

ORIGINAL ARTICLE

Full symptomatic recovery does not ensure full recovery of muscle-tendon function in patients with Achilles tendinopathy

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Objective: To assess the relationship between muscle-tendon function and symptoms in patients with Achilles tendinopathy using a validated test battery.

Design: A prospective non-randomised trial.

Setting: Orthopaedic Department, Sahlgrenska University Hospital, Sweden.

Patients: 37 patients with a clinical diagnosis of Achilles tendinopathy in the midportion of the tendon, with symptoms for >2 months, were evaluated at the initiation of the study and after 1 year.

Intervention: The patients were treated using a rehabilitation programme, under the supervision of a physical therapist, for 6 months.

Main outcome measurements: The patients were evaluated using the Swedish version of the Victorian Institute of Sports Assessment—Achilles questionnaire (VISA-A-S) for symptoms, and a test battery for evaluation of the lower leg muscle-tendon function.

Results: There were significant improvements in the VISA-A-S score ($p < 0.00$, $n = 37$) and the test battery ($p < 0.02$, $n = 19$) at the 1-year follow-up. The VISA-A-S questionnaire had an effect size of 2.1 and the test battery had an effect size of 0.73. A low correlation ($r = 0.178$, $p > 0.05$) was found between the VISA-A-S score and the test battery. A high correlation ($r = 0.611$, $p < 0.05$) was found between the drop counter movement jump and the VISA-A-S score. All other tests in the test battery had low correlations ($r = -0.305$ to 0.155 , $p > 0.05$) with the VISA-A-S score. Only 25% (4/16) of the patients who had full symptomatic recovery had achieved full recovery of muscle-tendon function as measured by the test battery.

Conclusion: Full symptomatic recovery in patients with Achilles tendinopathy does not ensure full recovery of muscle-tendon function. The VISA-A-S questionnaire and the test battery are sensitive to clinically relevant changes with treatment and can be recommended for use in both the clinic and research.

Achilles tendinopathy is a common overuse injury, especially among athletes involved in activities that include running and jumping.^{1–4} Primary treatment can be challenging, but the condition is also renowned for its propensity for recurrence. Thus, it is not unusual for patients with Achilles tendinopathy to have pain on and off for many years. When physical activity is discontinued, symptoms subside, only to recur as soon as physical activity is resumed.²

Rehabilitation theory suggests that muscular strength, power, muscular endurance, flexibility and motor control might be necessary for full recovery after tendon injuries.^{4–6} One of the main treatments for Achilles tendinopathy is exercise training, and the consensus today seems to be that all patients should be treated with an exercise programme for 3–6 months before any other kind of treatment, such as surgery, is considered.^{7–15} Even with other types of treatment such as surgery, sclerosing injections, modalities and medication, some type of exercise is recommended as a complement to the treatment.^{16–21} Despite the common use of exercise as treatment, it is not fully understood how Achilles tendinopathy affects lower leg muscle-tendon functions.

To date, evaluation of the effect of treatment on Achilles tendinopathy has focused mainly on improving symptoms and not on the recovery of muscle-tendon function. The main outcome measure in most treatment studies is evaluation of pain associated with physical activity.^{8–11–13–15–22} More recently, the Victorian Institute of Sports Assessment—Achilles (VISA-A) questionnaire has been used to evaluate the clinical severity for patients with Achilles tendinopathy.^{23–24} The evaluations of muscle-tendon function previously used in treatment studies of patients with Achilles tendinopathy were strength measurements

using dynamometry and muscular endurance tests for the calf muscle.^{12–13–25–26} The operational definition of “muscle-tendon function” is, however, vague and includes various aspects related to strength, muscular endurance and the ability to utilise the stretch-shortening cycle. Therefore, it seems unrealistic to expect that one or two tests will be sufficient to detect possible muscle-tendon function deficits as well as improvements correlated with treatment.

