The effectiveness of combined prescription of ankle–foot orthosis and stretching program for the treatment of recalcitrant plantar fasciitis

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Introduction

Plantar fasciitis frequently responds to a wide range of conservative treatment modalities with various degrees of success [1,2]. However, despite adequate treatment for 6 months, 10–20% of patients will experience persistent symptoms and may require surgery [3–5]. There is no surgical treatment of chronic plantar fasciitis that is without complications [6,7]. Therefore, a continued search for an effective conservative treatment for plantar fasciitis exists.

Tightness of the plantar flexors limiting ankle dorsiflexion is an important etiological factor for the development of plantar fasciitis [8–10]. Furthermore, nocturnal tightness of the plantar flexors and fascia contributes to more stress of the plantar fascia and the persistence of symptoms [11]. This cycle of tissue tightness and plantar fasciitis should be interrupted as soon as possible by stretching of the plantar flexors and plantar fascia [12].

Stretching of the tight structures can be done by stretching exercises [13,14] and night ankle–foot orthosis [11]. This orthosis is designed to provide stretch of the plantar flexors and fascia and to prevent overnight tissue tightness [15,16]. However, treatment of plantar fasciitis with stretching exercises...
or night ankle–foot orthosis has received mixed results [1,17–19].

No single treatment is guaranteed to alleviate pain in plantar fasciitis [20,21], and many authors agree that successful treatment requires a combination of treatment modalities [14,22,23]. This has led to the hypothesis that combining the use of night ankle–foot orthosis and stretching exercises of the plantar flexors and fascia would be more effective in the treatment of plantar fasciitis than either treatment alone; therefore, the aim of this study is to evaluate the effects of individually prescribed night ankle–foot orthosis, stretching exercises, and a combined prescription of them on chronic plantar fasciitis.

Patients and methods
This study is a prospective randomized case–control study. Seventy-five patients with unilateral recalcitrant plantar fasciitis [24] were recruited from those who attended the outpatient clinic. There were 24 female and 51 male patients, ranging in age from 33 to 61 years. The inclusion criteria were heel pain for at least 6 months and those with at least three other types of treatments without relief. They were visiting our institution from February 2012 to May 2014.

Exclusion criteria
The exclusion criteria were other rheumatic disorders, heel pain of neural or vascular origin, trauma, infection, tumors, and deformities in and around the ankle joint and foot.

All the benefits and discomfort involved in this study and duration of the study were explained to the participants, and all participants provided written informed consent for participation in the study.

The participants were randomized to one of the three treatment groups, by drawing a folded paper with the corresponding group number from a sealed box. Twenty-five patients were present in each group. Group I was treated with stretching exercises of the plantar flexors and plantar fascia. The gastrocnemius muscle was stretched with the knee extended. The soleus muscle was stretched with the knee flexed, and a stretch was applied to the toe flexors to stretch the plantar fascia [25]. Each one was stretched for 15 min every other day. Group II was treated using night-stretch ankle–foot orthosis. It was made of polypropylene and was applied to the lower leg and foot with Velcro straps; it was designed to maximize patient compliance by gradual stretch until the footplate provided 5° of ankle dorsiflexion and 20° of extension of the metatarsophalangeal joints. Each patient was instructed regarding proper application of the orthosis and to wear it only while sleeping for 6–8 h. Group III received the same stretching exercises as in group I in combination with night-stretch ankle–foot orthosis as in group II. These treatments were continued in all patients for a 2-month period.

Assessment
The participants were assessed at baseline (before treatment) and 2 months after completion of treatment. All participants’ demographic information, previous treatment history, and plain radiograph of the foot and ankle were obtained during the initial visit. Five outcomes were measured before and after treatment.

1. The heel pain score was defined as two 10-cm VAS scores: heel pain when taking the first steps in the morning and heel pain while doing daily activities [26].
2. Maryland Foot Score: from 5 to 100 [27].
3. The American Orthopedic Foot and Ankle Society scale: from 0 to 100 [28].
4. The Mayo Clinical Scoring system: from 0 to 100 [29].
5. Goniometric measurement of passive ankle dorsiflexion and plantar flexion [30].

