*P* < .05/3; significance < .017).

Table 4. Effectiveness Between (1) and (2) Treatment Groups Immediately and 1 Week Posttreatment

Difference Main Outcomes	Active and Latent TrP-DN Group (1)		Active TrP-DN Group (2)		Student <i>t</i> Test <i>P</i> Value ^a	Mann-Whitney <i>P</i> Value	Repeated-Measures ANOVA Interaction <i>P</i> Value ^b	Eta ² (η^2)	Effect Size Cohen <i>d</i> ^c
	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)					
Pain intensity									
A ₁ -A ₀	32	-2.25 (1.46)	31	-1.19 (0.94)	.001	.002	<.001	0.159	0.870
A ₂ -A ₀	32	-3.37 (1.56)	30	-1.73 (1.14)	<.001	<.001		0.269	1.214
Anterior deltoid PPT, kg/cm ²									
A ₁ -A ₀	32	0.77 (0.51)	31	0.34 (0.31)	<.001	<.001	<.001	0.206	1.017
A ₂ -A ₀	32	0.80 (0.53)	30	0.25 (0.37)	<.001	<.001		0.271	1.219
Extensor carpi radialis brevis PPT, kg/cm ²									
A ₁ -A ₀	32	1.11 (0.66)	31	0.29 (0.36)	<.001	<.001	<.001	0.377	1.555
A ₂ -A ₀	32	1.09 (0.65)	30	0.10 (0.33)	<.001	<.001		0.481	1.924
Grip strength (kg)									
A ₁ -A ₀	32	1.04 (3.03)	31	0.55 (3.36)	.540	.841	.193	0.006	0.158
A ₂ -A ₀	32	1.15 (2.21)	30	2.18 (3.39)	.160	.299		0.033	0.368

Abbreviations: A₀, assessment at baseline; A₁, assessment immediately postintervention; A₂, assessment 1 week postintervention; ANOVA, analysis of variance; PPT, Pressure Pain Threshold; TrP-DN, trigger point dry needling.
^aThe Student *t* test for independent samples.
^bConsidering the significance of the Greenhouse-Geisser test.
^c $d = 2t/\sqrt{gdl}$.

