

## Eccentric exercise in treatment of Achilles tendinopathy

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Accepted for publication 23 January 2006

**Aim:** Prognosis and treatment of Achilles tendon pain (achillodynia) has been insufficiently studied. The purpose of the present study was to examine the long-term effect of eccentric exercises compared with stretching exercises on patients with achillodynia. **Methods:** Patients with achillodynia for at least 3 months were randomly allocated to one of two exercise regimens. Exercise was performed daily for a 3-month period. Symptom severity was evaluated by tendon tenderness, ultrasonography, a questionnaire on pain and other symptoms, and a global assessment of improvement. Follow-up was performed at time points 3, 6, 9, 12 weeks and 1 year. **Results:** Of 53 patients with

achillodynia 45 patients were randomized to either eccentric exercises or stretching exercises. Symptoms gradually improved during the 1-year follow-up period and were significantly better assessed by pain and symptoms after 3 weeks and all later visits. However, no significant differences could be observed between the two groups. Women and patients with symptoms from the distal part of the tendon had significantly less improvement. **Conclusions:** - Marked improvement in symptoms and findings could be gradually observed in both groups during the 1-year follow-up period. To that extent this is due to effect of both regimens or the spontaneous improvement is unsettled.

Achilles tendon pain (achillodynia) is common in recreational runners and athletes whose training contains a large amount of running and jumping (Kvist, 1994). The pathophysiology of the chronic tendon disorders has not yet been fully elucidated, but pathoanatomic findings may include degenerative changes (tendinosis), inflammation of tendon or peritenon or partial rupture, the degenerative changes being the most common finding (Leadbetter, 1992; Khan et al., 1999; Kannus et al., 2002). Typical symptoms are morning stiffness and disabling pain especially after exercise, including swelling of the tendon and tenderness.

Ultrasonography has shown good accuracy when compared with gold standard as operative or pathological findings (Kainberger et al., 1990; Kalebo et al., 1992; Sell et al., 1997). The ultrasonographic findings include tendon thickening, edema, fibril discontinuity, calcifications, partial/total ruptures and bursitis.

Treatment of Achilles pain is often difficult, and the latest Cochrane review states no treatment to be evaluated as sufficiently proven (McLauchlan & Handoll, 2001). Short-term studies have shown the effect of ultrasonographically guided steroid injections around the tendon; however, the improvement does not seem to persist (Fredberg et al., 2004). Recent studies by Swedish groups have suggested

improvement of symptoms by eccentric exercises (Alfredson et al., 1998; Mafi et al., 2001; Silbernagel et al. 2001; Fahlstrom et al., 2003; Ohberg et al., 2004). These results have however not been replicated by other groups. The aim of the present study was to examine whether eccentric exercises improve achillodynia. As a “control treatment” stretching exercise of the tendon was chosen, as stretching is often recommended to patients with Achilles tendon pain, and no evidence was found for a positive effect of stretching exercises on achillodynia.

### Methods

#### Patients

Consecutive patients with non-traumatic pain in the Achilles tendon area with a duration of 3 months or more were examined for participation in the study. All patients were recruited by the Clinic of Sports Medicine, Bispebjerg Hospital from January 1999 till July 2000. Some patients were referred for treatment at the clinic; others were recruited by advertisements in local sports clubs.

Inclusion criteria were as follows.

1. Pain in the Achilles tendon area with one of the two following findings.
  - a. Distinct tenderness of Achilles tendon with no pain in the neighboring structures.

- b. Ultrasonographic changes defined as local thickening of the symptomatic tendon or a globally more than 2 mm thicker tendon on the sick side.
2. Diffuse pain in the posterior region of the ankle with local tenderness of the Achilles tendon and ultrasonographic changes (as described above).

Exclusion criteria were as follows.

- Treatment of achillodynia with stretching or eccentric training for more than 2 weeks within the last 2 years.
- Other injuries in the lower extremity or the knee, which by the examining doctor was evaluated to influence the evaluation of symptoms or the ability to perform the training program.
- Acute symptoms with ultrasonographic changes consistent with a partial rupture of the tendon.
- Age less than 18 years or over 70 years.
- Previous operation on the tendon or steroid injections.

Fifty-three patients fulfilled inclusion criteria, of which 45 accepted to participate in the randomized-controlled treatment study. They were randomized to one of the two rehabilitation regimens by a computer using a minimization procedure to prevent differences in sex, age and duration of symptoms.

In order to study the inter-investigator variability of the examination 20, of the included patients (29 symptomatic tendons) were examined twice by two different doctors (J. N., L. D.).