Statistical analysis
Statistical tests were conducted using SPSS (version 10; SPSS Inc., Chicago, Illinois, USA), with a significant level at $P$ value less than 0.05. The results are expressed as mean±SD and range. Analysis of variance measures combined with post-hoc test were used to check comparability of the baseline characteristics of the three groups. $t$-Test was used to detect the degree of improvement after treatment.

Results
Table 1 summarizes the baseline characteristics of the individuals at the start of treatment. The analysis of the baseline measures revealed no significant differences between the three groups.

Two patients in group II (night ankle–foot orthosis) were unable to wear the orthosis because of discomfort and inability to sleep with the orthosis. Three participants in group I (stretching exercises) and two participants in both groups II and III (combined group) dropped out without providing any reasons.
At the end of treatment, the number of participants assessed was 22 in group I, 21 in group II, and 23 in group III.

Patients receiving the combination of stretching exercises and night ankle–foot orthosis (group III) experienced greater reduction in morning and activity pain \((P<0.01)\), greater improvement in assessment scores \((P<0.001)\), and more improvement of ankle dorsiflexion range of motion as compared with those receiving night ankle–foot orthosis only (group II) \((P<0.05)\) (Table 2). Patients receiving stretching exercises (group I) provided no statistically significant benefit in pain, assessment scores, and ankle dorsiflexion range of motion. In addition, no significant differences were observed in the ankle plantar flexion after treatment in the three groups (Table 2).

### Discussion

The relationship between tightness of the plantar flexors and plantar fasciitis has previously been well documented in the literature. Patel and DiGiovanni et al. [8] observed limited ankle dorsiflexion in most of the individuals with plantar fasciitis. They found that 80% of 254 patients with plantar fasciitis had limited ankle dorsiflexion and contracture of the plantar flexors. Bolívar et al. [9] concluded that tightness of the plantar flexors plays an important role in the development of plantar fasciitis.

During the hours of sleep, in supine or prone position, the ankle assumes a plantar flexed position, which leads to tightness of the plantar flexors and fascia. During activity, these abnormalities overstretch the plantar fascia during walking and cause microtears, inflammation, degeneration, and fibrosis of the plantar fascia [11,31]. Therefore, stretching of the tight structures is particularly important in the treatment of plantar fasciitis.

The results of this study demonstrated that night ankle–foot orthosis combined with stretching exercises resulted in a significantly greater improvement compared with either prescription of ankle–foot orthosis or stretching exercises alone. This might be because stretching with night ankle–foot orthosis and exercise program complement each other. The initial goals of stretching exercises should be to improve flexibility of the plantar flexors and fascia, eventually leading to return to normal function; in addition, during sleep the ankle–foot orthosis is used to hold the ankle joint in slight dorsiflexion. This stretches the plantar flexors and fascia, decreases their tightness, and maintains their anatomical length with the stretching program [6,16]. This relieves the stress put on the plantar fascia by either tightness of the plantar flexors or the plantar fascia itself being tight, as both the Achilles tendon and plantar fascia insert into the calcaneus [10]. The significant difference between the two stretching protocols was for the group of

