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Original Research

Using Pressure Massage for Achilles Tendinopathy

A Single-Blind, Randomized Controlled Trial Comparing a Novel Treatment Versus an Eccentric Exercise Protocol

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Background: Eccentric exercises are the only conservative treatment that has shown good clinical results in studies of Achilles tendinopathy (AT), but success rates vary, indicating the need for alternative treatments. Soft tissue treatments are widely used for AT, but strong scientific evidence is lacking to support those treatments.

Purpose/Hypotheses: This study aimed to determine whether pressure massage to the calf muscles is a useful treatment for AT and to compare this treatment versus an eccentric exercise protocol. Our first hypothesis was that pressure massage treatment is equivalent or superior to eccentric exercises with regard to pain reduction time (ie, pain would be reduced more quickly with pressure massage). The second hypothesis was that pressure massage is equivalent or superior to eccentric exercises with regard to function of the calf muscles.

Study Design: Randomized controlled trial; Level of evidence, 1.

Methods: A total of 60 patients with AT were randomized into 3 groups: group 1 underwent an eccentric exercise protocol, group 2 underwent pressure massage, and group 3 underwent pressure massage and the eccentric exercise protocol. Patients were evaluated with the Icelandic version of the Victorian Institute of Sports Assessment–Achilles questionnaire (VISA-A-IS), an algometer to test the pressure pain threshold (PPT) of the Achilles tendon, tests for ankle range of motion (ROM), and real-time ultrasonographic (US) scanning of tendon thickness and degree of neovascularization. Measurements for VISA-A-IS, PPT, and ROM were taken at 0, 4, 8, 12, and 24 weeks. US scan measurements were taken at 0, 12, and 24 weeks. Mixed-model analysis of variance was used for statistical analysis.

Results: All groups improved when evaluated with VISA-A-IS scores ($P < .0001$). The pressure massage group improved significantly more than the eccentric exercise group at week 4, which was the only between-group difference. Ankle ROM increased significantly over time (ROM bent knee $P = .006$ and ROM straight knee $P = .034$), but no significant difference was found between groups. No significant difference was found in evaluations of PPT or US scan measurements.

Conclusion: Pressure massage is a useful treatment for Achilles tendinopathy. Compared with eccentric exercise treatment, pressure massage gives similar results. Combining the treatments did not improve the outcome.

Keywords: Achilles tendinopathy; tendon; pressure massage; eccentric exercises; VISA-A; range of motion; massage; pressure pain

Achilles tendinopathy (AT) is a common problem among athletes as well as the general population.[31,47] AT has been reported to affect 7% to 30% of runners[51] and is frequently seen by general practitioners with an incidence rate of 2.35 per 1000 in the adult general population (21-60 years).[10] Few evidence-based conservative treatments are available, and only eccentric exercises have shown a persistent significant effect.[¶] Not all patients respond to eccentric exercises, however. Success rates from 60% to 90% have been reported,[35] and these exercises seem to be more effective in men than women.[27] One study found an eccentric exercise program to be less effective in a sedentary population,

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[¶]References 1, 14, 15, 22, 28, 30, 33, 34, 48.

with 40% not improving after 6 months.[42] Thus, alternative treatment regimens are needed.

Soft tissue treatments are widely used for AT, but strong scientific evidence to support those treatments is lacking.[41,53] The literature provides some evidence that heavy pressure and deep massage might have some positive effect on chronic tendinopathies by promoting healing.[16] Ischemic pressure has been reported to reduce pain from trigger points in office workers.[8] Some studies have linked changes in range of motion (ROM) in plantar flexion and dorsiflexion in the ankle joint to increased risk of overuse symptoms in the muscle-tendon junction of the calf musculature.[50] Muscle tightness has been linked with decreased ROM,[52] but ankle ROM has improved after the release of myofascial trigger points in the soleus,[17] and these trigger points give referred pain to the Achilles tendon area.[17] Thus, relaxing the calf muscles to improve healing in the damaged Achilles tendon might make sense. Pressure massage is a treatment whereby pressure is applied to stiff and painful areas in the calf muscles and held until the muscles relax. Clinical experience indicates quick pain relief and reduced stiffness in the calf muscles, mainly the soleus, and subjectively this treatment has shown some benefit.

The purpose of this study was therefore to investigate whether pressure massage is a useful treatment for AT by comparing it with eccentric exercise treatment. Our first hypothesis was that pressure massage treatment is equivalent or superior to eccentric exercises with regard to pain reduction time (ie, pain would be reduced more quickly with pressure massage). Our second hypothesis was that pressure massage is equivalent or superior to eccentric exercise with regard to function of the calf muscles.

METHODS

This was a prospective, single-blinded, randomized controlled trial (RCT) that compared 3 interventions with repeated measures. The interventions were performed from November 2011 to November 2013. The study was approved by the Icelandic National Bioethics Committee, and the Icelandic Data Protection Authority was informed. All participants signed a written consent form. The first author (S.H.S.), who performed the treatments, was blinded to the test results (ie, did not have access to results until the end of all interventions), and the person who performed the testing was blinded regarding which treatment each patient received. Patients who had been diagnosed with AT were recruited from clinicians and physical therapists and were referred to the first author. The patients were evaluated and asked to join the study if they met the inclusion criteria (Table 1). Study inclusion and exclusion criteria were based on those used in previous AT studies.[19]

TABLE 1
Inclusion/Exclusion Criteria[a]

Inclusion Criteria	Exclusion Criteria
Age ≥18 years	Insertional tendinopathy
Clinically diagnosed with AT by a clinician	History of fracture to the ankle affecting the joint
Pain on palpation over Achilles tendon	Rheumatic conditions
Duration >12 weeks	Circulatory disorders or diabetes
Swelling of tendon	Injuries to the Achilles tendon, other than AT
AT confirmed on ultrasonographic scan	

[a]AT, Achilles tendinopathy.