In a previous study, we developed a test battery for evaluation of lower leg muscle-tendon function in patients with Achilles tendinopathy.²⁷ The test battery was reliable and had a high ability to detect impairments in lower leg function when comparing an injured or “most” symptomatic leg with an uninjured or “least” symptomatic leg in patients with Achilles tendinopathy.²⁷ The test battery had, furthermore, a higher demand on the patients' muscle-tendon function compared with each individual test.²⁷ Therefore, the conclusion was that Achilles tendinopathy causes pain and also impairs lower leg function. The test battery, evaluating several different aspects of lower leg muscle-tendon function, was more sensitive—that is, it had a higher ability to detect side-to-side differences than—each individual test.²⁷ It still remains to be evaluated whether the impairment in muscle-tendon function is a true functional deficit or is only due to pain, or a combination of both.

Leadbetter²⁸ has suggested that Achilles tendinopathy occurs when the body's reparative capability is exceeded by repetitive

Abbreviations: CMJ, counter movement jump; LSI, limb symmetry index; VISA-A, Victorian Institute of Sports Assessment—Achilles; VISA-A-S, Swedish version of VISA-A

Table 1 Effect sizes comparing baseline test results with those at the 1-year follow-up

Test	Effect size	n
CMJ	0.05	33
Hopping	0.40	32
Drop CMJ	0.25	33
Concentric toe-raise	0.24	34
Eccentric toe-raise	0.48	34
Toe-raise for muscular endurance	0.43	32
Test battery score with CMJ	0.75	19
Test battery score without CMJ	0.73	19
VISA-A-S questionnaire score	2.10	37

CMJ, counter movement jump; VISA-A-S, Swedish version of Victorian Institute of Sports Assessment—Achilles questionnaire.

microtrauma. It is known that, during running and jumping, the Achilles tendon is subjected to loads as high as 6–12 times the weight of the body, and this high repetitive loading is thought to be one of the main pathological stimuli causing Achilles tendinopathy.^{14 29–31} It is suggested that there is a fine line between adequate and healthy loading and overloading of the Achilles tendon. The microtrauma of the tendon might occur before the patient experiences symptoms²⁸ and resuming heavy physical activity too soon and too quickly has a major risk of re-injury. If the injury process in Achilles tendinopathy starts before symptoms, the absence of symptoms might not mean full recovery of muscle-tendon function. The challenge in rehabilitation is to determine when an athlete is ready to return to full physical activity. Our clinical experience of patients with Achilles tendinopathy is that they are susceptible to re-injury during the return to sports phase. Athletes who compete close to their limits need to know when they are able to fully load their Achilles tendon with minimal risk of re-injury.

The primary purpose of this study was to assess the relationship between muscle-tendon function and symptoms (as measured with the VISA-A questionnaire) in patients with Achilles tendinopathy using a validated test battery.

MATERIALS AND METHODS

The patients were recruited through mailings to hospitals, orthopaedic surgeons, physical therapy clinics and orthopaedic technicians in the greater Göteborg area, Sweden. Initially, the patients were examined by an experienced licensed physical therapist who determined whether they met the required criteria to participate in the study. Men and women 20–60 years of age with Achilles tendinopathy and duration of pain for >2 months were included. The definition of Achilles tendinopathy was clinical diagnosis characterised by a combination of Achilles tendon pain, swelling and impaired performance as described in the literature.^{14 29 32} The exclusion criteria were injury to foot, knee, hip or back, and/or history of rheumatoid arthritis or any other illness or injury thought to interfere with participation in the study. Patients with insertion tendinopathy were also excluded.

A total of 37 people (17 women and 20 men) were included in the study and they ranged in age from 30 to 58 years, with a mean (SD) age of 46 (8) years. The duration of symptoms ranged from 3 to 360 months, with a mean (SD) of 37 (67) months. Twelve of the patients reported symptoms from both the right and the left Achilles tendons.

All study participants received oral and written information about the purpose and procedure of the study, and written informed consent was obtained. Ethics approval was obtained from the Human Ethics Committee at the Medical Faculty, Göteborg University, Sweden.

