Original article

Deep massage to posterior calf muscles in combination with neural mobilization exercises as a treatment for heel pain: A pilot randomized clinical trial

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A R T I C L E   I N F O

Article history:
Received 22 September 2012
Received in revised form 12 August 2013
Accepted 22 August 2013

Keywords:
Plantar heel pain syndrome
Deep massage
Neural mobilization
Functional status

A B S T R A C T

Background: Plantar heel pain syndrome (PHPS) is a common foot disorder; however, there is limited clinical evidence on which to base treatment. Repeated clinical observations indicating heel pain during heel rise and minisquat on the affected leg, involving activation of posterior calf muscles, formed the basis of this study.

Objective: To compare deep massage therapy to posterior calf muscles and neural mobilization with a self-stretch exercise program (DMS) to a common treatment protocol of ultrasound therapy to the painful heel area with the same self-stretch exercises (USS).

Methods: Patients with PHPS were assigned to a program of 8 treatments over a period of 4–6 weeks in a single-blind randomized clinical trial. Functional status (FS) at admission and discharge from therapy as measured by the Foot & Ankle Computerized Adaptive Test was the main outcome measure.

Results: Sixty-nine patients were included in the trial (mean age 53, standard deviation (SD) 13, range 25–86, 57% women), 36 received DMS treatment and 33 with USS. The overall group-by-time interaction for the mixed-model analysis of variance (ANOVA) was found statistically significant \((p=0.034)\), with a change of (mean (confidence interval, CI)) 15 (9–21) and 6 (1–11) FS points for the DMS and USS groups, respectively.

Conclusions: Data indicated that both treatment protocols resulted in an overall short-term improvement, however, DMS treatment was significantly more effective in treating PHPS than USS treatment.

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1. Introduction

Plantar heel pain syndrome (PHPS) encompasses a broad spectrum of pathologies. Several studies have hypothesized that certain risk factors contribute to the development of this condition, insinuating that the etiology of PHPS is multifactorial (Rome et al., 2001; Irving et al., 2006; Yi et al., 2011). Approximately 10% of the general population will experience PHPS during their lifespan, accounting for 15% of all adult foot complaints requiring professional care in both athletic and nonathletic populations (Rome et al., 2001; Irving et al., 2006).

Treatment is usually conservative with a few intractable cases referred to surgery (Taunton et al., 2002; DiGiovanni et al., 2003). Though, to date, there is limited clinical evidence on which to base treatment practice for PHPS (Crawford & Thomson, 2003; McPoil et al., 2008), thus provoking the motive for further research. Increased heel pain on a single stance heel rise and single stance minisquat was observed by the authors in a large proportion of patients diagnosed with PHPS, a finding supported by Rome et al. (2001) in 53% of 36 athletic patients with this syndrome. These two movements affect the foot by unloading heel weight bearing and, theoretically, would be expected to cause a decrease in pain level. Inspection by manual palpation of plantar flexor muscles in the posterior calf, that are actively involved in these movements, detected incompliant and painful soft tissue in isolated or multiple sites on the affected leg in patients with PHPS. Identification of painful muscle tissue by manual palpation has been shown to have good inter-tester reliability (Lucas et al., 2009). Areas of painful calf muscle tissue in PHPS have been recorded (Nguyen, 2010; Renarde-Ordine et al., 2011), and are similar to myofascial trigger points (Travell and Simons, 1983).

Lack of evidence regarding effective care for patients seeking treatment for PHPS, and personal clinical observations described, led to the proposal of a treatment procedure directed to the...
posterior calf muscles. The aim of this study was to compare this approach to a more common protocol of treatment directed to the heel area. The hypothesis was that deep, soft tissue massage (Cyriax, 1984) to posterior calf muscles with neural mobilization combined with stretching exercises (DMS) would lead to increased pain relief and improved function compared to local ultrasound therapy combined with the same stretching exercise program (USS) for patients with PHPS.

2. Methods

2.1. Design and participants

This study was a parallel-group, prospective, single, blind, randomized clinical trial. Consecutive patients over the age of 18 referred by an orthopedic surgeon to an outpatient physiotherapy clinic (Maccabi Healthcare Services, Petach Tikva, Israel) for treatment of PHPS were enrolled in the study. The Consolidated Standards of Reporting Trials guidelines were utilized in the study to improve reporting standards (Moher et al., 2001).