Sampling and Randomization

After previous RCTs were evaluated, a power calculation was performed with regard to the Victorian Institute of Sports Assessment–Achilles (VISA-A) scores from the original VISA-A article by Robinson and coworkers.[39] The effect size was 5.4 and the standard deviation was 6.3, giving a sample size of 17 per group for 3 groups ($q_1 = 0.33$). Expecting a 10% dropout rate, we aimed for 20 patients in each group. A total of 60 patients entered the study; 30 had unilateral AT and 30 had bilateral AT, and they were placed into 4 categories according to patient sex and age (Figure 1). For allocation into the treatment groups, the first patient in each of the 4 sex and age categories drew a number 1, 2, or 3 and entered that group; the second patient entered the following group, and so on. If the first patient drew group number 2, the next patient would enter group 3, and the third patient group 1.

Treatment

Group 1 patients followed an eccentric exercise protocol for 12 weeks (Table 2) as described by Alfredson et al,[2] in which patients stood on a step, lifted up onto their toes, put their weight on their injured leg, and slowly lowered their heel as far as possible until a maximal stretch was felt. The protocol was performed with both straight knee and bent knee. As pain decreased, extra weight was added, 5 kg at a time. If the patient was pain-free for the full 15 repetitions for 3 sets, another 5 kg was added for the next phase, and so on.

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The authors declared that there are no conflicts of interest in the authorship and publication of this contribution. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.
Ethical approval for this study was obtained from the Icelandic National Bioethics Committee (VSN 11-038).

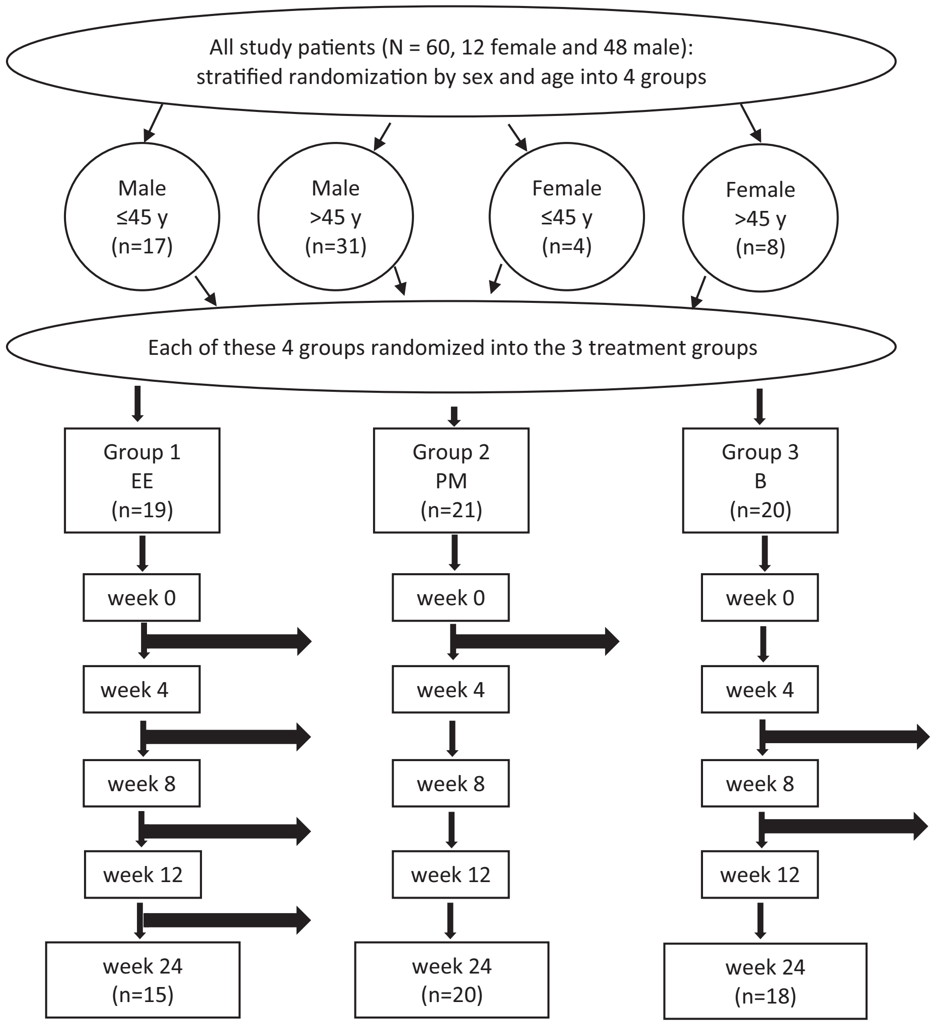

Figure 1. Flowchart of the study design. B, group receiving both eccentric exercise and pressure massage; EE, eccentric exercise group; PM, pressure massage group. Horizontal arrow indicates 1 dropout patient.

TABLE 2
Eccentric Exercise Protocol[a]

Time	Exercise Repetitions
Days 1-2	1 × 10
Days 3-4	2 × 10
Days 5-6	3 × 10
Days 7-14	3 × 15
Weeks 3-12	3 × 15, twice a day

[a]Patients stood on a step, lifted up onto their toes, put their weight on their injured leg, and slowly lowered their heel as far as possible until a maximal stretch was felt.

Each patient was taught how to perform the protocol at the first session with the physical therapist; in addition, patients received written instructions and had access to a video explaining the exercises.

Group 2 patients received pressure massage with a physical therapist twice a week (2 or 3 days between treatments) for 6 weeks and once a week for 6 weeks. The technique used in this study was developed through the clinical experience of the authors. The therapist used his or her knee to put pressure on the soleus muscle at 3 different locations (blue *X*s in Figure 2). Pressure was held until pain started to decrease and the muscle started to relax but not for more than 60 seconds. The patient's pain tolerance was used to control the amount of pressure; with this technique, the patient should always be able to tolerate the pain. If the patient could not tolerate the pressure (ie, it was too painful), pressure was removed, and the patient was allowed to recover before starting the treatment again with less pressure. Typically, the therapist started at a proximal location on the calf and moved down to the muscle-tendon junction, working from a less painful area to the most painful area, just above the Achilles tendon. The therapist then looked for tender or trigger points or stiffness at lateral and medial locations in the soleus (lines in Figure 2).[17] If tender points or trigger points were found on the lines (usually where the *X*s are on the lines in Figure 2), they were treated with

