


## ORIGINAL ARTICLE

# How many runners with new-onset Achilles tendinopathy develop persisting symptoms? A large prospective cohort study

Iris F. Lagas<sup>1</sup>  | Tryntsje Fokkema<sup>2</sup>  | Sita M. A. Bierma-Zeinstra<sup>1,2</sup> |  
Jan A. N. Verhaar<sup>1</sup> | Marienke van Middelkoop<sup>2</sup>  | Robert-Jan de Vos<sup>1</sup>

<sup>1</sup>Department of Orthopaedic Surgery and Sports Medicine, Erasmus MC, University Medical Center Rotterdam, Zuid-Holland, The Netherlands

<sup>2</sup>Department of General Practice, Erasmus MC, University Medical Center Rotterdam, Zuid-Holland, The Netherlands

## Correspondence

Iris F. Lagas (MD), Erasmus MC, University Medical Center Rotterdam, Department of Orthopaedic Surgery and Sports Medicine, room NC-419, Doctor Molewaterplein 40, 3015 GD Rotterdam, The Netherlands.  
Email: i.lagas@erasmusmc.nl

## Funding information

This study received financial support from the Netherlands Organization for Health Research and Development (ZonMw), a semi-governmental organization (grant number 63001001). The views expressed in the submitted article are our own and not an official position of the institution or funder. The approval for conducting this study was obtained from the Medical Ethical Committee of the Erasmus University Medical Centre Rotterdam, The Netherlands (MEC-2016-292). Trial registration number (The Netherlands Trial Register): ID number: NL5843.

**Background:** Achilles tendinopathy (AT) occurs in half of the elite runners. AT is a difficult-to-treat tendon disease, which may progress from new onset to a chronic state. It is unknown how many runners with new-onset AT develop persisting symptoms and which prognostic factors are associated with this course.

**Objective:** To describe how many runners develop persisting symptoms 1 year after onset of reactive AT.

**Study Design:** Prospective cohort study.

**Methods:** Runners registering for a Dutch running event (5–42.2 km) were eligible for inclusion. Runners reporting new-onset AT between registration for the running event and 1 month after received a 1-year follow-up questionnaire. The 1-year follow-up questionnaire inquired about persisting symptoms (yes/no), running activity, and metabolic disorders. We calculated the percentage of runners with persisting symptoms and performed a multivariable logistic regression analysis to study the association between potential prognostic factors and persisting symptoms.

**Results:** Of 1929 participants, 100 runners (5%) reported new-onset AT. A total of 62 runners (62%) filled in the 1-year follow-up questionnaire. Persisting symptoms were reported by 20 runners (32%). A higher running distance per week before new-onset AT was associated with a lower risk of developing persisting symptoms (odds ratio (OR): 0.9, 95% confidence interval (CI): [0.9;1.0]). There was a positive trend toward an association between metabolic disorders and persisting symptoms (OR: 5.7, 95% CI: [0.9;36.2]).

**Conclusion:** One third of runners develop persisting symptoms 1 year after new-onset AT. Interestingly, a higher running distance per week before new-onset AT potentially lowers the risk of developing persisting symptoms.

## KEYWORDS

ankle injuries, athletes, athletic injuries/prevention and control, epidemiology, mass screening/methods, wounds and injuries

**Trial registration number:** The Netherlands Trial Register (ID number: NL5843).

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2020 The Authors. *Scandinavian Journal of Medicine & Science In Sports* published by John Wiley & Sons Ltd.

## 1 | INTRODUCTION

Running grows in popularity due to its health benefits and low costs, and the incidence of running-related injuries is growing simultaneously.<sup>1</sup> While acute sports injuries already rank third place in total healthcare costs,<sup>2</sup> the subgroup of athletes with chronic injuries account for even higher costs due to more medical visits and absence of work.<sup>3,4</sup> One of the most common running injuries is Achilles tendinopathy (AT), with approximately half of the elite runners developing AT during their running career.<sup>5</sup> It is therefore important to accurately identify the number of runners that develop persisting symptoms and additionally to identify prognostic factors for developing persisting symptoms.

The phases of AT are currently considered to be a spectrum ranging from new-onset tendinopathy to degenerative chronic tendinopathy.<sup>6</sup> In new-onset AT, collagen integrity is considered to be normal, with the presence of increased cell proliferation.<sup>6</sup> Chronic AT may develop when symptoms persist or recur and is characterized by a loss of well-organized tendon tissue structure.<sup>6</sup> We know that high activity levels and general health are important factors for the development of a chronic tendon disease.<sup>6</sup> In case of general health, metabolic disorders are frequently associated with AT and AT is more prevalent in runners with a worse metabolic profile.<sup>7-9</sup> It is, however, unknown which percentage of runners with new-onset AT develop persisting symptoms and which prognostic factors are associated with an increased risk of developing persisting symptoms.