Study design

The patients were evaluated before initiating treatment and after 1 year. Evaluation consisted of the Swedish version of the VISA-A questionnaire (the VISA-A-S questionnaire)³³ for symptoms and a test battery developed to evaluate muscle-tendon function in patients with Achilles tendinopathy.²⁷

Test battery

The test battery consisted of three different jump tests, two different strength tests and one muscular endurance test.²⁷ The jump tests were a counter movement jump (CMJ), a drop CMJ and hopping. The CMJ was a vertical jump where the starting position was an upright position with hands placed behind the back. The maximal jumping height (in cm) was used for data analysis. For the drop CMJ, the patients started by standing on one leg on a 20 cm high wooden box. The patients were instructed to “fall” down onto the floor and to perform a maximum vertical one-legged jump directly on landing. The maximal jumping height (in cm) was used for data analysis. The strength tests were a concentric toe-raise and an eccentric-concentric toe-raise. The maximal power (in W) was used for data analysis. The muscular endurance test was a standing toe-raise test with 10% of the body weight added with a weight belt. The total amount of work performed (in J) was used for data analysis. The test battery has been shown to be reliable and valid for evaluation of lower-leg function in patients with Achilles tendinopathy, and was performed as described by Silbernagel *et al.*²⁷

Treatment protocol

The Achilles tendon and calf muscle strengthening protocol was based on our previous study,¹³ but has been modified at the clinic over the years. The exercises were performed once a day, and the intensity and number of repetitions were based on the patients' status. The exercises consisted mainly of two-legged and one-legged concentric-eccentric toe-raises, and eccentric and fast rebounding toe-raises. The intensity was increased gradually by increasing the range of motion (starting standing on the floor and then performing the exercise standing on a step), number of repetitions (starting at a maximum amount of three sets tolerated up to a maximum of 15 repetitions), load (using either a back-pack or a weight machine) and speed of loading. In phase three of the rehabilitation programme, plyometric training was included. The progression of the exercise programme was monitored by the treating physical therapists for 6 months.

Responsiveness

The responsiveness of the VISA-A-S questionnaire, the individual tests in the test battery and the test battery were evaluated by comparing the results before initiating treatment with the results after 1 year. To evaluate the test battery, only the patients who had one healthy side (defined in this study as a VISA-A-S score >95) before initiating treatment and who completed all the tests in the test battery at both the initial evaluation and at the 1 year follow-up were included. This left 19 subjects for the evaluation of the responsiveness of the test battery. Counting the number of tests where the patients had a 90% or better capacity in the injured side compared with the uninjured side gave the final score of the test battery.

Changes in the VISA-A-S score and test battery with treatment

To evaluate changes in the VISA-A-S score and the test battery, we compared results before treatment with the results from the 1 year follow-up (table 2).

Table 2 Results of the various tests at baseline and at the 1-year follow-up

	0 months		12 months	
	Injured side	Healthy side	Injured side	Healthy side
CMJ (height in cm)	(n = 25)	(n = 25)	(n = 22)	(n = 22)
Mean	11.0	11.4	11.0	11.0
SD	5.1	4.5	5.1	4.8
Range	3.2 to 24.1	4.8 to 21.7	5.8 to 24.7	5.1 to 22.3
Drop CMJ (height in cm)	(n = 25)	(n = 25)	(n = 22)	(n = 22)
Mean	9.4	11.1	10.7	11.1
SD	5.2	4.4	4.9	4.3
Range	0 to 23.2	3.3 to 20.5	3.5 to 21.7	5.6 to 21.3
Hopping (plyometric quotient)	(n = 25)	(n = 25)	(n = 21)	(n = 21)
Mean	0.389	0.510	0.498	0.498
SD	0.258	0.165	0.177	0.163
Range	0.0 to 1.210	0.316 to 1.106	0.318 to 1.118	0.326 to 1.074
Concentric toe-raise (power in W)	(n = 25)	(n = 25)	(n = 23)	(n = 23)
Mean	217	259	244	244
SD	94.6	157.9	106.7	126.4
Range	0 to 380	93 to 907	54 to 541	57 to 623
Eccentric toe-raise (power in W)	(n = 25)	(n = 25)	(n = 23)	(n = 23)
Mean	287	341	353	377
SD	132.1	152.4	180.9	194
Range	0 to 614	100 to 794	131 to 875	175 to 1070
Toe-raise for endurance (work in J)	(n = 24)	(n = 24)	(n = 22)	(n = 23)
Mean	1793	1973	2490	2315
SD	1063	938	1127	1122
Range	0 to 4076	851 to 4790	1079 to 5552	1042 to 5322
VISA-A-S score	(n = 25)	(n = 25)	(n = 25)	(n = 25)
Mean	56	99.8	89	100
SD	16.5	0.8	10.6	0
Range	24 to 89	96 to 100	66 to 100	100 to 100

CMJ, counter movement jump; VISA-A-S, Swedish version of Victorian Institute of Sports Assessment—Achilles questionnaire.

