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Original article

Epidemiology of insertional and midportion Achilles tendinopathy in runners: A prospective cohort study

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Abstract

Background: Achilles tendinopathy (AT) is a common problem among runners. There is only limited evidence for risk factors for AT, and most studies have not defined the AT subcategories. No study has compared the incidence and risk factors between insertional AT and midportion AT, though they are considered distinct. This study aimed to assess incidence and risk factors of AT based on data from a large prospective cohort. The secondary aim was to explore differences in risk factors between insertional and midportion AT.

Methods: Participants were recruited from among registered runners at registration for running events. Questionnaires were completed at baseline, 1 month before the event, 1 week before the event, and 1 month after the event. Information concerning demographics, training load, registered events, and running-related injuries were collected at baseline. The follow-up questionnaires collected information about new injuries. A pain map was used to diagnose midportion and insertional AT. The primary outcome was the incidence of AT. Multivariable logistic regression analysis was applied to identify risk factors for the onset.

Results: We included 3379 participants with a mean follow-up of 20.4 weeks. The incidence of AT was 4.2%. The proportion of insertional AT was 27.7% and of midportion AT was 63.8%; the remaining proportion was a combined type of insertional and midportion AT. Men had a significantly higher incidence (5%, 95% confidence interval (95%CI): 4.1−6.0) than women (2.8%, 95%CI: 2.0−3.8). AT in the past 12 months was the most predominant risk factor for new-onset AT (odds ratio (OR) = 6.47, 95%CI: 4.27 −9.81). This was similar for both subcategories of AT (insertional: OR = 5.45, 95%CI: 2.51−11.81; midportion: OR = 6.96, 95%CI: 4.24−11.40). Participants registering for an event with a distance of 10/10.55 km were less likely to develop a new-onset AT (OR = 0.59, 95%CI: 0.36−0.97) or midportion AT (OR = 0.47, 95%CI: 0.23 −0.93). Higher age had a significant negative association with insertional AT (OR = 0.97, 95%CI: 0.94−1.00).

Conclusion: The incidence of new-onset AT among recreational runners was 4.2%. The proportion of insertional and midportion AT was 27.7% and 63.8%, respectively. AT in the past 12 months was the predominant risk factor for the onset of AT. Risk factors varied between insertional and midportion AT, but we could not identify clinically relevant differences between the 2 subtypes.

Keywords: Achilles tendon injury; Incidence; Risk factor; Running-related injury

1. Introduction

Achilles tendinopathy (AT) is a tendon disorder with the triad of pain, swelling, and impaired performance.[1,2] AT can be subclassified into insertional AT and midportion AT, which are regarded as separate entities with different etiology and treatment options.[3] AT has a lifetime incidence of 6% in the general population.[4] It is more common in endurance runners with a cumulative lifetime incidence of 52%.[4] In addition to the high incidence, there is a substantial negative impact of AT on quality of life, work productivity, and total costs (approximately EUR 840 per conservatively treated AT patient annually).[5] A substantial proportion (25%−60%) of AT patients experience symptoms for 5−10 years.[2,6] Given its longstanding nature, AT is a substantial healthcare problem in the middle-aged working population.

According to the Translating Research into Injury Prevention Practice framework, identifying risk factors through