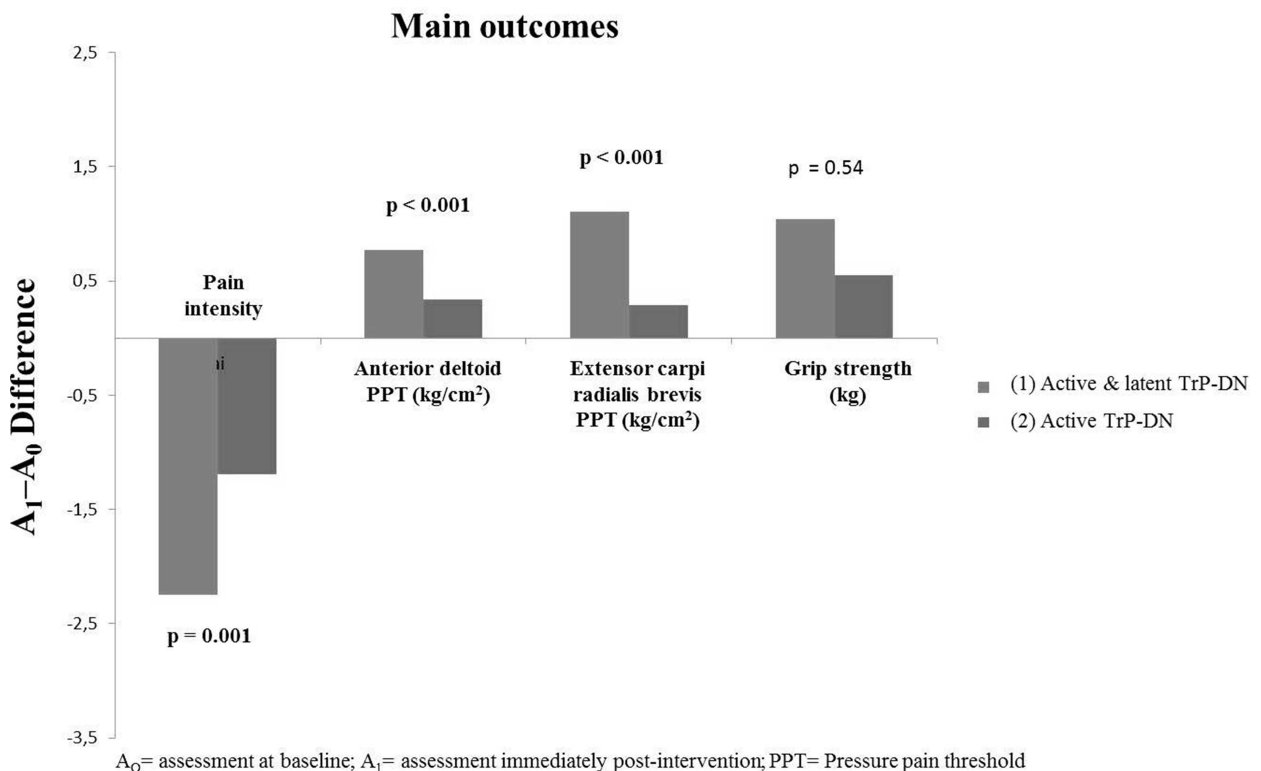
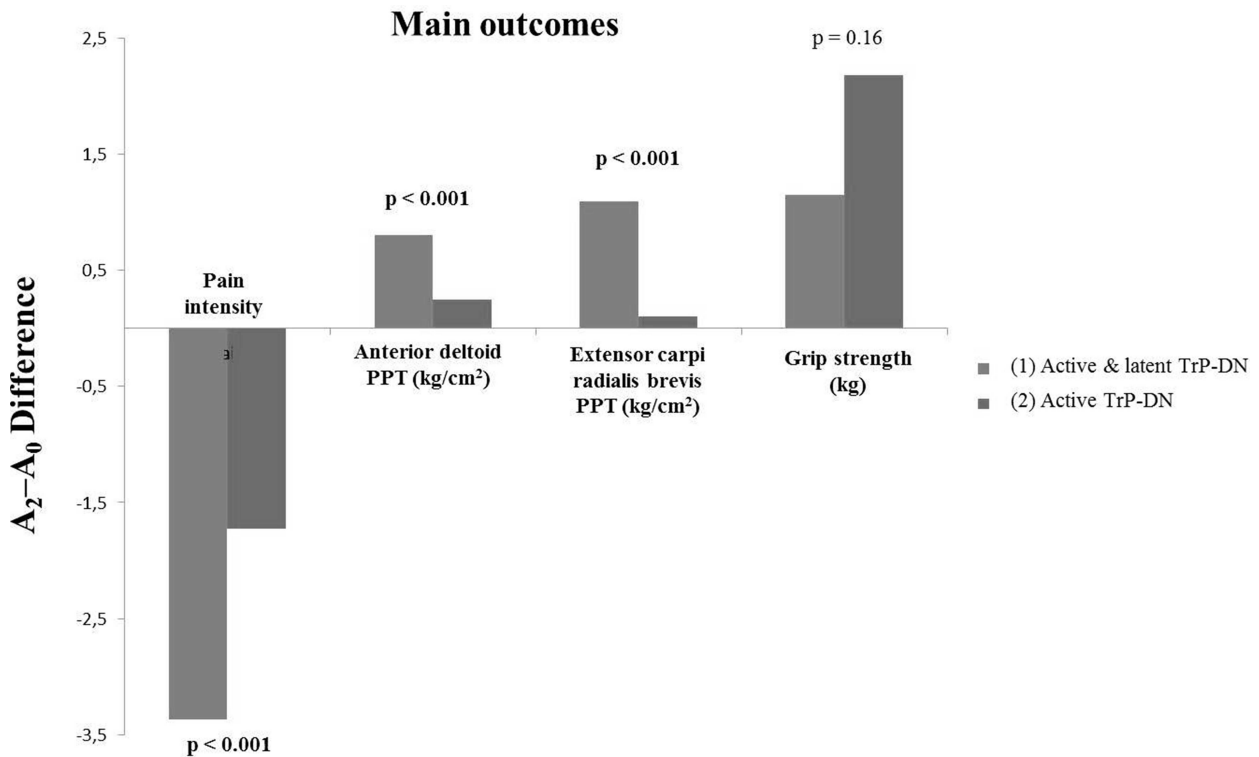


Figure 2. Statistical significance bars of the differences between the (1) and (2) trigger point dry needling (TrP-DN) groups immediately after the intervention (A₁-A₀).