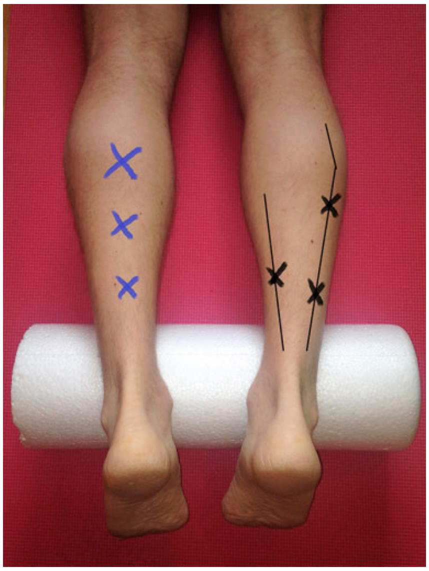

Figure 2. Areas for pressure massage. The blue *X*s indicate areas on which to apply pressure with the knee, the lines indicate where to examine for tender spots with the thumbs, and the black *X*s indicate classic trigger points.

pressure massage with the thumb; 3 or 4 points were treated at each appointment. Pressure was applied according to the patient's pain tolerance. With this technique, patients are expected to feel a sense of relief immediately after the treatment, as if a load has been lifted off the calf, and pain in the Achilles tendon area should be diminished. If patients did not sense this beneficial change, the treatment was repeated with slightly increased pressure. If that did not work, treatment was suspended until the next session, so the muscle could recover. Our clinical experience shows that this sense of relief is crucial for the treatment to produce the desired effect.

Group 3 patients received the same pressure massage program as group 2 and performed the same eccentric exercise protocol as group 1.

Evaluation Tools

Patients were evaluated before treatment and after 4, 8, 12, and 24 weeks (Figure 1). Patient anthropometric values, sex, age, height, weight, and duration of symptoms were gathered. Patients answered the Icelandic version of the VISA-A questionnaire (VISA-A-IS). Pain on palpation in the Achilles tendon was evaluated with an algometer (Somedic AB).[26] Stiffness of the calf muscle was evaluated with a ROM test on the ankle joint.[5] An ultrasonographic (US) scan was used to evaluate Achilles tendon thickness and neovascularization.[24] If patients had unilateral AT, the nonaffected tendon was used as a control to establish whether the pain threshold and ROM were distinguishable between affected and nonaffected tendon. If patients had bilateral symptoms, the tendon with the most symptoms was included in the study.

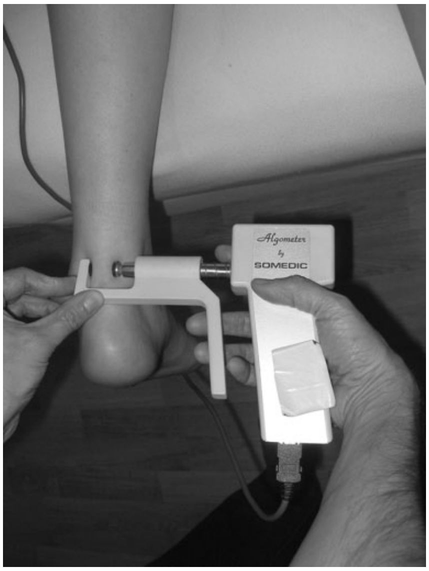

Figure 3. Algometer used to evaluate the pressure pain threshold.

VISA-A-IS Questionnaire. The VISA-A is a self-administered questionnaire that evaluates symptoms of AT and their effect on physical activity. Scores range from 100 to 0, with 100 indicating that the patient is symptom free.[39] To use the VISA-A questionnaire, we had to translate it to Icelandic and test it for reliability and validity. The VISA-A has been tested before and used in AT studies.[21] We used a similar approach to translation and testing to that used for the Swedish version,[44] and we found the Icelandic version to be reliable and valid (Stefansson et al, unpublished data, 2019).

Pressure Pain Threshold. To standardize pressure on palpation of the Achilles tendon, an algometer was used. The algometer has a round plate that is 1 cm in diameter. The plate was pressed on the Achilles tendon in a medial-lateral direction at its most painful spot, and the pressure was increased gradually. The patient lay prone with his or her feet relaxed over the edge of the treatment table, holding a button connected to the algometer (Figure 3). When the pressure from the algometer became painful, the patient pressed the button and the algometer locked in the amount of pressure (in KPa). The use of the algometer is well documented,[7,13] and it has been used in previous AT studies.[7] At each measurement, the test was performed 3 times and the mean calculated.

Range of Motion. To evaluate calf muscle stiffness, an ROM test for ankle dorsiflexion was used. The test entails a standing lunge performed both with the knee bent and with the knee straight. This test has been shown to have high intra- and interrater reliability.[5,29] For the straight-knee condition, the patient stood with the second toe and the center of the calcaneus on a line that was perpendicular to the wall. The knee was bent until it touched the wall, and the heel was slid backward (Figure 4). For the straight-knee condition, the patient placed his or her hands on the wall, held the knee completely straight, and then slid the foot backward (Figure 5). Patients were told to stretch to

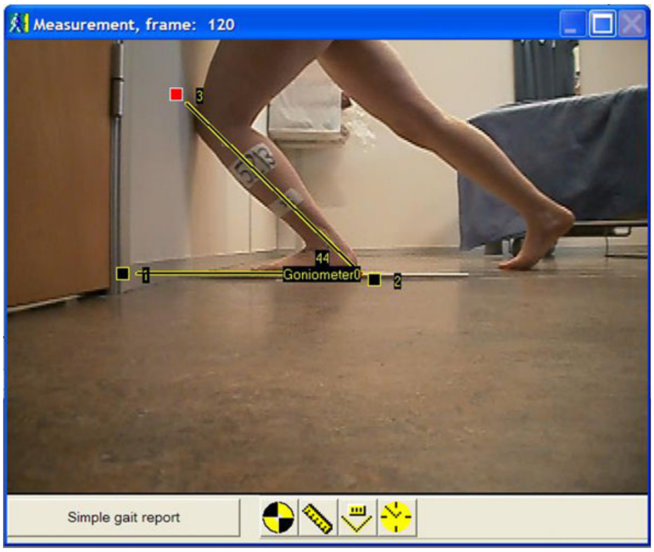

Figure 4. Ankle range of motion measurement in dorsiflexion with the knee bent.