### Table 1 Baseline characteristics of trial participants

| Characteristics          | Group I       | Group II      | Group III     |
|--------------------------|---------------|---------------|---------------|
| N                        | 25            | 25            | 25            |
| Age [mean (range)] (years)| 43.6 (35–61) | 44.7 (36–58) | 45.1 (33–60) |
| Sex (female/male)        | 17/8          | 18/7          | 16/9          |
| BMI                      | 27.3 (25–30)  | 26.9 (26–31)  | 27.2 (26–39)  |
| Disease duration [mean (range)] (months) | 6–13 (7.9) | 6–11 (7.4) | 7–12 (8.1) |
| Plantar spur [N (%)]     | 14 (56)       | 12 (48)       | 13 (52)       |
| Affected heel (right/left)| 12/13         | 14/11         | 13/12         |
| Previous treatments [N (%)] |              |               |               |
| NSAIDs                   | 25 (100)      | 25 (100)      | 25 (100)      |
| Corticosteroid injection | 17 (68)       | 15 (60)       | 18 (72)       |
| Foot orthosis            | 24 (96)       | 22 (83)       | 20 (80)       |
| Physiotherapy            | 19 (76)       | 20 (80)       | 18 (72)       |
| Pain [mean (range)]      |               |               |               |
| Morning                  | 6.1 (5–8)     | 5.8 (5–8)     | 5.9 (6–8)     |
| Activity                 | 5.9 (4–8)     | 5.6 (5–8)     | 5.8 (5–8)     |
| MFS [mean (range)]       | 55.1 (35–61)  | 52.7 (32–63)  | 54.5 (36–66)  |
| AOFAS [mean (range)]     | 57.7 (39–63)  | 54.3 (40–65)  | 58.1 (41–56)  |
| MCS [mean (range)]       | 48.9 (31–60)  | 47.6 (34–64)  | 49.3 (33–62)  |
| ADF [mean (range)] (deg.)| 7.3 (0–12)    | 7.1 (0–10)    | 6.9 (0–9)     |
| APF [mean (range)] (deg.)| 36.3 (32–40)  | 35.6 (30–42)  | 37.2 (33–41)  |

ADF, measurement of ankle dorsiflexion; AOFAS, American Orthopedic Foot and Ankle Society scale; APF, measurement of ankle plantar flexion; MCS, Mayo Clinical Scoring system; MFS, Maryland Foot Score.
ankle–foot orthosis that used long-duration continuous stretching. It is hypothesized that plastic deformation state of prolonged duration of passive stretching is successful in permanent elongation of connective tissues [32].

The purpose of stretching is to decrease stress on the tightened plantar flexors and fascia and to restore the normal range of motion of the ankle joint. The rationale is that when stretching is applied to a tight tissue the tissue responds through either the plastic (permanent lengthened state) or the elastic (temporary lengthened state) changes. To effectively treat the tightened tissues, the goal of the stretching program is to reach the plastic deformation state by ankle–foot orthosis [33,34]. Ankle–foot orthoses maintain the ankle joint at end–range stretching for a long time overnight, with permanent elongation of the connective tissue [32]. Stretching is associated with a decrease in viscoelastic properties of the muscle–tendon unit [35], a decrease in muscle–tendon stiffness [36], and an increase in muscle extensibility and joint flexibility [37].

The stretching exercise program group showed insignificant improvement in comparison with the combined or night ankle–foot orthosis groups. Stretching may be ineffective because of patients not stretching correctly, not stretching consistently, and not stretching long enough. The 1-hour-long appointment each week limits the total time that can be dedicated to stretching exercises. Night ankle–foot orthosis was beneficial because it delivered an additional stretch from 40 to 60 h/week while sleeping.

The results of this study regarding the individuals in the night ankle–foot orthosis group are consistent with the outcomes of previous studies, in which a high percentage of patients using night ankle–foot orthosis had improvements of their plantar fasciitis. Batt et al. [38] found that the use of ankle–foot orthosis is highly effective at the 12th week in 53 feet with plantar fasciitis. Gill and Kiebzak [39] conducted a retrospective study of 411 patients to assess results of nonoperative treatment for plantar fasciitis. They stated that a short leg walking cast was rated as the most effective treatment for plantar fasciitis. Powell et al. [40] reported that the use of ankle–foot orthosis for chronic plantar fasciitis, without the use of any other treatment, resulted in marked improvement for 27–37 patients with chronic plantar fasciitis. Barry et al. [33] reported a highly significant improvement in 89 patients with plantar fasciitis. Berlet et al. [41] obtained 75% recovery at 1 month of treatment. Lai et al. [42] confirmed the efficacy of splint in contracture reduction and its value in maintenance of gains in range of motion. Sharma and Loudon [43] showed that stretching with ankle–foot orthosis is effective at treating the pain and functional limitations associated with plantar fasciitis. Their data suggest that ankle–foot orthosis can be an alternative effective option for those individuals who may not perform self-stretching for plantar flexors and plantar fascia. Sheridan et al. [32] showed a 48% reduction in symptoms in the individuals treated with ankle–foot orthosis. This modality has been shown to be effective in lengthening connective tissues.

