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MYOFASCIAL PAIN AND TREATMENT: Mentored Research: Randomized Controlled Trial

Effects of myofascial trigger point dry cupping on pain and function in patients with plantar heel pain: A randomized controlled trial

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ABSTRACT

Objective: To investigate the effects of dry cupping on calf muscle myofascial trigger points (MTrPs) on pain and function in patients with plantar heel pain.
Methods: Seventy-one patients were randomly divided into an intervention group or control group. Both groups performed stretching exercises for the calf muscle and plantar fascia and ankle dorsiflexion exercises. The intervention group also received dry cupping. The primary outcome measures were visual analogue scale (VAS), pressure pain threshold (PPT), and patient-specific functional scale (PSFS). The secondary outcomes were ankle dorsiflexion range of motion (ROM) and ankle plantar flexor strength. These measurements were performed at baseline, immediately after intervention, and after 2 days.
Results: Current VAS significantly decreased immediately in the intervention group ($p = 0.002$), but not in the control group ($p \geq 0.220$). Morning VAS decreased significantly in both groups ($p < 0.001$) after 2 days, but decreased more in the intervention group ($p = 0.006$). Trigger point PPT significantly improved immediately in the intervention group ($p = 0.003$), but not in the control group ($p = 0.112$). Both groups improved significantly in PSFS ($p < 0.001$) and ankle dorsiflexion ROM ($p < 0.001$). Plantar flexor strength significantly increased immediately in the intervention group ($p < 0.001$), but not in the control group ($p = 0.556$).
Conclusion: Adding dry cupping on calf MTrPs to self-stretching and ankle dorsiflexion exercises for patients with plantar heel pain was superior to only self-stretching and active ankle dorsiflexion exercises in pain, ankle dorsiflexion ROM, and plantar flexor strength.

1. Introduction

Plantar heel pain is a condition often seen by healthcare providers that refers to the pain felt at the plantar aspect of the heel near the medial calcaneal tuberosity. There are different names and definitions for this condition in the literature, such as plantar heel pain, plantar fasciitis, plantar fasciosis, plantar fasciopathy, heel spur syndrome, and jogger's heel (Ieong et al., 2013). The reason for inconsistency in defining the condition is due to disagreement on the underlying pathology (Hossain et al., 2011). Approximately 15% of athletic and non-athletic adults who have foot complaints seek professional care for plantar heel pain (Hossain et al., 2011). A number of conditions may result in plantar heel pain, namely plantar fasciitis (most common), calcaneus fracture, heel fat pad atrophy, and peripheral nerve dysfunction (Alshami et al., 2008). Recently, studies have shown that myofascial trigger points or tender points in the calf muscles may be associated with plantar heel pain (Renan-Ordine et al., 2011; Saban et al., 2013).

Treatment of plantar heel pain usually targets the plantar fascia or other structures in the plantar heel area using several interventions such as cortisone injection, therapeutic ultrasound, laser, ice, heel pads, and night splints (Crawford et al., 2001). Evidence varies regarding the effectiveness of these interventions. This led to other interventions focusing on neighboring areas, such as release of myofascial trigger points (MTrPs) in calf muscles (Ajimsha et al., 2014), acupuncture to calf and hamstring muscles (Clark et al., 2012), dry needling (Cotchett et al., 2014), and neurodynamic mobilization to peripheral nerves (Saban et al., 2013). A study showed that dry cupping can alleviate pain like acupuncture without the disadvantage of invasive treatment (Tham et al., 2006). Cupping pulls the skin onto the cup and can be divided into two

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types, namely wet cupping (with skin incision and blood) and dry cupping (without skin incision or blood) (Yoo et al., 2004). To our knowledge, no studies have investigated dry cupping in patients with plantar heel pain. Therefore, the current study aimed to investigate the effect of dry cupping on MTrPs in the calf muscle in patients with plantar heel pain.

2. Materials and methods

2.1. Study design

Single-blind randomized controlled trial.