#### Outcome variables

Manually assessed tenderness, ultrasonography, self-reported symptoms in questionnaire and patient's global assessment were used as outcome parameters.

#### Manually assessed tenderness score

The tenderness of the symptomatic tendons was determined manually by applying a moderate amount of pressure (about 1 kg) with the first and second finger on each side of the tendon. The tendon was palpated 0, 1, 3, 5, 7 and 10 cm proximal to the calcaneal insertion, and at each level the tenderness score was noted according to the subjects' answers of the pain perceived (0 = none, 1 = mild, 2 = moderate and 3 = severe).

#### Ultrasonography

Ultrasonography was performed with the patient in a prone position and the feet hanging free in a neutral position over the end of the table. A Sonoline Versa Pro ultrasonographic equipment (Siemens, Erlangen, Germany) with a 7.5 MHz linear-array transducer was used. Care was taken to place the transducer strictly orthogonal to the tendon. In all patients both tendons were scanned in a longitudinal/sagittal projection and the thickness was measured at 3 cm cranial to the calcaneal insertion and at the site of maximal thickness. Moreover, qualitative findings such as intra-tendinous edema, fiber splitting and calcifications were noted and graded (0 = none, 1 = mild, 2 = moderate and 3 = severe). All examinations were performed by one skilled doctor (J. N.).

Subjects were subsequently classified as enthesopathy (insertion-related disease) if the pain and thickening of the tendon was more pronounced at the insertion (0–1 cm) com-

pared with the area 3 cm proximal to the insertion at the calcaneus.

#### Questionnaire

The subjective symptoms of each patient were evaluated with a self-composed questionnaire, as no validated questionnaire for assessment of achillodynia existed when the study was initiated. The questionnaire was a modification of the knee injury and osteoarthritis outcome score (KOOS) questionnaire of knee injuries (Roos et al., 1998). Some of the KOOS questions were left out and a few new questions were added. Like the original KOOS scale, the questions were organized into dimensions: symptoms (swelling, redness, heat), pain (at night, when sitting down, standing, walking, stair-climbing, running, jumping, etc.), stiffness (when awakening in the morning, after sitting or lying down) and quality of life (how often they experienced symptoms and changes activities). These options for answering the questions were no (= 0), mild (= 1), moderate (= 2), severe (= 3) or extreme (= 4) pain. For quality of life answers were never (= 0), each month (= 1), each week (= 2), every day (= 3) and all the time (= 4). Each question in the questionnaire received a score and a mean score were calculated for the four dimensions. The patients with symptoms from both tendons only filled out one questionnaire for the tendon where the worst pain was experienced, as they were found to have large difficulties in differentiating between symptoms from the two tendons. There were also questions about participation in sports (what kind of sport and how many hours a week).

#### Patient's global assessment

The patients were asked to what extent the symptoms from the sick tendon had changed. The answers were graded into eight ordinal categories: much worse, moderately deteriorated, slightly deteriorated, unchanged, slightly improved, moderately improved, very significantly improved and completely cured.

#### Exercise regimens

The patients were randomized to either stretching exercises or eccentric exercise as previously described (Alfredson et al., 1998). The patients in both groups were told that the exercises they should perform had a positive effect on Achilles tendon symptoms. Patients in both treatment groups were instructed to perform the exercise regimen for the injured leg twice daily for a period of 12 weeks. They were shown the exercises and given a written instruction with illustrations. After 3 weeks they were seen at a follow-up visit, where it was controlled that they performed the exercises as intended. They were allowed to continue ongoing pain-free sporting activities, but were told not to take up new activities or increase the amount of training. The patients were instructed to register the number of repetitions, sessions and load (eccentric group) in a training diary. The diary was not systematically delivered and only scarce data are presented here in the paper.

#### Eccentric exercises

The patients were instructed to stand with straight legs on a small step, lift up on the toes, hereafter put the weight on the injured leg and slowly lower the heel as far as possible until they felt a maximal stretch of the calf muscles and/or the Achilles tendon. The exercises were repeated 15 times. Then the patients were told to repeat the exercises with semi-flexed

knee. If possible the series should be repeated twice increasing to three times at each session. If pain decreased they should increase the load on the Achilles tendons by wearing a rug sack and increasing the weight of the rug sack by adding weights (5 kg each). The patients were told that some pain was to be expected from the tendon during exercise, but that increasing daily pain or morning stiffness indicated that the exercises had been progressed too fast.

