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MYOFASCIAL PAIN AND TREATMENT: PILOT STUDY

The effects of dry needling and radial extracorporeal shockwave therapy on latent trigger point sensitivity in the quadriceps: A randomised control pilot study

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ABSTRACT

Objectives: Latent myofascial trigger points (TrP) can alter joint kinematics, reduce strength and alter activation patterns, affecting athletic performance. TrP sensitivity can be measured with the pressure pain threshold (PPT). Dry needling (DN) has been used to treat latent TrPs, but may cause post-needling soreness. Radial extracorporeal shockwave therapy (rESWT) could be used as an alternative to DN during heavy training or competition.

Methods: After baseline measures, 21 recreational athletes were split into three groups: DN, rESWT or control group, and were treated for three sessions in one week. Follow-up outcome sessions were conducted two to four and seven days after the last treatment. TrP sensitivity was measured using the PPT.

Results: There was a groupXtime interaction for the PPT ($p < 0.05$). After a decrease in PPT during treating, there was a significant increase ($p < 0.05$) in PPT for the DN group (12.92%). The rESWT group also significantly ($p < 0.05$) increased (13.26%), but did not show any post-treatment soreness during the treatment phase. There was no difference in the PPT in the control group during any session.

Conclusion: DN is effective for increasing PPT of latent TrPs, but can be associated with post-treatment soreness. rESWT is as effective, but without the post-treatment soreness. Future studies should include treating multiple TrPs in the lower kinetic chain as well as measuring muscle activation and joint function. Furthermore, consideration for the current training load and up-coming competition is needed. Optimum timing and longer follow-up periods of such interventions should be explored.

Level of evidence: 2b.

Summary: Treating latent TrPs in the lower kinetic chain may improve muscle activation. Unlike DN, rESWT does not cause post- treatment soreness. Consideration of training load and up-coming competition is needed to deliver the optimum treatment strategy for athletes with latent TrPs.

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1. Introduction

Myofascial trigger points (TrPs) can cause local pain (Paolucci et al., 2016) or referred pain and sensory and motor phenomena (Espí-López et al., 2014). Latent TrPs are not spontaneously painful (Bron and Dommerholt, 2012). A subject with latent TrPs may not be aware that they have TrPs or that the latent TrPs may be altering joint kinematics (Jafri, 2014). Latent TrPs can reduce muscle strength (Celik and Yeldan, 2011) as well as altering activation patterns (Ibarra et al., 2011; Lucas et al., 2010). The pressure pain threshold (PPT) has been used to measure the severity of TrPs (Sciotti et al., 2001; Walsh et al., 2017).

Dry needling (DN) is considered an effective treatment option for TrPs and uses filament acupuncture needles to stimulate the muscle directly (Cerezo-Téllez et al., 2016; Espí-López et al., 2014; Yeganeh Lari et al., 2016). The exact mechanism of DN is not entirely understood (Mayoral et al., 2013). DN can cause post-needling soreness lasting up to 72 h (Martín-Pintado-Zugasti et al., 2016, 2015). Radial extracorporeal shockwave therapy

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(rESWT) has recently been proposed as a treatment for TrPs (Ramon et al., 2015). rESWT offers a non-invasive treatment strategy for TrPs and may not cause post-treatment soreness.

Previous studies that have investigated TrPs in the vastus lateralis (VL) and vastus medialis (VM) have focused on patients with pathologies such as knee osteoarthritis and patellofemoral pain syndrome (Espí-López et al., 2017; Vas et al., 2014). There is a substantial gap in the literature about the effects of latent TrPs, especially in the lower limb, on athletic performance. Therefore, the present study aims to determine the effects of DN and rESWT on the severity of latent TrPs in the VL and VM. The null hypotheses are 1) that using DN or rESWT to treat latent TrPs in the VL and VM will not affect the PPT; 2) there will be no difference between DN and rESWT on the severity of latent TrPs in the VL and VM.