2.2. Participants

Ethical approval from the Institutional Review Board at Imam Abdulrahman Bin Faisal University (IRB-2014-04-322) was obtained prior to conducting the study. In this study, we assumed that the correlation among the repeated measures was 0.3. To calculate the sample size, we used G*Power 3.0 (Faul et al., 2007). The following input data were used: number of groups = 2, number of measurements = 3, α error rate = 0.05, power = 0.8 (80%), effect size = 0.25. Based on this, we obtained a sample size of 71, and used the method of convenience sampling. Participants with plantar fasciitis and/or plantar heel pain, who were referred to the department of physical therapy at Qatif Central Hospital by the referring physician, were recruited into the study if they met the following inclusion criteria:

1. Adult patients
2. Unilateral plantar heel pain with sharp pain during weight-bearing after a prolonged period of non-weight-bearing, pain at the beginning of an activity that involves weight-bearing, lessening of pain with light activity, such as walking, and central or centro-medial tenderness in the plantar aspect of the heel (Crawford et al., 2001).
3. Trigger point(s) in the gastrocnemius/soleus muscle(s) with two or more of the following characteristics:
   a) Spot tenderness
   b) Presence of a taut band
   c) Patient recognition of pain
   d) Referred pain (Al-Shenqiti et al., 2005)

The participants were excluded if they had any of the following:

1. Tumor, fracture, rheumatoid arthritis, osteoporosis, or any vascular condition in the lower limbs
2. Sciatica, tarsal tunnel syndrome, or fibromyalgia
3. Previous surgery in the affected leg below the hip
4. Previous manual therapy treatment for the same condition within the past 6 months
5. History of more than three corticosteroid injections within the past year (Renan-Ordine et al., 2011)

2.3. Outcome measures

2.3.1. Primary

- ***pain intensity.*** Pain intensity was measured via a 10-cm visual analogue scale (VAS), which has good validity and reliability (Bijur et al., 2001).
- ***pressure pain threshold (PPT).*** The PPT was measured with an electronic algometer (Somedic AB, Farsta, Sweden) with a circular probe of 1 cm^2. The algometer has good reliability and validity (Kinser et al., 2009). Pressure was applied at a rate of 40 kPa/s, and participants pressed a switch when the sensation changed from pressure only to pressure and pain. At this point, the pressure stimulus was terminated, and the pressure was recorded. Three measurements at each site were performed. A 30-s rest period was given between each test. The mean of three trials was calculated for each site and was used for analysis. The PPT was measured over the trigger point in the affected leg and at the most tender point in the heel.
- ***function.*** The patient-specific functional scale (PSFS) is a clinical outcome measure that allows participant to report their own functional status. The examiner asked the participant about three important activities that they were unable to do or had difficulty doing. The participants rated their level of function on a scale starting from 0, which is the lowest functional level, to 10, which is the highest level of function (Hefford et al., 2012). The test is valid and reliable for many musculoskeletal conditions (Hefford et al., 2012).

2.3.2. Secondary

- ***ankle range of motion (ROM).*** An inclinometer (BASELINE bubble inclinometer, White Plains, New York) was used to measure the ROM of ankle dorsiflexion. The inclinometer is a valid and reliable measure for ankle dorsiflexion (Van Gheluwe et al., 2002). The participant was asked to stand in a calf-stretch position, with knee extended or knee flexed (modified lunge position). The examiner asked the participant to hold this position and placed the inclinometer over the shin of the tibia to record ROM.
- ***ankle plantar flexion strength.*** Ankle plantar flexion strength was assessed by asking the participant to perform as many single-leg heel rises as possible while standing with the knee extended at a rate of one every 2 s. The participant was allowed to place their hand on the wall to ensure balance during the procedure. This method has been shown to be reliable (Maurer et al., 2007).

2.4. Interventions

Dry cupping. Dry cupping was done for the intervention group, not for the control group. First, the therapist identified the MTrP on calf muscle. Then, the participant lay in a prone position with the ankle off the edge of the bed. Ultrasound gel was placed over the trigger point as a lubricant to increase the suctioning of the plastic vacuum cup, after which the cup was placed. Air was withdrawn from the cup to create a suction force. The cup was placed on the treated site for 5 min. Then, the participant was asked to do active ankle dorsiflexion exercise (description to follow) while the therapist held the cup in place to prevent it from losing its tension. After the ankle dorsiflexion exercise, the cup was kept in place for 3 min. Thus, the cup was maintained in position for a total of 10 min (see Fig. 1). The following exercises were done by both groups:

Active ankle dorsiflexion exercise. This exercise was performed in the prone position for three sets of 10 repetitions with 30 s of rest between sets.