*Stretching exercises*

The patients were instructed in standing stretching exercises of the gastrocnemius (straight leg) and soleus (bended knee). The stretch was slowly increased and maintained for 30 s. This stretch was to be repeated five times during each session. The patients were instructed that the stretching should be pain free, although a small degree of unpleasantness was allowed.

*Time schedule and practical follow-up*

It was planned that the patients were objectively examined (ultrasonography and tenderness) at inclusion and after 12 and 39 weeks. Furthermore they were told to fill out the questionnaire after 1, 3, 6, 12 and 39 weeks and global assessment was performed at 12 and 39 weeks. Although much effort was made to include all the patients at the follow-ups, not all participants attended the planned visits despite being contacted by phone or letter. This was primarily due to many of the patients being young athletes with busy lives. Due to lack of resources and low attention from the patients, the vast majority did not show up at 39 weeks, and the final follow-up was instead performed after a mean of 424 days (SD = 110). Therefore we use the term 1 year in the following.

*Ethics*

The study was approved by the local scientific ethical committee ((KF) 01–157/98, (KF) 01–109/99), and signed informed consent was obtained from all participants.

*Statistical analysis*

Changes in outcome parameters within groups were analyzed using the paired *t*-test, and differences between the two treatment groups by unpaired *t*-test. Mann–Whitney’s test was used to compare the ordinal global assessments. Reproducibility of qualitative ultrasonographic findings and of the manually assessed tenderness scores was analyzed by  $\kappa$  statistics. The inter-observer reproducibility of the tendon thickness was assessed by calculating the standard deviation of the differences. Correlation analysis (Spearman) was performed to examine whether outcome was related to pre-treatment characteristics. A significance level of 5% was chosen for comparisons within and between groups. A level of 1% was chosen for the correlation analysis to correct for many comparisons performed. All statistical calculations were performed with the MINITAB statistical program.

**Results**

*Inter-observer study*

*Tenderness*

The tenderness score was highest (mean > 0.7 for symptomatic tendons) at sites 1, 3 and 5 cm above

Table 1. Baseline characteristic of the two groups, given as mean and SEM

Variable	Eccentric	Stretching
Age	41 (2)	43 (2)
% Males	48	54
Symptom duration (months)	26 (9)	31 (8)
Bilateral symptoms (%)	52	46
Number with enthesopathy	4	3

calcaneus. At each of these sites tenderness was reliably assessed with  $\kappa$  values between 0.6 and 0.7. At the other sites reproducibility was low with a  $\kappa$  value < 0.4. Therefore we chose only to use the mean score of tenderness at 1, 3 and 5 cm as a score of mean tenderness.

*Ultrasonographic findings*

The assessment of edema and fiber splitting was poorly reproducible with  $\kappa$  values < 0.4. Calcium deposits were only found in two to three tendons. Therefore these parameters were not used in the further analysis. The mean thickness at 3 cm was  $5.8 \pm 0.9$  mm and the mean diameter at the point of maximal thickness was  $6.6 \pm 0.8$  mm. The SD of the differences between observers was 0.9 and 0.8 mm, respectively.

*Randomized controlled study*

There were no significant differences in the baseline characteristics in the two treatment groups (Table 1). Of the 45 randomized patients, four patients were excluded at the first follow-up control visit after 3 weeks, one at 6, 9 and 12 weeks each, and 10 at the final follow-up control visit after 1 year for different reasons. Two patients reported an increase in symptoms and treatment was excluded for that reason. The rest were excluded because they did not attend the follow-up. In summary, 38 of the 45 randomized subjects were followed for at least 3 months. Some patients did not attend all visits; the exact number are shown in the tables. The compliance to exercises was high in the vast majority of subjects evaluated from there training diaries. The analysis of the data analyzed includes all randomized subject attending the follow-up visits. Significant improvements could be observed in all observed questionnaire dimensions (Table 2), with no differences between the eccentric and the stretching exercise group. With regard to tenderness and ultrasonography the results at 12 weeks were slightly improved (Table 3), and at the final follow-up visit at 12 months significant improvement could be observed in all parameters. No significant differences could be observed between the

Table 2. Self-reported symptoms in questionnaire and changes at time points 3–52 weeks presented as mean (SEM)

