Title: Acute effects of self-myofascial release compared to dry needling on myofascial pain syndrome related outcomes: range of motion, muscle soreness and performance. A randomized controlled trial.

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Research Article

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Head title: Effects of foam roller vs dry needling on myofascial pain.

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ABSTRACT

Objectives: myofascial pain syndrome (MPS) is associated with reductions in range of movement (ROM), decrease in physical function and performance and increase in pain in different populations. Elucidating the best prevention and treatment strategies for MPS has been one of the main goals in the last decade. The objective of the present study was to compare the acute effects of self-myofascial foam rolling (SFR) and dry-needling (DN) techniques on ankle dorsiflexion ROM, soreness post-needling and performance through countermovement jump (CMJ) height.

Methods: a prospective crossover design composed by 12 active adults, aged 23.41 ± 1.68 years (weight: 78.33 ± 9.02 Kg; height: 1.79 ± 0.088 m) with active ankle dorsiflexion restriction was performed. Participants were randomized into the SFR and DN techniques to analyze its effects on ankle dorsiflexion ROM, muscle soreness and jump height at pre, post and 24 h post-intervention.

Results: significant improvements were found by DN on ankle dorsiflexion at 24 hours post intervention and muscle soreness by SFR at the same time point. No significant differences were found between conditions.

Conclusions: Both SFR and DN are effective in improving ankle dorsiflexion and performance in young adults without producing an acute effect in muscle soreness.

Keywords: foam roller, countermovement jump, hyperalgesia, range of motion, myofascial trigger point pain.

INTRODUCTION

Injury prevention and recovery strategies are two basic areas in sport and physical exercise fields. One of the aspect that have generated most interest in the last decade in these two areas has been the myofascial pain syndrome (MPS) [1]. MPS usually appears when the demands in sport and exercise activities exceeds the tolerance capacity of the muscle tissue, leading with pain, weakness and lack of mobility [2]. The appearance of myofascial trigger points (MTrPs) has been described within the MPS as something common [3].These are defined as a hypersensitive area in a tight band of a muscle [4].

In recent years, foam rolling has become one of the main tools used for the treatment of MPS as well as for the recovery of muscle tissue after the damage produced by the sport and exercise activities [5]. Foam rolling has shown beneficial effects on improving hamstring range of movement (ROM), muscle stiffness, late onset of pain and also pressure pain threshold (PPT) [6].

On the other hand, another treatment used in MPS is the dry needling (DN) technique [7]. This tool has been shown to be effective to relieve pain and increase ROM in the short-term [8]. For example, a meta-analysis performed by Gattie, Cleland and Snodgrass [9] revealed that very low quality to moderate quality evidence suggests that DN is more effective that no treatment for reducing pain and improving PPT.

Interestingly, a recent meta-analysis leaded by Wiewelhove et al.[10] showed that a treatment with SFR shows minors and partially negligible positive effects on performance and muscle recovery. However, the use of foam roller could be beneficial in some cases

as it increases sprint performance and flexibility. In addition, previous studies have detected that self-myofascial foam roller (SFR) can also reduce muscle pain sensation [11].

However, regarding the DN technique, one of the main side-effects is the appearance of post-needling soreness. This post-needling soreness response is variable, and despite the fact that not all subjects experience it with the same intensity level, the risk of the its appearance could determine the choice of this technique over others [12]. However, this symptom does not have to affect the muscle contractile properties [13].

Therefore, the present study aimed to examine and compare the acute effects in terms of magnitude and duration of SFR and DN techniques on ankle mobility, pain and jump height in active and healthy young adults. We hypothesized that both interventions, SFR and DN, would lead similar acute (immediate and post 24h) effects on all the parameters analyzed, with no significant differences between conditions in any of them.

RESULTS

Table 1 shows the descriptive statistics of all dependent variables analyzed during both intervention conditions. The 12 participants who where initially randomly assigned to each condition received the treatment and were analyzed for the primary and secondary variables. There were no dropouts.