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cohort studies is an essential step in injury prevention.[7] Several systematic reviews[8,9] have previously identified and summarized clinical risk factors for AT, including: being overweight, having certain genetic variants, a prior lower-extremity tendinopathy, frequent alcohol use, plantar flexor strength, certain gait-related parameters, administration of ofloxacin, renal dysfunction, heart transplantation, and winter training. The evidence for these risk factors was, however, limited.[9] Furthermore, as suggested by Bahr and Holme,[10] to detect the association between a risk factor and injury in a cohort, at least 20 injury cases are needed to provide sufficient statistical power. However, 6 of the 10 included cohort studies being analyzed by the systematic reviews had less than 20 cases of AT.[11−13] Moreover, these risk factors have been assessed in specific populations, like military personnel[14] or patients undergoing a heart transplantation,[15] making them less applicable for generalizing to athletic populations. Research in recreational runners is highly relevant as they represent a large population[16] and have a high susceptibility to AT.[4] Risk factors for AT were recently assessed in a large population of recreational runners.[17] This study found that AT in the preceding 12 months, using a training schedule, and sport compression socks increased the risk of developing AT. Though a limitation of this study was the use of self-reported injuries without additional tools. This may have prevented the ability to accurately diagnose AT and to distinguish between insertional and midportion AT. No study to date has compared the incidence and risk factors between insertional AT and midportion AT, even though the literature considers them to be distinct entities.[3]

The current study uses data from a large prospective cohort of recreational runners with the primary aim of assessing risk factors for new-onset AT using a standardized pain map. Our secondary aim was to explore differences in risk factors between insertional and midportion AT.

2. Methods

2.1. Study design

The current study was part of the Shaping up Prevention of Running Injuries in the Netherlands using Ten steps (SPRINT) study, which was registered in the Netherlands Trial register (www.trialregister.nl; NL7694). Medical ethics approval was obtained from the Medical Ethical Committee of the Erasmus Medical Centre Rotterdam, the Netherlands (MEC-2019-0136).

2.2. Participants

Registered runners from any 1 of 4 running events (10−42.195 km) in the Netherlands[18] were invited to participate in this research project. Recruitment was performed by way of online registration from August 2019 to February 2020. The inclusion criteria included: (a) age ≥18 years, (b) registration at least 2 months before the event, (c) a good understanding of the Dutch language, (d) access to a personal email box, and (e) no participation in the INtervention Study on Prevention of Injuries in Runners at Erasmus University Medical Center (MC) study,[19] which was a large randomized controlled trial of runners who were included in a comparable study in the same setting.

2.3. Procedures and data collection

Participants were requested to provide digital informed consent and fill in 4 questionnaires, i.e., at baseline (at registration), 1 month, and 1 week prior to the registered running event, and 1 month after the event. Moreover, an *ad hoc* questionnaire was attached to a biweekly newsletter of the SPRINT study and sent to participants to increase the likelihood of registration of new-onset injuries. Participants who completed none of the follow-up or the *ad hoc* questionnaires were excluded from the current study.

The baseline questionnaire collected information concerning demographics, training, registered running events, and previous or current running-related injuries. The follow-up and *ad hoc* questionnaires collected information on new-onset injuries (including the location of symptoms using a standardized Achilles tendon pain map) (Fig. 1). The specific items in the questionnaires are presented in Supplementary Table 1.

The collected baseline data were considered as potential risk factors for new-onset AT. Based on previous publications[8,9,17] and clinical experience, 14 potential risk factors were pre-selected for the analyses: sex, age (year), body weight (kg), running experience (year), distance of the registered event (10−42.195 km), use of a training schedule (yes/no), use of compression socks (yes/no), landing type (hindfoot/midfoot/forefoot), running ≥80% on paved road (yes/no), have a history of AT (yes/no), have a history of other running-related injury (yes/no), change of training load (presented as month:year distance ratio and month:year speed ratio, and physical activity level (Short Questionnaire to Assess Health) score). The month:year distance ratio was calculated by dividing the average running distance per week of last month by that of last year. The month:year speed ratio was calculated by dividing the mean running speed of last year by the mean running speed of last month). Short Questionnaire to Assess Health scores come from a validated questionnaire with the general purpose of assessing habitual physical activity.[20]

Fig. 1. The standardized Achilles tendon pain map. The purple area indicates the first 2 cm from the attachment of the Achilles tendon to the calcaneus, also known as the insertional region; the red area indicates >2 cm above the attachment of the Achilles tendon, also known as the midportion region.