Relationship between symptoms and muscle-tendon function

To evaluate of the relationship between symptoms and muscle-tendon function, the VISA-A-S score was correlated with the results of each individual test and the test battery at the 1-year follow-up. Data from all tests were available for 24 patients who also had a healthy leg (VISA-A-S score >95). The results from the individual tests were given as a limb symmetry index (LSI), defined as the ratio of the involved limb score and the uninvolved limb score.

Statistical analysis

All data were analysed using SPSS V.11.5 for Windows. Descriptive data are reported as mean (SD) and range.

Responsiveness was calculated by effect size, defined as the mean score change divided by the SD of the pretreatment score. Effect sizes of 0.2 were considered small, 0.5 moderate and 0.8 large.³⁴

Spearman's *r* was used to evaluate the correlation between the VISA-A-S score, the individual tests in the test battery and the test battery at 1-year follow-up.

Wilcoxon's signed rank test was used to evaluate changes in VISA-A-S score and the test battery between the initial evaluation and the 1-year follow-up. The level of significance was set at $p < 0.05$.

LSI was calculated for classification of a normal or abnormal side-to-side difference. The LSI was defined as the ratio of the involved limb score to the uninvolved limb score expressed in percentage (involved/uninvolved $\times 100$). An LSI $\geq 90\%$ was classified as normal. An acceptable level of muscle function

was defined as having normal capability on all tests in the test battery. A VISA-A-S score of ≥ 90 was classified as fully recovered.

RESULTS

Responsiveness

The effect size of the VISA-A-S questionnaire was 2.1. The effect sizes for each individual test ranged from 0.24 to 0.48, except for CMJ, which had an effect size of 0.05 (table 1). Because of the low effect size for CMJ and because CMJ has previously been shown to have low sensitivity—that is, low ability to detect differences between injured and non-injured side—it was decided to exclude CMJ from the test battery. All the following evaluations of the test battery were, therefore, performed without CMJ.

Changes in the VISA-A-S score and test battery with treatment

Significant improvement was found in the VISA-A-S score ($p < 0$, $n = 37$) and the test battery ($p < 0.02$, $n = 19$) at the 1-year follow-up.

Comparison between VISA-A-S questionnaire and test battery

A low correlation ($r = 0.178$, $p = 0.405$) was found between the VISA-A-S score and the test battery. A high correlation ($\rho = 0.611$, $p < 0.01$) was found between the drop CMJ and the VISA-A-S score. All other tests in the test battery had low correlations ($r = -0.305$ to 0.155 , $p = 0.15$ to 0.85) with the VISA-A-S score.

At the 1-year follow-up, out of 24 patients 16 (67%) were classified as having fully recovered (VISA-A-S score ≥ 90), 2

What is already known on this topic

- Achilles tendinopathy is a common overuse injury and patients often suffer from symptoms on and off for many years.
- Strengthening exercises are often recommended as treatment.
- Achilles tendinopathy causes symptoms in and impairments to lower leg function; however, the correlation between symptoms and muscle-tendon functional recovery after treatment is not well known.

What this study adds

- The VISA-A questionnaire and the test battery are sensitive to changes following treatment.
- Full recovery of symptoms does not ensure full recovery of muscle-tendon function in patients with Achilles tendinopathy.

(8%) had an acceptable VISA-A-S score (>80), 4 (17%) had a score of 70–80 and 2 (8%) had a score between 65 and 70.