The primary aim of this study was to describe the percentage of runners that develop persisting AT symptoms 1 year after new-onset AT. Our secondary aims were to describe symptom severity in runners 1 year after development of new-onset AT, the course of symptoms, healthcare consumption, and running activity, and to identify prognostic factors that are associated with developing persisting symptoms.

## 2 | METHODS

### 2.1 | Design

This prospective cohort study is a 1-year follow-up of runners who were included in the INSPIRE trial (INtervention Study on Prevention of Injuries in Runners at Erasmus MC) and reported new-onset AT. The INSPIRE trial study was approved by the Medical Ethics Committee of the Erasmus MC Rotterdam, the Netherlands (MEC-2016-292), and registered at the Netherlands Trial Registry (NTR number: NL5843). The INSPIRE trial is a randomized controlled trial that investigated the effect of an online injury prevention

program on the number of running-related injuries in runners preparing for a running event.<sup>10</sup> The online prevention program did not decrease the number of running-related injuries, which is why we can consider the included patients as a cohort.<sup>10</sup>

Extensive description of the methods is published by Fokkema et al<sup>11</sup> Recruitment was from October 2016 until April 2017. Informed consent was obtained from all participants, and their rights to privacy were protected. Runners received one baseline questionnaire  $\leq 2$  months before and three follow-up questionnaires 2 weeks before, 1 day after, and 1 month after a Dutch running event (5-42.2 km). The baseline questionnaire inquired information about age, sex, body mass index (BMI), running experience in years, running distance in the week before baseline questionnaire, runs per week, average hours ran per week in the previous 3 months, average kilometers ran per week in the previous 3 months, and average pace in minute per kilometer in the previous 3 months. The follow-up questionnaires inquired whether the runner had developed a running-related injury and on which location.

### 2.2 | Prospective follow-up study

For the current study, runners who developed a self-reported new-onset AT between event registration and 1 month after the running event were included. AT was defined as an injury localized in the Achilles tendon caused by running, and one or more of the following criteria had to be met: (1) The injury caused a reduction in running distance, frequency, speed, or duration for at least 1 week; (2) the injury led to an appointment with a doctor and/or physiotherapist; and (3) medication was used to reduce symptoms.<sup>10</sup> There was no question to distinguish between insertional AT and midportion AT, as there is yet no validated questionnaire-based approach to make this distinction. An follow-up questionnaire was sent 1 year after the running event to runners who reported new-onset AT. This questionnaire was divided into six sections: (1) current symptoms of AT, (2) symptom severity, (3) healthcare consumption, (4) course of AT symptoms, (5) running activity, and (6) presence of metabolic disorders (Figure 1).

### 2.3 | Outcome measures

The primary outcome measure was the percentage of runners who reported developing persisting symptoms localized in the Achilles tendon 1 year after development of new-onset AT. Persisting symptoms were expressed in a single question "Do you still experience symptoms of your Achilles tendinopathy?" (Figure 1).

**Current symptoms**

Question: Do you still experience symptoms of your Achilles tendinopathy?

1. Yes
2. No

Questionnaire: VISA-A score (Dutch language)

**Course of Achilles tendinopathy symptoms**

Question: Which image best describes the type of pain of your Achilles tendinopathy symptoms?

1. Gradually decreasing pain
2. Gradually increasing pain
3. Persisting pain with slight fluctuations
4. Persisting pain with pain attacks
5. Pain attacks with pain in between
6. Pain attacks without pain in between

**Healthcare consumption**

Question: Have you visited a medical professional for treatment of your Achilles tendinopathy in the period of your registry for the running event and now? Multiple answers allowed.

1. No
2. Yes, physiotherapist
3. Yes, general practitioner
4. Yes, medical specialist
5. Yes, other: ...

Question: How many times have you visited a medical professional?  
In numbers.

Question: Did you undergo one of the following examinations for your Achilles tendinopathy? Multiple answers allowed.

1. Ultrasound
2. X-ray
3. MRI
4. I have not had any imaging performed.

Question: Which treatments were applied to stimulate recovery of your Achilles tendinopathy? Multiple answers allowed.