Self-stretching of the calf muscles. In a standing position, with the affected foot furthest away from the wall, the participant leaned forward while keeping the heel on the floor. To focus stretching on the gastrocnemius muscle, the affected knee was kept in full extension, whereas to focus on the soleus muscle, the affected knee was bent. In this position, the patient leaned forward until feeling a stretch in the calf and/or achilles heel region (Renan-Ordine et al.,

Fig. 1. Placement of cupping on the trigger point at the calf muscle (arrow indicates the direction of foot movement during active ankle dorsiflexion).

2011). This exercise was performed for 20 s, followed by a 20-s rest, for a total of 3 min.

Self-stretching of the plantar fascia. In a seated position, the participants crossed the affected foot over the contralateral thigh. The participant placed the thumb of one hand over the origin of the plantar fascia and pressed down toward the heel, placing the fingers of the other hand over the base of the toes. The participant grasped the base of the toes and pulled the toes back toward the shin until they felt a stretch in the plantar fascia. The participant was instructed to start gently at first and then to work more aggressively as long as the pain was tolerable (Renan-Ordine et al., 2011). This exercise was performed for 20 s, followed by a 20-s rest, for a total of 3 min.

2.5. Procedure

The procedure was explained to each participant by the primary researcher, both verbally and by providing them with written details. If a person agreed to participate, they were screened for the inclusion/exclusion criteria and then asked to sign a consent form. The primary researcher performed the screening for inclusion of potential male participants and provided the treatment; whereas an experienced female therapist performed the same procedure for the female participants. The department receptionist assigned each participant to one of the study groups as they arrived consecutively according to a pre-set table. A therapist who was unaware of the group allocation was responsible for taking all the outcome measurements. The therapist (primary researcher or female therapist) who was responsible for applying the treatment covered the treated MTrP with a piece of non-elastic tape (see Fig. 2) to keep the assessor blinded to group allocation. All outcome measures were performed for both groups in three stages: 1) baseline before intervention, 2) immediately after intervention, and 3) 2 days after intervention, except PSFS and morning VAS were measured at baseline and 2 days after intervention. The intervention group (group 1) received dry cupping, active ankle dorsiflexion exercise, and stretching exercises; whereas the control group (group 2) received active ankle dorsiflexion exercise and stretching without dry cupping (Fig. 3 shows the study flow chart).

2.6. Statistical analysis

The demographic characteristics were calculated as mean and standard deviation or as frequency and percentages, based on the data type, and an independent *t*-test was used for comparison. Two-way repeated-measures analysis of variance (ANOVA) was used to analyze the differences in pain intensity, PPT, PSFS, ankle dorsiflexion ROM, and ankle plantar flexion strength, with two repeated-measure factors (GROUP with two levels, and STAGE with three levels). Bonferroni multiple comparison tests were used for post-hoc comparison, and partial eta squared for the effect size. Wilcoxon (for within-group comparison) and Mann-Whitney (for between-group comparison) tests were performed on PSFS data. The mean of the control group was used for the missing data in the intervention group (Armijo-Olivo et al., 2009). Statistical analysis was performed using IBM SPSS statistics for Windows, version 21 (SPSS Inc., Chicago IL, USA). Statistical significance was set at $p < 0.05$.

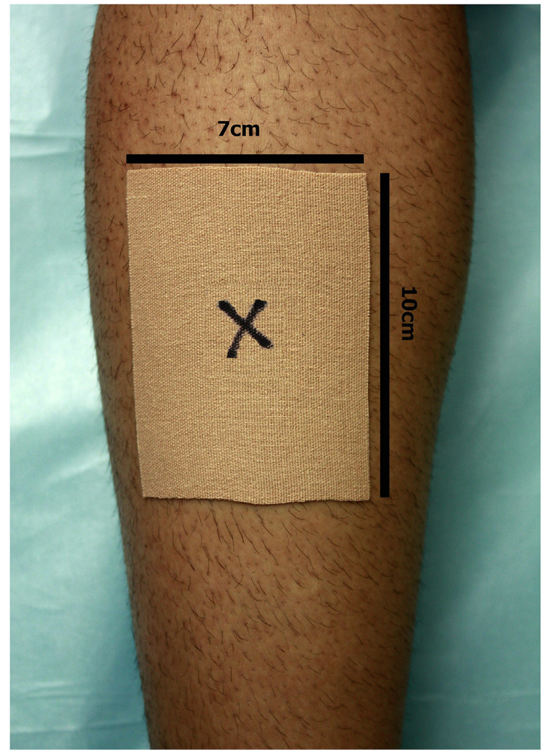

Fig. 2. A tape covering the trigger point area to keep the assessor blinded to group allocation.

