Tissue-Specific Plantar Fascia-Stretching Exercise Enhances Outcomes in Patients with Chronic Heel Pain

A Prospective, Randomized Study

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Background: Approximately 10% of patients with plantar fasciitis have development of persistent and often disabling symptoms. A poor response to treatment may be due, in part, to inappropriate and nonspecific stretching techniques. We hypothesized that patients with chronic plantar fasciitis who are managed with the structure-specific plantar fascia-stretching program for eight weeks have a better functional outcome than do patients managed with a standard Achilles tendon-stretching protocol.

Methods: One hundred and one patients who had chronic proximal plantar fasciitis for a duration of at least ten months were randomized into one of two treatment groups. The mean age was forty-six years. All patients received prefabricated soft insoles and a three-week course of celecoxib, and they also viewed an educational video on plantar fasciitis. The patients received instructions for either a plantar fascia tissue-stretching program (Group A) or an Achilles tendon-stretching program (Group B). All patients completed the pain subscale of the Foot Function Index and a subject-relevant outcome survey that incorporated generic and condition-specific outcome measures related to pain, function, and satisfaction with treatment outcome. The patients were reevaluated after eight weeks.

Results: Eighty-two patients returned for follow-up evaluation. With the exception of the duration of symptoms ($p < 0.01$), covariates for baseline measures revealed no significant differences between the groups. The pain subscale scores of the Foot Function Index showed significantly better results for the patients managed with the plantar fascia-stretching program with respect to item 1 (worst pain; $p = 0.02$) and item 2 (first steps in the morning; $p = 0.006$). Analysis of the response rates to the outcome measures also revealed significant differences with respect to pain, activity limitations, and patient satisfaction, with greater improvement seen in the group managed with the plantar fascia-stretching program.

Conclusions: A program of non-weight-bearing stretching exercises specific to the plantar fascia is superior to the standard program of weight-bearing Achilles tendon-stretching exercises for the treatment of symptoms of proximal plantar fasciitis. These findings provide an alternative option to the present standard of care in the nonoperative treatment of patients with chronic, disabling plantar heel pain.

Level of Evidence: Therapeutic study, Level I-1a (randomized controlled trial [significant difference]). See Instructions to Authors for a complete description of levels of evidence.

Proximal plantar fasciitis is a common problem in the adult population. It occurs over a wide age range and is seen in both sedentary and athletic individuals. Although its precise cause remains unclear, the most common theory is repetitive partial tearing and chronic inflammation of the plantar fascia at its insertion on the medial tubercle of the calcaneus[1-5]. Nonoperative treatments for plantar fasciitis vary widely and include shoe modifications, use of prefabricated and custom inserts, stretching exercises, physical therapy, nonsteroidal anti-inflammatory medications, cortisone

injections, night splints, application of a cast, or any combination of the foregoing modalities[6-10].

Although the majority of patients with plantar fasciitis have resolution of the symptoms within ten months, approximately 10% have development of persistent and often disabling symptoms[11]. A poor response to treatment may be due, in part, to inappropriate and nonspecific stretching techniques or to improper recommendations for shoe inserts. Stretching protocols given to patients by physicians and physical therapists often emphasize stretching the Achilles tendon, but they do not specifically address the plantar fascia[7,9-12]. In addition, many individuals are prescribed rigid custom foot orthoses that have been reported, in a recent multicenter study, to result in poorer outcomes compared with those after use of prefabricated, flexible designs[10]. The response of patients with chronic (ten months or more) disabling proximal plantar fasciitis to a treatment protocol emphasizing structure-specific plantar fascia-stretching combined with the use of a prefabricated, flexible orthotic device and a brief course of nonsteroidal anti-inflammatory medications is not known. It was our experience that a large percentage of patients seen by an orthopaedic foot and ankle specialist at a tertiary referral center noted improvement in symptoms in response to the above treatment protocol. We hypothesized that patients with chronic plantar heel pain who are managed with a tissue-specific plantar fascia-stretching protocol have a better functional outcome after eight weeks of treatment compared with that after a standard Achilles tendon-stretching protocol.