1. I have not received or performed any treatments.
2. Rest (rest or temporary adjustments in running activities)
3. Exercise (stretching, strengthening exercises)
4. Orthotics (use of adjusted shoes, brace, bandage, insoles)
5. Medication (use of paracetamol, anti-inflammatories like diclofenac, topical agents)
6. Injections (e.g. corticosteroid injections)
7. Passive (sport compression socks, tape, dry needling, massage, ultrasound, shockwave)
8. Surgery (as a treatment for Achilles tendinopathy)

**Running activity**

Question: Have you adjusted your current running activities?

1. No
2. Yes, due to the Achilles tendinopathy
3. Yes, due to other injuries
4. Yes, due to other reasons.

Question: Which adjustments in running activity have you made because of the Achilles tendinopathy? Multiple answers allowed.

1. Frequency (frequency of training)
2. Duration of running activities
3. Speed during running
4. I have not made any adjustments
5. Other: ...

Question: How many hours did you run per week on average in the previous 3 months?  
In hours.

Question: How many kilometers did you run per week on average in the previous 3 months?  
In kilometers.

Question: What was your average pace in minute per kilometer in the previous 3 months?  
In minute per kilometer.

**Metabolic disorders**

Question: Are you or have you been diagnosed with one of the following disorders? Multiple answers allowed.

Options:

1. High blood pressure (systolic blood pressure of 140 mmHg or higher, and/or diastolic blood pressure of 90 mmHg or higher, and/or use of antihypertensive drugs)
2. Elevated cholesterol (total cholesterol of 6.5 mmol/l or higher, or use of cholesterol lowering medication)
3. Diabetes (fasting blood glucose of 7mmol/l or higher and/or use of blood glucose improving medication)
4. I have not been diagnosed with one or more of the abovementioned diseases.

**FIGURE 1** Six different sections of the follow-up questionnaire with subdivided variables

Secondary outcome measures were the symptom severity in runners 1 year after development of new-onset AT, expressed in the Victorian Institute of Sports Assessment-Achilles tendinopathy (VISA-A) score, course of AT symptoms, healthcare consumption, running activity, and potential prognostic factors for developing persisting symptoms. Potential prognostic factors were sex, age, body mass index (BMI), running experience in years, running distance per week and previous AT (all reported in the baseline questionnaire before onset of AT), and adjustments in running activity and having a metabolic disorder (both reported in the 1-year follow-up questionnaire, based on the answers on the questions in Figure 1).

## 2.4 | Statistical analysis

To assess possible differences in baseline characteristics of runners with new-onset AT who completed and who did not complete the 1-year follow-up questionnaire, we used an independent-sample *t* test (normal distribution), Mann-Whitney *U* test (no normal distribution), or chi-square test (categorical variables). A similar analysis was performed to assess possible differences in baseline characteristics and running activity between runners who reported persisting symptoms and runners who reported recovery. The percentage of runners reporting persisting symptoms was calculated by dividing the number of symptomatic runners by the number of recovered runners. Symptom severity was analyzed using descriptive statistics and expressed as mean VISA-A (standard deviation (SD)). Descriptive statistics were used to report the course of AT symptoms, healthcare consumption, and running activity (as recorded with the questions in Figure 1). Potential prognostic factors for developing persisting symptoms were analyzed using a multivariable binary logistic regression model (ENTER method). Results were presented as odds ratio (OR) with 95% confidence interval (CI).

In all statistical analysis, a *P*-value < .05 was deemed significant. SPSS software (V.24.0.0.1; SPSS, Chicago, Illinois, USA) was used for statistical analysis.

## 3 | RESULTS

A total of 1929 runners were included in the INSPIRE trial and completed at least one of the follow-up questionnaires, and 100 reported new-onset AT (5%). Of these runners with new-onset AT, 62 runners (62%) filled in the 1-year follow-up questionnaire. One runner (1%) did not fully complete the VISA-A questionnaire. Runners who filled in the 1-year follow-up questionnaire were on average 5.2 years older than

runners who did not fill in the 1-year follow-up questionnaire. Additionally, runners who completed the 1-year follow-up questionnaire registered more often for a full marathon and less for half a marathon (Supplementary File S1). Other baseline characteristics were comparable.

### 3.1 | Persisting symptoms

In 32% of cases, runners reported having persisting symptoms. Table 1 describes differences in baseline characteristics between runners with persisting AT symptoms and runners that did not have persisting symptoms (recovery group).