| Table 2 Mean±SD outcome measurements before and after treatment |
|---------------------------------|-----------------|-----------------|-----------------|
| Measurement                      | Group I         | Group II        | Group III       |
| Before (n=25)                    | 25              | 25              | 25              |
| After (n=22)                     | 22              | 21              | 20              |
| Morning pain                     |                 |                 |                 |
| Before (n=25)                    | 5.1±1.59        | 5.8±1.53        | 5.9±1.49        |
| After (n=22)                     | 5.1±1.59        | 4.9±1.45        | 3.8±1.51        |
| t                               | 1.713           | 2.083           | 4.861           |
| P                               | 0.094           | 0.043           | 0.0001          |
| Activity pain                   |                 |                 |                 |
| Before (n=25)                    | 5.9±1.62        | 5.8±1.53        | 5.9±1.49        |
| After (n=22)                     | 5.9±1.62        | 4.9±1.45        | 3.8±1.51        |
| t                               | 1.713           | 2.083           | 4.861           |
| P                               | 0.094           | 0.043           | 0.0001          |
| MCS                             |                 |                 |                 |
| Before (n=25)                    | 55.1±11.14      | 52.7±10.91      | 54.6±10.21      |
| After (n=22)                     | 60.9±10.12      | 57.3±9.85       | 66.0±9.71       |
| t                               | 1.875           | 2.047           | 3.965           |
| P                               | 0.067           | 0.047           | 0.0003          |
| AOFAS                           |                 |                 |                 |
| Before (n=25)                    | 57.7±10.25      | 54.3±11.21      | 58.1±10.95      |
| After (n=22)                     | 63.6±11.11      | 61.1±10.92      | 70.1±9.81       |
| t                               | 1.883           | 2.078           | 4.001           |
| P                               | 0.066           | 0.044           | 0.0002          |
| MCS                             |                 |                 |                 |
| Before (n=25)                    | 48.9±11.59      | 47.6±10.91      | 49.3±11.19      |
| After (n=22)                     | 54.9±10.9       | 53.9±10.11      | 61.1±10.21      |
| t                               | 1.879           | 2.067           | 3.821           |
| P                               | 0.067           | 0.045           | 0.0004          |
| DDF                             |                 |                 |                 |
| Before (n=25)                    | 7.3±3.22        | 7.1±3.10        | 6.9±3.41        |
| After (n=22)                     | 9.2±3.91        | 9.3±3.9         | 10.5±2.91       |
| t                               | 0.853           | 2.091           | 3.947           |
| P                               | 0.398           | 0.042           | 0.0003          |
| APF                             |                 |                 |                 |
| Before (n=25)                    | 36.3±2.21       | 35.6±2.31       | 37.2±2.19       |
| After (n=22)                     | 37.7±2.91       | 36.1±2.42       | 38.4±2.23       |
| t                               | 1.839           | 0.627           | 0.634           |
| P                               | 0.073           | 0.534           | 0.529           |

ADF, measurement of ankle dorsiflexion; AOFAS, American Orthopedic Foot and Ankle Society scale; APF, measurement of ankle plantar flexion; MCS, Mayo Clinical Scoring system; MFS, Maryland Foot Score.
tissues and increasing the range of motion. Low-load prolonged-duration stretch with ankle-foot orthosis should be considered an integral addition to the standard treatment of plantar fasciitis [16]. In contrast, Probe et al. [44] and Crawford and Thomson [45] reported that ankle-foot orthosis has no beneficial effect in the treatment of plantar fasciitis, perhaps because of the different way of assessment (SF36 in the first study) or different types of orthoses assessed in the second study.