A₀= assessment at baseline; A₂= assessment 1 week post-intervention; PPT= Pressure pain threshold

Figure 3. Statistical significance bars of the differences between the (1) and (2) trigger point dry needling (TrP-DN) groups 1 week after the intervention (A₂-A₀).

Physiotherapist 2 intraexaminer reliability in the MTrPs of assessment

Physiotherapist 2 (C.C.L.) determined the most hyperalgesic latent MTrPs in the upper extremity with the same position used for the PPT measurement to facilitate the blinded procedure. Both the most hyperalgesic latent MTrP for the anterior deltoid and the most hyperalgesic latent MTrP for the extensor carpi radialis brevis were marked with a filled-in circle in a permanent marker to facilitate the PPT measurement of A₂. These points were reviewed for the week after TrP-DN and covered with tape.¹⁴ The distances (cm) from the anterior deltoid and extensor carpi radialis brevis MTrPs were measured with respect to the acromion lateral angle and the elbow lateral epicondyle, respectively, at 2 different moments with an interval of 1 week.

Statistical Analysis

The sample size calculation used the anterior deltoid PPT as the main variable because it provided the highest sample size based on its effect size (Cohen *d*), according to the results of a previous pilot study carried out on 20 participants.¹⁴ G*power 3.1.3 for Windows and David Walker's effect size calculator ($d = 2t/\sqrt{gdl}$) were used.^{46,47} A 1-tailed hypothesis test, an α error of 0.05 (95% CI),

a desired power of 80% (β error of 0.2), an effect size (Cohen *d*) of 0.66, and a ratio of the sample sizes between the 2 groups of 1 (N₂/N₁) determined a sample size of at least 30 participants per group. Assuming that 10% of the possible patients could be lost during follow-up, the final sample size was 66 patients, 33 per group. A 1-tailed hypothesis test was used because of a previous pilot study showing statistically significant differences ($P < .05$) for the (1) treatment group in the PPT primary outcome.¹⁴ Consequently, the sample size was calculated considering the unilateral null hypothesis (H_0 : (1) treatment group \leq (2) treatment group).

SPSS version 22.0 for Windows (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) was used for statistical analysis. A Shapiro-Wilk test was used to test normality taking into account all of the participants together, and each group independently assessed.

Considering the (1) and (2) treatment groups, a descriptive analysis was selected to summarize the outcomes in the 3 measurements that were carried out (A₀, A₁, A₂) and included the mean, SD, median, interquartile range, quartiles, asymmetry, and kurtosis.

Afterward, the homogeneity of both the sociodemographic data and main outcomes at baseline (A₀) was

Table 5. Linear Regression Model for Each Main Outcome Difference Immediately ($A_1 - A_0$) and 1 Week Postintervention ($A_2 - A_0$)

Difference Main Outcomes	Model	R ² Change	Model R ²
Pain intensity			
$A_1 - A_0$	0.075		0.287
	-0.283 × Pain intensity (A_0)	0.194 ^a	
	-0.831 × Treatment group	0.093 ^a	
$A_2 - A_0$	0.712		0.477
	-0.436 × Pain intensity (A_0)	0.305 ^a	
	-1.288 × Treatment group	0.141 ^a	
	-0.026 × Grip strength (A_0)	0.030 ^b	
Anterior deltoid PPT, kg/cm²			
$A_1 - A_0$	0.869		0.277
	+0.446 × Treatment group	0.206 ^a	
	-0.212 × Anterior deltoid PPT (A_0)	0.071 ^a	
$A_2 - A_0$	1.049		0.398
	+0.583 × Treatment group (A_0)	0.271 ^a	
	-0.320 × Anterior deltoid PPT (A_0)	0.128 ^a	
Extensor carpi radialis PPT, kg/cm²			
$A_1 - A_0$	-0.153		0.438
	+0.744 × Treatment group	0.377 ^a	
	+0.099 × Pain intensity (A_0)	0.061 ^a	
$A_2 - A_0$	0.729		0.534
	+0.963 × Treatment group	0.481 ^a	
	-0.277 × Extensor carpi radialis brevis PPT (A_0)	0.053 ^a	
Grip strength (kg)			
$A_1 - A_0$	-2.619		0.167
	+1.952 × Anterior deltoid PPT (A_0)	0.104 ^a	
	-0.074 × Grip strength (A_0)	0.063 ^a	
$A_2 - A_0$	6.018		0.182
	-3.743 × Sex	0.128 ^a	
	-0.093 × Grip strength (A_0)	0.055 ^b	