### 3.2 | Symptom severity

After 1 year, runners who completed the VISA-A score (61%) had a symptom severity of 85.1 (17.9), expressed in mean VISA-A score (SD). When dichotomizing the VISA-A score with a cutoff of  $\geq 97$  points on the VISA-A scale (normal range for healthy runners),<sup>12</sup> 64% of the runners scored <97 points, while 36% of the runners scored  $\geq 97$  points. None of the runners who reported persisting symptoms had a VISA-A score of  $\geq 97$ . Of runners who reported recovery, 52% had a VISA-A score of >97.

### 3.3 | Course of symptoms

The pain as a consequence of AT was most frequently described as "gradually decreasing pain" (60%) (Table 2). This description was used by 70% of runners who reported recovery. There was a large variation within the group of runners with persisting symptoms: 30% described their course as "gradually decreasing pain," followed by "persisting pain with slight fluctuations" (25%), "pain attacks without pain in between" (15%), "pain attacks with pain in between" (15%), "gradually increasing pain" (10%), and "persisting pain with pain attacks" (5%).

### 3.4 | Healthcare consumption

Over the course of 1-year follow-up, more than half of all runners (56%) visited a medical professional for their AT (Table 2). Runners who visited a medical professional and reported persisting symptoms had a median (interquartile range, IQR) of 5.0 (9.0) visits, and runners who reported recovery had a median (IQR) of 4.5 (4.0) visits. Most runners visited a physiotherapist (48%, Table 2). Ultrasound was

**TABLE 1** Baseline characteristics of the runners who reported persisting symptoms or recovery 1 year after new-onset AT

	Persisting symptoms		Recovered		P-value
	N	%/ mean (SD)/ median; IQR	N	%/ mean (SD)/ median; IQR	
N	20		42		
Demographics					
Sex (female)		35%		29%	.608
Age (years)		49.0 (8.1)		46.2 (10.7)	.318
Length (cm)		179.5 (9.7)		179.5 (10.3)	.993
Weight (kg)		77.1 (12.3)		74.5 (12.0)	.440
BMI (kg/m <sup>2</sup> )		23.8 (2.3)		23.0 (2.4)	.231
Training					
Running experience (years)		4.8; 9.5		4.3; 7.0	.928
Running distance per week (km)		13.5; 15.0		25.0; 25.0	.033*
Runs per week		2.0; 2.0		3.0; 1.0	.052
Event distance					
5 km		-		7%	-
7.5 km		-		-	-
10 km		30%		24%	.629
21.1 km		25%		17%	.753
42.2 km		45%		52%	.831

Abbreviations: BMI, body mass index; IQR, interquartile range; SD, standard deviation.

\*Statistically significant difference (p-value < 0.05)

the most frequently reported imaging tool (16%). Almost all runners used some form of treatment, of which relative rest (82%) and exercises (77%) were most popular. Descriptive statistics of applied treatments between runners with persisting symptoms and runners who reported recovery are displayed in Supplementary File S2.

### 3.5 | Running activities

After development of new-onset AT, 66% of runners adjusted their running activities during the course of 1 year because of AT symptoms: 53% in frequency, 47% in speed, and 45% in duration (Table 2). One year after development of new-onset AT, 23% of runners still had adjusted their running activities because of AT symptoms.

Runners with persisting symptoms decreased the distance ran per week from median (IQR) 20.0km (20.0) at 3 months before baseline to 15.0km (20.0) 3 months before 1-year follow-up ( $P = .041$ ). There was no significant change in median (IQR) running hours per week from 3.0 hours (2.0) to 2.0 hours (2.5) ( $P = .100$ ), and there was no significant change in median (IQR) pace (5.0 min/km (1.0) vs 5.5 min/km (1.5),  $P = .329$ ). Runners who reported recovery decreased their median (IQR) pace significantly

from 5.0 min/km (1.0) to 6.0 min/km (1.3),  $P = .030$ , while hours per week (2.8 hours (2.6) vs 3.0 hours (2.0),  $P = .196$ ) and kilometers per week (20.0 km (23.5) vs 20.0 km (26.3),  $P = .912$ ) did not change significantly. There were no between-group differences in median running hours, kilometers covered, or running pace.

### 3.6 | Prognostic factors for developing persisting symptoms

A higher running distance per week before onset of AT was associated with a lower risk of developing persisting symptoms (OR 0.9, 95% CI [0.9;1.0]). There was a tendency that having one of the metabolic disorders (OR 5.7, 95% CI [0.9;36.2]) was associated with an increased risk of developing persisting symptoms. There were no significant associations between developing persisting symptoms and other included factors (Table 3).