The results of the present study did not show a significant benefit of using stretching exercises for the treatment of plantar fasciitis. These results are consistent with outcomes of Radford et al. [18]. They have reported that stretching of the plantar flexors resulted in no significant benefit in pain and function in patients with plantar fasciitis. Previous reviewers De Vera Barredo et al. [46] and McPoil et al.[47] concluded that the available evidence was inadequate to support stretching exercises as being more effective than other interventions or no intervention in the treatment of plantar fasciitis. Almubarak and Foster [1] demonstrated that stretching exercise of the plantar flexors and fascia was not effective in reduced foot pain and function compared with the control/sham exercise. In contrast, a prospective study by Chakraborty et al. [13] and Renan-Ordine et al. [22] showed that stretches of the plantar flexors and fascia significantly decreased pain and improved foot function in patients with chronic plantar fasciitis. Overall, larger, well-controlled studies are necessary to determine the ideal program of stretching exercise for the treatment of plantar fasciitis [12].

The limitations of this study were small sample size, short period of follow-up, and that there was no guarantee of the patients’ compliance.

Conclusion
Combined prescription of night-stretch ankle-foot orthosis and stretching exercises for plantar flexors and fascia had greater therapeutic effects compared with each treatment alone. Stretching exercises only are not beneficial in the treatment of recalcitrant plantar fasciitis.

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Conflicts of interest
There are no conflicts of interest.