2. Methods

2.1. Sample size

The sample size was calculated using Equation (1) (Gissane, 2015), using data from a reliability study measuring the PPT on VL and VM (Walsh et al., 2017). To have a power of 0.80, with an α level of 0.05 with a level of confidence of 1.96, it was determined that a minimum of seven subjects (n = 7) be needed for each group.

$$n = 16 \cdot \frac{SD^2}{MDC^2} \quad (1)$$

Where n is group size, SD is standard deviation, MDC is minimal detectable change.

2.2. Subjects

vTwenty-seven recreational athletes who participate in more than 4 h a week of a sport that involve jumping such as athletics, basketball, dancing, Gaelic football, hurling/camogie, rugby, soccer, tennis, or volleyball were sampled using convenience sampling from the Health Science and Sports Departments in Insitute of Technology Carlow, between September 2016 and February 2017. Before testing, subjects completed an informed consent form, in line with Insitute of Technology Carlow's Ethics Board. Subjects were precluded from the study if they were not between 18 and 35 years of age; having or have had a systemic disease of the muscular or nervous system, congenital or acquired hip disease; hip or knee trauma and or surgery in the lower extremity in the past 12 months; inflammatory joint disease, tumours, lower limb or lower back injury requiring treatment in the previous six months and pregnancy; having active TrPs in the VL and VM defined as spontaneous pain in the referral patterns of the VL or VM. One subject (n = 1) had a lower limb injury in the previous six months and was precluded. Subjects also had to have met the inclusion criterion, of having at least two latent TrPs in both the VL and VM. One subject (n = 1) failed to meet the inclusion criterion. Two subjects (n = 2) declined to participate in the study. Twenty-three subjects began testing. Two subjects (n = 2) were not analysed as they withdrew from the study, one for personal reasons and one because of an ankle injury. Subjects were asked to refrain from vigorous exercise 24 h before testing.

2.3. Procedure

The present study was a parallel with equal allocation ratio design and was approved by the Insitute of Technology Carlow's Ethics Board. The study flow chart is illustrated in Fig. 1. Physiological measures were recorded. Subjects were then tested for the presence of Latent TrPs using the flat palpation method to meet the inclusion criterion. Palpation of TrPs was a completed by the primary rater, an athletic therapist with three years' experience in palpating TrPs. If Latent TrPs were present, then the subject was selected for testing. If more than two TrPs were present, then the two most tender TrPs in each of the muscles were treated. Before each session the order of TrPs to be treated for each subject was randomised using block allocation according to the leg then muscle, then the order of TrP sensitivity (Random function Microsoft Excel™ 2013 for Windows™ 7, Redmond, Washington, USA). Group randomisation, enrolment and allocation were conducted by the primary rater using block allocation (Random function Microsoft Excel™ 2013). The four muscles were right VM, right VL, left VM and left VL. For the palpation of TrPs in the VM, subjects were placed in a supine position. For VL, subjects were positioned in side-lying with a pillow between their knees and knees in 30° of flexion. The location of the TrPs at the baseline testing (B-line) was recorded using the anatomical landmark system (ALS) and has been found reliable (Barbero et al., 2012; Walsh et al., 2017). The outcomes were measured before each treatment session (Tx) to prevent any TrP sensitisation from post-needling soreness. To ensure the same TrP was measured and treated in subsequent test sessions the location of the latent TrPs was determined using the ALS (Walsh et al., 2017). The three Tx sessions were completed over one week (Ziaeifar et al., 2014). Follow-up outcome sessions (FU) were conducted 2–4 days after (Ziaeifar et al., 2014) and seven days after last Tx (Martín-Pintado-Zugasti et al., 2015).

2.4. Outcomes

The PPT was used to measure the sensitivity of TrPs in the VL and VM and has been shown to be reliable (Walsh et al., 2017). The PPT was measured using a Commander™ algometer (*JTECH medical,* Midvale, Utah, USA) and was described to the subject as '*The point where the sensation of pressure turned to a perception of pain*' (Ohrbach and Gale, 1989). To prevent bruising a 1 cm^2 head was used (Takahashi et al., 2005). The rater was blinded to the pressure placed through the algometer by using the maximum pressure recall feature of the algometer. The rater increased pressure via the algometer by 1 N s^{-1} until the subject reported the change of the pressure to pain (Nussbaum and Downes, 1998).

