Poor association between tendon structure and self-reported symptoms following conservative management in active soldiers with mid-portion Achilles tendinopathy

M A Paantjens, P H Helmhout, F J G Backx, M T A W Martens, J P A van Dongen, E W P Bakker

ABSTRACT

Introduction Mid-portion Achilles tendinopathy (mid-AT) is currently the preferred term for persistent Achilles tendon pain, defined as located 2–7 cm proximal to the calcaneus, and with loss of function related to mechanical loading. Histologically, mid-AT is considered to represent a degenerative condition. Therefore, monitoring of tendon structure additional to pain and function may be warranted, to prevent progression of degeneration or even tendon rupture. The aim of this study was to determine the association between pain and function, relative to the Achilles tendon structure, in soldiers treated with a conservative programme for mid-AT.

Methods A total of 40 soldiers (40 unilateral symptomatic tendons) were included in this study. Pain and function were evaluated with the Victorian Institute of Sports Assessment – Achilles (VISA-A) questionnaire. Tendon structure was quantified using ultrasound tissue characterisation (UTC). We quantified both the Achilles tendon mid-portion (2–7 cm) and the area of maximum degeneration (AoMD) within the tendon mid-portion. VISA-A and UTC measurements were taken at baseline and after 26 weeks of follow-up. Spearman’s rho was used to determine the correlation between VISA-A and UTC. Correlations were calculated for baseline, follow-up and change score values.

Results Negligible correlations were found for all analyses, ranging from −0.173 to 0.166 between mid-portion tendon structure and VISA-A, and from −0.137 to 0.150 between AoMD and VISA-A. While VISA-A scores improved, on average, from 59.4 points at baseline to 93.5 points at follow-up, no detectable improvement in aligned fibrillar structure was observed in our population.

Conclusion Pain and function are poorly associated with Achilles tendon structure in soldiers treated with a conservative programme for mid-AT. Therefore, we advise clinicians to use great caution in communicating relationships between both clinical entities.

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INTRODUCTION

Achilles tendinopathy (AT) is currently the preferred term for persistent Achilles tendon pain and loss of function related to mechanical loading. The treatment is initially conservative. AT has been reported to occur in a wide age range of 20–69 years, with peaks between 40 and 59 years. Active individuals are most frequently affected, particularly runners, with life-time prevalences ranging up to 52%. AT is also common in soldiers, significantly impacting activity levels and military operational readiness.

AT can be divided into mid-portion Achilles tendinopathy (mid-AT) and insertional Achilles tendinopathy. Mid-AT, defined as located 2–7 cm proximal to the calcaneus, is an isolated tendinopathy, generally considered to represent a degenerative condition. In tendinopathy, tendon loading may cause progressive degeneration, in rare occasions (4%) ultimately leading to a tendon rupture. However, tendon loading can also be an anabolic stimulus to improve tendon structure.

Clinicians should primarily assess the domains of pain and function when evaluating patients with mid-AT, using the Victorian Institute of Sports Assessment-Achilles (VISA-A) questionnaire as the preferred patient reported outcome measure. Additional monitoring of a tendon’s structural response to biomechanical loading may also be of importance, especially in physically demanding professions, such as soldiers, for whom
the rare event of an Achilles tendon rupture can have serious consequences.

Ultrasound tissue characterisation (UTC) is an imaging technique to visualise and quantify the mid-portion Achilles tendon structure. UTC discriminates four echo-types (I–IV) within the Achilles tendon matrix. Combined echo-types I+II represent aligned fibrillar structure, whereas echo-types III+IV can be seen as disorganised tendon structure. UTC can be used to monitor load or to evaluate treatment.

While growing evidence indicates that tendon structure should not be used to explain the presence or severity of current and future symptoms in AT, the evidence is still conflicting. While UTC is a validated, disease-specific instrument to assess pain, function in daily living and sporting activity. The sum score on the VISA-A can range from 0 to 100 points, where 100 represents a perfect asymptomatic score. All participants independently completed the VISA-A questionnaire prior to the UTC investigation, in order to avoid the imaging outcome to influence the VISA-A scoring.