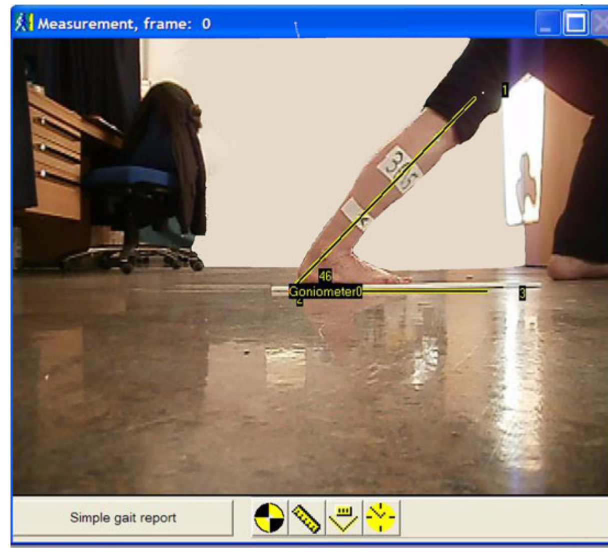

Figure 5. Ankle range of motion measurement in dorsiflexion with the knee straight.

their self-selected limit without pain while maintaining heel contact with the ground. Markers were put on the fibular head and the lateral malleolus. Patients held the stretch for 5 to 10 seconds while a short video was taken with a digital camera (Olympus X-940; Olympus Imaging Corp) placed 5 cm above the floor and 100 cm from the foot. The lens of the camera was perpendicular to the lateral malleolus. The dorsiflexion angle was analyzed with the Kine-View system (KINE ehf). The dorsiflexion was set at 0° when the fibula was perpendicular to the floor, and then the dorsiflexion angle between the fibula and the floor was measured (Figures 4 and 5).

Ultrasound. Real-time US scans were used to confirm diagnosis[24] at 0 weeks, after 12 weeks (end of intervention), and at 24 weeks of follow-up. All measurements were performed by a senior radiologist using a linear, high-frequency, 5- to 12-MHz transducer (Toshiba Xario; Toshiba Medical Systems). Tendon thickness in both the transverse and longitudinal planes (medial-lateral and anterior-posterior thickness) was measured, and neovascularization was determined by Doppler US using the modified Ohberg scale.[43,54] Patients lay prone with their feet relaxed over the edge of the treatment table and ankles in neutral or relaxed position.

Statistical Analysis

All statistical calculations were performed with SAS Enterprise Guide, version 6.100. Descriptive data are presented as means, standard deviations, and 95% confidence levels. Alpha (α) was set at .05. Data were tested for normality by use of the Kolmogorov-Smirnov test. Patient anthropometric values were tested with analysis of variance (ANOVA). VISA-A-IS, pressure pain threshold (PPT), ankle ROM, and US scan measurements were analyzed with mixed-model ANOVA. To establish whether the pain threshold and ROM could distinguish between affected and nonaffected tendons, the 2-sample t test was used.

RESULTS

No significant difference was found in patient anthropometric values between groups (Appendix Table A1). No significant difference was found between the 3 groups at the first measurements (week 0) on any evaluation test. Seven patients dropped out during the study (see Figure 1). Four patients dropped out of group 1; of these, 2 patients said the exercises aggravated their symptoms, and 2 patients said they did not have time. The other 3 patients who dropped out (1 patient in group 2 and 2 patients in group 3) did not give a reason.

VISA-A-IS Scores

VISA-A-IS scores improved significantly over time in all groups ($P < .001$) (Figure 6). In measurement 2 (week 4), group 2 (pressure massage) improved significantly more than group 1 (eccentric exercises) ($P = .03$), but that was the only difference between groups (Figure 6).

Pressure Pain Threshold

The algometer distinguished between the affected and nonaffected tendons in patients with unilateral symptoms ($P < .001$) (Table 3). Pressure pain did not change significantly over the 24-week period in any group or between groups (Table 3).

Ankle ROM

Ankle ROM, in dorsiflexion, increased over time with the knee bent ($P = .006$) (n = 60). With the knee straight, the

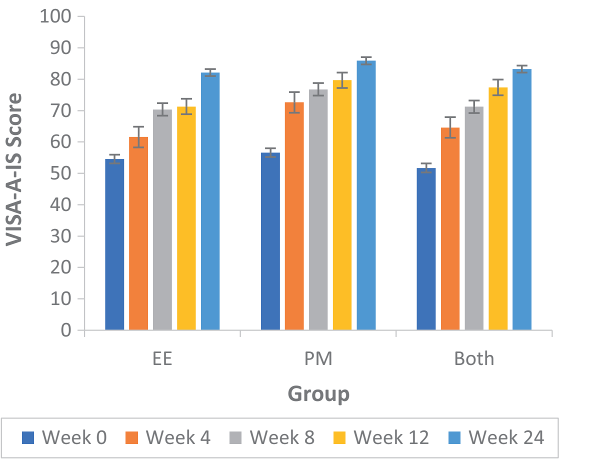

Figure 6. Results of the Icelandic version of the Victorian Institute of Sports Assessment–Achilles (VISA-A-IS) questionnaire over the 24-week period. Error bars indicate SEM. Both, group receiving both eccentric exercise and pressure massage; EE, eccentric exercise group; PM, pressure massage group.

dorsiflexion did not change (Table 4), and no changes were found between groups. No difference was found when the affected tendon was compared with the nonaffected tendon in patients with unilateral AT, with either bent or straight knee.

Ultrasonographic Scans

The US scanning measurements did not change over the period of 24 weeks. No difference was found in either tendon thickness (medial-lateral and anterior-posterior) or neovessel ingrowth in any measurement either within or between groups (Table 5).