2.5. Interventions

Subjects were randomly assigned to one of the treatment groups or the control group Microsoft Excel™: DN group (n = 8), rESWT group (n = 8), control group (n = 7). Subjects were treated in the same order as the PPT was measured.

2.5.1. DN

For the DN group, a 0.30 mmX60 mm L-type™ disposable sterile stainless steel acupuncture needle (*Seirin Corporation*, Shizuoka, Japan) was inserted into the two most painful TrPs in the VL and VM, bilaterally, using a cone shape technique until a local twitch response (LTR) was induced (Hsieh et al., 2000). The LTR is a clinical feature of TrPs; therefore, once a LRT was elicited the needle was in the TrP (Rha et al., 2011). The sensitive loci within the TrP were stimulated dynamically using the fast-in-fast-out technique for 30 s (Salom-Moreno et al., 2014). If LTRs were still present, then a subsequent 30 s of treatment was applied. TrP stimulation continued in 30 s increments until LTR was absent or for a maximum of 2 min (Hsieh et al., 2012). If the fast-in-fast-out stimulation was too painful to be tolerated by the subject, then the needle was stimulated statically by twisting the needle. DN was a completed by the primary rater, who has had postgraduate training and has two years' experience in using DN.

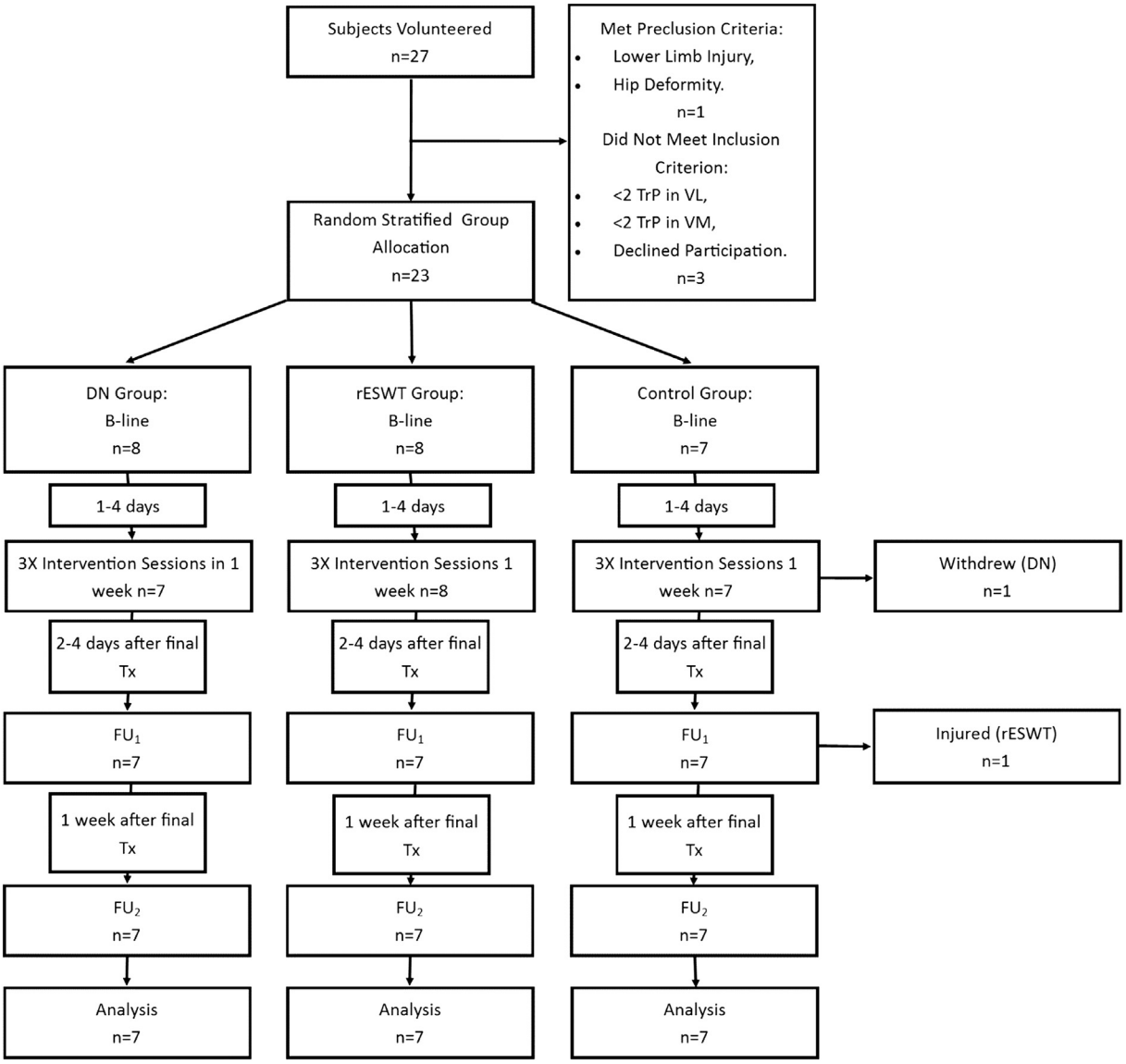

Fig. 1. The effects of DN and rESWT study flow chart. Where TrP is trigger points, VL is vastus lateralis, VM is vastus medialis, DN is dry needling, rESWT is radial extracorporeal shockwave therapy, B-line is baseline, $Tx_{(n)}$ is treatment, $FU_{(n)}$ is follow-up.

2.5.2. rESWT

In the rESWT group, rESWT was applied bilaterally to the two most painful TrPs in the VL and VM with an Intellect™ radial pressure wave shockwave therapy device (*Chattanooga™, DJO Global,* Guildford, Surrey, UK). The maximum tolerable pressure setting was used for each subject (Schmitz et al., 2015). Each TrP was treated using the 15 mm Deep Impact™ transducer head with 1000 pulses at 20 Hz with up to 5 bars of pressure and the transducer head left in situ (Schmitz et al., 2015). The surrounding tissue was treated using the 35 mm D-ACTOT™ transducer head with 2000 pulses at 20 Hz with up to 3 bars of pressure and the transducer head travelling in alignment with the fibres of the muscle (Gleitz and Hornig, 2012). rESWT was a completed by the primary rater, who has had postgraduate training and has two years' experience in using rESWT.

