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 treatments with various degrees of success. Therefore, a continued search for an effective conservative treatment for plantar fasciitis exists.
Aim
The aim of this study was to evaluate the effects of individually prescribed night ankle–foot orthosis, stretching exercises, and a combined prescription of them on chronic plantar fasciitis.
Settings and design
This study is a prospective randomized case–control study.
Patients and methods
Seventy-five patients with unilateral recalcitrant plantar fasciitis were randomized to one of three treatment groups. Group I was treated with stretching exercises to the plantar flexors and plantar fascia. Group II was treated using a night-stretch ankle–foot orthosis. Group III received the same stretching exercises as in group I in combination with night-stretch ankle–foot orthosis as in group II.
Results
Patients receiving the combination of stretching exercises and night ankle–foot orthosis showed a statistically significant reduction in morning and activity pain, improvement in assessment scores, and improvement of ankle dorsiflexion range of motion as compared with those receiving night ankle–foot orthosis only. Patients receiving stretching exercises provide no statistically significant improvement of pain, assessment scores, and ankle dorsiflexion range of motion. No significant differences were observed in the ankle plantar flexion after treatment in the three groups.
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 alone are not beneficial in the treatment of recalcitrant plantar fasciitis.

Keywords:
exercises, orthosis, plantarfasciitis

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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.

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 heal (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.

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 2 Mean±SD outcome measurements before and after treatment

	Group I	Group II	Group III
Measurement (*n*)			
Before	25	25	25
After	22	21	20
Morning pain			
Before (*n*=25)	6.1±1.45	5.8±1.51	5.9±1.61
After (*n*=22)	5.5±1.31	4.8±1.42	4.2±1.50
t	1.492	2.314	3.794
P	1.427	0.025	0.0005
Activity pain			
Before (*n*=25)	5.9±1.62	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
MFS			
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
ADF			
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.

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 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.

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