TABLE 3
Pressure Pain Threshold as Tested With an Algometer[a]

	Pressure Pain Threshold, KPa	
	Mean ± SD	95% CI
Tendon with Achilles tendinopathy	222.0 ± 103.1	183.5-260.5
Healthy tendon	323.0 ± 158.1	264.3-382.4[b]
Group 1		
Week 0	227.5 ± 90.2	184.0-271.0
Week 4	224.1 ± 66.2	191.1-257.0
Week 8	217.0 ± 66.7	183.9-250.2
Week 12	215.4 ± 125.1	151.0-279.7
Week 24	240.8 ± 80.1	192.4-289.2
Group 2		
Week 0	226.7 ± 86.4	187.3-266.0
Week 4	285.3 ± 137.1	221.2-349.5
Week 8	239.0 ± 105.2	189.8-288.3
Week 12	228.4 ± 82.7	188.5-268.2
Week 24	238.7 ± 100.5	190.2-287.2
Group 3		
Week 0	226.1 ± 130.1	165.2-286.9
Week 4	240.5 ± 131.6	178.8-302.1
Week 8	264.4 ± 124.9	204.2-324.5
Week 12	242.3 ± 86.0	199.5-285.1
Week 24	275.9 ± 105.4	217.6-334.3

[a]Group 1, eccentric exercise; group 2, pressure massage; group 3, eccentric exercise + pressure massage.
[b]Healthy tendons tolerated higher pressure than did tendons with Achilles tendinopathy ($P < .001$) before the pressure turned into pain.

DISCUSSION

Our results showed reduced symptoms in all groups as measured with the VISA-A-IS. The pressure massage group improved significantly more than the eccentric exercise group at week 4 on the VISA-A-IS scale, indicating a faster recovery when pressure massage rehabilitation was used. These findings indicate that with regard to pain reduction time and calf function, pressure massage is at least as good as eccentric exercise, in agreement with our hypothesis. Pressure massage therefore seems a valid treatment and can be used as an alternative to eccentric exercises if they are not successful.

In the literature,[18,48] eccentric exercises are recommended for patients with AT, but because these exercises are less successful in cases of insertional tendinopathy,[36] we excluded patients with insertional problems. In this study we used a similar protocol to Alfredson et al[2] but with a gradual onset of the exercises. This was done to minimize muscle soreness, which is typical after eccentric muscle work. The literature provides no consensus on what protocol to use.[18] The success rate for eccentric exercises in AT is reported to range from 60% to 90%,[25] with the least effect in people living a sedentary lifestyle.[42] To cover all types of AT patients, this study included the general population, not only athletic people. Participants received a written exercise protocol, video instructions were available, and patients performed the exercises at home. A previous study showed that using supervision improves the outcome of home-based treatment.[38]

We developed the new pressure massage technique because eccentric exercises did not work well enough for all of our patients, and we required an alternative treatment. These patients usually had stiffness in their calf muscles, so relaxing the calf muscles with pressure massage seemed logical to reduce the pull on the tendon. After the pressure massage, the patients usually felt an immediate relief of symptoms and reported progress after just 1 treatment. Clinical experience indicates that this immediate relief is crucial for the effectiveness of the pressure massage. We could not find any other studies on the effect of pressure massage in the literature. However, studies on insertional tendinopathy have found that eccentric exercises combined with soft tissue mobilization were superior to eccentric exercises alone.[36] A study linked gastrocnemius stiffness with increased risk of developing AT,[23] and gastrocnemius lengthening seems effective in treating AT.[12] In the literature, evidence suggests that heavy pressure and deep massage might have some positive effect on chronic

TABLE 4
Ankle Dorsiflexion of Affected Tendon With Bent Knee and Straight Knee[a]

	Dorsiflexion With Bent Knee			Dorsiflexion With Straight Knee		
	Mean ± SD	95% CI	*P* Value	Mean ± SD	95% CI	*P* Value
Group 1						
Week 0	37.4 ± 6.1	34.4-40.4		34.3 ± 6.2	31.8-37.9	
Week 4	38.3 ± 5.7	35.5-41.4	NS	33.2 ± 5.3	30.4-35.8	NS
Week 8	38.9 ± 4.5	36.7-41.4	NS	35.2 ± 4.6	32.9-37.5	NS
Week 12	38.8 ± 4.7	36.3-41.2	NS	35.6 ± 4.8	33.2-38.1	NS
Week 24	39.9 ± 5.4	36.7-43.2	.016	35.0 ± 4.4	32.3-37.7	NS
Group 2						
Week 0	38.5 ± 3.4	36.9-40.0		34.9 ± 4.3	32.9-36.8	
Week 4	39.6 ± 4.0	37.7-41.5	NS	35.6 ± 4.4	33.5-37.6	NS
Week 8	39.6 ± 4.4	38.3-42.7	.018	35.7 ± 5.2	33.2-38.2	NS
Week 12	40.5 ± 4.6	38.2-42.7	NS	36.1 ± 4.5	33.9-38.3	NS
Week 24	40.6 ± 4.9	38.3-43.0	NS	36.6 ± 5.7	33.8-39.3	NS
Group 3						
Week 0	39.0 ± 4.2	37.0-41.0		37.9 ± 4.4	35.8-40.0	
Week 4	39.4 ± 5.4	36.8-42.0	NS	35.4 ± 4.8	33.1-37.6	.003
Week 8	40.7 ± 4.2	36.7-42.7	.035	36.3 ± 5.3	33.7-38.8	NS
Week 12	41.0 ± 3.8	39.0-42.8	.033	35.6 ± 4.3	33.4-37.9	NS
Week 24	41.1 ± 4.2	38.8-43.4	NS	37.7 ± 5.9	34.4-41.0	NS

[a]Mean, SD, and CI values are expressed as degrees. Group 1, eccentric exercise; group 2, pressure massage; group 3, eccentric exercise + pressure massage. NS, nonsignificant compared with week 0 values ($P \geq .05$).