UTC scans were collected and processed according to a standardised protocol, which has shown excellent intra-rater and inter-rater reliability in the same patient group used for this study. A single experienced examiner in UTC (MP) collected the UTC scans. Images were acquired with a 12 MHz linear ultrasound transducer (Terason 12L5 Smartprobe, Vermon, France), using Terason software (t2000+ OEM). This transducer was embedded in a motorised tracking device (UTC tracker, UTC imaging, 617GD Stein, The Netherlands, serial no. UTC-201-041). An independent researcher (MTAWM, physical therapist), blinded to the VISA-A scoring, processed the UTC scans, aiming to quantify: (1) the mid-portion Achilles tendon structure (2–7 cm) and subsequently (2) the area of maximum degeneration (AoMD) within the tendon mid-portion.

Rehabilitation programme
The rehabilitation programme of 26 weeks (figure 2) consisted of patient education, extracorporeal shockwave therapy (ESWT), exercise on a cross-trainer or stair climber and a return to running programme (online supplemental file 1). Sample size calculation
Based on prior research, for sample size calculation we assumed a low correlation of .45 between UTC and VISA-A scores. With a default alpha of .05 and a statistical power of .80, a sample size of 36 participants was calculated. Taking into account a 10% loss to follow-up, we included a total of 40 active soldiers for this study.

Statistics
Baseline characteristics of our study population were presented with appropriate measures of central tendency and dispersion. For tendon structure, aligned fibrillar structure (echo-types I+II) and disorganised tendon structure (echo-types III+IV) were used as the two outcomes. Both echo-type combinations were expressed as a percentage of the total Achilles volume analysed with UTC.

Pearson’s correlation coefficients were chosen to determine the strength and direction of the association between UTC and VISA-A scores. When data were not normally distributed, Spearman’s rank correlation coefficients were used. Correlation coefficients were interpreted either as: negligible (0.00 to

METHODS
Study setting
The study was conducted at the Sports Medicine Centre of the Department of Training Medicine and Training Physiology of the Royal Netherlands Army, Utrecht, the Netherlands. This centre is a secondary care facility for soldiers that predominantly focuses on researching and treating persistent musculoskeletal health problems.

Eligibility criteria
Consecutive patients, referred to the Sports Medicine Centre for AT between July 2019 and January 2021, were potentially eligible for inclusion based on the following criteria: (1) military personnel in active duty (18–60 years); (2) a clinically established diagnosis of mid-AT and (3) symptoms for 2 months or more. In case of bilateral symptoms, only the side with the lowest VISA-A score was included into the analysis.

Participants were excluded if they reported concomitant insertional Achilles tendinopathy; or on the presence of factors that may have adversely affected tendon structure: (1) signs of a complete Achilles tendon rupture; (2) prior surgery to the Achilles tendon; (3) use of statins, fluoroquinolones or corticosteroids and (4) a previous diagnosis of rheumatoid arthritis, diabetes mellitus or psoriasis. All participants were recruited by the main researcher (MP, physical therapist). Prior to inclusion, each participant provided written informed consent for anonymous use of their data.

Patient evaluation
Patient characteristics
At baseline, the following patient characteristics were retrieved: age (years), height (cm), weight (kg), body mass index (BMI, %), gender (male/female) and symptom duration (months).

Baseline and follow-up measurements
Measurements were performed at baseline and during follow-up at week 26, and consisted of a written VISA-A questionnaire and a UTC scan (Figure 1).

VISA-A is a validated, disease-specific instrument to assess pain, function in daily living and sporting activity. The sum score on the VISA-A can range from 0 to 100 points, where 100 represents a perfect asymptomatic score. All participants independently completed the VISA-A questionnaire prior to the UTC investigation, in order to avoid the imaging outcome to influence the VISA-A scoring.

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RESULTS

A total of 40 patients were included in this study, of which 12 reported bilateral symptoms. No participants were lost to follow-up. Patient characteristics are presented in Table 1.

The mean VISA-A score improved from baseline (59.4±SD 17.3, range 15–86) to follow-up at 26 weeks (93.5±SD 9.8, range 48–100).

The mean UTC echo-types for the Achilles tendon mid-portion and the AoMD are displayed in Table 2. Echo-type change scores were calculated from baseline to follow-up. We determined their clinical relevance by comparing the values with the minimal detectable changes (MDC) calculated for this particular cohort.15

In the mid-portion, aligned fibrillar structure (echo-type I+II) showed a 4.6% improvement, which was below the MDC of 5.9%. Disorganised tendon structure (echo-type III+IV) in the mid-portion decreased with 4.6%, exceeding the MDC of 4.2%. In the AoMD, aligned fibrillar structure improved with 4.1%, not exceeding the MDC of 9.8%. Disorganised tendon structure in the AoMD decreased with 4.2%, also not exceeding the MDC of 10.0%.