Abbreviation: A_0 , assessment at baseline; A_1 , assessment immediately postintervention; A_2 , assessment 1 week postintervention; PPT, pressure pain threshold; treatment group (active trigger point dry needling = 0; active and latent trigger point dry needling = 1); sex (men = 0; women = 1).
^a $P < .05$. ^b $P < .10$.

compared between treatment groups. For sex, homogeneity was assessed using the Fisher exact test. Age was divided into 3 intervals (65-70, 71-80, and >80 years), and the Pearson chi-square test was calculated to assess the homogeneity of the treatment groups. Furthermore, for age and A_0 outcomes (pain intensity, PPT, and grip strength) and the sex and age group for each A_0 outcome, the Student *t* test for independent samples and a Mann-Whitney *U* test were used to check the homogeneity.

Next, the main outcomes in the 3 measurements (A_0 , A_1 , A_2) were separately analyzed in each treatment group. Repeated-measures analysis of variance (ANOVA) was performed considering the significance of the Greenhouse-Geisser correction when the Mauchly test rejected the sphericity. A nonparametric analysis was also carried out using the Friedman test. Changes between 2 specific phases of the study ($A_1 - A_0$; $A_2 - A_0$; $A_2 - A_1$) were studied using the Student *t* test for related samples and the Wilcoxon

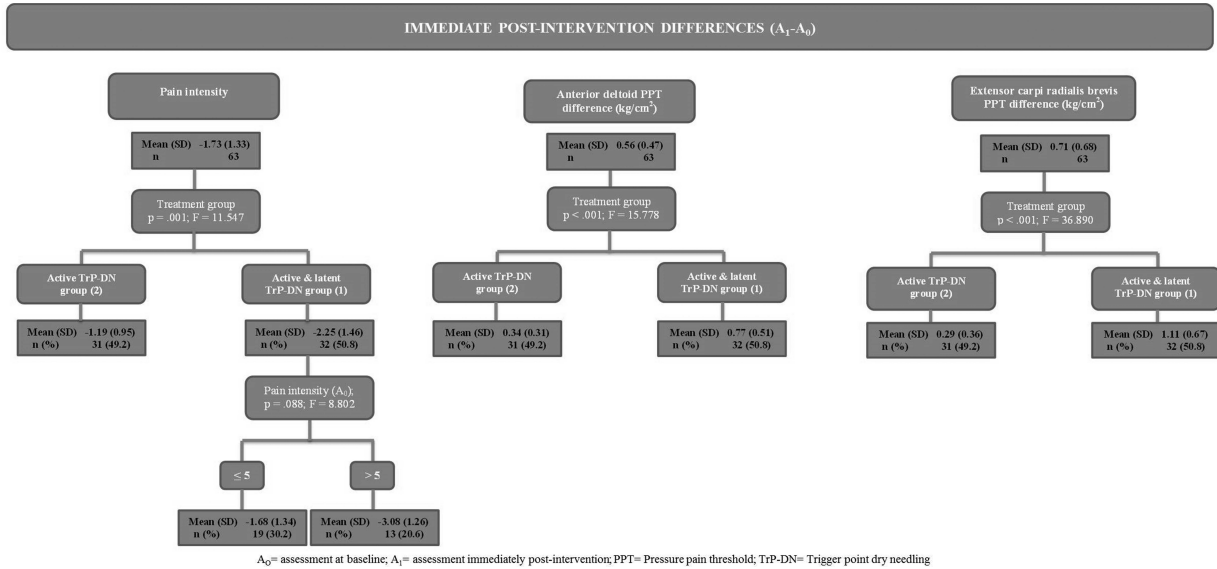


Figure 4. Regression tree nodes or subgroups to predict the pain intensity and PPT difference immediately after intervention (A_1-A_0).

test, according to the *P* values obtained by the Bonferroni correction.