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2.4. Outcome measures

The primary outcome measure was the incidence of self-reported AT using the standardized pain map during follow-up. A new-onset AT was determined when the participant reported a new injury at the location of the Achilles tendon caused by running but had been asymptomatic at baseline. An injury was defined as a musculoskeletal symptom resulting in (a) a reduction of training volume (running distance, speed, duration or frequency) ≥1 week or 3 successive planned training sessions, or (b) a consultation with a health professional. The pain map (Fig. 1) was provided in the questionnaire for participants who reported a new-onset AT to select the specific location of symptoms on the Achilles tendon. A recent publication showed that the agreement between patient-reported pain on a pain map and clinical diagnosis by a physician is almost perfect.[21] If a participant selected both the insertional and midportion part of Achilles tendon, this was regarded as a combined type of AT. If the participant selected a different location on the Achilles tendon pain map at different follow-up time-points, the first chosen AT subtype was used for further evaluation.

2.5. Statistical analysis

Descriptive statistics were used to describe all variables (frequency and percentage for categorical variables; mean and SD for continuous variables). χ^2 tests (for categorical variables), independent sample t tests (for normally distributed continuous variables), and Mann−Whitney U tests (for non-normally distributed continuous variables) were used to compare the baseline characteristics between responders and non-responders (those lost to follow-up).

Incidence with 95% confidence interval (95%CI) was calculated as the percentage of participants with new-onset AT during follow-up. The incidence was also calculated for subgroups based on sex and event distance. The proportions of the different subtypes of AT were calculated as the percentage of the total number of AT cases and applied in subgroups of different sex and event distance as well. The number of days between the reported injury date and the event day was calculated to present the distribution of the event.

Logistic regression analyses were applied to identify potential risk factors for the onset of overall AT, insertional AT, and midportion AT. The analyses were conducted between participants who developed a new-onset AT and those who had no new running-related injury during the follow-up. First, univariate logistic regression analyses of potential risk factors were performed. Thereafter, variables with a p value of <0.2 in the univariate analysis were entered into the multivariable logistic regression (ENTER model). The results were expressed as odds ratio (OR) with 95%CI.

A sensitivity analysis on potential risk factors was carried out in participants that completed all 3 follow-up questionnaires. The statistical analysis was conducted using SPSS (Version 26.0; IBM Corp., Armonk, NY, USA). A p value of <0.05 was considered statistically significant.

3. Results

3.1. Participant characteristics

There were 4050 participants who were included in the SPRINT study (Fig. 2). Of these, 3379 (83.4%) completed at least 1 follow-up or *ad hoc* questionnaire and were included in the present study. The follow-up duration was 20.4 ± 6.2 weeks (mean ± SD), and 2329 participants (57.5%) completed all 3 follow-up questionnaires. Significant differences in age (43.1 year *vs.* 37.9 year, $p < 0.001$), weight (74.1 kg *vs.* 75.9 kg, $p < 0.001$), and years of training (10.7 year *vs.* 8.1 year, $p < 0.001$) were found between the responders and those who completed no follow-up or *ad hoc* questionnaire (Supplementary Table 2). Baseline information for all included runners, runners with no new-onset AT, and runners with each subtype of AT is presented in Table 1.

3.2. Incidence of new-onset AT

A total of 141 participants suffered from new-onset AT during follow-up (incidence of 4.2% (95%CI: 3.5−4.9)) (Table 2). Men had a higher incidence (5.0%, 95%CI: 4.1−6.0) compared to women (2.8%, 95%CI: 2.0−3.8). Participants who registered for a marathon event had a higher incidence (5.0%, 95%CI: 4.1−6.1) compared to participants who participated in other event distances (3.1% to 3.7%).