## 4 | DISCUSSION

This is the first study to report how many runners develop persisting symptoms at 1 year after new-onset AT. One



**TABLE 2** Course of AT symptoms, healthcare consumption, running activity, and presence of metabolic disorders of included runners

	N	Included runners %/ mean (SD)
N	62	
Course of AT symptoms		
Gradually decreasing pain	37	60%
Gradually increasing pain	3	5%
Persisting pain with slight fluctuations	9	15%
Persisting pain with pain attacks	1	2%
Pain attacks without pain in between	5	8%
Pain attacks with pain in between	7	11%
Healthcare consumption		
Visit of medical professional (yes)	35	56%
Physiotherapist	30	48%
General practitioner	7	11%
Medical specialist	4	6%
Other <sup>a</sup>	5	8%
Number of visits		5.0 (5.0)
Use of imaging (yes)	10	16%
Ultrasound	10	16%
X-ray	1	2%
MRI	0	-
Treatment applied (yes)	60	97%
Relative rest	51	82%
Exercises	48	77%
Orthotics	18	29%
Medication	18	29%
Passive modalities	30	48%
Injections	0	-
Surgery	0	-
Running activity		
Adjustments after onset of AT	41	66%
Frequency	33	53%
Speed	29	47%
Duration	28	45%
Adjustments at 1-year follow-up	14	23%
Metabolic disorder (yes)		
Hypertension	9	15%
Hypercholesterolemia	6	10%
Diabetes	1	2%

Abbreviations: AT, Achilles tendinopathy; MRI, magnetic resonance imaging; SD, standard deviation.

<sup>a</sup>osteopath, podiatrist.

third of runners reported persisting symptoms 1 year after new-onset AT. One quarter still adjusted their running activities one year after developing new-onset AT because of

persisting AT symptoms. In runners that developed AT, a higher running distance per week before onset of AT was associated with a lower risk of developing persisting symptoms. Furthermore, we found a positive trend toward an association between having a metabolic disorder and developing persisting symptoms.

#### 4.1 | Persisting symptoms

Johannsen et al<sup>13</sup> reported that 37% of patients with chronic AT experience some degree of pain and reduced function after 10 years follow-up, which is similar to the 32% of self-reported persisting symptoms in our study. Noticeable is the small difference in persisting symptoms between our 1-year follow-up study and this 10-year follow-up study.<sup>13</sup> Other studies reported approximately 35%-60% of patients with chronic AT having persisting symptoms after a follow-up of 5 years or longer.<sup>4,14,15</sup> The difference can be explained by the heterogeneity of the studies, as there were differences in the definition of recovery (self-reported recovery<sup>13-15</sup> vs pain free<sup>4</sup>), type of AT (insertional, midportion,<sup>4,15</sup> or a mix<sup>13,14</sup>), duration of AT (chronic AT vs<sup>4,14</sup> a mix of new-onset AT and chronic AT<sup>13,15</sup>), and researched population (active patients<sup>4,14</sup> vs a mix of active and sedentary patients<sup>13,15</sup>). Nevertheless, all studies, including ours, reported a relatively large subgroup of patients with persisting symptoms. There is a need to better identify the characteristics of this specific subgroup with persisting symptoms at an early stage.

The percentage of self-reported persisting symptoms (32%) was lower than the percentage with persisting symptoms according to the dichotomized VISA-A score (64%). This difference might be explained by the acceptance of limitations by the patient: The patient experiences no AT symptoms due to, for example, decreased sports activity. Therefore, patients might not report persisting symptoms due to acceptance of limitations, while the patient has not fully recovered to the pre-injury sports activity. For adequate expectation management, it is important to inform runners with new-onset AT that their symptoms might cause long-lasting adjustments in sports activity.