2.5.3. Control

The control group rested for 7 min in each of the four positions used to measure PPT.

2.6. Statistical analysis

The mean PPT was assessed for normal distribution using the one sample Kolmorogov-Smirnov test. A one-way analysis of variance (ANOVA) was performed to determine any difference in PPT between groups at B-line. A two-way ANOVA was performed for the PPT. Variables were session time (B-line, Tx_1 [2–3 days after the B-line]; Tx_2 [1–4 days after Tx_1], Tx_3 [2–3 days after Tx_2], FU_1 [2–4 days after Tx_3], FU_2 [seven days after Tx_3]) and group (DN, rESWT, control). A statistical significance of $p < 0.05$ was set. All statistical analyses were conducted in SPSS™ version 22 software (*SPSS Incorporated,* Chicago, Illinois, USA).

3. Results

3.1. Normality

Twenty-one subjects completed the testing and were assessed. Physiological and ALS data for each muscle was tested for normality

using the one sample Kolmorogov-Smirnov test and were found to be normally distributed ($p > 0.05$). A one-way ANOVA was performed to determine any difference in PPT between groups at B-line. There was a significant statistical difference in PPT at the B-line between the control group and the rESWT group. The PPT was lower in the rESWT group than the control group for the most sensitive TrP ($p = 0.011$) and second most sensitive TrP ($p = 0.011$) of the VM of the standing leg; the second most sensitive TrP of the VL of the standing leg ($p = 0.019$); and the second most sensitive TrP of the VL ($p = 0.027$) were higher.

3.2. Descriptive

The mean age of the males ($n = 9$) was 23.44 (95% CI: 21.13 to 25.75) years; compared to the mean age of the female subjects ($n = 12$), which was 22.42 (95% CI: 20.74 to 24.10) years. The mean mass of the male subjects was 78.16 (95% CI: 68.71 to 87.61) kg; while the mean mass of the females was 63.65 (95% CI: 54.49 to 72.91) kg. The mean height of the males was 1.78 (95% CI: 1.73 to 1.84) m; whereas, the females had a mean height of 1.65 (95% CI: 1.60 to 1.70) m. Physiological measures are presented in Table 1.