Inclusion criteria comprised pain consistent with PHPS, operationally defined as plantar heel pain with increased pain on initial weight bearing after a period of rest, lessening with continued activity (McPoil et al., 2008). Exclusion criteria included systemic disease, tumor, fracture, prolonged history of steroid use, severe vascular disease, prior lower leg surgery, possibility of referred pain to the heel (excluding the calf muscles), or inability to comply with the treatment schedule. Eligible patients undergoing other treatments for heel pain prior to the study were requested to stop treatments one month before entering the study. Participating patients, all volunteers, signed an informed consent. This study was approved by the Institutional Review Board for the Protection of Human Subjects, Maccabi Healthcare Services, Israel (serial number 2006031).

2.2. Sample size

A sample size of 56 patients was chosen to provide 80% power to detect a difference of 10 points between treatment groups after 8 treatments. This calculation is based on using an independent t-test at a 2-sided p-level of 0.05 and assumes a previously published within-group standard deviation (SD) at admission of 13 points (Hart et al., 2005).

2.3. Therapists

One author (BS), who did not provide treatment and was not involved in the randomization, conducted physical examinations at admission and discharge. After initial examination, patients were assigned to receive treatment by one of the staff members. Fifteen physiotherapists participated in the study (mean age 36 years, SD 9 years, range 27–54 years, mean clinical experience 11 years, SD 10 years; range 1–30 years).

2.4. Randomization and interventions

Randomization was conducted after initial examination by the patients who chose a sealed opaque envelope containing either DMS or USS protocol. All patients were treated 1–2 times a week, receiving a total of 8 treatments over a 6-week period. All participating physiotherapists underwent practical training sessions on manual techniques and exercises included within each treatment protocol, including clarifications of study procedures and operational definitions, before commencement of the trial and ongoing as required.

2.4.1. Deep massage therapy

Patients lay in a prone position with their shins resting on a pillow and their feet hanging over the edge of the bed. Relevant painful areas of the muscles were identified by deeply palpating the entire muscle group (Fig. 1), a technique that has been shown to have good inter-rater reliability (k range, 0.57–1.00) (Lucas et al., 2009). Deep massage therapy consisted of 10 min of forceful soft tissue massage mobilization techniques, described by Cyriax (1984), directed to the incompressible and painful areas of the posterior calf muscle group. The technique was applied across the muscle fibers both medially and laterally, with sufficient sweep and depth (Cyriax, 1984) until obtaining a pain response to the pressure.
The therapist could choose to work with thumbs or another other body parts, i.e. elbow (Fig. 2), to enable sufficient force to reach deeper muscle areas.

2.4.2. Ultrasound therapy

No evidence has been found as to the use of therapeutic ultrasound (Crawford and Thomson, 2003; McPoil et al., 2008) for reducing pain in individuals with PHPS. Yet, therapeutic ultrasound continues to be a commonly used intervention (Crawford and Snaithe, 1996; Deutscher, 2002; Cleland et al., 2009). Reviews of therapeutic ultrasound have failed to identify a dose-response relationship, though intensities from 0.5 W/cm² to 3 W/cm² have been advocated (van der Windt et al., 1999; Robertson and Baker, 2001).

Ultrasound parameters matched customary procedures used in the clinic, a frequency of 1 MHz and intensity of 1.0 W/cm², continuous dose. Ultrasound, at each session, was applied to the painful area of the heel for 3 min (Watson, 2000) using Enraf Nonius Sonoplus 492, ENRAF, Netherlands (coupling gel: Aquasonic, USA). Slow circular movements were applied over the painful area of the heel using a transducer head of 5 cm².

2.4.3. Stretching exercise protocol

Several studies have demonstrated that calf muscle stretching is effective in management of PHPS at short- and long-term follow-ups (Porter et al., 2002; Cleland et al., 2009). All patients were instructed in self-stretching techniques directed at the posterior calf muscles 3 times per day with 5 repetitions for each stretch, using intermittent stretching of 20 s followed by 10 s of rest (Young et al., 2001; Porter et al., 2002). Self-stretching of the calf muscles was performed in a standing position, the affected foot furthest away from the wall and both feet positioned on a line. To focus stretch on the gastrocnemius muscle the knee on the affected side was kept in full extension (Fig. 3a), whereas to focus stretch on the soleus muscle the knee on the affected side was bent (Fig. 3b). While holding these positions, patients leaned forward keeping the heels on the floor until a stretch in the calf and/or the Achilles tendon region was felt. In addition to verbal instruction, all subjects received an illustrated instruction sheet with details of the required daily program.