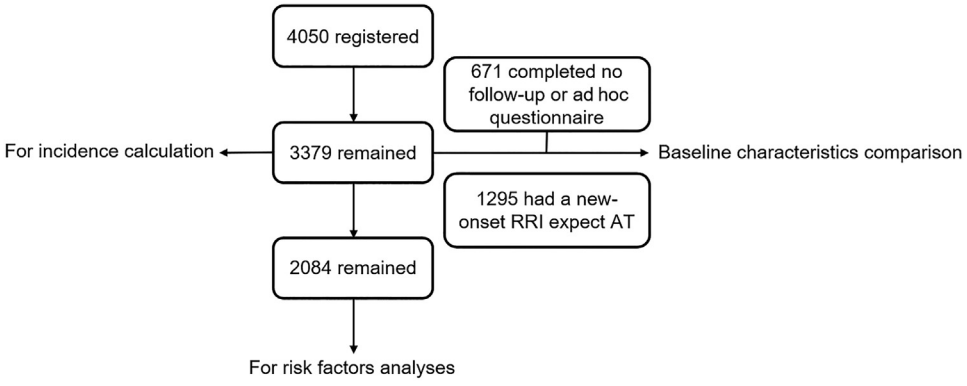

Fig. 2. Flowchart of the current study. AT = Achilles tendinopathy; RRI = running-related injury.

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Table 1
Study characteristics of study participants.

	Total ($n = 3379$)	No new-onset AT ($n = 3238$)	New-onset AT ($n = 141$)	Insertional ($n = 39$)	Midportion ($n = 90$)	Combined ($n = 12$)
Demographics						
Sex (male)	63.1%	62.6%	75.2%	76.9%	75.6%	66.7%
Age (year)	43.1 ± 12.2	43.1 ± 12.2	44.1 ± 12.2	40.3 ± 12.2	44.9 ± 11.6	50.1 ± 14.2
Weight (kg)	74.1 ± 11.6	74.1 ± 11.6	75.3 ± 11.0	75.1 ± 9.9	75.4 ± 11.6	75.4 ± 10.7
SQUASH	9866.1 ± 5057.3	9849.0 ± 5073.8	10,259.3 ± 4661.9	11271.9 ± 3852.5	9737.8 ± 4785.1	10,879.4 ± 5814.1
Training						
Years of training (year)	10.7 ± 10.3	10.6 ± 10.2	12.2 ± 11.6	8.8 ± 10.4	12.9 ± 11.4	18.5 ± 14
MYDR	1.3 ± 1.3	1.3 ± 1.4	1.4 ± 1.1	1.1 ± 0.5	1.5 ± 1.2	1.2 ± 1.1
MYSR	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1
Use of training schedule (yes)	65.3%	65.3%	67.4%	53.8%	74.4%	58.3%
Running ≥80% on paved road (yes)	77.7%	77.8%	75.2%	87.2%	75.6%	33.3%
Use of compression socks (yes)	20.7%	20.6%	24.1%	20.5%	25.6%	25.0%
Landing type[a]						
Hindfoot	29.9%	29.7%	34.0%	25.6%	35.6%	50.0%
Midfoot	30.6%	30.7%	29.1%	38.5%	25.6%	25.0%
Forefoot	14.1%	14.3%	10.6%	10.3%	10.0%	16.7%
Event distance						
10/10.55 km	22.2%	22.4%	16.3%	25.6%	12.2%	16.7%
15/16.1 km	13.7%	13.7%	12.1%	12.8%	11.1%	16.7%
Half marathon	14.7%	14.8%	12.1%	5.1%	16.7%	0.0%
Marathon	49.5%	49.0%	59.6%	56.4%	60.0%	66.7%
Previous injuries						
AT in the previous 12 months (yes)	8.1%	7.1%	31.2%	25.6%	33.3%	33.3%
An RRI, except AT, in the previous 12 months (yes)	41.7%	41.8%	38.3%	35.9%	36.7%	36.7%

Note: Data are presented as % or mean ± SD.
[a] Apart from those who chose 1 of the 3 landing types, the rest of participants did not have a fixed landing type or did not know their landing type.
Abbreviations: AT = Achilles tendinopathy; MYDR = month:year distance ratio; MYSR = month:year speed ratio; RRI = running-related injury; SQUASH = the Short Questionnaire to Assess Health.