3.3. The effects of DN and rESWT on PPT

The mean PPT for the most painful and second most painful TrPs in the VL and VM of both legs were collated. The PPT of the DN group was 28.25 (95% CI: 26.61 to 29.90) N at the B-line and increased to 31.68 (95% CI: 29.73 to 33.62) N at FU_2. The rESWT group also demonstrated an increase in the PPT over the same period, from 22.08 (95% CI: 20.48 to 23.67) N at the B-line to 24.07 (95% CI: 22.64 to 25.00) N at FU_2. The PPT for the control group went from 31.55 (95% CI: 29.86 to 33.24) N at the B-line to 32.09 (95% CI: 30.52 to 33.65) N at FU_2.

A two-way ANOVA was performed for the PPT. Variables entered into the ANOVA were session time and intervention group. There was a statistical significant interaction between group versus session time ($F\,[10, 987] = 2.715$, $p = 2.71 \cdot 10^{-3}$, $\eta_p^2 = 0.027$) with an observed power of 0.969. A Tukey post hoc test for time revealed that the DN group was statistically significantly different to the rESWT group ($p = 5.09 \cdot 10^{-9}$) and the control group ($p = 0.002$) and the rESWT group was significantly different to the control group for time ($p = 5.09 \cdot 10^{-9}$). A Tukey post hoc test revealed that the B-line measurement was statistically significantly different to Tx_1 ($p = 7.46 \cdot 10^{-4}$) and FU_2 ($p = 4.47 \cdot 10^{-4}$). Tx_1 was statistically different to FU_1 ($p = 3.28 \cdot 10^{-8}$) and FU_2 ($p = 6.59 \cdot 10^{-14}$). Tx_2 was statistically significantly different to FU_1 ($p = 6.25 \cdot 10^{-4}$) and FU_2 ($p = 1.34 \cdot 10^{-8}$). Tx_3 was statistically significantly different to FU_1 ($p = 0.016$) and FU_2 when accounting for group ($p = 2.32 \cdot 10^{-6}$). Percent changes are presented in Table 2. The mean PPT measures of the most painful TrPs in each muscle are illustrated in Fig. 2 and Fig. 3.

Table 1
Physiological measure for subject completing jump reliability study ($n = 21$).

Subjects	Sample group (95% CI)
Gender (% female)	57.1%
Age (years)	22.86 (21.59–24.12)
Mass (kg)	69.87 (62.95–76.79)
Height (m)	1.71 (1.66–1.76)
Hours of physical activity per week (hours)	6.71 (5.45–7.98)
Standing leg (% right)	28.6%
Right VL-$ALS_{\_d}$ (m)	0.51 (0.50–0.52)
Left VL-$ALS_{\_d}$ (m)	0.51 (0.50–0.52)
Right VM-$ALS_{\_d}$ (m)	0.47 (0.46–0.49)
Left VM-$ALS_{\_d}$ (m)	0.48 (0.47–0.50)

Where VM is vastus medialis, VL is vastus lateralis, $ALS_{\_d}$ is estimated length of muscle using the anatomical landmark system.

4. Discussion

The null hypotheses are 1) that using DN or rESWT to treat latent TrPs in the VL and VM will not affect the PPT; 2) there will be no difference between DN and rESWT on the severity of latent TrPs in the VL and VM. There was a groupXtime interaction for PPT ($p < 0.05$). The DN group improved TrP sensitivity by 12.92% between B-line and FU_2; compared to the rESWT group who reported an improvement of 13.26%. Therefore, the null hypotheses can be rejected.