2.4.4. Neural mobilization

The DMS group was instructed to perform one additional exercise, a passive straight leg raise combined with dorsiflexion using a long belt (SLR&DF) (Fig. 4), with the same regime as for calf stretches. The proposed rationale for this exercise was to increase stretch on neural structures (Butler, 2000; Meyer et al., 2002).

2.5. Measures

2.5.1. Demographic information

Information was collected at initial examination using a standardized questionnaire tailored-made for this study. Data included...
age, gender, body mass index, duration of symptoms in weeks, work activity, sports participation and previous treatments for PHPS.

2.5.2. Outcome measures

Functional status (FS) outcomes were quantified using the Foot & Ankle Computerized Adaptive Test (CAT) (Hart et al., 2005) and defined as the main outcome measure. Development, simulation and use of the CAT have been previously described (Hart et al., 2005; Deutscher et al., 2008), as well as validity, sensitivity to change and responsiveness as assessed by utilizing minimal detectable change and minimal clinical important change (MCIC) (Hart et al., 2008a). The Foot & Ankle CAT was developed as a body part specific CAT (Milsap and Everson, 1993; Hart et al., 2005), and represents the item response theory conceptualization of the Lower Extremity Functional Scale (LEFS) (Binkley et al., 1999). FS scores ranged from 0 (low) to 100 (high functioning), with a MCIC of 8 points determined by Wang et al. (2009). Before implementing the Foot & Ankle CAT into Maccabi Health Services clinics, items were translated from the original English version into Hebrew, Russian and Arabic following published procedures (Lewin-Epstein et al., 1998; Hart et al., 2009). The knee CAT (Hart et al., 2008b, 2009) Hebrew and Russian translations, using the same items from the LEFS as the Foot & Ankle CAT was found valid with negligible differential item functioning (Hart et al., 2009; Deutscher et al., 2010) and strong known groups construct validity (Deutscher et al., 2011). A customized version of Patient Inquiry software developed by FOTO, Inc. has been fully integrated into Maccabi’s electronic health record system (Swinkels et al., 2007; Deutscher et al., 2008).

Description of pain felt on taking first steps in the morning was assessed with a 10 cm visual analog scale (VAS) used as a secondary outcome measure. The VAS has been previously described (Woodforde and Merskey, 1972) and found to be reliable (Ferraz et al., 1999; Hawker et al., 2011) and valid (Downie et al., 1978; Price et al., 1983; Hawker et al., 2011) for measuring pain. A MCIC of 1.4 cm has been determined for a 10 cm pain VAS in patients with rotator cuff disease evaluated after 6 weeks of non-operative treatment (Tashjian et al., 2009).

2.6. Statistical analysis

Patient demographic characteristics and outcome measures at baseline were compared between the two treatment groups to estimate quality of randomization. Frequency distributions were used to describe categorical data and means and standard deviations to describe continuous data. The Kolmogorov–Smirnov test was used to determine a normal distribution of continuous FS and VAS outcome variables ($p > 0.05$). Student’s $t$-test was used for comparisons of normally distributed continuous variables; Mann–Whitney test for abnormally distributed data and $\chi^2$ test for categorical variables. These tests were reapplied to compare patients who had completed the treatment sessions to those who had not.

All subjects were analyzed according to the intention-to-treat principle, with imputation of data by the last outcome carried forward. A multivariate mixed-model analysis of variance (ANOVA) was used with time (pre-intervention, post-intervention) as a within-subject variable and group (DMS, USS) as a between-subject variable, to examine effects of interventions on FS and VAS. If the interaction of time and treatment was found significant, it was followed by paired Student’s $t$-test for outcome measures performed using baseline and discharge scores. Independent $t$-test was performed for comparison of outcome measures between groups before, and after intervention. All statistical tests were two-sided, $p < 0.05$ was considered statistically significant. Change scores were expressed as means and confidence intervals (CIs). The change in score within each group and between groups was compared to the MCIC. Data were analyzed using the SPSS version 15.