Variable	Self-myofascial foam roller	Dry needling	Mean Difference [$CI_{95\%}$]	% of change
Ankle dorsiflexion ROM				
Pre	27.92 (3.50)	27.33 (4.07)	0.58 [-3.21 to 4.38]	2
Immediate Post	29.83 (3.71)	29.33 (3.62)	0.50 [-3.30 to 4.30]	2
Post 24 h	28.00 (3.51)	26.41 (3.17)	1.58 [-2.21 to 5.38]	6
Post intervention soreness (EVA)				
Pre	3.37 (1.38)	3.39 (1.26)	-0.02 [-1.73 to 1.70]	-1
Immediate Post	3.23 (1.41)	3.19 (1.18)	0.04 [-1.68 to 1.76]	-1
Post 24 h	2.30 (1.32)	3.38 (1.67)	-1.08 [-2.80 to 0.63]	- 47
CMJ height (cm)				
Pre	30.77 (4.53)	31.58 (4.69)	-0.81 [-4.68 to 3.06]	- 3
Immediate Post	31.69 (5.02)	31.34 (4.69)	0.35 [-3.52 to 4.22]	1
Post 24 h	33.43 (5.67)	31.34 (7.30)	2.09 [-1.78 to 5.96]	6

Note = all variables met the normality assumption ($p > 0.05$), CMJ = countermovement jump, ROM= range of motion. $CI_{95\%}$ = confidence interval at 95%.

Table 1. Effects of intervention.

The RM ANOVA did not show significant differences in main effect of "intervention" variable ($F_{[1,11]}$= 1.39, p = 0.264, eta = 0.05) on lunge test. The MD, $CI_{95\%}$ and ES were 0.89 (-0.77 to 2.55) and 0.34, respectively. On the other hand, non-significant differences were found at interaction effect of "*time x intervention*" ($F_{[2, 22]}$= 0.28, p = 0.759, n^2_p = 0.02). Bonferroni post hoc comparison revealed significant differences in post immediate intervention vs. post 24 hours post intervention in DN condition (see figure 1).

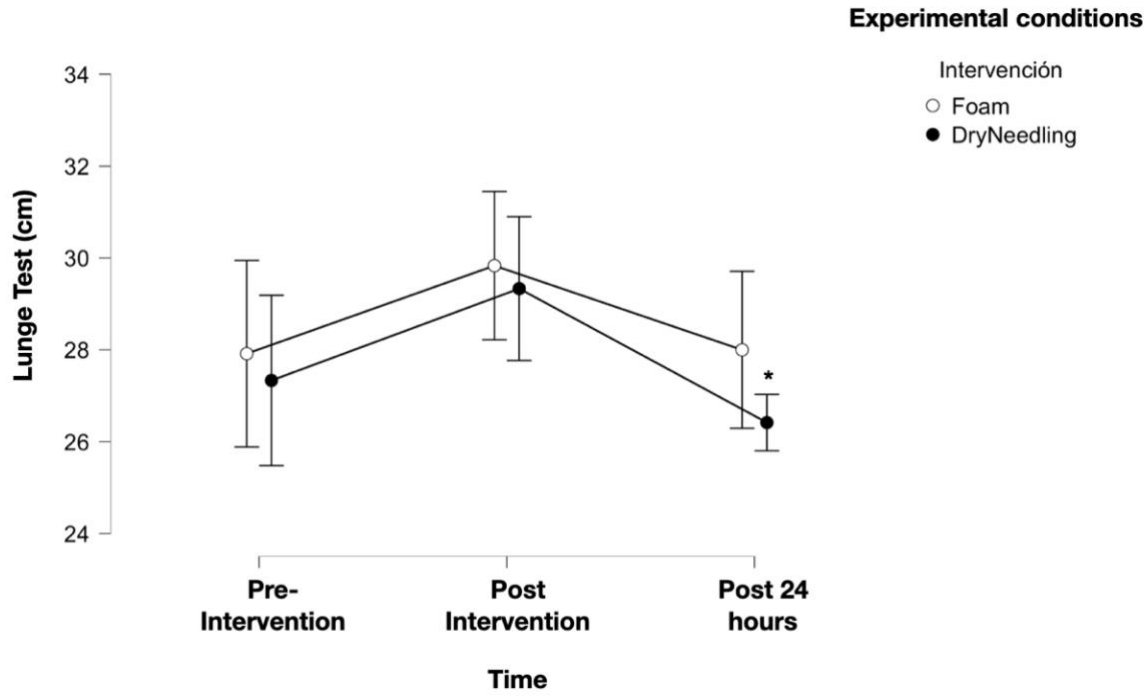

Figure 1. Interaction effect of time (pre, immediate post and 24 h post intervention) x intervention (i.e., SFR vs. DN on lunge test score). * Significant differences (p = 0.049) in comparison to post-intervention.