3. Results

There were no significant differences in all baseline measurements between both groups (Table 1). Calf muscle MTrPs were mainly in six areas (see Fig. 4).

3.1. Current visual analogue scale (VAS)

Current pain in the intervention group decreased significantly immediately post-intervention, with a large effect (partial eta squared = 0.146), but not at 2 days post-intervention ($p = 0.242$). There was no significant difference in VAS scores in the control group at any stage ($p \geq 0.220$) (see Fig. 5A).

3.2. Morning first-steps visual analogue scale (VAS)

Morning first-steps pain decreased significantly 2 days post-

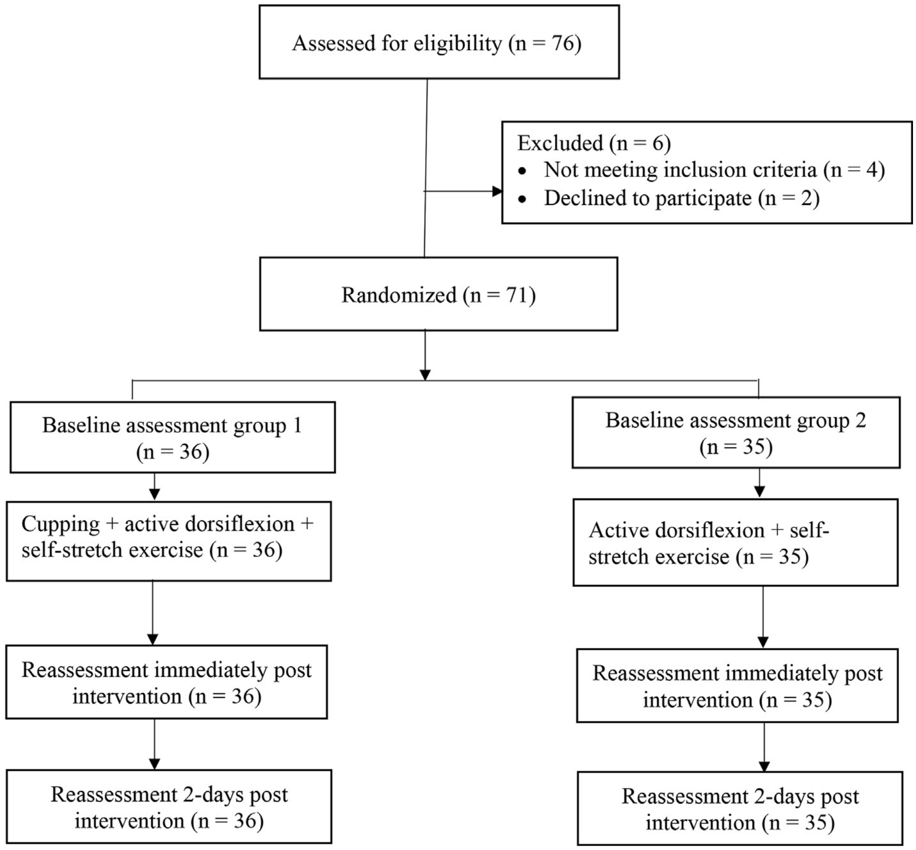

Fig. 3. Study flowchart.

Table 1
Baseline demographic characteristics for research groups.

Characteristics	Intervention group (n = 36)	Control group (n = 35)	P-value
Age in years*	41 ± 10	44 ± 10	0.959
Gender (Male/Female)	21/15	19/16	0.521
BMI*	31 ± 6	28 ± 6	0.695
Duration of symptoms (weeks)*	28 ± 47	56 ± 135	0.089
Affected side (Rt/Lt)	21/15	20/15	0.843
Current VAS*	4.1 ± 2.7	3.8 ± 2.4	0.288

* Values are presented as mean ± standard deviation.
BMI = body mass index.

intervention in both groups, but it decreased more in the intervention group compared with the control group ($p = 0.007$) (see Fig. 5B).