Materials and Methods

Patients

Between January 1, 2001, and June 1, 2001, 101 patients (thirty-three men and sixty-eight women) who had chronic heel pain for at least ten months were enrolled in the study. The mean age (and standard deviation) was 46 ± 7.5 years (range, twenty-three to sixty years). The study was approved by the institutional review board at the University of Rochester and was conducted in the Movement Analysis Laboratory at Ithaca College, Department of Physical Therapy, University of Rochester campus. All patients complained of maximum pain upon palpation of the origin of the plantar fascia on the medial calcaneal tubercle, consistent with a diagnosis of proximal plantar fasciitis. They had failed to respond to previous nonoperative treatments including nonsteroidal anti-inflammatory medications, orthoses, heel cups, exercises, night splints, injections, and/or activity modifications. Patients were excluded if they had a history of systemic disease, prior heel surgery, or heel pain that was not consistent with proximal plantar fasciitis. Verbal and written instructions regarding the study were given to the patients, and a University-approved consent form was signed prior to participation.

Protocol

The patients initially completed a self-administered questionnaire that provided background information and a history profile of the heel pain. The background information included age, gender, height and weight, hours spent standing during the day, duration of symptoms, and types of prior treatments. An orthopaedic surgeon who specialized in foot and ankle disorders conducted a physical examination and confirmed the clinical diagnosis of proximal plantar fasciitis. Patients who met the inclusion criteria for the study were then randomized into one of two treatment groups. The sequence of random allocation was concealed until interventions were assigned. Patients in both groups received over-the-counter, prefabricated full-length soft insoles (Spenco cross trainer; Spenco, Waco, Texas) and a three-week course of a nonsteroidal anti-inflammatory medication (Celebrex; celecoxib), and they also viewed an educational video about plantar fasciitis. Patients who were randomized to treatment Group A received instructions in a plantar fascia tissue-stretching program. They were instructed to perform this exercise while sitting and by first crossing the affected leg over the contralateral leg. Then, while using the hand on the affected side, they were to place the fingers across the base of the toes on the bottom of the foot (distal to the metatarsophalangeal joints) and pull the toes back toward the shin until they felt a stretch in the arch of the foot (Figs. 1-A, 1-B, and 1-C). They were to confirm that the stretching was correct by palpating the tension in the plantar fascia with the contralateral hand while performing the stretching.

Patients who were randomized into treatment Group B received instructions in an Achilles tendon-stretching program. They were taught to perform this exercise while standing and leaning into the wall with the affected leg placed behind the contralateral leg. Patients were asked to place the shoe insert under the affected foot in order to minimize excessive midfoot pronation while stretching. They were also instructed to "toe in" or point the toes of the affected foot toward the heel of the front foot. Patients were told to bend the front knee while keeping the back knee straight and the heel firmly on the ground (Fig. 2).

Patients in both groups were instructed to hold each stretch for a count of ten and to repeat it ten times. They were asked to perform the stretching program three times per day. For patients in Group A (plantar fascia-stretching program), the first stretch was to be done before taking the first step in the morning. For patients in Group B (Achilles tendon-stretching program), the first stretch was to be done immediately after getting out of bed in the morning. An examiner evaluated each patient to ensure that they were carrying out the exercises correctly. They were given a written protocol of the stretching program and asked to keep a daily log of exercise completion.

The patients were asked to discontinue any previous therapy that they were receiving for the heel pain. They were also encouraged not to change their regular shoe wear or activity level. If an individual could not tolerate the celecoxib, he or she was instructed to change to ibuprofen. If unable to tolerate ibuprofen, the patient was instructed to discontinue the nonsteroidal anti-inflammatory medication completely.