Finally, the contrast between both treatment groups was analyzed. Repeated-measures ANOVA with 2 factors, 2 (groups) × 3 (times: A_0 , A_1 , A_2), was carried out. The Student *t* test for independent samples and the Mann-Whitney *U* test were obtained to perform the univariate analysis of the difference of the variables (A_1-A_0 , A_2-A_0). The effect size calculation ($d = 2t/\sqrt{gdl}$), determined by SD in the groups, and the η^2 (η^2) coefficient were added. All of these data were supplemented with mean graphics to

illustrate the differences between the (1) and (2) treatment groups.

In addition, a multivariate predictive analysis was performed using linear regression and regression trees. On the one hand, linear regression was carried out using the stepwise selection method and the R^2 coefficient to determine the quality adjustment. Main outcomes at baseline (A_0), age (quantitative), sex (man = 0; woman = 1), and treatment group (control = 0; experimental = 1) were considered as independent variables. On the other hand, regression trees were calculated considering the variables

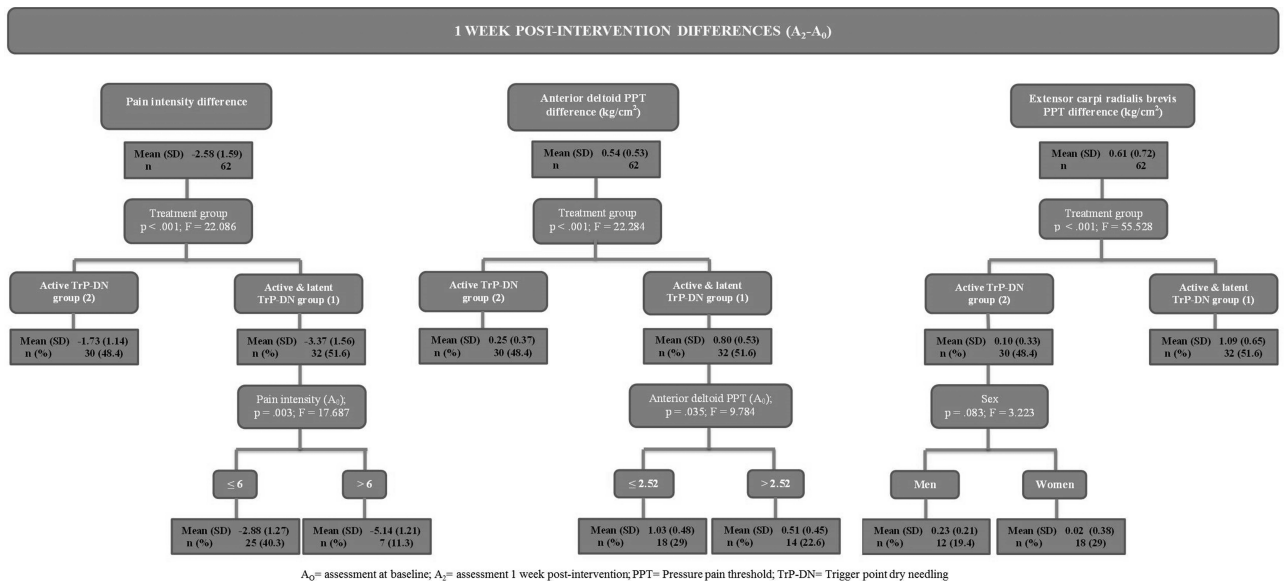


Figure 5. Regression tree nodes or subgroups to predict the pain intensity and PPT difference 1 week after intervention (A_2-A_0).

difference ($A_1 - A_0$, $A_2 - A_0$) as dependent variables, and the treatment group, sex, age group, and main outcomes at baseline were considered as independent variables.