References
1 Almubarak A, Foster N. Exercise therapy for plantar heel pain: a systemic review. Int J Exerc Sci 2012;5:276–295.
2 Chew KT, Leong D, Lin CY, Lim KK, Tan B. Comparison of autologous conditioned plasma injection, extracorporeal shockwave therapy, and conventional treatment for plantar fasciitis: a randomized trial. PM R 2013;5:1035–1043.
3 Morton TN, Zimmerman JP, Lee M, Schaber JD. A review of 105 consecutive uniport endoscopic plantar fascial release procedures for the treatment of chronic plantar fasciitis. J Foot Ankle Surg 2013;52:48–52.
4 Rosenbaum AJ, DiPreta JA, Misener D. Plantar heel pain. Med Clin North Am 2014;98:339–352.
5 Miller LE, Latt DL. Chronic plantar fasciitis is mediated by local hemodynamics: implications for emerging therapies. N Am J Med Sci 2015;7:1–5.
6 Chang KV, Chen SY, Chen WS, Tu YK, Chien KL. Comparative effectiveness of focused shock wave therapy of different intensity levels and radial shock wave therapy for treating plantar fasciitis: a systematic review and network meta-analysis. Arch Phys Med Rehabil 2012;93:1259–1268.
7 Monteagudo M, Maceira E, García-Virto V, Canosas R. Chronic plantar fasciitis: plantar fasciomytosis versus gastrocnemius recession. Int Orthop 2013;37:1845–1850.
8 Patel A, DiGiovanni B. Association between plantar fasciitis and isolated contracture of the gastrocnemius. Foot Ankle Int 2011;32:5–8.
9 Bolivar YA, Munuera PV, Padillo JP. Relationship between tightness of the posterior muscles of the lower limb and plantar fasciitis. Foot Ankle Int 2013;34:42–48.
10 Lin SC, Chen CP, Tang SF, Wong AM, Hsieh JH, Chen WP. Changes in windlass effect in response to different shoe and insole designs during walking. Gait Posture 2013;37:235–241.
11 Attard J, Singh D. A comparison of two night ankle-foot orthoses used in the treatment of inferior heel pain: a preliminary investigation. Foot Ankle Surg 2012;18:108–110.
12 Garrett TR, Neibert PJ. The effectiveness of a gastrocnemius-soleus stretching program as a therapeutic treatment of plantar fasciitis. J Sport Rehabil 2013;22:308–312.
13 Chakraborty M, Orta PR, Sathian B. Efficacy of stretching exercises in the treatment of chronic plantar fasciitis: a prospective study in Manipal Teaching Hospital, Pokhara, Nepal. Asian J Med Sci, 2011.2:97–101.
14 Young R, Nix S, Wholohan A, Bradhurst R, Reed L. Interventions for increasing ankle joint dorsiflexion: a systematic review and meta-analysis. J Foot Ankle Res 2013;6:46.
15 Lee WC, Wong WY, Kung E, Leung AK. Effectiveness of adjustable dorsiflexion night splint in combination with accommodative foot orthosis on plantar fasciitis. J Rehabil Res Dev 2012;49:1557–1564.
16 Furia JP, Willis FB, Shanmugam R, Curran SA. Systematic review of contracture reduction in the lower extremity with dynamic splinting. Adv Ther 2013;30:763–770.
17 Cole C, Seto C, Gazewood J. Plantar fasciitis: evidence-based review of diagnosis and therapy. Am Fam Physician 2005;72:2237–2242.
18 Radford JA, Landorf KB, Buchbinder R, Cook C. Effectiveness of calf muscle stretching for the short-term treatment of plantar heel pain: a randomised trial. BMC Musculoskelet Disord 2007;8:36.
19 Neufeld SK, Cerrato R. Plantar fasciitis: evaluation and treatment. J Am Acad Orthop Surg 2008;16:338–346.
20 Healey K, Chen K. Plantar fasciitis: current diagnostic modalities and treatments. Clin Podiatr Med Surg 2010;27:369–380.
21 Drake M, Bittenbender C, Boyles RE. The short-term effects of treating plantar fasciitis with a temporary custom foot orthosis and stretching. J Orthop Sports Phys Ther 2011;41:221–231.
22 Renan-Ordine R, Albuquerque-Sendin F, de Souza DP, Cleland JA, Fernández-de-Las-Peñas C. Effectiveness of myofascial trigger point manual therapy combined with a self-stretching protocol for the management of plantar heel pain: a randomized controlled trial. J Orthop Sports Phys Ther 2011;41:43–50.
23 Fong DT, Pang KY, Chung MM, Hung AS, Chan KM. Evaluation of combined prescription of rocker sole shoes and custom-made foot orthoses for the treatment of plantar fasciitis. Clin Biomech (Bristol, Avon) 2012;27:1072–1077.
24 Krishnan A, Sharma Y, Singh S. Evaluation of therapeutic effects of extracorporeal shock wave therapy in resistant plantar fasciitis patients in a tertiary care setting. Med J Armed Forces India 2012;68:236–239.
25 Zanon RG, Kundart A, Imamura M. Ultrasound continuous treatment of chronic plantar fasciitis Acta brazilian orthopedic. Acta Ortop Bras 2006;14:137–140.

26 Gerdesmeyer L, Frey C, Vester J, Maier M, Weil L Sr et al. Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis: results of a confirmatory randomized placebo-controlled multicenter study. Am J Sports Med 2008;36:2100–2109.

27 Myerson MS, Fisher RT, Burgess AR, Kenzora JE. Fracture dislocations of the tarsometatarsal joints: end results correlated with pathology and treatment. Foot Ankle 1986;6:225–242.

28 Porter D, Barrill E, Onearce K, May BD. The effects of duration and frequency of Achilles tendon stretching on dorsiflexion and outcome in painful heel syndrome: a randomized, blinded, control study. Foot Ankle Int 2002;23:619–624.

29 Daly PJ, Kitaoka HB, Chao EY. Plantar fasciopathy for intractable plantar fasciitis: clinical results and biomechanical evaluation. Foot Ankle 1992;13:188–195.