Of the 67% of patients who had fully recovered, only 25% (4/16) had reached an acceptable level of muscle function (ie, $\geq 90\%$ capability on all tests in the test battery). Another 19% (3/16) of those patients passed 4 of the 5 tests in the test battery at the 1-year follow-up. In all, 44% (7/16) of the patients passed 3 of the 5 tests and the remainder (12%) passed <2 tests at the 1-year follow-up.

A very low and non-significant correlation was found between the injured side and the preferred “jump leg” (Spearman’s $r = -0.2$).

DISCUSSION

Achilles tendinopathy causes pain, symptoms and also impairments in lower leg muscle-tendon function. Patients with Achilles tendinopathy who have reached full symptomatic recovery might not necessarily have recovered their lower leg function. Only 25% of the patients who were no longer symptomatic had full function as measured by the test battery. It therefore seems clear that functional recovery occurs later than the improvements in symptoms. Treatment protocols should therefore be aimed at improving symptoms as well as focus on full return of function. Accordingly, treatment studies are recommended to use reliable, valid and responsive outcome measures for both patients’ symptoms and muscle-tendon function.

The VISA-A questionnaire is a reliable and valid instrument for evaluation of the clinical severity of patients with Achilles tendinopathy.^{33–35} It has now been shown that the VISA-A questionnaire also has a large effect size, indicating that it is responsive to clinically relevant changes. The high responsiveness (as indicated by an effect size of 2.1) also indicates that the VISA-A-S questionnaire is useful as an outcome measure in scientific studies.

Each individual test in the test battery had small effect sizes at the 1-year follow-up, except for CMJ, which had a poor effect size. This test had also previously not been able to show difference between the most symptomatic leg (injured) and the least symptomatic leg (non-injured), and it does not add to improve the effect size for the whole test battery.²⁷ The validity of CMJ test was therefore considered very low for evaluation of lower leg muscle-tendon function in patients with Achilles

tendinopathy. The CMJ test was therefore excluded from the test battery. A significant improvement in the test battery, having a moderate effect size (0.73), was seen at the 1-year follow-up. The reason for the test battery having a much lower effect size compared with the VISA-A-S questionnaire could be best explained by the fact that function takes longer time to recover than symptoms.

It was found that there were no significant correlations between symptoms (as measured with the VISA-A-S questionnaire) and function (as measured with the test battery), except for the drop CMJ. The reason the drop CMJ had a significant correlation to the VISA-A-S score can be explained by the challenge posed by the test: the patient had to dare to jump from a 20 cm high box and land fully on the injured leg. This test requires that the patients overcome the fear of landing, and it is reasonable to assume that this fear would be higher when the patients had more pain.

For patients with Achilles tendinopathy, the symptoms of pain, tenderness to palpation and morning stiffness are the main complaints.^{10–14, 29} Often, patients report symptoms on and off for many years. One of the reasons for the reoccurrence of the symptoms might be that the function of the calf musculature and Achilles tendon has not fully recovered. As soon as the patient tries to increase their physical activity level, the load on the muscle-tendon unit exceeds its capacity and the injury process starts again. The Achilles tendon is loaded up to 6–12 times the body weight with physical activities such as running and jumping,^{30–31} and therefore these activities put a great demand on the muscle-tendon function.

In a recent study, we found that continued physical activity with the use of a pain-monitoring model does not seem to hinder recovery (unpublished data). Adjusted physical activity with enough time given for recovery over longer periods of time might help to recover full muscle-tendon function and prevent re-injury. Patients with VISA-A-S scores <90 points are often satisfied with their results as long as they can work and be physically active. These results suggest that patients with Achilles tendinopathy should be encouraged to continue their rehabilitation exercises even after the symptoms subside to further improve their function.

CONCLUSION

Full symptomatic recovery in patients with Achilles tendinopathy does not ensure full recovery of muscle-tendon function. The VISA-A-S questionnaire and the test battery are sensitive to clinically relevant changes with treatment and can be recommended for use both in clinic and research. Our study provides evidence that patients should be encouraged to continue their rehabilitation protocol even when their symptoms subside, to achieve full recovery of muscle-tendon function. Future studies should investigate whether this will reduce recurrence of symptoms.