Furthermore, the physiotherapist 1 and physiotherapist 2 intraexaminer reliability for the MTrP localization procedure was added. After determining the normality and descriptive analyses, repeated-measures ANOVA, intraclass correlation coefficient, the Cronbach alpha, SE of measurement, and minimum detectable change ($\sqrt{2} \times 1.96 \times sw$) were analyzed according to Bland and Altman.⁴⁸

The analysis was performed “per intent-to-treat.” The statistical tests were performed considering a 95% CI ($P < .05$). Nevertheless, a significant P value $< .10$ was considered in the multivariate analysis for exploring clinically interesting relationships.

RESULTS

One hundred twenty-five participants were screened for eligibility (Figure 1). Fifty-nine were excluded because of a lack of the required MTrPs ($n = 19$), taking medication ($n = 29$), infiltration ($n = 2$), cognitive deficit ($n = 2$), prior joint disorders or surgeries ($n = 5$), and declined to participate ($n = 2$). Thirty-three patients were assigned to the (1) treatment group and 33 to the (2) treatment group. Nevertheless, 3 participants did not receive the assigned intervention because they did not present any active MTrPs in the infraspinatus muscle on the day of treatment. Furthermore, only 1 subject was lost during follow-up at 1 week after the intervention. All patients ($n = 66$) were analyzed. No significant difference was found between the 2 groups in terms of the sociodemographic and main outcomes at baseline (Table 1).

Regarding the active and latent TrP-DN group (1) of treatment (Table 2), there were significant differences ($P < .001$) for pain intensity reduction between all of the assessments (mean differences: $A_1 - A_0 = -2.25$; $A_2 - A_0 = -3.37$; $A_2 - A_1 = -1.12$) and an increase in anterior deltoid ($A_1 - A_0 = 0.77$; $A_2 - A_0 = 0.80$; kg/cm²) and extensor carpi radialis brevis ($A_1 - A_0 = 1.11$; $A_2 - A_0 = 1.09$; kg/cm²) PPT immediately and 1 week postintervention, respectively. Nevertheless, grip strength was only increased significantly ($P < .01$; $A_2 - A_0 = 1.15$; kg) 1 week after the intervention.

Considering the active TrP-DN group (2) of treatment (Table 3), there were significant differences for pain intensity reduction ($P < .01$; $A_1 - A_0 = -1.19$; $A_2 - A_0 = -1.73$) as well as anterior deltoid ($P \leq .001$; $A_1 - A_0 = 0.34$; $A_2 - A_0 = 0.25$; kg/cm²) and extensor carpi radialis brevis ($P < .01$; $A_1 - A_0 = 0.29$; $A_2 - A_0 = 0.10$; kg/cm²) PPT increase immediately and 1 week postintervention, respectively. In addition, there was a significant difference ($P < .01$) for the pain intensity ($A_2 - A_1 = -0.53$) and extensor carpi radialis brevis PPT reduction ($A_2 - A_1 = -0.19$ kg/cm²)

between postintervention assessments. Grip strength was only increased significantly ($P < .01$; $A_2 - A_0 = 1.62$ kg) 1 week after the intervention.

Comparing both groups (Table 4; Figures 2 and 3), statistically significant differences, with a large η^2 and effect size values, were shown in the reduction of pain intensity ($P \leq .001$; $\eta^2 = 0.159-0.269$; $d = 1.017-1.219$) and the increase in PPT of the anterior deltoid ($P < .001$; $\eta^2 = 0.206-0.271$; $d = 0.870-1.214$) and extensor carpi radialis brevis ($P < .001$; $\eta^2 = 0.377-0.481$; $d = 1.555-1.924$) favoring the active and latent TrP-DN group (1), immediately and 1 week postintervention. Nevertheless, no statistically significant differences were reported in the grip strength ($P > .05$; $\eta^2 = 0.006-0.033$; $d = 0.158-0.368$), immediately and 1 week postintervention.

According to multivariate regression analysis, the linear regression model (Table 5) showed significant differences ($P < .10$) and a large model R^2 (0.167-0.534) for each main outcome difference immediately and 1 week after treatment. Furthermore, the regression trees determined 2 to 3 nodes or significant subgroups ($P < .10$) for each pain intensity and PPT difference immediately (Figure 4) and 1 week (Figure 5) after intervention. The grip strength difference [mean (SD)] only depended on the patient's sex ($P = .004$; $F = 8.780$) at 1 week postintervention, 3.07 ± 3.82 kg for men (33.1%) and 0.93 ± 1.90 kg for women (66.9%).