TABLE 5
Achilles Tendon Thickness and Degree of Neovascularization on Ultrasonography[a]

	Medial-Lateral Tendon Thickness, mm		Anterior-Posterior Tendon Thickness, mm		Neovascularization[b]	
	Mean ± SD	95% CI	Mean ± SD	95% CI	Mean ± SD	95% Cl
Group 1						
Week 0	14.8 ± 2.6	13.5-16.0	9.7 ± 2.6	8.4-11.0	3.6 ± 1.2	2.8-4.4
Week 12	15.7 ± 3.8	13.4-18.0	10.5 ± 3.2	8.6-12.5	3.0 ± 1.6	2.2-3.8
Week 24	16.5 ± 3.2	14.4-18.5	11.1 ± 2.8	9.3-12.9	3.7 ± 1.2	2.9-4.4
Group 2						
Week 0	15.1 ± 3.2	13.6-16.6	9.8 ± 2.6	8.6-11.0	2.8 ± 1.5	1.9-3.7
Week 12	14.6 ± 2.8	13.0-15.9	9.5 ± 2.2	8.4-10.6	3.8 ± 0.5	3.6-4.1
Week 24	14.6 ± 3.2	12.9-16.3	9.4 ± 2.8	7.9-11.0	3.8 ± 0.6	3.4-4.1
Group 3						
Week 0	15.6 ± 4.4	13.5-17.7	9.8 ± 2.8	8.5-11.0	3.2 ± 1.1	2.6-3.9
Week 12	15.8 ± 3.6	14.0-17.7	10.2 ± 2.8	8.7-11.6	3.6 ± 1.0	3.0-4.1
Week 24	15.3 ± 2.6	13.9-16.8	9.2 ± 2.8	7.9-10.5	3.8 ± 0.6	3.4-4.1

[a]Group 1, eccentric exercise; group 2, pressure massage; group 3, eccentric exercise + pressure massage.
[b]Neovascularization was determined according to the modified Ohberg scale[43,54]: 0 (no vessels visible), 1+ (1 vessel, mostly anterior to the tendon), 2+ (1 or 2 vessels throughout the tendon), 3+ (3 vessels throughout the tendon), or 4+ (>3 vessels throughout the tendon).

tendinopathies by promoting the healing process.[16] This is further supported by the results of an animal study that showed increased fibroblast numbers in muscles after augmented soft tissue mobilization.[9] A study on stretch reflexes in the calf showed that the reflex seems to be hyperactive in patients with AT and is reduced with osteopathic manipulative treatment. Patients showed clinical improvement in soreness, stiffness, and swelling.[20] All of this evidence supports the importance of treating the calf muscle complex in patients with AT.

In this study, we found significantly increased ROM with a bent knee. This can be a sign of decreased stiffness in the deep calf muscles (soleus), which could play a role in the development of AT. A stiff muscle (or a part of a muscle) would pull more on the tendon (or a part of the tendon). Relaxing the muscle decreases the resting tension or might equalize the distribution of forces on the whole tendon, which could encourage recovery. This theory, which is worth exploring, has support in other studies but requires further research. One study stated that static stretching may reduce musculotendinous injuries.[45] As well, eccentric exercises are likely to generate a passive stretch,[3] and a study comparing eccentric exercises versus stretching found no difference between the treatments.[37] If eccentric exercises, stretching, and pressure massage all have similar effects, this could be because they all relax the calf muscles, which could explain the decrease in ankle dorsiflexion angle as well. If that is the case, then self-treatment can be an option for people, and self-massage, stretching, and eccentric exercises can be advocated to relax calf muscles. This could possibly have a preventive effect, but further research is needed to evaluate this possibility.

Pain upon palpation over the Achilles tendon is one of the symptoms of AT.[32] The PPT has been used in AT studies before,[7] but those testers pushed straight down on the tendon (anterior-posterior direction), not in the medial-lateral direction (pinching it) as in the current study. No studies exist measuring pain on palpation and how it changes over longer time periods, but pain has been associated with tendon changes on US scans.[11] PPT in this study did not change over the 24 weeks in any group. Patients tended to become almost pain-free as seen on the VISA-A-IS scores (90 is considered normal[21]), although the tendon was still as sore on palpation as prior to treatment. One possible explanation is that the pain during activity is not coming from the damaged tendon but is referred from the calf muscles by trigger points. A trigger point in the tibialis posterior muscle or soleus can cause referred pain to the Achilles tendon area.[17] Relaxation of the calf muscle can possibly explain why people indicate pain reduction on the VISA-A-IS when treated with pressure massage but the tendon itself is still painful on palpation.

No changes were found on US scans over the 24 weeks. This is in accordance with other studies.[40,49] Tendons heal slowly,[46] and it has been recommended that US scanning not be used to determine whether sports participants are fit to return to play, as US abnormalities persist even after good functional recovery.[24] Our findings strengthen that opinion.

Study Strengths and Limitations

The main strength of this study is its design. Blinding in clinical studies is difficult but important. In this study, the person performing the measurements had no access to group allocations, and patients were instructed not to reveal their group. The person performing the treatment had no access to the measurement results until the end of the interventions. Given the pilot nature of this study, we had only 20 patients in each group, and therefore power was limited with regard to some measurements, as can be seen by the large 95% CI for the PPT. Nevertheless, power was in accordance with other studies using VISA-A as the primary outcome[4,6] and satisfied our power calculations except for the last measurement in group 1, when only 15 participants were available.

There are no similar RCTs in the literature. We recognize the need for a larger RCT to further evaluate the effectiveness of this treatment. We did not include a "wait-and-see" control group because this approach has been shown to be ineffective in treatment for AT.[40] We did not evaluate any ankle biomechanics in this study other than excluding ankle injury, which is a limitation for the ROM measurements. The general public might be more likely than athletes to have muscle soreness after eccentric exercises, and the inclusion of the general public might have meant that the group performing eccentric exercises (group 1) had slower pain relief and more dropouts compared with the pressure massage group. A longer follow-up would have been of great value.

CONCLUSION

Pressure massage is a valid treatment for AT and is at least as effective as eccentric exercises as measured with the VISA-A-IS questionnaire and ROM in ankle dorsiflexion. Symptoms seem to decrease faster with pressure massage than with eccentric exercises. Combining the treatments did not result in a better outcome. Despite decreased pain and improvement in function, pain threshold and US scanning results did not change. Because trigger points might contribute to the pain in AT, we suggest that treatment to the calf muscles be included in future treatments for Achilles tendinopathy.