Before treatment, the patients completed the pain sub-

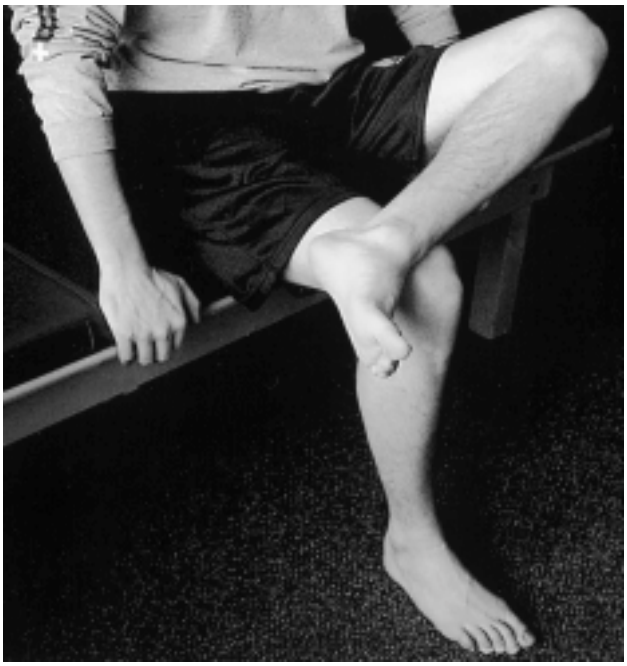

Fig. 1-A

Plantar fascia-stretching exercise. The patient crossed the affected leg over the contralateral leg (Fig. 1-A). While placing the fingers across the base of the toes, the patient pulled the toes back toward the shin until he or she felt a stretch in the arch or plantar fascia (Fig. 1-B). The patient confirmed that the stretch was correct by palpating tension in the plantar fascia (Fig. 1-C).

scale of the Foot Function Index (see Appendix) and a questionnaire related to activity level and function. At four weeks, the patients were contacted by telephone to answer any questions regarding the exercise protocols and to encourage continued participation. Patients returned at eight weeks for a follow-up examination and completion of the pain subscale of the Foot Function Index and a subject-relevant outcome measures questionnaire that incorporated generic and condition-specific outcome measures related to pain, function, and satisfaction (see Appendix). The outcomes of the study were analyzed by a different group of researchers from those who had provided treatment.

Questions from the pain subscale of the Foot Function Index were used to generate the primary numeric outcome scores. The questions were scored from 0 (no pain) to 10 (worst pain imaginable), depending on the location marked by the patients on the visual analog scale. Similar to a previous heel pain study that had comparable outcome measures[10], only the first seven items were used to generate an overall score. The remaining two items on the pain subscale were related to orthotic use and were not relevant to all subjects. The sum of the scores on the first seven items was then expressed as a percentage of the maximum possible score, resulting in an overall percentage score that ranged from 0 (no pain on any question) to 100 (worst pain imaginable on all applicable questions). The change in the overall pain score—that is, the score after eight weeks minus the baseline score—was used for subsequent analysis. Note that a negative change in the visual analog scale score signifies patient improvement. Additionally, as part of the study protocol, the changes in the numeric scores for the first two items on the pain subscale were selected a priori to be evaluated separately, as they were considered to represent the primary concerns articulated by patients with chronic heel pain.

Tests were conducted to assess the similarity of the groups on baseline measures. T tests were used for continuous data, and the Fisher exact test was used for response rate data. Differences between the groups with respect to changes in the