There was a significant improvement ($p < 0.05$) in the PPT for the DN group from 27.60 N at the B-line to 31.17 N at FU_2, equating to 12.92%, which was greater than the highest SEM (3.21 N) reported by Walsh et al. (2017) The findings of the present study are similar to the results of Cerezo-Téllez et al. (2016) who reported an improvement in the PPT of active TrPs in the upper trapezius muscle after one to three sessions of DN. The PPT in the present study were higher than those of Cerezo-Téllez et al. (2016), who treated active TrPs, but lower than the PPT reported in TrPs in the quadriceps muscles of patients with post-meniscectomy pain (Torres-Chica et al., 2014). However, the PPT was comparable to those reported by Zuil-Escobar et al. (2016) who measured the PPT of latent TrPs in the legs.

The rESWT group also demonstrated a significant improvement ($p < 0.05$) in the PPT from B-Line (21.08 N) to FU_2 (23.88 N) by 13.26% which was greater than the mean SEM (1.97 N) reported by Walsh et al. (2017). The improvements of the present study for rESWT are similar to the findings of Cho et al. (2012) who reported improvements in PPT of active TrPs in the upper trapezius muscle when treating TrPs with rESWT. The findings of the present study are not as substantial as a previous study that reported an increase of 25.42 N with one Tx of 1000 pulses of 0.12 mJ mm^{-2} of rESWT (Jeon et al., 2012). This less substantial improvement in PPT may be due to treating latent TrPs in the present study.

The difference in PPT of the most painful TrP in VM of the standing leg and the VM of the non-standing leg was lower by 1.08 N, suggesting that the non-standing limb may respond better to treatment as it is not subjected to a repetitive load, compared to the standing limb, which is a predisposing factor for the formation of TrPs (Dommerholt, 2011).

There was also a significant decrease in PPT ($p < 0.05$) between B-line and before Tx_1 (1.33–5.09 N) for all of the most painful TrPs, except for the most painful TrP in the in the VM of the standing leg of subjects in the rESWT group which had an increase of 1.97 N. The reduction in the pre-test and post-test PPT is similar to the findings of Jones et al. (2007) and Walsh et al. (2017). However, they are in contrast to the pre-test and post-test PPT of bilateral erector spinae muscles at the spinous processes of lumbar levels 1, 3 and 5, respectively (Koo et al., 2013). It should be noted that in the study by Koo et al. (2013) the PPT was measured at the spinous processes, not at TrPs. Thus, suggesting that using an algometer may have a

Table 2
Pressure pain threshold percent change for key times.

	DN ($n = 7$)	rESWT ($n = 7$)	Control ($n = 7$)
B-line - FU_2[a]	12.92	13.27	4.38
B-line - Tx_3	−6.46	2.82	0.18
Tx_3 - FU_1 [a]	20.73	6.86	0.70
Tx_3 - FU_2[a]	29.58	10.16	4.20

[a] is a significant difference for time in the analysis of variance. Where B-line is Baseline, $Tx_{(n)}$ is Treatment, $FU_{(n)}$ is Follow-up.