The RM ANOVA did not show significant differences in main effect of "*intervention*" variable ($F_{[1,11]}$= 0.63, p = 0.443, eta = 0.05) in hyperalgesia variable. The MD, $CI_{95\%}$ and ES were -0.35 [-1.33 to 0.62] and 0.23, respectively. On the other hand, significant differences were found at interaction effect of "*time x intervention*" ($F_{[2, 22]}$= 4.30, p = 0.027, n^2_p = 0.28). Bonferroni post Hoc comparison revealed significant differences in pre intervention vs. post 24 hours post intervention in SFR condition (see figure 2).

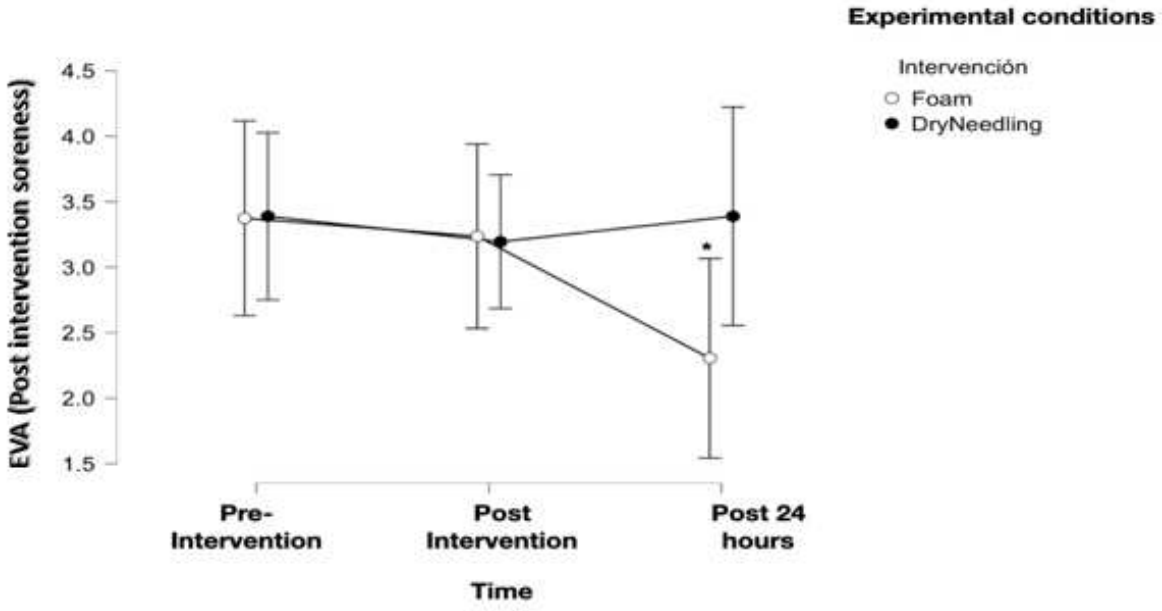

Figure 2. Interaction effect of time (pre, immediate post and 24 h post intervention) x intervention (i.e., SFR vs. DN) on soreness post interventions. * Significant differences (p = 0.028) in comparison to post-intervention.

The RM ANOVA did not show significant differences in main effect of "*intervention*" variable ($F_{[1,11]}$= 1.23, p = 0.313, eta = 0.10) in CMJ height. The MD, $CI_{95\%}$ and ES were -0.54 [-1.40 to 2.49] and 0.18, respectively. On the other hand, significant differences were found at interaction effect of "*time x intervention*" ($F_{[1.24,13.60]}$= 2.12, p = 0.167, n^2_p = 0.16). Bonferroni post Hoc comparison revealed no significant differences (see figure 3.)