### 3. Results

Sixty-nine volunteer patients who fulfilled the eligibility criteria and agreed to participate were recruited between September 2006 and March 2009 (mean age 53, SD 13, range 25–86, 57% women). Participating patients were randomized into DMS ($n = 36$) and USS ($n = 33$) groups. An additional 3 patients who had been assigned to the USS group were excluded by the ethics committee after randomization due to invalid consent forms (missing signatures). Comparisons of patient demographic and clinical characteristics at randomization showed no significant differences ($p > 0.05$). All participating physiotherapists treated patients from both the DMS and USS groups, with the same average number of patients per therapist in each treatment group ($3 \text{ patients (SD} 2, \text{ range } 1–7)$).

Fifty-one patients completed the treatment program and assessment at discharge, indicating a 74% completion rate, operationally defined as the percentage of episodes with FS intake data and FS discharge data (Deutscher et al., 2009) (Fig. 5). Completion rates for the DMS and USS groups were similar (72% and 76%, respectively, $p = 0.738$). Characteristics of dropouts in each group were similar to those patients who remained in the trial (Table 2). One patient in each group reported adverse reaction to treatment.

The group-by-time interaction for the mixed-model ANOVA was statistically significant for change score of the main outcome measure (FS) ($p = 0.034$, Table 3), which indicated a difference in treatment effects. This remained significant after controlling for age, gender, body mass index (BMI) and chronicity ($p = 0.025$). The DMS group achieved a mean change of 15 points (CI 95% 9–

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>DMS $n = 36$</th>
<th>USS $n = 33$</th>
<th>$p$-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54 ± 12 (32–81)</td>
<td>52 ± 13 (25–87)</td>
<td>0.57$^*$</td>
</tr>
<tr>
<td>Female (% (N))</td>
<td>47 (17)</td>
<td>67 (22)</td>
<td>0.10$^*$</td>
</tr>
<tr>
<td>BMI</td>
<td>30 ± 5 (23–44)</td>
<td>30 ± 6 (20–42)</td>
<td>0.98$^*$</td>
</tr>
<tr>
<td>Duration of pain at admission (weeks)</td>
<td>19 ± 19 (4–78)</td>
<td>25 ± 21 (2–78)</td>
<td>0.23$^*$</td>
</tr>
<tr>
<td>Work condition – standing most of the day (% (N))</td>
<td>17 (6)</td>
<td>21 (7)</td>
<td>0.63$^*$</td>
</tr>
<tr>
<td>No previous sports activity (% (N))</td>
<td>67 (24)</td>
<td>67 (22)</td>
<td>1.00$^*$</td>
</tr>
<tr>
<td>Previous treatments (% (N))</td>
<td>75 (27)</td>
<td>73 (24)</td>
<td>0.83$^*$</td>
</tr>
<tr>
<td>FS</td>
<td>47 ± 13 (29–77)</td>
<td>50 ± 13 (23–80)</td>
<td>0.38$^*$</td>
</tr>
<tr>
<td>Pain during 1st morning steps (VAS)</td>
<td>7.8 ± 3.0 (0–10)</td>
<td>7.0 ± 2.7 (0–10)</td>
<td>0.71$^*$</td>
</tr>
</tbody>
</table>

Data presented as mean ± standard deviation (SD) and (range) unless stated. DMS – deep massage to calf muscles and self-stretch exercise treatment group, USS – ultrasound therapy and self-stretch exercise treatment group; BMI – body mass index; Work condition – standing most of the day – the patient described standing as the main activity during the day; No previous sports activity – no participation in sporting activities; Previous treatment – patient reported having treatments of medication, insole or night splint; FS – functional status; VAS – 10 cm visual analog scale.

$^*$ t-Test. $^b$ $\chi^2$ test.

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1 Focus On Therapeutic Outcomes, Inc, P Box 11444, Knoxville, TN 37919.
21), whilst the USS treatment group achieved a mean change of 6 FS points (CI 95% 1–11). Change in FS score within both groups over time was statistically significant (DMS \( p < 0.001 \), USS \( p = 0.025 \)).