Regarding the changes of individual mid-portion echo-types, echo-type IV decreased with 2.3%. This was the only individual echo-type that showed a change score above the MDC (1.9%). All other change scores were below this threshold: echo-type I 3.1% (MDC 4.7%), echo-type II 1.6% (MDC 2.5%) and echo-type III 2.4% (MDC 3.6%).

No AoMD change scores of individual echo-types exceeded the MDC: echo-type I 3.6% (MDC 4.8%), echo-type II 0.4% (MDC 8.2%), echo-type III 2.9% (MDC 6.8%) and echo-type IV 1.4% (MDC 4.6%).

Baseline, follow-up and change score correlations between VISA-A and UTC are reported in Table 3.

DISCUSSION

Association between the VISA-A and tendon structure

The primary objective of this study was to investigate the association between pain and function, relative to tendon structure, in soldiers treated with a conservative programme for mid-AT. In tendinopathy, improvements in pain and function generally precede the much slower restoration of tendon structure.18 Therefore, we hypothesised that the AoMD would show a stronger association with VISA-A than the tendon mid-portion, since relative changes in tendon structure can be expected to be larger than in the mid-portion analysis. This turned out not to be the case as we found negligible correlations for all analyses, indicating that tendon structure is poorly associated with pain and function in soldiers with mid-AT.

Our findings are supported by two non-military studies evaluating the association between pain and function versus tendon structure, in mid-AT patients.11 12 In the first study, de Vos et al12 evaluated subjects who followed an eccentric loading programme, reporting negligible correlations between changes scores on VISA-A and echo-types I+II from baseline to follow-up that did not exceed the MDC of 4.2%.
follow-up at 24 weeks. Baseline echo-types I+II also showed negligible correlations with VISA-A scores after 24 weeks. In the second study, de Jonge et al evaluated eccentric loading combined with either a platelet-rich plasma injection or a saline injection, also reporting no associations between VISA and UTC. Both studies concluded that tendon structure was not related to disease severity or prognosis in mid-AT.

In tendinopathy, the exact pathophysiology and the source of nociception are currently unknown. The fact that recovery of tendon structure and improvement in pain and function do not follow the same pace may partly explain the poor associations. Positive changes in the pain system following tendinopathy treatment can already occur in 2 weeks, while full restoration of tendon structure takes considerably longer, from 24 weeks up to several years.

### Mean improvement on the VISA-A

The VISA-A score improved, on average, by 59.4 points at baseline to 93.5 points at follow-up. Although scores can range from 0 to 100 points, a score of 90 points is reported to represent full recovery from mid-AT. A recent meta-analysis concluded that VISA-A scores may be expected to improve by approximately 21 points, following exercise interventions for mid-AT. We have found a considerably higher mean VISA-A improvement of 34.1 points.

Several factors may explain the large improvements found in our study. One possible explanation is that we used a combination of ESWT and exercise in our rehabilitation programme, as this combination is suggested to achieve higher VISA-A scores than exercise alone. It is also possible that an increase in the mean VISA-A score, no improvement in aligned fibrillar tendon structure was observed after 24 weeks.

Our findings contradict the results of an in vivo study that suggest ESWT-induced tendon structure improvements, but are in line with a study by de Vos et al who reported no increase of aligned fibrillar structure following an eccentric loading programme after 24 weeks. Contrastingly, de Jonge et al reported a mean improvement in aligned fibrillar structure of 11% following an eccentric loading programme. It should be acknowledged that in the latter study, patients additionally received either a platelet-rich plasma injection or a saline injection.

### Rehabilitation programme

A total of 9 out of 40 participants included in this study had not undergone previous treatment. The other 31 patients were referred for ESWT due to unsatisfactory results in primary care, where they received various interventions, that is, non-steroidal anti-inflammatory drugs, ankle mobilisation, calf stretching exercises, massage and gait retraining. Tendon loading exercises had been a part of the previous treatment in 28 participants. Although these exercises currently represent the standard of care for mid-AT, a large number of patients does not seem to respond adequately, and up to half of all patients seeking alternative treatment.