#### 4.2 | Symptom severity

Symptom severity can be expressed with the validated VISA-A score (0-100 points, with 100 points representing full recovery). Patients reported a mean and SD of 85.1 (17.9) at 1 year after sustaining new-onset AT. We are the first to report symptom severity 1 year after development of new-onset AT. The patient acceptable symptom state (PASS), a

**TABLE 3** Potential prognostic factors for developing persisting symptoms, analyzed with a multivariable binary logistic regression analysis

	Persisting symptoms		Recovered		Multivariable analysis
	N	%/ mean (SD)/ median; IQR	N	%/ mean (SD)/ median; IQR	OR (95% CI)
	20		42		
Sex (female)		35%		29%	2.8 (0.7;11.5)
Age (years)		49.0 (8.1)		46.2 (10.7)	1.0 (0.9;1.1)
BMI (kg/m <sup>2</sup> )		23.8 (2.3)		23.0 (2.4)	1.2 (0.9;1.7)
Running experience (years)		4.8; 9.5		4.3; 7.0	1.0 (1.0;1.1)
Running distance per week (km)		13.5; 15.0		25.0; 25.0	0.9 (0.9;1.0)*
Previous AT (yes)		40%		24%	2.6 (0.6;11.2)
Adjusted running activity (yes) <sup>a</sup>		70%		64%	0.8 (0.2;3.1)
Any metabolic disorder (yes) <sup>b</sup>		30%		12%	5.7 (0.9;36.2)

Abbreviations: AT, Achilles tendinopathy; BMI, body mass index; CI, confidence interval; IQR, interquartile range; OR, odds ratio; SD, standard deviation.

<sup>a</sup>adjusted running activity after development of new-onset AT.

<sup>b</sup>included metabolic disorders are hypertension, hypercholesterolemia, and diabetes.

\*Statistical significant difference (p-value < 0.05).

value that represents the level of acceptable symptoms for the patient, is not yet determined for the VISA-A score.<sup>16</sup> It is currently unknown how to interpret the symptom severity in relation to the patients' experience of the symptoms. Determining the PASS for the VISA-A score will help future studies to interpret whether the symptom severity will be deemed acceptable by the patient. The high variability of this outcome in this homogenous population also suggests that a subgroup of patients with persisting severe symptoms is present.

### 4.3 | Course of symptoms

The course of AT symptoms was by both runners with persisting symptoms and runners who reported recovery most frequently described as "gradually decreasing pain." However, the course of AT symptoms in runners with persisting symptoms was more heterogeneous, and runners chose more frequently descriptions that included the word "fluctuations" or "pain attacks."

In a clinical setting, runners can be informed that the course of symptoms after onset of AT is gradually decreasing in most cases. However, in case of recurring fluctuations or pain attacks, it could be helpful to seek medical advice.

### 4.4 | Healthcare consumption

The majority of patients consulted a healthcare professional with a mean of almost 4 visits per patient. Almost all patients decided to apply some form of treatment. The use of treatment could influence the risk of developing persisting symptoms 1 year after new-onset AT. We think it is important to point out that we chose not to include this variable in the multivariable analysis, as almost all runners used any form of treatment. This would severely influence the outcome of the analysis. Furthermore, a randomized study design is necessary for analyzing treatment effect on developing persisting symptoms.

### 4.5 | Running activities

One in four runners adjusted their running activities at 1 year after development of new-onset AT because of AT symptoms. Runners with persisting symptoms decreased the distance ran per week by 5 km, while runners who reported recovery slowed down their pace by 1 min/km. The slower pace in runners who reported recovery fits the previously mentioned hypothesis why the percentage of self-reported recovery is higher than recovery according to the dichotomized VISA-A score. Runners presumably deem themselves recovered, while they

have not returned to their pre-injury level of sports. Although AT occurs frequently in active persons, there are no other studies describing adjustments in (running) activity because of AT symptoms.

#### 4.6 | Prognostic factors for developing persisting symptoms

We analyzed a number of potential prognostic factors for the development of persisting symptoms 1 year after new-onset AT. Surprisingly, a higher running distance per week, reported before onset of AT, was associated with a lower risk of developing persisting symptoms. Although this result is difficult to explain, we propose two plausible hypotheses. First, runners with high training loads might have had more constant training loads than the runners with low training load. This high variability in training load leads to "spikes" in training load, and theoretically, this can be a prognostic factor for persisting symptoms.<sup>17</sup> We did, however, not record changes in training load. A second hypothesis is that we only found an association due to the relatively low number of runners with AT. It is interesting to study whether there is a subgroup with a different training behavior over time that is more susceptible to develop persisting symptoms.