Decrease in pain level with first morning steps was significant for all participants after interventions (DMS \( p < 0.001 \), USS \( p < 0.001 \)), although the results were similar between groups \( (p = 0.921) \) (Table 4). The DMS group achieved a mean change

![CONSORT flow diagram for patient participation.](image)

### Table 2
Comparison of baseline patient characteristics by treatment adherence for each treatment group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>DMS Complete, ( n = 26 )</th>
<th>Incomplete, ( n = 10 )</th>
<th>( p )-Value</th>
<th>USS Complete, ( n = 25 )</th>
<th>Incomplete, ( n = 8 )</th>
<th>( p )-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53 ± 11 (32–81)</td>
<td>56 ± 14 (32–78)</td>
<td>0.52( ^* )</td>
<td>51 ± 15 (25–86)</td>
<td>55 ± 8 (37–63)</td>
<td>0.47( ^* )</td>
</tr>
<tr>
<td>Female (% ( N ))</td>
<td>46 (12)</td>
<td>50 (5)</td>
<td>0.74( ^* )</td>
<td>76 (19)</td>
<td>38 (3)</td>
<td>0.06( ^* )</td>
</tr>
<tr>
<td>BMI</td>
<td>29 ± 4 (23–42)</td>
<td>32 ± 6 (26–44)</td>
<td>0.08( ^* )</td>
<td>30 ± 6 (20–42)</td>
<td>30 ± 5 (24–39)</td>
<td>0.8( ^* )</td>
</tr>
<tr>
<td>Duration of pain at admission (weeks)</td>
<td>15 ± 11 (4–52)</td>
<td>30 ± 27 (6–78)</td>
<td>0.17</td>
<td>24 ± 22 (2–78)</td>
<td>26 ± 18 (4–52)</td>
<td>0.86</td>
</tr>
<tr>
<td>Work condition—standing most of the day (% ( N ))</td>
<td>15 (4)</td>
<td>20 (2)</td>
<td>-0.01( ^* )</td>
<td>24 (4)</td>
<td>13 (1)</td>
<td>-0.01( ^* )</td>
</tr>
<tr>
<td>No previous sports activity (% ( N ))</td>
<td>62 (16)</td>
<td>80 (8)</td>
<td>0.05( ^* )</td>
<td>64 (16)</td>
<td>75 (6)</td>
<td>0.06( ^* )</td>
</tr>
<tr>
<td>Previous treatments (% ( N ))</td>
<td>73 (19)</td>
<td>80 (8)</td>
<td>1.00( ^* )</td>
<td>76 (19)</td>
<td>63 (5)</td>
<td>0.65( ^* )</td>
</tr>
<tr>
<td>FS</td>
<td>46 ± 12 (29–72)</td>
<td>52 ± 15 (30–77)</td>
<td>0.18( ^* )</td>
<td>51 ± 13 (23–80)</td>
<td>46 ± 12 (26–59)</td>
<td>0.34( ^* )</td>
</tr>
<tr>
<td>Pain during 1st morning steps (VAS)</td>
<td>7 ± 3 (0–10)</td>
<td>6 ± 4 (0–10)</td>
<td>0.34</td>
<td>7 ± 3 (0–10)</td>
<td>7 ± 3 (0–10)</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Data presented as mean ± standard deviation (SD) and (range) unless stated.

DMS — deep massage to calf muscles and self-stretch exercise treatment group; USS — ultrasound therapy and self-stretch exercise treatment group; BMI — body mass index; Work condition — standing most of the day — the patient described standing as the main activity during the day; No previous sports activity — no participation in sporting activities; Previous treatment — patient reported having treatments of medication, insole or night splint; FS — functional status; VAS — 10 cm visual analog scale.

\( ^* \) \( p < 0.05 \); \( ^{**} \) \( p < 0.01 \).

\( ^a \) \( t \)-Test.

\( ^b \) \( \chi^2 \) test.

\( ^c \) Mann–Whitney test.

Please cite this article in press as: Saban B, et al., Deep massage to posterior calf muscles in combination with neural mobilization exercises as a treatment for heel pain: A pilot randomized clinical trial, Manual Therapy (2013), http://dx.doi.org/10.1016/j.math.2013.08.001
of −2.4 cm on the VAS scale (CI 95% −1.4 to −3.4), and the USS group achieved −2.5 cm (CI 95% −1.4 to −3.8).