3.3. Pressure pain threshold (PPT)

On MTrP at the calf muscle, PPT improved significantly in the intervention group immediately after intervention ($p = 0.003$), with a large effect (partial eta squared = 0.174), but not in the control group ($p = 0.112$).There was no difference in PPT at 2 days post-intervention in either group ($p \geq 0.365$). On the most tender area at the heel, there were no significant differences in PPT values at any stage in either group ($p \geq 0.179$) (see Fig. 6).

3.4. Patient-specific functional scale (PSFS)

For a single function, PSFS improved significantly in both groups ($p < 0.001$), with no difference between the groups ($p = 0.450$). The total function also improved significantly in both the intervention group ($p < 0.001$) and the control group ($p = 0.010$) (Table 2).

3.5. Ankle dorsiflexion ROM

Ankle dorsiflexion ROM improved in both groups with knee in extension and in modified lunge position ($p < 0.001$), with a large effect (partial eta squared ≥ 0.223) immediately and 2 days after intervention (see Fig. 7). However, the increase in ROM in the intervention group was clinically significant, whereas in the control group it was not.

3.6. Ankle plantar flexion strength

Interestingly, ankle plantar flexion strength increased significantly in the intervention group immediately post-intervention

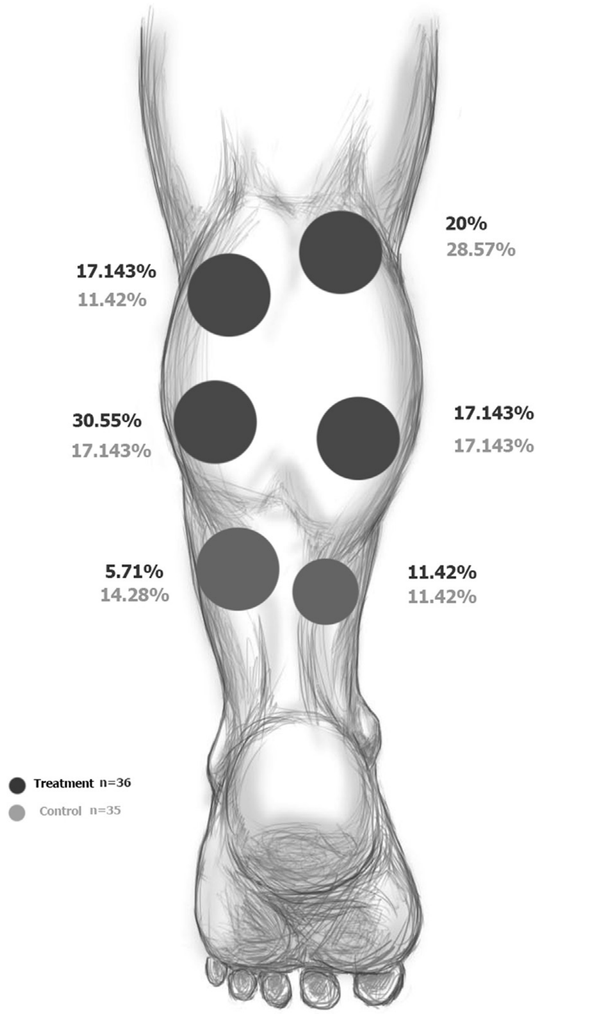

Fig. 4. Areas and percentages of trigger points at the calf muscle in both groups.

($p < 0.001$), but not in the control group ($p = 0.560$). Two days after intervention, both groups had a significant increase in strength ($p < 0.001$) (see Fig. 8).

4. Discussion

The study showed that adding MTrP decompression using dry cupping on the calf muscle to an exercise protocol resulted in immediate improvements in pain and muscle strength compared to exercises alone in patients with plantar heel pain associated with MTrP. The degree of this benefit was clinically important in some of the outcome measures as noted by high effect size.