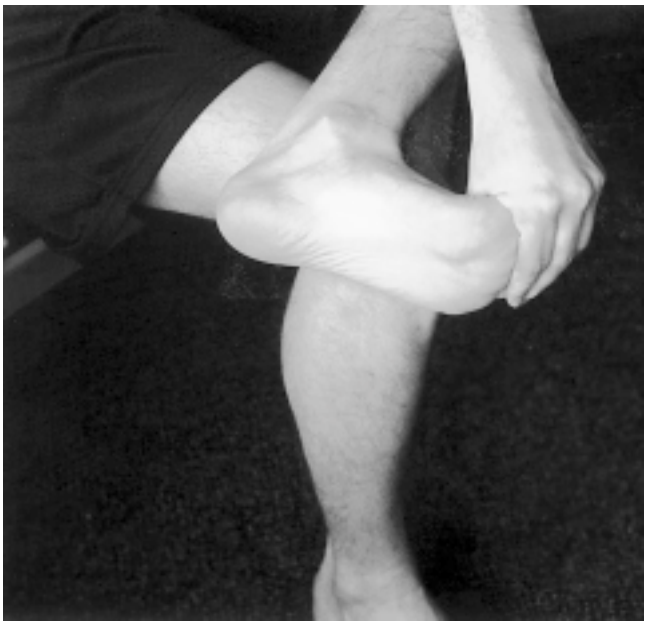

Fig. 1-B

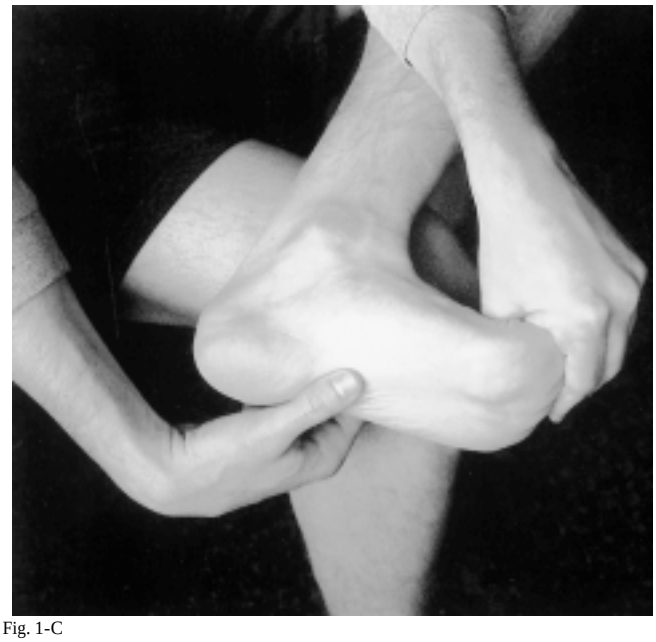

Fig. 1-C

TABLE I Summary of Baseline Measures for Treatment Groups*

Measurement	Group A (n = 46)	Group B (n = 36)
Age† *(yr)*	44.6 (23-60)	47.1 (31-60)
Gender (F/M)	31/15	27/9
Weight† *(kg)*	81.9 (48-127)	79.5 (57-102)
Body-mass index† *(kg/m^2)*	28.2 (21-33)	28.4 (30.2-30.6)
No. of hours standing†	6 (0.50-14.0)	5.4 (1.0-11.0)
Duration of symptoms		
10-12 mo	20	5
13-18 mo	4	15
19-24 mo	1	8
25-36 mo	9	3
>36 mo	12	5

*Group A was managed with a plantar fascia-stretching program, and Group B was managed with an Achilles tendon-stretching program.
†The values are given as the mean, with the range in parentheses.

visual analog scale scores for the pain subscale of the Foot Function Index were analyzed with use of standard statistical procedures. Independent sample t tests were used except in instances of violation of normal assumption, in which case the nonparametric equivalent was applied. To adjust for differences between the groups due to other factors, key variables that were considered important to the outcome of this study were also evaluated in a multiple regression analysis. In addition to treatment group, covariates that were considered included age, gender, body-mass index, weight, hours spent standing during the day, and duration of symptoms. Given that linear effects were of interest, the ordinal variable representing duration of heel pain was treated as continuous. An overall significance level was maintained at $p < 0.05$. Power estimates based on the change in the end point for the visual analog scale score and a standard error estimate obtained from a recent study with a similar design[10] revealed that a sample size of fifty subjects per group would result in a test power of approximately 80% in detecting differences of 18% or more between the groups with respect to the change in the visual analog scale scores.