4. Discussion

The basic premise for introducing deep massage treatment to the calf was that contraction of the ankle plantar flexor muscle group generated heel pain. The DMS treatment targeted to calf muscles demonstrated a greater improvement in functional abilities compared to ultrasound treatment directed to the heel pain area. The USS group achieved a statistically significant change in the FS score of 6 points at the end of treatment; however, this was not clinically significant as it did not reach the MCIC of 8 points. Whereas the change in the FS score of 15 points in the DMS treatment group was significant both statistically and clinically. The difference of 9 points (CI 95% 0.7–16) between the 2 groups also surpassed the MCIC, although the lower bound estimate of this value did not. All participants achieved a significant improvement, statistically and clinically, in their pain level with first morning steps, and results were similar in both groups (p = 0.921).

The FS score displayed more variance between the two treatment protocols than the pain VAS. This result could indicate that morning pain level reflects only one aspect of patients’ symptoms, not necessarily representative of perceived functional abilities, while the FS scale is more sensitive to various physical functions that present a wider range of the patient’s ability as a result of PHPS.

Renan-Ordine et al. (2011) conducted a study using a similar protocol and showed that treatment which included manual trigger point therapy applied to calf muscles with self-stretching exercises, resulted in a greater decrease of pain and greater improvement of physical function, compared to stretching exercises alone. Trigger point therapy techniques for PHPS were also suggested in a case study by Nguyen (2010), recommending treatment to muscles of the entire lower limb. These results support the finding that a soft tissue massage mobilization treatment to calf muscles with a self-stretching protocol is effective in improving function and decreasing pain in patients with PHPS.

Some positive changes were expected in both treatment groups based on results of previous studies including calf stretching exercises (Young et al., 2001; Porter et al., 2002). The exact mechanism of stretching efficacy in the management of PHPS is unclear as muscles of the posterior calf are attached to the posterior calcaneus, and therefore not directly connected to the plantar heel area.

The fascia, connecting the calf to the heel area and foot, was theorized to be released of strain during the clinical tests of heel rise and squat thus not considered as a possible source of PHPS. In addition, there is no consensus as to the possibility that stress on fascia is a cause of increased pain perception (Herrington et al., 2008).

It has been suggested that PHPS could originate from a dysfunction of the tibial, plantar or calcaneal nerves (Jolly et al., 2005; Alshami et al., 2008). The tibial nerve travels down the posterior calf in-between the superficial and deep muscle groups. It passes posterior to the medial malleolus and, after dividing into medial and lateral branches, enters the foot area deep to the abductor hallucis muscle at the medial process of the calcaneal tuberosity (Warwick and Williams, 1973). These nerves supply the skin of the heel and medial side of the sole of the foot. Rose et al. (2003) recorded an abnormal sensitivity in both medial calcaneal and medial planar nerves in 72% of patients with PHPS, thus suggesting a proximal neural origin. This lead the authors to include the SLR&DF exercise in the DMS group in order to promote mobility of these neural structures (Butler, 2000; Meyer et al., 2002).

Significant differences in patient characteristics between groups at baseline were not found indicating a successful randomization process. In addition, etiological factors associated with PHPS (Rome et al., 2001; Riddle et al., 2003) were evenly distributed between groups (Table 1).

This study had several limitations. All patients performed the exercises during their treatment sessions; however there was no record of daily self-exercise compliance, thus limiting our ability to fully assess the impact on results. Furthermore, the DMS group performed one additional exercise (SLR with DF), therefore introducing another variable into the trial. The massage techniques used in this trial have not previously been assessed for reliability. The results are appropriate only for the specific ultrasound parameters used in this study. There could be some difference in the attention allotted to patients between the groups, but it is difficult to gauge this impact, as the treatments were also different in nature i.e. painful massage for 10 min compared to non-painful ultrasound for 3 min. Missing data can bias the results, although dropout rates were similar between groups (p = 0.738), and similar to previous reports (Deutsch et al., 2009; Wang et al., 2009; Bezalel et al., 2010) and results supported no patient selection or participation bias (Table 2). There was no true control group and the sample was relatively small, thus this research is considered a pilot study. Additionally, there was no follow up of patients, thus limiting our ability to assess long-term results of these two treatment protocols.

5. Conclusion

This study supports the use of a treatment protocol that is easily implemented and is effective in individuals with PHPS. Deep
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The authors thank Mrs. Phyllis Curchack Kornspan for her editorial services.

Acknowledgments

The authors are grateful to the management and staff of the Physiotherapy Clinic, Maccabi Health Services, Petach Tikva, Israel. A special dedication to Dr. Dennis L Hart (deceased), PT, PhD, for his support of this project and for providing practical functional status measurement tools.