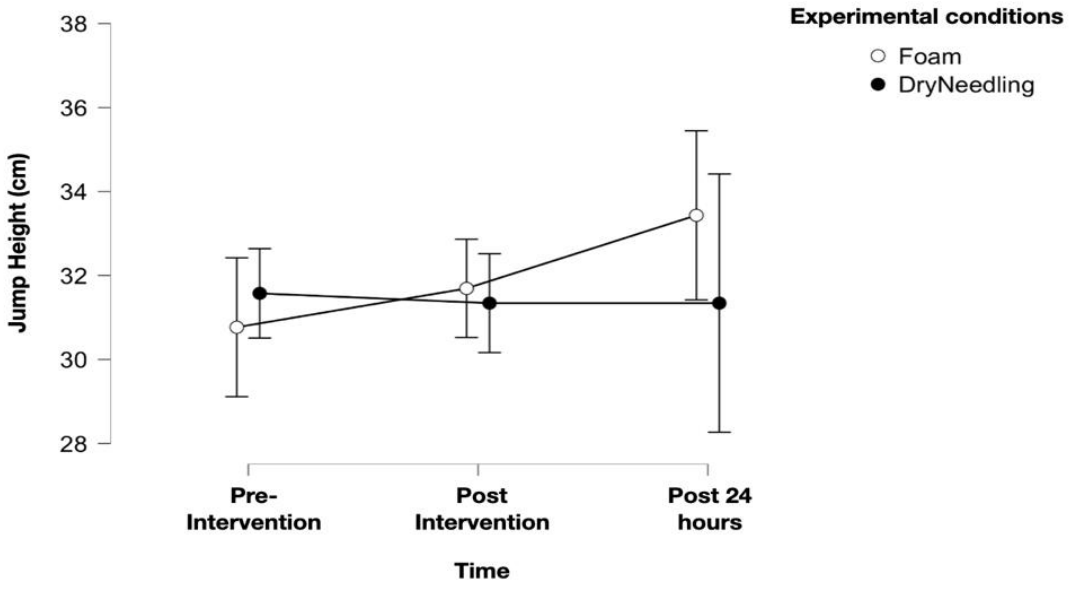

Figure 3. Interaction effect of time (pre, post and 24 h post intervention) x intervention (i.e., SFR vs. DN) on jump heigh (cm). Note: bar represent the 95% CI.

ADVERSE EVENTS

No adverse events or unintended effects were recorded.

DISCUSSION

This study aimed to examine and compare the acute effects of SFR vs. DN techniques on ankle mobility, post-intervention soreness and performance in active and healthy young adults. The main finding of the present study was that both techniques, SFR and DN, reported similar values in all dependent variables assessed (passive ankle dorsiflexion mobility, muscle soreness and jump height). However, although non-statistically significant differences were found between conditions, moderate ES were obtained on post-intervention soreness and jump height in favour of SFR condition at post 24 h in comparison to DN.

A recent systematic review suggests that both SFR and the roller massage may offer short-term benefits for increasing sit and reach scores and ROM at the ankle without performance improvements [14]. Our results are partially in line with this current because we found positive changes at immediate post-intervention ankle ROM, but also improvements in jump height at the same moment, although the magnitude of the changes was not enough to be statistically significant. A previous study found that the dorsiflexion ROM immediately increased 6° (22%) in the triceps surae muscle after the SFR intervention [15]. Our results are in accordance with previous studies where the SFR increases the ROM of the ankle joint immediately, both in the athletic and general population [16]. Similarly, Bushell et al reported that SFR induced muscle relaxation and increased ROM in college athletes [17].

Contrary to some studies, which showed negative effects on performance when SFR was applied in pre-competition [18], we found that the gains in ankle flexibility did not have a negative impact on performance, evaluated through the jump height in a CMJ. However,

our results are in line with previous research where knee, ankle, hip and trunk ROM improvements also had no negative consequences on different performance parameters [19]. It should be noted that the effects reported in our studies were acute effects. These discrepancies between studies can be related with the heterogeneity in the protocols of SFR applied and in the samples.

Several possibilities such us the activation mechanoreceptors and autonomic nervous system response [20] could be considered responsible for the changes of the ankle ROM due to the activation of central pain modulatory paths, through neural inhibition mechanisms [21]. In fact, the application to the lower extremity prior to the activity does not enhance or negatively affect muscle performance but may change the perception of fatigue [22]. In fact, there is an emerging consensus on how SFR treatment affects improving power, strength, elasticity and balance in athletes. However, no significant anatomical changes has been observed in fascicle length in the gastrocnemius muscle [15].

On the other hand, among the existing tools for the treatment of MPS, together with non-invasive myofascial self-liberation techniques such as the aforementioned SFR, there are techniques with an invasive approach such as wet needling or DN. DN has been recommended for management MTrPs pain [23]. MTrPs dry needling procedures have shown to be associated with post-needling soreness which usually lasting less than 72 hours [24]. This post needling soreness will not be of similar intensity in all patients, and some of them may not even perceive said post-intervention sequelae.