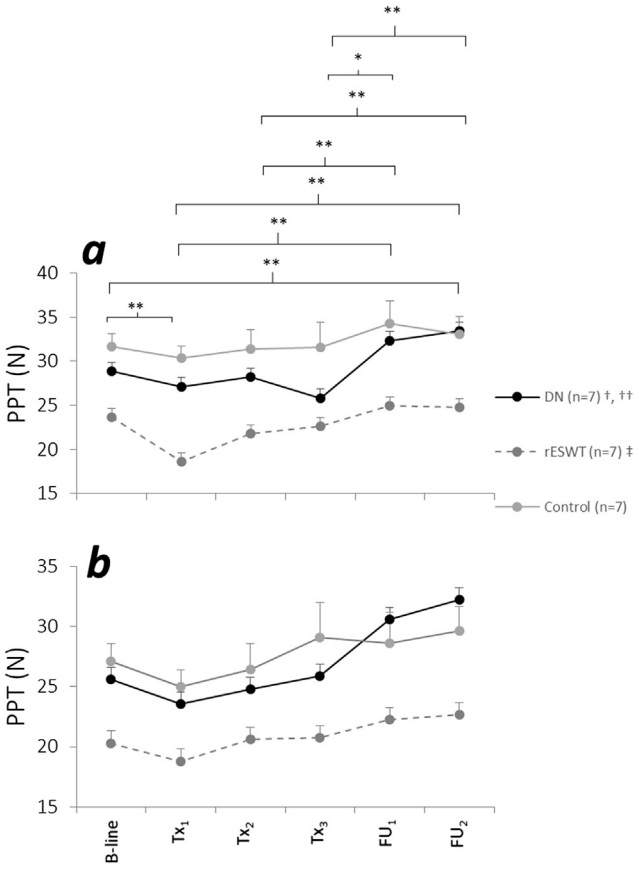

Fig. 2. Mean PPT of the most painful TrP in the vastus lateralis of the (*a*) standing leg (*b*) non-standing leg. Where PPT is pain pressure threshold, DN is dry needling, rSWT is radial extracorporeal shockwave therapy, B-line is baseline, $Tx_{(n)}$ is treatment, $FU_{(n)}$ is follow-up. * is a difference between sessions ($p < 0.05$) for both legs, ** is a difference between sessions ($p < 0.01$) for both legs, † is a difference between DN and control ($p < 0.05$), †† is a difference between DN and rESWT ($p < 0.01$), ‡ is a difference between rESWT and control, error bars are standard error ($p < 0.01$).

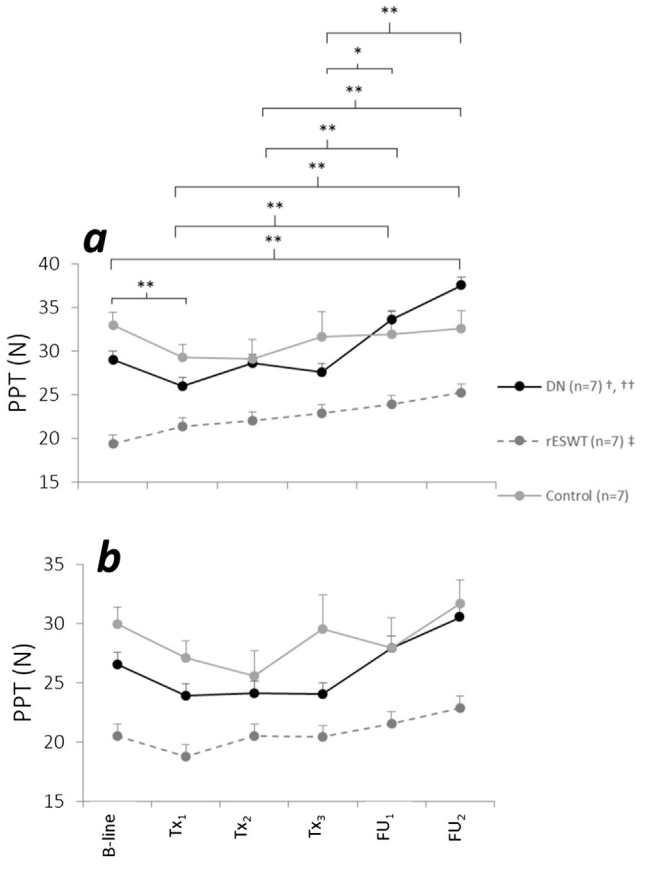

Fig. 3. Mean PPT of the most painful TrP in the vastus medialis of the (*a*) standing leg (*b*) non-standing leg. Where PPT is pain pressure threshold, DN is dry needling, rSWT is radial extracorporeal shockwave therapy, B-line is baseline, $Tx_{(n)}$ is treatment, $FU_{(n)}$ is follow-up. * is a difference between sessions ($p < 0.05$) for both legs, ** is a difference between sessions ($p < 0.01$) for both legs, † is a difference between DN and control ($p < 0.05$), †† is a difference between DN and rESWT ($p < 0.01$), ‡ is a difference between rESWT and control, error bars are standard error ($p < 0.01$).

sensitising effect on subjects with latent TrPs.

During the treatment phase, there was a statistically significant ($p < 0.05$) increase of sensitivity in the DN group with a reduction in the PPT of 0.80–3.05 N. Thus, suggesting that there was some post-needling soreness. These PPTs are similar to the finding of Martín-Pintado-Zugasti et al. (2014, 2015, 2016) who treated latent TrPs in the trapezius. The DN group did demonstrate a greater level of improvement from Tx_3 to FU_2 (6.41–9.90 N), depending on the muscle and leg; compared to 2.05–3.15 N for the rESWT group.