There was a tendency toward an association between having a metabolic disorder and developing persisting symptoms. We selected metabolic disorders (hypertension, hypercholesterolemia, and diabetes) that were associated with AT in previous literature.<sup>7,9,18</sup> We noticed a similar tendency for BMI, which is part of the metabolic syndrome, although the clinical relevance of BMI was less striking (mean difference of 0.8 kg/m<sup>2</sup>). Metabolic disorders influence the tendon via different mechanisms, which can lead to matrix destruction due to systemic inflammation and hypoxia.<sup>19,20</sup> As inflammation is part of many metabolic disorders,<sup>7</sup> it could maintain the chronic state of the tendinopathy and prevents proper healing. Tendinopathy could prevent patients from exercising and worsen the metabolic state.<sup>21</sup> This could eventually form a vicious circle: Patient starts exercising to improve their metabolic state, the metabolic disorder leads to AT, which hampers mobility and the metabolic state is not improved or even worsens.<sup>7</sup>

#### 4.7 | Strengths and limitations

A major strength of our study is the number of included cases, which increases the likelihood to identify prognostic factors for the course of AT. As we report more than 50 cases, we were able to detect moderate-to-strong

associations.<sup>22</sup> A limitation of this study is using online questionnaires to inquire about injuries. A strict injury definition, reported in the original publication by Fokkema et al,<sup>10</sup> was used to prevent contamination of the data by injuries that were not actually injuries. As distinguishing between insertional AT and midportion AT through an online questionnaire has not been validated, we chose not to collect and present this information. We therefore do not know the difference in prognosis between these two entities. Another limitation was the response rate of 62%. The responding group consisted of slightly older runners and registered more often for a full marathon, which makes the results of this study more appropriate for slightly older marathon runners. Another possible limitation is recall bias, especially for the presence of metabolic disorder. As metabolic disorders develop over a longer period of time, we assume that they were already present at baseline. However, we did not perform physical examination or blood tests. It could be that runners have had an underlying metabolic disorder, but were not diagnosed. This potential bias is possibly existent in both the recovered and non-recovered groups.

#### 4.8 | Recommendation for future research

Our study shows an interesting association between running distance per week and persisting symptoms. It is currently unclear how the runners exactly adjusted their running activities. Global Positioning System (GPS) data are often used by runners to evaluate personal progress, and it offers a valid alternative to subjective reporting.<sup>23</sup> It would be interesting to analyze the association between running distance per week, analyzed with GPS data, and development of persisting symptoms in runners 1 year after new-onset AT, in order to identify optimal training load adjustments for this patient group.

A tendency toward an interesting association between metabolic disorders and persisting symptoms was also identified. As runners could have undiagnosed metabolic disorders, we propose to perform a large prospective follow-up study with the use of objective outcome measures representing metabolic disorder.

### 5 | CONCLUSION

One third of runners develop persisting symptoms 1 year after new-onset AT. One year after developing new-onset AT, one quarter of runners still had adjusted their running activities because of AT symptoms. A higher running distance per week, reported before new-onset AT, was associated with



a lower risk of developing persisting symptoms. There was a positive trend toward an association between metabolic disorders and developing persisting symptoms. Future research is needed for in-depth analysis of the association between external and internal prognostic factors and the development of persisting symptoms.

## 5.1 | Perspective

One third of runners develop persisting symptoms 1 year after new-onset Achilles tendinopathy and one quarter of runners still had to adjust their running activities due to symptoms. We identified that a higher running distance per week before developing new-onset AT is associated with a lower risk of developing persisting symptoms. By describing the course of symptoms and the effect on running activities, this study supports the clinician in providing evidence-based information to the patient and forming adequate expectations.

## ACKNOWLEDGMENTS

We would like to thank all runners that participated in the INSPIRE trial. We thank Vereniging voor Sportgeneeskunde (VSG) and Golazo Sports for the pleasant collaboration. We are grateful for ZonMw for funding this study.

## CONFLICT OF INTEREST

This study received financial support from the Netherlands Organization for Health Research and Development (ZonMw), a semi-governmental organization (grant number 63001001). The views expressed in the submitted article are our own and not an official position of the institution or funder.

## ORCID

Iris F. Lagas  <https://orcid.org/0000-0002-4550-8284>

Trynysje Fokkema  <https://orcid.org/0000-0002-3767-2770>

[org/0000-0002-3767-2770](https://orcid.org/0000-0002-3767-2770)

Marijenke van Middelkoop  <https://orcid.org/0000-0001-6926-0618>

[org/0000-0001-6926-0618](https://orcid.org/0000-0001-6926-0618)