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REFERENCES

1. Alfredson H. Chronic midportion Achilles tendinopathy: an update on research and treatment. *Clin Sports Med*. 2003;22(4):727-741.
2. Alfredson H, Pietila T, Jonsson P, Lorentzon R. Heavy-load eccentric calf muscle training for the treatment of chronic Achilles tendinosis. *Am J Sports Med*. 1998;26(3):360-366.
3. Allison GT, Purdam C. Eccentric loading for Achilles tendinopathy—strengthening or stretching? *Br J Sports Med*. 2009;43(4):276-279.
4. Bell KJ, Fulcher ML, Rowlands DS, Kerse N. Impact of autologous blood injections in treatment of mid-portion Achilles tendinopathy: double blind randomised controlled trial. *BMJ*. 2013;346:F2310.
5. Bennell KL, Talbot RC, Wajswelner H, Techovanich W, Kelly DH, Hall AJ. Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. *Aust J Physiother*. 1998;44(3):175-180.
6. Beyer R, Kongsgaard M, Kjaer BH, Ohlenschlaeger T, Kjaer M, Magnusson SP. Heavy slow resistance versus eccentric training as treatment for Achilles tendinopathy: a randomized controlled trial. *Am J Sports Med*. 2015;43(7):1704-1711.
7. Bussin ER, Cairns B, Bovard J, Scott A. Randomised controlled trial evaluating the short-term analgesic effect of topical diclofenac on chronic Achilles tendon pain: a pilot study. *BMJ Open*. 2017;7(4): e015126.
8. Cagnie B, Dewitte V, Coppieters I, Van Oosterwijck J, Cools A, Danneels L. Effect of ischemic compression on trigger points in the neck

and shoulder muscles in office workers: a cohort study. *J Manipulative Physiol Ther*. 2013;36(8):482-489.
9. Davidson CJ, Ganion LR, Gehlsen GM, Verhoestra B, Roepke JE, Sevier TL. Rat tendon morphologic and functional changes resulting from soft tissue mobilization. *Med Sci Sports Exerc*. 1997;29(3): 313-319.
10. de Jonge S, van den Berg C, de Vos RJ, et al. Incidence of midportion Achilles tendinopathy in the general population. *Br J Sports Med*. 2011;45(13):1026-1028.
11. De Jonge S, Warnaars JL, De Vos RJ, et al. Relationship between neovascularization and clinical severity in Achilles tendinopathy in 556 paired measurements. *Scand J Med Sci Sports*. 2014;24(5):773-778.
12. Duthon VB, Lubbeke A, Duc SR, Stern R, Assal M. Noninsertional Achilles tendinopathy treated with gastrocnemius lengthening. *Foot Ankle Int*. 2011;32(4):375-379.
13. Fredberg U, Bolvig L, Pfeiffer–Jensen M, Clemmensen D, Jakobsen B, Stengaard-Pedersen K. Ultrasonography as a tool for diagnosis, guidance of local steroid injection and, together with pressure algometry, monitoring of the treatment of athletes with chronic jumper's knee and Achilles tendinitis: a randomized, double-blind, placebo-controlled study. *Scand J Rheumatol*. 2004;33(2):94-101.
14. Frohm A, Saartok T, Halvorsen K, Renstrom P. Eccentric treatment for patellar tendinopathy: a prospective randomised short-term pilot study of two rehabilitation protocols. *Br J Sports Med*. 2007;41(7):e7.
15. Gardin A, Movin T, Svensson L, Shalabi A. The long-term clinical and MRI results following eccentric calf muscle training in chronic Achilles tendinosis. *Skeletal Radiol*. 2010;39(5):435-442.
16. Gehlsen GM, Ganion LR, Helfst R. Fibroblast responses to variation in soft tissue mobilization pressure. *Med Sci Sports Exerc*. 1999;31(4): 531-535.
17. Grieve R, Clark J, Pearson E, Bullock S, Boyer C, Jarrett A. The immediate effect of soleus trigger point pressure release on restricted ankle joint dorsiflexion: a pilot randomised controlled trial. *J Bodyw Mov Ther*. 2011;15(1):42-49.
18. Habets B, van Cingel RE. Eccentric exercise training in chronic midportion Achilles tendinopathy: a systematic review on different protocols. *Scand J Med Sci Sports*. 2015;25(1):3-15.
19. Herrington L, McCulloch R. The role of eccentric training in the management of Achilles tendinopathy: a pilot study. *Phys Ther Sport*. 2007;8(4):191-196.
20. Howell JN, Cabell KS, Chila AG, Eland DC. Stretch reflex and Hoffmann reflex responses to osteopathic manipulative treatment in subjects with Achilles tendinitis. *J Am Osteopath Assoc*. 2006;106(9): 537-545.
21. Iversen JV, Bartels EM, Langberg H. The Victorian Institute of Sports Assessment–Achilles questionnaire (VISA-A)—a reliable tool for measuring Achilles tendinopathy. *Int J Sports Phys Ther*. 2012;7(1):76-84.
22. Jonsson P, Alfredson H, Sunding K, Fahlstrom M, Cook J. New regimen for eccentric calf-muscle training in patients with chronic insertional Achilles tendinopathy: results of a pilot study. *Br J Sports Med*. 2008;42(9):746-749.
23. Kaufman KR, Brodine SK, Shaffer RA, Johnson CW, Cullison TR. The effect of foot structure and range of motion on musculoskeletal overuse injuries. *Am J Sports Med*. 1999;27(5):585-593.
24. Khan K, Forster B, Robinson J, et al. Are ultrasound and magnetic resonance imaging of value in assessment of Achilles tendon disorders? A two year prospective study. *Br J Sports Med*. 2003;37(2): 149-153.
25. Kingma JJ, de Knikker R, Wittink HM, Takken T. Eccentric overload training in patients with chronic Achilles tendinopathy: a systematic review. *Br J Sports Med*. 2007;41(6):e3.
26. Kinser AM, Sands WA, Stone MH. Reliability and validity of a pressure algometer. *J Strength Cond Res*. 2009;23(1):312-314.
27. Knobloch K, Schreibmueller L, Kraemer R, Jagodzinski M, Vogt PM, Redeker J. Gender and eccentric training in Achilles mid-portion tendinopathy. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(5): 648-655.
28. Knobloch K, Schreibmueller L, Longo UG, Vogt PM. Eccentric exercises for the management of tendinopathy of the main body of the Achilles tendon with or without the AirHeel Brace: a randomized controlled trial. A: effects on pain and microcirculation. *Disabil Rehabil*. 2008;30(20-22):1685-1691.
29. Konor MM, Morton S, Eckerson JM, Grindstaff TL. Reliability of three measures of ankle dorsiflexion range of motion. *Int J Sports Phys Ther*. 2012;7(3):279-287.
30. Kulig K, Lederhaus ES, Reischl S, Arya S, Bashford G. Effect of eccentric exercise program for early tibialis posterior tendinopathy. *Foot Ankle Int*. 2009;30(9):877-885.
31. Kvist M. Achilles tendon injuries in athletes. *Sports Med*. 1994;18(3): 173-201.
32. Maffulli N, Sharma P, Luscombe KL. Achilles tendinopathy: aetiology and management. *J R Soc Med*. 2004;97(10):472-476.
33. Maffulli N, Walley G, Sayana MK, Longo UG, Denaro V. Eccentric calf muscle training in athletic patients with Achilles tendinopathy. *Disabil Rehabil*. 2008;30(20-22):1677-1684.
34. Mafi N, Lorentzon R, Alfredson H. Superior short-term results with eccentric calf muscle training compared to concentric training in a randomized prospective multicenter study on patients with chronic Achilles tendinosis. *Knee Surg Sports Traumatol Arthrosc*. 2001;9(1): 42-47.
35. Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. *Clin J Sport Med*. 2009;19(1):54-64.
36. McCormack JR, Underwood FB, Slaven EJ, Cappaert TA. Eccentric exercise versus eccentric exercise and soft tissue treatment (Astym) in the management of insertional Achilles tendinopathy. *Sports Health*. 2016;8(3):230-237.
37. Nørregaard J, Larsen CC, Bieler T, Langberg H. Eccentric exercise in treatment of Achilles tendinopathy. *Scand J Med Sci Sports*. 2007; 17(2):133-138.
38. Ram R, Meeuwisse W, Patel C, Wiseman DA, Wiley JP. The limited effectiveness of a home-based eccentric training for treatment of Achilles tendinopathy. *Clin Invest Med*. 2013;36(4):e197-e206.
39. Robinson JM, Cook JL, Purdam C, et al. The VISA-A questionnaire: a valid and reliable index of the clinical severity of Achilles tendinopathy. *Br J Sports Med*. 2001;35(5):335-341.
40. Rompe JD, Nafe B, Furia JP, Maffulli N. Eccentric loading, shock-wave treatment, or a wait-and-see policy for tendinopathy of the main body of tendo Achillis: a randomized controlled trial. *Am J Sports Med*. 2007;35(3):374-383.
41. Rowe V, Hemmings S, Barton C, Malliaras P, Maffulli N, Morrissey D. Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic review and clinical reasoning. *Sports Med*. 2012;42(11):941-967.
42. Sayana MK, Maffulli N. Eccentric calf muscle training in non-athletic patients with Achilles tendinopathy. *J Sci Med Sport*. 2007;10(1): 52-58.
43. Sengkerij PM, de Vos RJ, Weir A, van Weelde BJ, Tol JL. Interobserver reliability of neovascularization score using power Doppler ultrasonography in midportion Achilles tendinopathy. *Am J Sports Med*. 2009;37(8):1627-1631.
44. Silbernagel KG, Thomee R, Karlsson J. Cross-cultural adaptation of the VISA-A questionnaire, an index of clinical severity for patients with Achilles tendinopathy, with reliability, validity and structure evaluations. *BMC Musculoskelet Disord*. 2005;6:12.
45. Small K, Mc Naughton L, Matthews M. A systematic review into the efficacy of static stretching as part of a warm-up for the prevention of exercise-related injury. *Res Sports Med*. 2008;16(3):213-231.
46. Sunding K, Fahlstrom M, Werner S, Forssblad M, Willberg L. Evaluation of Achilles and patellar tendinopathy with greyscale ultrasound and colour Doppler: using a four-grade scale. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(6):1988-1996.
47. Tan SC, Chan O. Achilles and patellar tendinopathy: current understanding of pathophysiology and management. *Disabil Rehabil*. 2008; 30(20-22):1608-1615.
48. van der Plas A, de Jonge S, de Vos RJ, et al. A 5-year follow-up study of Alfredson's heel-drop exercise programme in chronic midportion Achilles tendinopathy. *Br J Sports Med*. 2012;46(3):214-218.