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REFERENCES

- 1 Józsa L, Kannus P. *Human tendons. Anatomy, physiology and pathology*. Champaign: Human Kinetics, 1997.
- 2 Kvist M. Achilles tendon injuries in athletes. *Sports Med* 1994;**18**:173–201.
- 3 Paavola M, Kannus P, Paakkala T, et al. Long-term prognosis of patients with achilles tendinopathy. An observational 8-year follow-up study. *Am J Sports Med* 2000;**28**:634–42.
- 4 Stanish WD, Curwin S, Mandell S. *Tendinitis: its etiology and treatment*. New York: Oxford University Press, 2000.
- 5 Cook JL, Purdam CR. Rehabilitation of lower limb tendinopathies. *Clin Sports Med* 2003;**22**:777–89.
- 6 Hess GP, Cappiello WL, Poole RM, et al. Prevention and treatment of overuse tendon injuries. *Sports Med* 1989;**8**:371–84.
- 7 Alfredson H, Pietilä T, Jonsson P, et al. Heavy-load eccentric calf muscle training for the treatment of chronic Achilles tendinosis. *Am J Sports Med* 1998;**26**:360–6.
- 8 Angermann P, Hovgaard D. Chronic Achilles tendinopathy in athletic individuals: results of nonsurgical treatment. *Foot Ankle Int* 1999;**20**:304–6.
- 9 Alfredson H, Lorentzon R. Chronic Achilles tendinosis: recommendations for treatment and prevention. *Sports Med* 2000;**29**:135–46.
- 10 Alfredson H. Chronic midportion Achilles tendinopathy: an update on research and treatment. *Clin Sports Med* 2003;**22**:727–41.
- 11 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**:42–7.
- 12 Niesen-Vertommen S, Taunton J, Clement D, et al. The effect of eccentric versus concentric exercise in the management of Achilles tendonitis. *Clin J Sport Med* 1992;**2**:109–13.
- 13 Silbernagel KG, Thomeé R, Thomeé P, et al. Eccentric overload training for patients with chronic Achilles tendon pain—a randomised controlled study with reliability testing of the evaluation methods. *Scand J Med Sci Sports* 2001;**11**:197–206.
- 14 Kader D, Saxena A, Movin T, et al. Achilles tendinopathy: some aspects of basic science and clinical management. *Br J Sports Med* 2002;**36**:239–49.
- 15 Roos EM, Engström M, Lagerquist A, et al. Clinical improvement after 6 weeks of eccentric exercise in patients with mid-portion Achilles tendinopathy—a randomized trial with 1-year follow-up. *Scand J Med Sci Sports* 2004;**14**:286–95.
- 16 Schepsis AA, Wagner C, Leach RE. Surgical management of Achilles tendon overuse injuries. A long-term follow-up study. *Am J Sports Med* 1994;**22**:611–19.
- 17 Testa V, Capasso G, Benazzo F, et al. Management of Achilles tendinopathy by ultrasound-guided percutaneous tenotomy. *Med Sci Sports Exerc* 2002;**34**:573–80.
- 18 Alfredson H. The chronic painful Achilles and patellar tendon: research on basic biology and treatment. *Scand J Med Sci Sports* 2005;**15**:252–9.
- 19 Paavola M, Kannus P, Orava S, et al. Surgical treatment for chronic Achilles tendinopathy: a prospective seven month follow up study. *Br J Sports Med* 2002;**36**:178–82.
- 20 Paavola M, Orava S, Leppilähti J, et al. Chronic Achilles tendon overuse injury: complications after surgical treatment. An analysis of 432 consecutive patients. *Am J Sports Med* 2000;**28**:77–82.
- 21 Neeter C, Thomeé R, Silbernagel KG, et al. Iontophoresis with or without dexamethazone in the treatment of acute Achilles tendon pain. *Scand J Med Sci Sports* 2003;**13**:376–82.
- 22 Alfredson H, Öhberg L. Sclerosing injections to areas of neo-vascularisation reduce pain in chronic Achilles tendinopathy: a double-blind randomised controlled trial. *Knee Surg Sports Traumatol Arthrosc* 2005;**13**:338–44.
- 23 Peers KH, Brys PP, Lysens RJ. Correlation between power Doppler ultrasonography and clinical severity in Achilles tendinopathy. *Int Orthop* 2003;**27**:180–3.
- 24 Sayana MK, Maffulli N. Eccentric calf muscle training in non-athletic patients with Achilles tendinopathy. *J Sci Med Sport* 2006;.
- 25 Alfredson H, Pietilä T, Öhberg L, et al. Achilles tendinosis and calf muscle strength. The effect of short-term immobilization after surgical treatment. *Am J Sports Med* 1998;**26**:166–71.
- 26 Mahieu NN, Witvrouw E, Stevens V, et al. Intrinsic risk factors for the development of achilles tendon overuse injury: a prospective study. *Am J Sports Med* 2006;**34**:226–35.
- 27 Silbernagel KG, Gustavsson A, Thomeé R, et al. Evaluation of lower leg function in patients with Achilles tendinopathy. *Knee Surg Sports Traumatol Arthrosc* 2006;**14**:1207–17.
- 28 Leadbetter WB. Cell-matrix response in tendon injury. *Clin Sports Med* 1992;**11**:533–78.
- 29 Paavola M, Kannus P, Järvinen TA, et al. Achilles tendinopathy. *J Bone Joint Surg Am* 2002;**84-A**:2062–76.
- 30 Fukashiro S, Komi PV, Järvinen M, et al. In vivo Achilles tendon loading during jumping in humans. *Eur J Appl Physiol Occup Physiol* 1995;**71**:453–8.
- 31 Sayana MK, Maffulli N. Eccentric calf muscle training in non-athletic patients with Achilles tendinopathy. *J Sci Med Sport* 2007;**10**:52–8.
- 32 Maffulli N, Kenward MG, Testa V, et al. Clinical diagnosis of Achilles tendinopathy with tendinosis. *Clin J Sport Med* 2003;**13**:11–15.
- 33 Silbernagel KG, Thomeé 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.
- 34 Kazis LE, Anderson JJ, Meenan RF. Effect sizes for interpreting changes in health status. *Med Care* 1989;**27**(3 Suppl):S178–89.
- 35 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**:335–41.