At the follow-up visit, patients were also asked to rate the change in the pain between the initial and follow-up visits as well as their perceptions of overall improvement since beginning the study (see Appendix). In order to simplify the interpretation of our analyses, the responses to the questions on the subject-relevant outcome measures were collapsed into dichotomized data indicating a positive response versus a nonresponse. Nonresponse represented little or no improvement. The association of treatment with response rates was analyzed with use of the Fisher exact test for association in general two-way contingency tables. Logistic regression was used to evaluate and control for covariates that may have significantly affected outcome measures. Covariates considered were the same as those considered in the analysis of the visual analog scale scores. An

Fig. 2
Achilles tendon-stretching exercise. The patient was instructed to place the shoe insert under the affected foot. He or she was then told to place the affected leg behind the contralateral leg, with the toes of the affected foot pointed toward the heel of the front foot, and to lean into the wall. The patient was then instructed to bend the front knee while keeping the back knee straight and the heel firmly on the floor.

overall significance level was maintained at $p < 0.05$.

Results

Of the 101 patients randomized into the study, eighty-two returned for a follow-up evaluation after eight weeks and completed the study, giving an overall attrition rate of 18.8%. When categorized by study group, the attrition rate was higher for the fifty patients managed with the Achilles tendon-stretching program (fourteen; 28%) than for the fifty-one patients managed with the plantar fascia-stretching program (five; 9.8%).

Table I summarizes the baseline characteristics of the subjects who completed the study. The analysis of baseline measures for the two groups revealed that they were very similar with regard to age, body-mass index, and duration of hours standing per day. With the exception of duration of symptoms ($p < 0.01$), covariates for baseline measures demonstrated no significant differences between the two groups. The patients in Group A (plantar fascia-stretching program) were clustered at the extremes of the spectrum of symptom duration while the patients in Group B (Achilles tendon-stretching program) were more evenly distributed with regard to the duration of symptoms.

Although both groups reported an overall reduction in pain, the results of the analysis for the pain subscale scores of the Foot Function Index showed significant differences between the groups with respect to item 1 (worst pain; $p = 0.02$) and item 2 (first steps in the morning; $p = 0.006$), with greater improvement noted in Group A (Table II). No differences were detected between the groups when all seven items were combined ($p = 0.17$). After adjusting for covariate differences in the groups, these results remained unchanged.

A summary of the responses to the subject-relevant outcome measures is presented in Table III. Analysis of the response rates to the outcome measures demonstrated a significant difference between the groups for all measures, with p values ranging between 0.0006 and 0.025. The percentage of positive responses with regard to pain, activity limitations, and patient satisfaction was greater in Group A than in Group B. Similar to the findings reported for the continuous variables, the results remained the same after adjusting for covariates. A complete description of the group responses to these outcome measures is presented in the Appendix. The daily exercise logs were not collected for analysis. However, patients were questioned about their compliance with the frequency of the exercise program, and this revealed that one subject in Group A and four subjects in Group B had stopped the stretching exercises.

Discussion

In a recent multicenter clinical trial, Pfeffer et al.[10] found that use of a prefabricated shoe insert in combination with a stretching program was the most effective treatment modality to reduce symptoms in patients with predominantly acute plantar fasciitis for a duration of six months or less. Davis et al.[11] noted that approximately 90% of patients with plantar fasciitis have resolution of their symptoms within ten months. The fate of the other 10%, who have development of chronic, disabling plantar heel pain, is not well understood. Surgical intervention may be appropriate for patients who do not respond to traditional nonoperative approaches. However, recent studies have noted that, despite improvement in the symptoms, a prolonged recovery time and persistent pain were not uncommon[13-15]. Davies et al.[13] reported that <50% of patients with chronic heel pain were totally satisfied with the results of surgical intervention.

In light of these findings, we believe that attempts to further optimize nonoperative treatment modalities in pa-

TABLE II Change Between Pain Subscale Scores of the Foot Function Index at Baseline and Eight-Week Follow-up Evaluation*

	Univariate Analysis (%)		Covariate Analysis (%)	
	Mean Change	95% Confidence Interval	Mean Change	95% Confidence Interval
Item 1 (pain at its worst)†				
Group A	–26.0	(–33.0 to –19.0)	–24.6	(–31.8 to –17.5)
Group B	–14.7	(–21.2 to –8.2)	–12.4	(–20.6 to –4.2)
Item 2 (first steps in the morning)‡				
Group A	–31.1	(–39.3 to –22.7)	–30.2	(–38.5 to –21.9)
Group B	–13.2	(–22.2 to –4.1)	–11.3	(–20.8 to –1.7)
Combined scores for items 1-7§				
Group A	–19.0	(–24.8 to –13.3)	–17.3	(–23.2 to –11.3)
Group B	–13.0	(–19.8 to –6.2)	–11.1	(–18.0 to –4.1)