Current pain on VAS decreased significantly immediately after intervention in the intervention group, and morning first steps pain decreased after 2 days. The PPT in the calf muscle increased immediately after intervention, but not after 2 days. However, this increase was only statistically, but not clinically, significant. Ankle dorsiflexion ROM increased significantly in both groups immediately after intervention and 2 days later. Ankle plantar flexion strength improved significantly immediately after intervention and after 2 days in intervention group, but only after 2 days in the control group.

The exact mechanism of how cupping works is not yet known (Rozenfeld et al., 2016). However, several hypotheses have been proposed to explain the effect of cupping. One theory is that

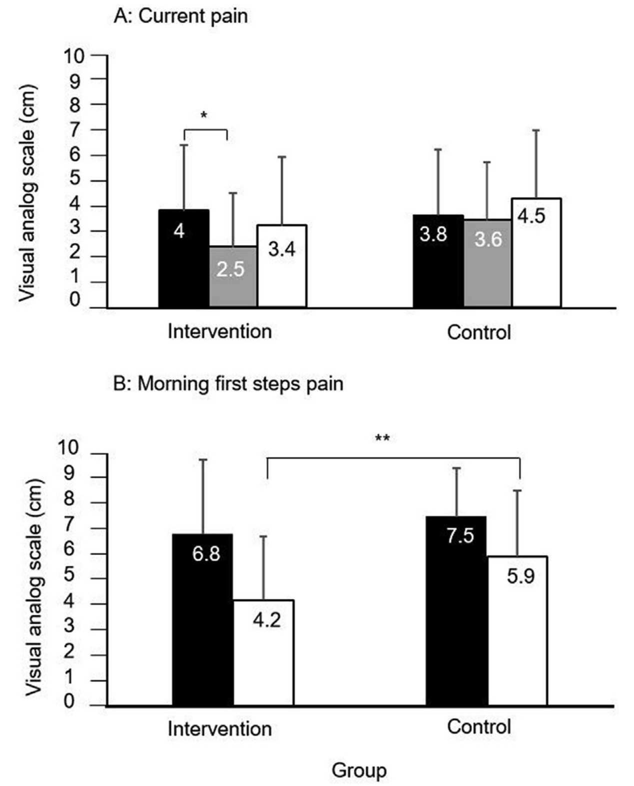

Fig. 5. Results of (A) current and (B) morning first–steps visual analog scale (VAS). Error bars denote standard deviation. * and ** indicates a p-value of ≤ 0.05. ■ Baseline, ■ Immediately after intervention, □ 2 days after intervention.

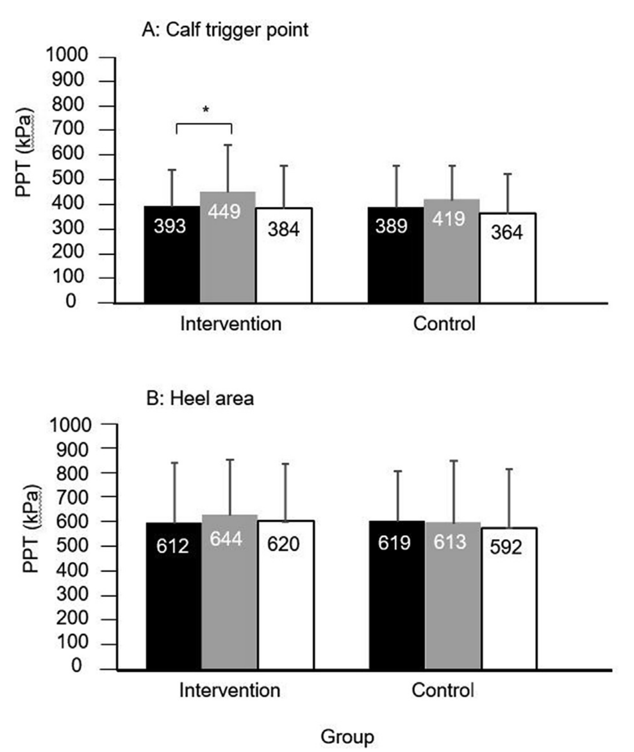

Fig. 6. Results of pressure pain threshold (PPT) on (A) the trigger point at the calf muscle and (B) most tender area on the heel. Error bars denote standard deviation. * indicates a p-value of ≤ 0.05. ■ Baseline, ■ Immediately after intervention, □ 2 days after intervention.