## REFERENCES

1. Sportblessures Blessurecijfers 2013 (Sport injuries Injury numbers 2013). 2015. Accessed April 03, 2019.
2. Polinder S, Haagsma J, Panneman M, Scholten A, Brugmans M, Van Beeck E. The economic burden of injury: Health care and productivity costs of injuries in the Netherlands. *Accid Anal Prev*. 2016;93:92-100.
3. Hespanhol Junior LC, van Mechelen W, Postuma E, Verhagen E. Health and economic burden of running-related injuries in runners training for an event: A prospective cohort study. *Scand J Med Sci Sports*. 2016;26(9):1091-1099.
4. 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.
5. Kujala UM, Sarna S, Kaprio J. Cumulative incidence of achilles tendon rupture and tendinopathy in male former elite athletes. *Clin J Sport Med*. 2005;15(3):133-135.
6. Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. *Br J Sports Med*. 2009;43(6):409-416.
7. Ackermann PW, Hart DA. *Metabolic Influences on Risk for Tendon Disorders. Advances in Experimental Medicine and Biology*. (Vol 920). Switzerland: Springer International Publishing AG Switzerland; 2016.
8. Abate M, Salini V. Mid-portion Achilles tendinopathy in runners with metabolic disorders. *Eur J Orthop Surg Traumatol*. 2019;29(3):697-703.
9. Holmes GB, Lin J. Etiologic factors associated with symptomatic achilles tendinopathy. *Foot Ankle Int*. 2006;27(11):952-959.
10. Fokkema T, de Vos R-J, van Ochten JM, et al. Online multifactorial prevention programme has no effect on the number of running-related injuries: a randomised controlled trial. *Br J Sports Med*. 2019;53(23):1479-1485.
11. Fokkema T, Vos R-J, van Ochten JM, et al. Preventing running-related injuries using evidence-based online advice: the design of a randomised-controlled trial. *BMJ Open Sport Exerc Med*. 2017;3(1):e000265.
12. 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.
13. Johannsen F, Jensen S, Wetke E. 10-year follow-up after standardised treatment for Achilles tendinopathy. *BMJ Open Sport Exerc Med*. 2018;4(1):e000415.
14. Silbernagel KG, Brorsson A, Lundberg M. The majority of patients with Achilles tendinopathy recover fully when treated with exercise alone: a 5-year follow-up. *Am J Sports Med*. 2011;39(3):607-613.
15. Paavola M, Kannus P, Paakkala T, Pasanen M, Jarvinen M. Long-term prognosis of patients with achilles tendinopathy. An observational 8-year follow-up study. *Am J Sports Med*. 2000;28(5):634-642.
16. Tubach F, Ravaud P, Baron G, et al. Evaluation of clinically relevant states in patient reported outcomes in knee and hip osteoarthritis: the patient acceptable symptom state. *Ann Rheum Dis*. 2005;64(1):34-37.
17. Blanch P, Gabbett TJ. Has the athlete trained enough to return to play safely? The acute:chronic workload ratio permits clinicians to quantify a player's risk of subsequent injury. *Br J Sports Med*. 2016;50(8):471-475.
18. Rechart M, Shiri R, Karppinen J, Jula A, Heliovaara M, Viikari-Juntura E. Lifestyle and metabolic factors in relation to shoulder pain and rotator cuff tendinitis: a population-based study. *BMC Musculoskelet Disord*. 2010;11:165.
19. Abate M, Schiavone C, Salini V, Andia I. Occurrence of tendon pathologies in metabolic disorders. *Rheumatology (Oxford)*. 2013;52(4):599-608.
20. Andia I, Rubio-Azpeitia E, Maffulli N. Platelet-rich plasma modulates the secretion of inflammatory/angiogenic proteins by inflamed tenocytes. *Clin Orthop Relat Res*. 2015;473(5):1624-1634.

21. Abate M, Salini V, Schiavone C. Achilles tendinopathy in elderly subjects with type II diabetes: the role of sport activities. *Aging Clin Exp Res*. 2016;28(2):355-358.
22. Bahr R, Holme I. Risk factors for sports injuries—a methodological approach. *Br J Sports Med*. 2003;37(5):384-392.
23. Townshend AD, Worringham CJ, Stewart IB. Assessment of speed and position during human locomotion using nondifferential GPS. *Med Sci Sports Exerc*. 2008;40(1):124-132.

## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

**How to cite this article:** Lagas IF, Fokkema T, Bierma-Zeinstra SMA, Verhaar JAN, van Middelkoop M, de Vos R-J. How many runners with new-onset Achilles tendinopathy develop persisting symptoms? A large prospective cohort study. *Scand J Med Sci Sports*. 2020;30:1939–1948. <https://doi.org/10.1111/sms.13760>