30 Fong CM, Blackburn JT, Norcross MF, McGrath M, Padua DA. Ankle-dorsiflexion range of motion and landing biomechanics. J Athl Train 2011;46:5–10.

31 Thomas JL, Christensen JC, Kravitz SR, Mendicino RW, Schuberth JM, Vanore JV et al. American College of Foot and Ankle Surgeons heel pain committee. The diagnosis and treatment of heel pain: a clinical practice guideline-revision 2010. J Foot Ankle Surg 2010;49(Suppl):S1–19.

32 Sheridan L, Lopez A, Perez A, John MM, Willis FB, Shanmugam R. Plantar fasciopathy treated with dynamic splinting: a randomized controlled trial. J Am Podiatr Med Assoc 2010;100:161–165.

33 Barry LD, Barry AN, Chen Y. A retrospective study of standing gastrocnemius–soleus stretching versus night splinting in the treatment of plantar fasciitis. J Foot Ankle Surg 2002;41:221–227.

34 Hodgson MJ, Docherty D, Zehr EP. Postactivation potentiation of force is independent of t-reflex excitability. Int J Sports Physiol Perform 2008;3:219–231.

35 Mizuno T, Matsumoto M, Umeruara Y. Viscoelasticity of the muscle-tendon unit is returned more rapidly than range of motion after stretching. Scand J Med Sci Sports 2013;23:23–30.

36 Cé E, Longo S, Rampichini S, Devoto M, Limonta E, Venturelli M, Esposito F. Stretch-induced changes in tension generation process and stiffness are not accompanied by alterations in muscle architecture of the middle and distal portions of the two gastrocnemii. J Electromyogr Kinesiol 2015;25:469–478.

37 Taniguchi K, Shinohara M, Nozaki S, Katayose M. Acute decrease in the stiffness of resting muscle belly due to static stretching. Scand J Med Sci Sports 2015;25:32–40.

38 Batt ME, Tanji JL, Skattum N. Plantar fasciitis: a prospective randomized clinical trial of the tension night splint. Clin J Sport Med 1996;6:158–162.

39 Gill LH, Kiebzak GM. Outcome of nonsurgical treatment for plantar fasciitis. Foot Ankle Int 1996;17:527–532.

40 Powell M, Post WR, Keener J, Wearden S. Effective treatment of chronic plantar fasciitis with dorsiflexion night splints: a crossover prospective randomized outcome study. Foot Ankle Int 1998;19:10–18.

41 Berlet GC, Anderson RB, Davis H, Kiebzak GM. A prospective trial of night splinting in the treatment of recalcitrant plantar fasciitis: the ankle dorsiflexion dynamplint. Orthopedics 2002;25:1273–1275.

42 Lai JM, Francisco GE, Willis FB. Dynamic splinting after treatment with botulinum toxin type-A: a randomized controlled pilot study. Adv Ther 2009;26:241–248.

43 Sharma NK, Loudon JK. Static progressive stretch brace as a treatment of pain and functional limitations associated with plantar fasciitis: a pilot study. Foot Ankle Spec 2010;3:117–124.

44 Probe RA, Baca M, Adams R, Preece C. Night splint treatment for plantar fasciitis. A prospective randomized study. Clin Orthop Relat Res 1999;368:190–195.

45 Crawford F, Thomson C. Interventions for treating plantar heel pain. Cochrane Database Syst Rev 2003;3:CD000416.

46 De Vera Barredo R, Menna D, Farris JW. An evaluation of research evidence for selected physical therapy interventions for plantar fasciitis. J Phys Ther Sci 2007;19:41–56.

47 McPoil TG, Martin RL, Cornwall MW, Wukich DK, Irrgang JJ, Godges JJ. Heel pain-plantar fasciitis: clinical practice guidelines linked to the international classification of function, disability, and health from the orthopaedic section of the American Physical Therapy Association. J Orthop Sports Phys Ther 2008;38:A1–A18.