Table 2
Patient specific functional scale scores (mean ± SD) at baseline and 2 days later.

Group	Baseline	2 days post-intervention	Within-group P-value
Single function			
Intervention (n = 36)	4.4 ± 2	5.8 ± 3	<0.001
Control (n = 35)	4.3 ± 2	5.4 ± 2	<0.001
Between-group P-value	0.921	0.450	
Total functions			
Intervention (n = 36)	5 ± 1.6	6.2 ± 2	<0.001
Control (n = 35)	5 ± 1.7	5.7 ± 1.9	<0.001
Between-group P-value	0.655	0.422	

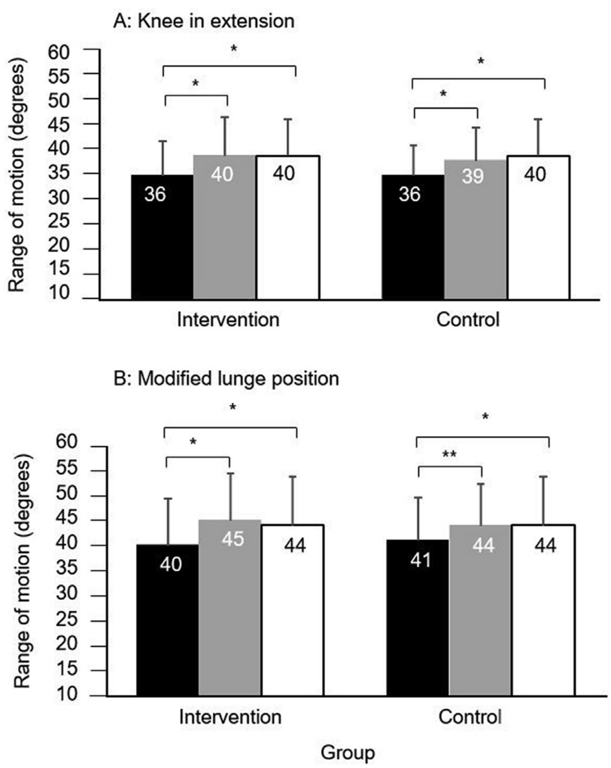

Fig. 7. Results of ankle dorsiflexion range of motion (ROM) with (A) knee in extension and in (B) modified lunge position. Error bars denote standard deviation. * and ** indicate a p-value of ≤ 0.05. ■ Baseline, ■ Immediately after intervention, □ 2 days after intervention.

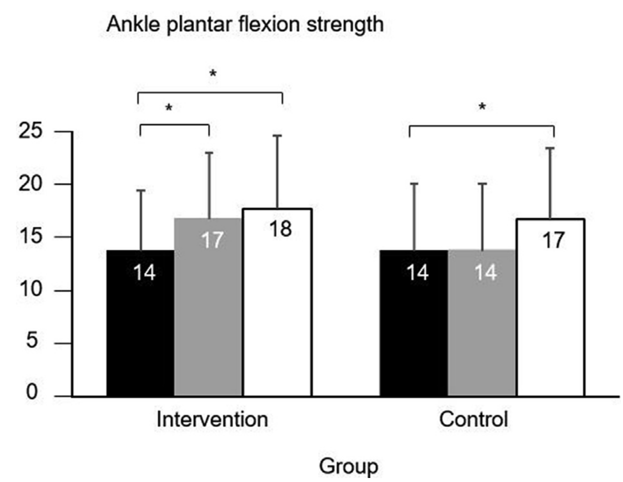

Fig. 8. Results of plantar flexion strength at the affected side. Error bars denote to standard deviation. * indicates a p-value of ≤ 0.05. ■ Baseline, ■ Immediately after intervention, □ 2 days after intervention.