*Group A was managed with a plantar fascia-stretching program, and Group B was managed with an Achilles tendon-stretching program. Note that negative values reflect a reduction in pain score. †P = 0.022 for univariate differences; after adjusting for covariates, p = 0.017. ‡P = 0.006 for univariate differences; after adjusting for covariates, p = 0.002. §P = 0.171 for univariate differences; after adjusting for covariates, p = 0.15 (not significant).

TABLE III Positive Response Rates by Group for Subject-Relevant Outcome Measures (SROM)*

Question (Definition of Positive Response)	No. of Positive Responses	Total No. of Responses	Positive Responses (%)	95% Confidence Interval
SROM1† (overall better off than before treatment)				
Group A	38	46	82.6	68.6 to 92.2
Group B	20	36	55.6	38.1 to 72.1
SROM2‡ (no heel pain or less pain than before treatment)				
Group A	38	46	82.6	68.6 to 92.2
Group B	21	36	58.3	40.8 to 74.5
SROM3§ (>50% improvement in heel pain)				
Group A	22	46	47.8	32.9 to 63.1
Group B	5	36	13.9	4.7 to 29.5
SROM4# (heel pain all or much better)				
Group A	24	46	52.2	37.0 to 67.1
Group B	8	36	22.2	10.1 to 39.2
SROM5** (>50% improvement in work and/or recreational activities)				
Group A	20	46	43.4	28.9 to 58.9
Group B	4	35	11.4	3.2 to 26.7
SROM6†† (totally satisfied with treatment or satisfied with minor reservations)				
Group A	42	46	91.3	79.2 to 97.6
Group B	21	35	60.0	42.1 to 76.1

*Group A was managed with a plantar fascia-stretching program, and Group B was managed with an Achilles tendon-stretching program. †P = 0.014 without covariates; after adjusting for covariates, p = 0.003. ‡P = 0.025 without covariates; after adjusting for covariates, p = 0.006. §P = 0.002 without covariates; after adjusting for covariates, p = 0.0006. #P = 0.007 without covariates; after adjusting for covariates, p = 0.004. **P = 0.002 without covariates; after adjusting for covariates, p = 0.0006. ††P= 0.007 without covariates; after adjusting for covariates, p = 0.004.

tients with chronic heel pain are warranted. To our knowledge, this study is the first prospective, randomized clinical trial to evaluate response rates to different stretching protocols in subjects with chronic, disabling proximal plantar fasciitis. Our hypothesis was based on clinical observations that a large proportion of patients improved in response to a treatment protocol emphasizing stretching of the plantar fascia even though these patients had exhausted typical nonoperative treatment measures, including the use of a standard Achilles tendon-stretching protocol. Currently, a treatment modality to specifically and optimally stretch the plantar fascia is often not prescribed or is underemphasized and simply grouped in with other stretching exercises[7,9-12].

Our evaluation criteria were chosen to target specifically the effects of the protocols on pain and overall daily function (including work and/or recreation) as well as patient satisfaction. Scoring systems often include subcategories that have little clinical relevance to patients with chronic plantar fasciitis[16]. Recent studies have noted the difficulties associated with these scoring systems and have instead focused on descriptive questions concerning pain, function, and satisfaction[13]. We also chose to evaluate measures with a questionnaire that generated feedback with regard to the patient's perceptions of the outcome, that is, the subject-relevant outcome measures (see Appendix). We developed these outcome questions to provide an additional measurement tool that concentrated on function and satisfaction and supplemented the pain subscale of the Foot Function Index.