Although the symptom is not reported by all patients equally, there are previous studies that show that in asymptomatic patients, the use of DN over latent MTrPs within the

medial gastrocnemius muscle produced an increase in magnetic resonance imaging using the Short Tau Inversion Recovery sequence (MRI-STIR), compatible with intramuscular edema and an increase of muscle stiffness [13]. Due to this important side-effect, it is very necessary for physical therapists to know the clinical conditions and time periods for which DN produced post-needling soreness. It is well-known that the number of needle insertions is associated with this symptom [25]. Currently, several strategies has been used to control post-dry needling soreness [26].

In the case of our study, the SFR not only increases the ROM and improves CMJ height, but also reduced the pain significantly at 24 hrs. Previous results suggests there is an acute increase on the PPTs post-foam roller [27]. However, contrary to what could be expected, post-needling soreness was similar in the three evaluation periods (pre, immediate post and 24h, with no significant increase as a result of the DN intervention. It should be noted that, both SFR and DN conditions achieved similar pre and immediate post muscle soreness, showing only acute and significant effects between interventions at 24 hours in favor of SFR but due to a decrease in the VAS values of the SFR, not to an increase as a consequence of the DN intervention.

It is important to highlight that, corroborating previous studies where the use of SRF was not associated with a decrease in strength and performance after its immediate application [28], the use of DN seems to follow the same behavior after treatment on the variables studied in the present investigation. It seems, therefore, that, despite the tissue damage generated by DN, both techniques can be used to increase ankle dorsiflexion mobility and performance without an increase in magnitude and duration of acute post-treatment pain. In addition, no adverse events were recorded during the study period.

Our study is not without limitations, which must be considered. Firstly, there is no significant differences between conditions, but it is possible to appreciate that there is a tendency in the post-intervention soreness in favour of SFR, being the small sample size used in the study (type I error) possible bias. Secondly, the lack of measures (i.e., ultrasound) to identify possible structural (intra-articular) artifacts associated with dorsiflexion limitation. Lastly, the absence of objective diagnosis for the detection of MTrPs with the use of ultrasound.

Finally, despite the widespread use of SFR and DN in sport and clinic fields, the current literature measuring the effects of SFR and DR as a preventive, treatment or recovery performance tools is still emerging. Thus, futures studies should investigate the effects of these techniques using different protocols and samples, and implemented short and long-term interventions to analyze their chronic effects.

METHODS

Experimental approach to the problem

A randomized prospective crossover trial design was used to compare the acute effects of SFR and interventions in terms of magnitude and duration on the physiological variables of ankle mobility (ROM), pain (PPTs and visual analogue scale; VAS) and performance (countermovement [CMJ] height) in active and healthy young adults. The conditions of SFR and DN were randomized and counterbalanced among participants to control the sequential effect of the order and transfer through by an independent investigator using Epidat 3.1 (www.sergas.es). The author V-M J. implemented the allocation sequence, while B-V J. enrolled the participants and assigned participants to interventions. All

dependent variables were measured at pre-intervention, immediate post-intervention and post-intervention at 24 h (Figure 4). Data collectors and data analytics were blinded to interventions.