Visit	0		1		2		3		4		5	
	E	S	E	S	E	S	E	S	E	S	E	S
Number of patients $\Omega$	45	18	17	14	16	11	14	13	17	8	7	
Follow-up day	0	25 (4)		45 (5)		66 (4)		90 (10)		353 (66)		
mean (SD)												
Symptoms	1.7 (1.0)	0.5 (0.3)	0.6 (0.2)*	0.6 (0.2)+	0.7 (0.2)*	1.1 (0.2)*	0.6 (0.2)*	0.8 (0.2)*	0.7 (0.3)+	1.3 (0.4)*	0.6 (0.6)	
Pain	1.6 (0.6)	0.1 (0.1)	0.2 (0.1)	0.3 (0.1)+	0.3 (0.1)+	0.4 (0.2)+	0.3 (0.2)	0.4 (0.2)	0.4 (0.2)+	1.0 (0.2)*	0.7 (0.2)+	
Stiffness	1.9 (0.9)	0.3 (0.2)	0.1 (0.1)	0.4 (0.2)	0.0 (0.1)	0.7 (0.2)+	0.3 (0.2)	0.5 (0.3)	0.5 (0.2)	1.0 (0.5)	0.6 (0.5)	
Quality of life	2.5 (0.7)	0.1 (0.1)	0.1 (0.1)	0 (0.2)	0.3 (0.1)+	0.4 (0.3)	0.3 (0.1)	0.3 (0.3)	0.5 (0.3)	1.1 (0.5)	1.0 (0.4)+	

$\Omega$ : variation in number due to missing patients.

Significance level symbolized with \* < 0.01, + < 0.05 using paired *t*-test with comparison with the baseline value of the treatment group.

E, eccentric exercises; S, stretching exercises.

Table 3. Ultrasonographic thickness and tenderness at inclusion and the changes after 3 months and at the final visit

	Inclusion: all	3 months (patients = 27)		1 year (patients = 28)	
		Eccentric	Stretching	Eccentric	Stretching
Tendon number	67	21	24	22	21
Thickness at 3 cm (mm), mean (SD)	6.6 (1.7)	0.4 (0.3)	-0.4 (0.2)	-1.0 (0.3)*	-0.6 (0.3)
Maximal thickness, mean (SD)	7.6 (2.1)	0.6 (0.3)	-0.1 (0.2)	-1.3 (0.4)*	-0.7 (0.3)+
Tenderness, mean (SD)	0.7 (0.4)	-0.2 (0.2)	-0.3 (0.2)	-0.7 (0.1)*	-0.7 (0.2)*
Maximum tenderness, mean (SD)	1.7 (1.0)	-0.4 (0.2)+	-0.3 (0.2)	-1.3 (0.2)*	-1.0 (0.3)*

Significance level indicated with \* < 0.01, + < 0.05 using paired *t*-test with comparison with the baseline value of the treatment group.

Table 4. Evaluation of global improvement at 3 months and at the final follow-up

Treatment	3 months		1 year	
	Eccentric	Stretching	Eccentric	Stretching
Number of tendons	21	24	23	19
Moderate deterioration	0	2	0	0
Slight deterioration	1	0	0	1
Unchanged	5	6	1	2
Slight improvement	6	5	1	0
Moderate improvement	4	6	0	4
Very significant improvement	5	2	12	5
Completely cured	0	3	9	7

two treatment groups. Evaluated from the patient’s global assessment, the vast majority of tendons were reported to be relatively unchanged after 3 months, but markedly improved at the final visit (Table 4). No significant differences in any of the presented parameters between treatments could be detected.

*Predictors of outcome*

We further examined whether some pre-treatment characteristics (e.g., sex, age, symptom duration, previous sports activity, ultrasonographic thickness, tenderness, location of maximum tenderness) were related to outcome parameters and changes in these after 12 weeks and 1 year. The initial maximal ultrasonographic thickness (of both sides) at 3 cm

was significantly negatively correlated to pain intensity after 12 months ( $r = -0.73$ ;  $P < 0.01$ ) and maximal thickness was correlated to quality of life ( $r = -0.66$ ;  $P < 0.01$ ); thus thicker tendons had a better prognosis. Women had significantly poorer improvement in pain and stiffness ( $P < 0.01$ ) after 3 months. The global assessment of improvement was also poorer in women ( $P = 0.02$ ) after 3 months. In those with insertion pathology the global assessment was poorer after 3 months compared with the other patients ( $P < 0.01$ ).

*Other variables*

There was no significant correlation between changes in ultrasonographic thickness and changes in symp-

toms. The self-reported weekly amount of physical activities was reduced with 3 h weekly after 3 weeks ( $P < 0.01$ ). After 6 weeks, 3 months and 1 year the physical activity level was still reported to be approximately 1 h lower in average compared with before the injury (NS) mainly due to a lower amount of running.