Finally, the MTrP localization procedure showed high intraexaminer reliability by means of repeated-measures ANOVA ($P = .114-.646$), intraclass correlation coefficient (0.967-0.988; $P < .001$), the Cronbach alpha (0.983-0.994), SE of measurement (0.112-0.305 cm), and minimum detectable change (0.327-0.845 cm) for the anterior deltoid and extensor carpi radialis brevis latent MTrPs after 1 week (physiotherapist 1), as well as the infraspinatus active and latent MTrPs after 1 hour assessment (physiotherapist 2).

DISCUSSION

To test the initial hypothesis, this research study shows that latent TrP-DN, associated with the key active TrP-DN, may improve pain and irritability of the satellite MTrPs in older adults with nonspecific shoulder pain in short term.^{14,16}

Considering the primary outcomes, significant minimal detectable increases were obtained in the anterior deltoid and extensor carpi radialis brevis PPT differences between both groups, more than 0.54 kg/cm² according to Koo et al.³⁹ Consequently, the clinical usefulness of active and latent TrP-DN comparing with the active TrP-DN were PPT increments (1-2 groups) in the anterior deltoid 1 week postintervention (0.55 kg/cm²) and in the extensor carpi radialis brevis immediately (0.82 kg/cm²) and 1 week posttreatment (0.99 kg/cm²). Finally, clinical decisions based on linear regression (Table 5) and regression

trees (Figures 4 and 5) may be carried out to improve the mechanosensitivity of the upper extremity in older adults with nonspecific shoulder pain. A similar intervention using infraspinatus active TrP-DN in participants with bilateral shoulder pain, comparing each patient's nontreated shoulder as a control group, was carried out by Hsieh et al.¹⁶ Clinically, their immediate differences achieved only significant increases in the anterior deltoid PPT (0.9 kg/cm²). Nevertheless, the extensor carpi radialis longus PPT differences (0.4 kg/cm²) did not reach the clinical relevant differences proposed by Koo et al.³⁹

Regarding the secondary outcomes, the pain intensity reductions obtained between both intervention groups did not show any clinically significant change immediately (15.13%) and 1 week posttreatment (23.87%), more than 33% according to Williamson and Hoggart.³⁷ Besides, the immediate active TrP-DN with respect to the contralateral nontreated shoulder pain control group, did not achieve the required clinically relevant change proposed by Hsieh et al.¹⁶ In addition, grip strength changes were not significantly different for the intervention groups. Today, no studies in the literature evaluate grip strength changes after infraspinatus TrP-DN. However, Hsieh et al.¹⁶ showed significant differences between experimental and control groups in active (48%) and passive (38.5%) range-of-motion changes on shoulder internal rotation.

With regard to adverse effects postintervention, 4 patients (6.35%), divided equally in both groups, showed a visible local hematoma of less than 1 cm² in the TrP-DN region. Coinciding with Ga et al,^{28,29} hemorrhages (>4 cm²) were not found in both TrP-DN interventions in older adults. Nevertheless, Ga et al^{28,29} showed that the use of thicker and "wet" needles produced a visible subcutaneous hemorrhage more frequently than TrP-DN in the older adults.

This study has several limitations, such as the lack of a placebo or nontreated control group. TrP-DN might be influenced by variations of the innervation in the extensor carpi radialis brevis associated with segmental antinociceptive effects.^{15,49} The number of LTRs during TrP-DN was not measured and may influence the clinical effectiveness of TrP-DN.^{35,50} Postneedling pain was not taken into account.¹⁰ Sympathetic responses were not controlled during examination and may disturb the PPT assessment.⁵¹ Grip strength might be altered by various comorbid conditions in the older adults.⁴¹

CONCLUSIONS

One dry needling intervention of the latent MTrP associated with the key active MTrP of the infraspinatus reduces pain intensity and the irritability of the satellite MTrP, located in the referred pain area in older adults with nonspecific shoulder pain in the short term.

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