The pain subscale of the Foot Function Index was chosen because it is a validated instrument[17]. Recent studies, including the multicenter clinical trial on acute plantar fasciitis by Pfeffer et al.[10], have used the first seven items of the pain subscale of the Foot Function Index as the primary numeric outcome measure. In clinical practice, patients routinely complain about the severe pain with the first steps in the morning and focus on the pain when it is at its worst. Consequently, at the start of the study, we chose to independently analyze item 1 (worst pain) and item 2 (pain with first steps in the morning), since these were thought to be most clinically relevant to the patients' complaints. When combining the scores for all seven items and thus including the effects of walking barefoot and walking with use of shoe-wear, no significant differences were detected between the groups. Many patients reported that they never stood or walked barefoot because of the pain.

Others reported that the type of surface that they stood on (carpet or hardwood floor), rather than footwear, made a difference in the heel pain but was not reflected in these questions. Differences in shoe-wear preferences among the patients also may have influenced the variability in response to these equally weighted questions, thus minimizing any differences that may have existed between the groups.

Although improvement from the baseline symptoms was noted in both groups, the group managed with the non-weight-bearing plantar fascia-stretching program was found to have superior results. These findings are encouraging, particularly considering that the patient population that was studied had exhausted numerous other treatment methods, including a standard Achilles tendon-stretching program. We believe that the Achilles tendon-stretching exercise has a beneficial effect, as illustrated by the improvement noted in the patients in Group B. However, it does not optimally isolate the plantar fascia and should be viewed as supplemental to the stretching exercise specific to the plantar fascia. Furthermore, the typical Achilles tendon-stretching exercise does not specifically recreate the windlass mechanism[18,19], and it is routinely performed after the initiation of weight-bearing. We believe that it is important to commence stretching prior to weight-bearing in the morning as weight-bearing without stretching may restart the cycle of microtearing and inflammation.

The plantar fascia-stretching protocol can be likened to the use of dorsiflexion night splints that incorporate toe dorsiflexion[8,12]. In a recent prospective, randomized outcome study of patients with chronic plantar fasciitis, Powell et al.[8] noted improvement of symptoms in 88% of the patients and satisfaction in 73% after use of a dorsiflexion night splint for one month. The plantar fascia-stretching protocol utilized in our study has two important advantages compared with use of a night splint. First, it eliminates the problem of poor compliance frequently associated with the use of bulky night splints. Second, the plantar fascia-stretching exercises can be performed throughout the course of the day, especially prior to standing after prolonged sitting, something that is not possible with the night splints.

In addition to the prospective, randomized design, an additional strength of this study is the stringent method of patient selection. In order to minimize confounding variables, specific attention was paid to the inclusion of only patients who clearly had classic proximal plantar fasciitis. If they did not exhibit signs and symptoms of classic proximal plantar fasciitis, including tenderness localized to the medial tubercle of the calcaneus and pain with the first step in the morning, they were not enrolled in the study. A limitation of the study that could lead to a bias in clinical outcomes is the dissimilarity in the attrition rates for the groups (five of the fifty-one patients in the group managed with plantar fascia-stretching exercises and fourteen of the fifty patients managed with Achilles tendon-stretching exercises did not return for follow-up visits). Because there was no basis to believe that the responses of the patients who dropped out of the study would vary significantly from those of the subjects who returned for follow-up visits, we did not conduct a sensitivity analysis. An additional potential limitation is that the duration of follow-up was limited to eight weeks only. While we were encouraged by the changes in a relatively short period of time, the long-term effects on pain and activity limitations are not known.

The major goals of the plantar fascia-stretching protocol were to recreate the windlass mechanism and to limit repetitive microtrauma and associated chronic inflammation by performing the exercises prior to the first steps in the morning or after any prolonged sitting or inactivity. After eight weeks of treatment, the group managed with plantar fascia-stretching exercises exhibited enhanced outcomes with regard to pain, function, and overall satisfaction compared with those of the group managed with standard Achilles tendon-stretching exercises. This protocol provides a nonoperative treatment option that resulted in a rate of improvement of symptoms that surpassed the responses to more traditional treatment methods for patients with chronic, disabling proximal plantar fasciitis.

Appendix

Tables showing the Foot Function Index scale, the subject-relevant outcome measures instrument, and the detailed results of the subject-relevant outcome measures are available with the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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