### Discussion

We found significant improvements of symptoms and pain in both the eccentric training group and the stretching group at the 3 weeks visit and later. After 1 year a marked improvement was found in the vast majority of the patients. Whether this is due to a spontaneous healing of the tissue or because both the treatment principles had an effect cannot be concluded. A recent study could indicate an effect of stretching exercises (Porter et al., 2002). However, no control group was included in that study.

The questionnaire and the global assessment indicated only minor improvement in both eccentric and stretching exercise groups after 3 months. This is in contrast to the studies by the Swedish research group, where a marked improvement after 3 months has been documented using the same eccentric exercises as in the present study (Alfredson et al., 1998; Fahlstrom et al., 2003). The reason for this discrepancy is unknown. In general we used the same training regimen as previously described as effective, but the supervision of the exercises was not as constant in the present study as in the previous studies, which could result in differences in the compliance and thus the amount of training performed.

Furthermore, it seems as if the physiotherapist in the previously published studies might have urged the patient to exercise in spite of increasing amount of pain from the tendon, which we did not do in the present study.

Another possible explanation could be that the patients included in the previous studies were different from the ones used in the present study. The physical activity level of the patients before the injuries might have been important for the success of the treatment. We mainly used ordinary subjects with no specific athletic background as well as the patients in the present study were older than the ones previously used. This could be of importance for the perception and acceptance of pain, and thus the effectiveness of the eccentric training regime.

In addition a recent publication suggests that the eccentric exercises is primarily effective in the mid-portion type of Achilles tendinopathy (Alfredson,

2003). We used wider inclusion criteria and some of the patients had insertion site pathology and others had only small changes evaluated from ultrasonography. We cannot specify how many of the patients had mid-portion Achilles tendinopathy, but definitely fewer patients than in the previously published studies.

Another patient-related aspect is sex. We observed tendencies toward a poorer prognosis in women, and relatively more women were included in the present study compared with previously (Ohberg et al., 2004). As females are known to have increased and prolonged pain sensations in many pain chronic and acute conditions in humans and animals, maybe due to central nervous mechanism (Rollman, 2003), this could have influenced the present results.

In addition to the above-mentioned reasons for the discrepancy in the results obtained compared with the literature, the way in which the patients were asked about their symptoms may have influenced the results. We used questionnaires in contrast to previous studies where direct interviews were used (Alfredson, 1998). The relationship between the patient and the therapist may have influenced the answers.

Surprisingly, we found that a thick symptomatic tendon was associated with a good outcome after 1 year, and furthermore we found no correlation between reduction in tendon thickness and symptoms. These findings are to some extent in contrast to a previous study where ultrasonographic thickness of Achilles and patellar tendons was a predictor of poor outcome (Fredberg et al., 2004). However, this study was performed on highly active soccer players, who did not have any symptoms from the tendons at the time of the ultrasound scan. In other studies on patellar tendons (Cook et al., 2001) and Achilles tendons (Archambault et al., 1998; Khan & Kannus, 2000), hypoechogenicity was not associated with later symptoms. The present study provides no data on the reason for subjects with thin tendons having a poorer prognosis, but one reason could be heterogeneity of the diagnosis and a difference in the etiology of the pain. Perhaps some of the patients with thin tendons have pain due to another mechanism than the subjects with thick tendons, e.g., central pain mechanisms might be of greater importance. The above aspect regarding the poorer prognosis of women might also be of importance.

In conclusion, the present study emphasize that achillodynia in a mixed population of patients is treated with good results by both eccentric training and stretching. In addition, the data may indicate that the acceptance of pain during eccentric loading may be of importance for the excellent results previously published.

## Perspectives

We found significant but rather small improvements in symptom and pain after 3 months of eccentric or stretching exercises in patients with achillodynia. The relatively slow improvement might be due to a lower intensity of exercise than in previously published studies. However, after 12 months a marked improvement was observed in both treatment groups. This long-term response confirms that conservative non-surgical treatment is advisable in patients with even longstanding symptoms. Further studies are needed to confirm that stretching exercises match the results of eccentric exercises and to study treat-

ment in sub-groups (according to sex, thickness and location of pathology).

**Key words:** randomized-controlled trial, reliability, prognosis.

## Acknowledgements

The Institute of Disease Prevention (Christian Gluud) is acknowledged for help in planning of the study and the randomization procedure. M. D. Tove Lorenzen and Louise Diederichsen are acknowledged for help in the practical conduction of the study. This study was supported by a grant from the Danish Medical Research Council.

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