### Clinical applicability

As tendon structure appears poorly associated with pain and function in mid-AT, we recommend assessing both clinical entities separately. We strongly advise clinicians to use great caution in communicating (causal) relationships between tendon structure and pain and function in soldiers suffering from mid-AT, as our results cannot support this in any way. It is our belief that in physically highly active populations, like soldiers, assessment of Achilles tendon structure should be used to evaluate load, or

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**Table 3** Correlations between the VISA-A scores and UTC-typing at baseline, during follow-up after 26 weeks and with regard to the change scores

<table>
<thead>
<tr>
<th>VISA-A baseline</th>
<th>VISA-A follow-up</th>
<th>VISA-A difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-portion baseline ET1+2</td>
<td>ρ=0.166, sig. (two-tailed) 0.306</td>
<td></td>
</tr>
<tr>
<td>Mid-portion follow-up ET1+2</td>
<td>ρ=0.046, sig. (two-tailed) 0.778</td>
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<tr>
<td>Mid-portion difference ET1+2</td>
<td>ρ=−0.013, sig. (two-tailed) 0.935</td>
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<tr>
<td>Mid-portion baseline ET3+4</td>
<td>ρ=−0.173, sig. (two-tailed) 0.287</td>
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</tr>
<tr>
<td>Mid-portion follow-up ET3+4</td>
<td>ρ=−0.048, sig. (two-tailed) 0.769</td>
<td></td>
</tr>
<tr>
<td>Mid-portion difference ET3+4</td>
<td>ρ=0.018, sig. (two-tailed) 0.912</td>
<td></td>
</tr>
<tr>
<td>AoMD baseline ET1+2</td>
<td>ρ=0.131, sig. (two-tailed) 0.422</td>
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<tr>
<td>AoMD follow-up ET1+2</td>
<td>ρ=0.150, sig. (two-tailed) 0.354</td>
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<tr>
<td>AoMD difference ET1+2</td>
<td>ρ=0.024, sig. (two-tailed) 0.882</td>
<td></td>
</tr>
<tr>
<td>AoMD baseline ET3+4</td>
<td>ρ=−0.126 sig. (two-tailed) 0.422</td>
<td></td>
</tr>
<tr>
<td>AoMD follow-up ET3+4</td>
<td>ρ=−0.137, sig. (two-tailed) 0.398</td>
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</tr>
<tr>
<td>AoMD difference ET3+4</td>
<td>ρ=−0.024, sig. (two-tailed) 0.885</td>
<td></td>
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</tbody>
</table>

VISA-A, Victorian Institute of Sports Assessment-Achilles questionnaire; ρ, Spearman’s rho.
to evaluate interventions targeting tendon structure, and also to prevent potential structural damage to Achilles tendons. 3

Limitations
A number of potential limitations may have influenced the results of this study.

First, both the UTC scans and VISA-A scores were collected by the same researcher. It is unlikely that this has influenced the outcomes, as the VISA-A is a self-completing questionnaire, 21 and the UTC scanning procedure is highly standardised. 15

Second, for reasons of standardisation, and due to positive clinical experiences over the years, we have chosen to replace traditional tendon loading exercises 3 by a stair climber or cross-trainer in our study. This appears to have had no major negative effects on pain and function, as the mean VISA-A score at follow-up (93.5 points) indicates complete recovery from mid-AT. 21 We did not observe detectable improvements in aligned fibrillar structure after 26 weeks. Whether this would have been the case if we had incorporated traditional tendon loading exercises into our rehabilitation programme is questionable, as there is currently limited and conflicting evidence regarding this topic. 11 12 Possibly, our follow-up of 26 weeks was too short to observe improvement of aligned fibrillar structure. 18

Third, while tendon loading exercises had been part of a previous treatment programme in 28 participants included in our study, it should be acknowledged that 13 of those 28 participants had not completed a full 12-week programme as recommended by the clinical guideline. 2 Because improvements in pain and function are reported to peak at 12 weeks following inception of such a programme, 20 it is quite possible that for some of these 13 participants tendon loading would have been more effective if they had completed the full 12 weeks.

Possible future studies could compare traditional tendon loading exercises with exercise on a stair climber or cross-trainer in mid-AT, or explore the relationship between the use of ultrasound, illness perceptions and patient-reported outcomes evaluating pain and function in mid-AT.

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Competing interests None declared.

Patient consent for publication Consent obtained directly from patient(s).

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Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The data supporting the findings of this study are available from the corresponding author on reasonable request.

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