cupping increases the circulation around the treated area by high stresses in the cup, causing severe dilatation of the capillaries leading to rupture and infiltration of blood to the surrounding tissues (Tham et al., 2006). Another theory suggests that cupping has a similar pain relief effect to acupuncture and acupressure (Rozenfeld et al., 2016; Tham et al., 2006). Small-diameter nerves in the muscles are stimulated, which then send impulses to the spinal cord, mid brain, and pituitary, leading to release of chemical transmitters such as endorphins to block the pain messages (Rozenfeld et al., 2016). Finally, Musial et al. (2013) hypothesized that cupping improves the performance at all neurophysiological levels (spinal cord, change of milieu, and nociceptors). Dry cupping may stimulate the inhibitory receptive fields of cortically projecting multi-receptive dorsal horn neurons or provoke diffuse inhibitory controls (Le Bars, 2002). The resultant hypoalgesia of dry cupping may be explained by changing the local cellular environment of MTrPs, where the energy crisis is resolved with increased circulation and release of contracture of the sarcomere (Gerwin et al., 2004).

Our results are consistent with the results of previous studies that showed a decrease in pain with dry cupping in patients with other pain syndromes such as neck pain (Lauche et al., 2011; Teut et al., 2012; Young et al., 2007). We found a significant decrease in plantar heel pain in morning first steps 2 days after the intervention. The decrease was clinically meaningful in the intervention group [minimal clinically important difference (MCID) = 1.9], but not in the control group. Similar findings with the myofascial release technique on the calf muscles in patients with plantar heel pain were reported in the literature (Renan-Ordine et al., 2011; Saban et al., 2013).

In the current study, PPT increased significantly in the intervention group immediately after the intervention at the affected MTrP in the calf muscle but not over the tender point in the heel. Emerich et al. (2014) found that PPT increased significantly in a group of patients with neck pain immediately after dry cupping in a distant area after dry cupping on the upper trapezius muscle; but, they did not find a difference in PPT in the cupping area. It is important to mention that the authors used cupping over the muscle, not on the MTrP, and there was no pathology in the distal area.

Our study showed that there was a significant increase in ankle dorsiflexion ROM in both the intervention and control groups. However, the increase in the control group was not clinically significant. This increase in ROM may be attributed to the release of muscle tension and increased muscle flexibility due to improved circulation and metabolic changes in the muscles (Rozenfeld et al., 2016). The myofascial release technique regained the normal length of the calf muscle and improved ankle dorsiflexion ROM in patients with limited ankle dorsiflexion (Grieve et al., 2011).

In this study, there was a significant improvement (21%) in ankle plantar flexion strength in the intervention group immediately after intervention; and, 2 days after intervention, there was a 28% improvement. This increase in strength may be due to the release of inhibited muscle by MTrPs (Mauntel et al., 2014).

This study demonstrated significant improvements in PSFS for single function and total function score in both groups. However, this improvement was not clinically significant for both (single function is 3 points, and average function is 2 points), possibly because participants only had a single treatment session, which was not enough to have a meaningful clinical effect. In addition, the assessment was performed only 2 days after intervention, which probably was not long enough.

4.1. Limitations

A limitation of this study was that there was no true sham or placebo group. The intervention group received cupping, but the control group did not. Although Lee et al. (2010) developed a sham cupping device, the validity of this device has not yet been confirmed. The authors reported that patients could still guess if they had received real cupping or not, which may affect the outcome of the intervention (Lee et al., 2010). Although multiple MTrPs were found in the calf muscles, we only used cupping over one point.

5. Conclusion

In patients with plantar heel pain, the addition of dry cupping on calf muscle MTrPs to self-stretching and active ROM exercises significantly improved current pain, PPT over calf muscle MTrP, and plantar flexion muscle strength immediately after intervention, and it also improved morning first steps pain 2 days after intervention. Furthermore, ankle dorsiflexion ROM in both knee extended and in modified lunge position increased significantly in both groups. However, the improvement in dorsiflexion ROM in the intervention group was clinically significant, whereas the improvement in the control group was not. Therefore, dry cupping on MTrPs in the calf muscle in patients with plantar heel pain could be a simple technique that could be used to decrease pain for at least 2 days. Future research is recommended to address the long-term efficacy of this technique in patients with plantar heel pain associated with calf MTrPs.

6. Clinical relevance

- Adding dry cupping on calf muscle MTrP to self-stretching and active ROM exercises decreased pain in patients with plantar heel pain.
- Dry cupping also improved ankle dorsiflexion ROM and plantar flexion muscle strength.

Conflicts of interest

The authors of this study state that they had no conflict of interest.

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