COMMENTARY

When is it safe to return to sport? This simple, yet often vexing question, applies particularly to cases of tendinopathy. Recurrence is a hallmark of the condition.^{1 2} Although expert clinicians have long argued that patients need to continue their rehabilitation exercises even after pain has abated, research has been unable to point to factors that may explain recurrences (other than tissue healing); nor has there been a test battery that could be used as a functional test for full recovery.

To deal with this clinically relevant issue, the authors of this paper investigated the recovery of muscular strength, power, endurance, flexibility and motor control in patients recovering from Achilles tendinopathy. They have previously developed a test battery that evaluates lower leg muscle–tendon function comprehensively³—this instrument detected impaired function in patients with painful Achilles tendons. This study—an assessment of muscle tendon function in the now pain-free tendon—aimed at determining whether this was due to pain or due to a true functional deficit.

Importantly, the present paper showed that functional deficits remained even when symptoms improved. This provides important evidence that further rehabilitation is indicated even after the pain has disappeared. What was previously a clinical hunch can now be added to the more evidence-based textbooks. Thus, the authors' conclusions would make an excellent poster (choose your image of choice to go with the text) to be framed and hung up on the walls of physiotherapy clinics and the locker rooms of high-level teams... “patients should be encouraged to continue their rehabilitation protocol even when symptoms subside in order to achieve full recovery...”.

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REFERENCES

- 1 Alfredson H, Lorentzon R. Chronic Achilles tendinosis: recommendations for treatment and prevention. *Sports Med* 2000;**29**:135–46.
- 2 Paavola M, Kannus P, Paakkala T, et al. Long-term prognosis of patients with Achilles tendinopathy. An observational 8-year follow-up study. *Am J Sports Med* 2000;**28**:634–42.
- 3 Silbernagel KG, Gustavsson A, Thomeé R, et al. Evaluation of lower leg function in patients with Achilles tendinopathy. *Knee Surg Sports Traumatol Arthrosc* 2006;**14**:1207–17.