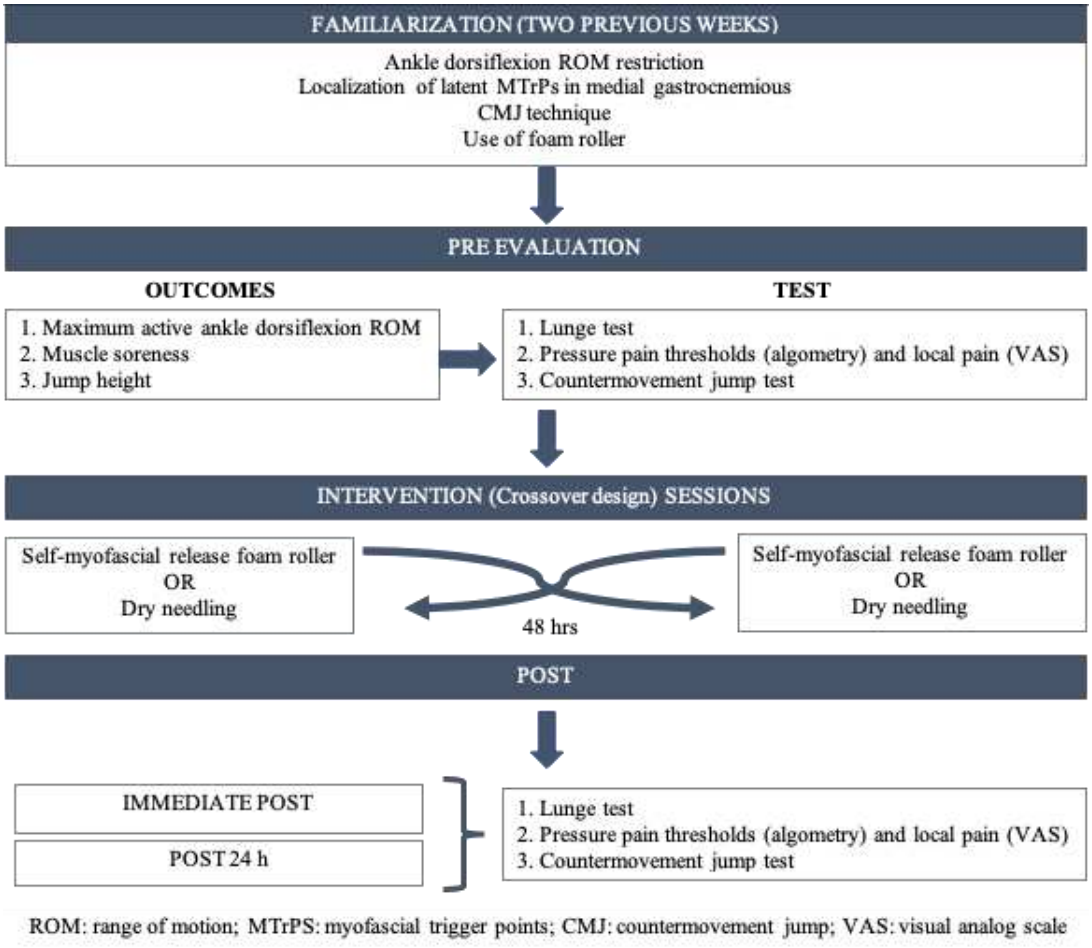

Figure 4. Intervention design

Ethics

The study adhered to the CONSORT guidelines [29]. It was conducted in accordance with the Declaration of Helsinki and approval by the local ethics committee of the Catholic University of Valencia was obtained (UCV/2019-2020/062). Each included subject signed informed consent. The trial was registered (1/05/2020) at clinicaltrials.gov (NCT04600830).

Subjects

A total of 12 participants were involved in the present study. The sample was collected through an informative form for participation in a research study. The participants were young healthy and active male adults (age: 23.41 ± 1.68 years; height: 1.79±0.088 m; body mass: 78.33 ± 9.03 Kg; body mass index (BMI): 24.14 ± 1.45 kg/m^2). Participants were students recruited from the Catholic University of Valencia through initial screening to select the participants who met the following inclusion criteria: active ankle dorsiflexion restriction (<11.5cm or 1.5cm difference between both limbs) [30]. Exclusion criteria were as follow: (i) chronic pain syndromes such as low back pain, fibromyalgia or others, (ii) skin injuries in the area to be treated, (iii) peripheral and central neuropathic pain, (iv) recent surgery in the lower limbs (last 12 months), (v) cardiovascular, neurological, inflammatory and rheumatic diseases; and (vi) engage in physical activity/sports during the total length of the experimental study.

Procedures

The study encompassed three sessions. During the first session (familiarization) performed two prior weeks, the ankle dorsiflexion ROM was assessed to identify the subjects with mobility restriction during this movement (regardless of whether the restriction was present in the dominant or non-dominant limb.) During this session, with the participants finally included, latent MTrPs in medial gastrocnemius muscle were screened following the International Delphi instructions [31]. Aiming to reduce location-specific variance between participants and assessments, the test were performed by a trained staff (physiotherapist) in the area of MPS and trigger points according to Travell and Simons procedures [32]. The gastrocnemius muscle was chosen because it has been shown to exhibit the highest prevalence of latent MTrPs in healthy subjects [33]. Furthermore, the first session was used to familiarize the sample with the use of the foam roller and the CMJ procedure (explanation and performing the technique four times).