There was a steady, gradual decrease in the sensitivity of the PPT in subjects in the rESWT group (0.18–2.66 N). This gradual increase of pressure would suggest that the rESWT does not produce post-treatment soreness and may be used on patients who have highly sensitive TrPs. Post-needling soreness is an area of research that is still being investigated, but the literature would suggest that it can last up to 72 h in healthy subjects and longer in patients with active TrP (Martín-Pintado-Zugasti et al., 2016, 2015, 2014). It is unknown if the post-needling soreness affects function and further investigation is needed.

4.1. Limitations

The major limitations of the present study are, 1) the only muscles treated were the VL and VM; and 2) treatment was restricted to just the two most painful TrPs in each of the respective muscles. Athletic movements such as jumping and running involve many muscles around the hip, knee, and ankle called the kinetic chain (Decker et al., 2003). It should stand that treating all of the sensitive loci within a muscle could further improve muscle function (Tsai et al., 2010). Conditions such as tension-type headaches (Fernández-de-Las-Peñas et al., 2006) and knee osteoarthritis (Itoh et al., 2008) have required the treatment of multiple TrPs in multiple muscles. Therefore, it would be prudent to assess the effects of DN and rESWT to TrPs on the whole kinetic chain.

Latent TrPs are believed to alter activation patterns in the quadriceps and contribute towards pathologies such as patellofemoral pain syndrome (Espí-López et al., 2017) and knee osteoarthritis (Mayoral et al., 2013), possibly due to altered biomechanics or sensitisation (Culvenor et al., 2014). Addressing dysfunction in the supporting soft tissue may improve knee kinematics (Barton et al., 2015). The delayed activation of the VM in patellofemoral pain syndrome patients during sit-to-stand tasks may cause fatigue in the VL (Cavazzuti et al., 2010), even in asymptomatic subjects (McClinton et al., 2007). Prolonged activation of the VM and VL may cause fatigue and perhaps activate TrPs. There is a need to measure the activation of the VL and VM with electromyography in more functional tasks such as the depth jump to understand the effects of treating TrPs in the VL and VM (Ameloot and Bagust, 2016).

In the present study, there was an upward trend shown in the PPT of the most painful TrP in the VL and VM of the non-standing leg and the VM of the standing leg. A previous study of the

effects of DN multiple muscles in the lower limb, including the quadriceps, in patients with knee osteoarthritis, reported an improvement in Western Ontario and McMaster Osteoarthritis Index (WOMAC) functional scale ten weeks after four once-a-week treatments (Itoh et al., 2008). A longer FU period may identify the time course of the effects of DN and rESWT on latent TrPs with regards performance and strength.

4.2. Clinical application

In the present study, DN has been shown to improve PPT in TrPs in the VL and VM. However, there is a temporary adverse effect on the PPT in TrPs in the VL and VM which can last up to three days. This adverse effect may be as a result of post-needling soreness (Martín-Pintado-Zugasti et al., 2016, 2015). rESWT also improved PPT in the VL and VM. However, rESWT does not appear to have such a transient adverse effect as DN and may be an alternative treatment for TrPs in athletes who cannot afford to reduce training load or who are preparing for major competition.

5. Conclusion

An investigation was conducted into the effects of DN and rESWT to latent TrPs on the VL and VM on muscle sensitivity. DN appears to have a positive effect on the PPT of TrPs in the VL and VM once the post-needling soreness had subsided. rESWT is as comparable to DN at the completion of three treatments but has a less dramatic improvement between Tx_3 and FU_2 possibly due to no post-treatment soreness. Future studies should include treating multiple TrPs in multiple muscles involved in athletic movements. Also, outcomes measures such as muscle activation and joint kinematics should be included. Furthermore, longer FU periods should be used to determine the time course of DN and rESWT. Therapists should consider the current training load, season periodization and upcoming competition to deliver the optimum treatment strategy for athletes with latent TrPs.

Conflicts of interest

There are no conflicts of interests with the authors of this paper.

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