49. van Snellenberg W, Wiley JP, Brunet G. Achilles tendon pain intensity and level of neovascularization in athletes as determined by color Doppler ultrasound. *Scand J Med Sci Sports*. 2007;17(5):530-534.
50. Whitting JW, Steele JR, McGhee DE, Munro BJ. Dorsiflexion capacity affects Achilles tendon loading during drop landings. *Med Sci Sports Exerc*. 2011;43(4):706-713.
51. Woodley BL, Newsham-West RJ, Baxter GD. Chronic tendinopathy: effectiveness of eccentric exercise. *Br J Sports Med*. 2007;41(4): 188-198.
52. You JY, Lee HM, Luo HJ, Leu CC, Cheng PG, Wu SK. Gastrocnemius tightness on joint angle and work of lower extremity during gait. *Clin Biomech (Bristol, Avon)*. 2009;24(9):744-750.
53. Zwiers R, Wiegerinck JI, van Dijk CN. Treatment of midportion Achilles tendinopathy: an evidence-based overview. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(7):2103-2111.
54. Öhberg L, Alfredson H. Ultrasound guided sclerosis of neovessels in painful chronic Achilles tendinosis: pilot study of a new treatment. *Br J Sports Med*. 2002;36:173-177.

APPENDIX

TABLE A1
Patient Anthropometric Values for the Study Groups

	Group 1		Group 2		Group 3	
	Mean ± SD	95% CI	Mean ± SD	95% CI	Mean ± SD	95% CI
Age, y	46.0 ± 12.9	39.6-52.4	42.3 ± 11.1	37.2-47.3	46.0 ± 9.9	41.4-50.7
Height, cm	177.0 ± 7.7	173.0-181.0	178.0 ± 8.4	174.0-181.0	178.0 ± 6.0	175.0-180.0
Weight, kg	93.1 ± 18.6	83.8-102.4	87.0 ± 14.2	80.5-93.5	87.1 ± 21.7	77.0-97.3
Body mass index	29.7 ± 4.8	27.2-32.1	27.4 ± 3.3	25.9-29.0	27.6 ± 7.3	24.1-31.1
Symptom duration, mo	28.8 ± 39.7	8.4-49.2	22.3 ± 31.4	8.0-36.6	34.1 ± 40.5	15.2-53.1