During the second session, the interventions techniques along with the assessments of the dependent variables were carried out. The order of the assessments was: lunge test, CMJ height and post-intervention pain through PPTs and VAS. Both sessions (50 min each one) were performed in university clinics during the last week of May with a rest period of 48 hours between sessions. Participants were also instructed to refrain from taking any medications that would interfere with testing and maintain their usual nutrition intake and physical activity levels.

Intervention

Foam Roller

The myofascial self-release technique with the uniform polystyrene Black Roll PRO foam roller (Bottighogen, Switzerland; density 2.3Kg/m^3; 15x91cm [diameter x length]) was performed on the ground with the participant lying over the foam roller. The foam roller was placed under the gastro-soleus complex, while the subject slowly moved his body in the same direction as the muscle fibers, using his hands to push himself and make the roller slide back and forth. The intervention divided the gastrocnemius into two zones. The zone one and two corresponded to the medial and lateral gastrocnemius, respectively.

The device was only applied at the muscular level, avoiding the Achilles tendon area and the popliteal fossa [15]. A total of three sets of 60-sec with 30-sec rest between them were performed on the lower limb with the ankle mobility restriction. The subjects performed around 30 self-myofascial release cycles in the target area during the minute (~1 second each back and forward movement measured with metronome) (Smart Metronome; Tomohiro Ihara, Japan) [34]. In detail the subjects completed a total of 90 cycles in three minutes (3 sets x 30 cycles each set). A research member recorded the cycles. This total

time was stablished based on the lack of effects on ROM when SFR is applied during two minutes [35]**.** The pressure intensity was the maximum tolerable. Pressure was adjusted by applying body weight to the roller and using the hands and feet to offset weight as required. The subjects underwent prior familiarization before completing the intervention and were instructed at all times. Each participant practiced 3 or 4 times to learn the correct technique with the supervision of a research staff. Each participant performed warm-up exercises (5 minutes of light aerobic cycling at 60% of maximum heart rate was initiated) before all participants performed the pre-test.

Dry Needling

One session of DN were carried out. DN were performed with disposable stainless Steel needles (0,3 x 40mm. Myofib, Toledo, Spain) and applied manually by the therapists (>10 years of experience) on the latent MTrPs of medial gastrocnemius area. The area was cleaned previously by the therapist with alcohol and always sterile gloves were used. Hong's fast-in and fast-out technique was implemented during the DN intervention [36]. The needle was moved up and down 2-3 mm vertically through the latent MTrPS, which was located within the a muscle taut band [34]. Approximately 25 insertions without leaving the skin during half minute were implemented [32]. At the end of the intervention, a cotton piece was applied to the treated area for one minute to ensure an adequate control of hemostasis.

Parameters

Post-intervention muscle soreness

Pressure pain sensibility (primary outocome), named also as pressure pain perception, is defined as the minimal amount of pressure at which the sense of pressure first changes to pain [37]. The PPT was measured with mechanical stimuli which were applied using a

manual analogue algometer with a Wagner FDK/FDN series Force Dial analogue Fisher algometer (Wagner Instruments, Greenwich, CT). Firstly, the subjects were familiarized with the procedure [38]. It was determined by deep palpation of MTrPs location on the interventional sides of medial gastrocnemius (trigger point 2). After identification of a taut band, a hard hubber probe ($1cm^2$) was placed perpendicular to the skin [39]. The examiner applied increasing pressure up $4kg/cm^2$ was applied with the thumb to the most sensitive tender spot/nodule for 5 seconds, and the subject had of pain using a 0–10 cm VAS ruler with 2 extremes: no pain and worst pain ever felt [40].

The position used is shown in Figure 5. The PPTs was measured three times. The mean value from the 3 assessments was used in the analyses [41]. PPTs was assessed before and immediately after the needling procedure, and at 24 hours after intervention. Visual analogue scale this procedure has demonstrated good reliability [42].

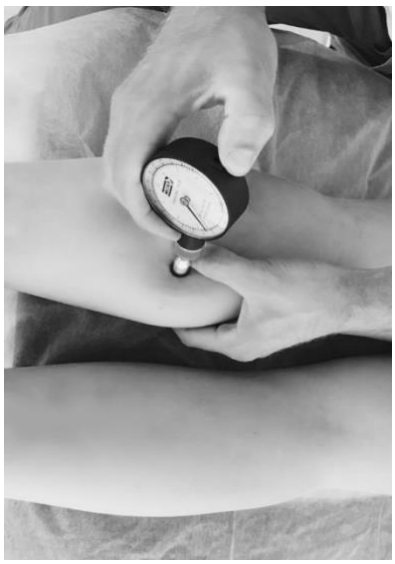

Figure 5. Measurement of the pressure pain threshold at the MTrPs treated.

Weight-bearing lunge test

To evaluate ankle mobility, the weight-bearing lunge test was used. The participants lunged forward trying to touch a vertical line on the wall with their knee while maintaining the heel of the same limb evaluated in contact with the ground. They moved their foot away from the wall in order to reach maximum dorsiflexion ROM [43]. The foot of each participant was positioned so that the horizontal line on the base of the platform was between the 2nd and 3rd toes and bisected the calcaneus [44]. Participants were instructed to lunge their knee forward, keeping their heel in contact with the platform. The subjects performed three familiarization trials followed by three test trials without rest interval between these two phases and between trials. The mean distance in cm of the three trials was recorded. During the test, the subjects were allowed to put the non-tested leg in a comfortable position behind the testing limb and to hold onto the wall to maintain their balance [45]. Participants were instructed to blend the ankle and knee as far as possible, but no encouragement was provided during the testing.

Countermovement jump

The CMJ jump height was measured with a light barrier system (OptoGait, Microgate, Bolzano Bozen, Italy) which has been used in similar studies [46]. This device measures the contact time on the floor and the flight time, using photoelectric cells. Participants were placed standing with each foot on the floor (barefoot) at shoulder height and with hands akimbo, then, restricting arm movements to be focused only on the force generated via lower limbs [47]. Participants were instructed to lower themselves as low as possible, as

quickly as possible and jump as high as possible vertically, returning to the standing position after landing. They performed three attempts with 15 seconds rest between them, as has been established in previous studies. The research staff team control visually the correct technique of each attempt to identify any possible mistake despite all participants performed a previous familiarization session where learned the correct execution (at least four jumps, two weeks before). Flight time was used to calculate the height of the rise using the body's centre of gravity [48]. The typically observed warm-up consisted of squatting movements, toe touches, hopping, and practice jumps, and lasted 3-5 minutes [49]. The average value of the three attempts was used for the subsequent analysis.

Statical Analysis

All variables were expressed as a mean and standard deviation (SD). The assumption of normality was assessed using Kolmogorov-Smirnov ($p > 0.05$). Repeated measures analysis of variance (ANOVA RM) was used to determine the effect of intervention technique (i.e., foam roller or dry needling) in ankle dorsiflexion ROM, muscle soreness and jump height. All comparisons between measures were corrected using Mauchly test (i.e., Greenhouse-Geisser approximation). For all analyses, when a significant main effect was detected, post hoc related Student´s t-test with Bonferroni corrections was used to determine which comparisons differed. The Cohen effect size (ES) used was expressed as the difference of typified mean change. The ES was considered trivial (<0.20), small (0.20 – 0.59), moderate (0.60 – 1.19), large (1.20 – 1.99) and very large (>2.00). The Pearson correlation coefficient was used to analyse the association between variables. A "trivial" association was established as $r < 0.25$, "small" between $0.25 < R < 0.50$, "moderate to strong" between $0.50 < r < 0.75$ and "very strong" as $r > 0.75$. The significance level was set at $p < 0.05$. All analyses were performed using statistical

analysis software (SPSS Inc, Chicago, Illinois, USA). Sample size was calculated based on the effect size reported by Sánchez-Infante et al. (2021) who measured "pressure pain perception" (ES = 0.61), considering the probability of loss during follow-up (30%) the minimal number of participants, the minimal required to attain a power of 0.9 and a bilateral α level of 0.05 for analysis of variance (ANOVA) with repeated measures.

CONCLUSIONS

Both SFR and DN are effective to improve ankle dorsiflexion and performance in healthy young male adults without generating an acute negative effect in muscle soreness. Then, both types of strategies could be used since the pain generated by both tools does not affect the performance and ankle dorsiflexion, although future studies with higher sample size and with different population are needed.

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AUTHOR CONTRIBUTIONS STATEMENT

V-M J and B-V L conceived and designed the experiment; L-S J, T-V J and GP conducted the experiment and collected the data; B IJ performed the statistical analysis. All authors wrote and reviewed the manuscript.

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COMPETING INTEREST

The authors of the present manuscript declare no competing interests.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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