Insertional AT took up 27.7% of the cases, midportion AT took up 63.8%, and combined type took up 8.5%. Most of the cases emerged between 44 and 15 days prior to the event (42.6%, Fig. 3).

3.3. Risk factors for new-onset AT

Logistic regression analyses of pre-selected potential risk factors are presented in Table 3. In univariate analyses, a history of AT in the past 12 months was significantly associated with new-onset AT and both subtypes of AT. Being male and registering for an event with a distance of 10/10.55 km were significant factors both for having a new-onset AT and having a midportion AT. Use of a training schedule was significantly associated with a new-onset midportion AT.

In the multivariate model, the presence of AT in the previous 12 months at baseline was associated with new-onset AT (OR = 6.47, 95%CI: 4.27−9.81), which was also seen in both categories (insertional AT: OR = 5.45, 95%CI: 2.51−11.81; midportion AT: OR = 6.96, 95%CI: 4.24−11.40). Registration for an event with a distance of 10/10.55 km was negatively associated with developing a new-onset AT (OR = 0.59, 95%CI: 0.36−0.97) as well as new midportion AT (OR = 0.47, 95%CI: 0.23−0.93) when compared with

Table 2
Incidence and proportion of subcategories of AT in subgroups.

	New-onset AT (n)	Incidence (% (95%CI))	Insertional (%)	Midportion (%)	Combined (%)
Total	141	4.2% (3.5−4.9)	27.7%	63.8%	8.5%
Sex					
Male	106	5.0% (4.1−6.0)	28.3%	64.2%	7.5%
Female	35	2.8% (2.0−3.8)	25.7%	62.9%	11.4%
Event distance					
10/10.55 km	23	3.1% (2.0−4.5)	43.5%	47.8%	8.7%
15/16.1 km	17	3.7% (2.2−5.7)	29.4%	58.8%	11.8%
Half marathon	17	3.4% (2.1−5.3)	11.8%	88.2%	0.0%
Marathon	84	5.0% (4.1−6.1)	26.2%	64.3%	9.5%

Abbreviations: 95%CI = 95% confidence interval; AT = Achilles tendinopathy.

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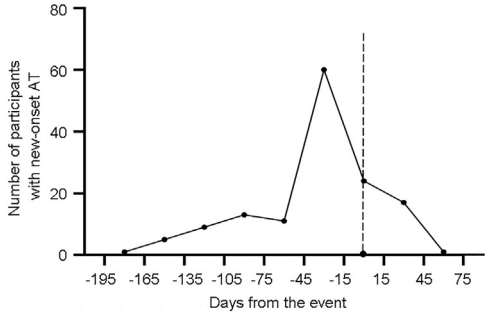

Fig. 3. Distribution of new-onset AT over time from registration for the event until the end of follow-up. The big dot on the horizontal axis marks the day of the event. AT = Achilles tendinopathy.

registration for a marathon. Higher age was significantly associated with new-onset insertional AT (OR = 0.97, 95%CI: 0.94−1.00). Sensitivity analysis of the multivariate analysis in participants who completed all follow-up questionnaires showed similar results, except that registration for an event with a distance of 10/10.55 km had no significant association with new-onset AT when compared with registration for a marathon (Supplementary Table 3).

4. Discussion

This is the first prospective cohort study on AT that separately reports the proportion of insertional and midportion AT as well as their risk factors. The incidence of AT in our study was 4.2% during a mean follow-up of 20 weeks. The proportion of insertional and midportion AT was 28% and 64%, respectively, and 8% had a combined type of insertional and midportion AT. Male participants and runners registering for a marathon had the highest incidence of AT. AT in the past 12 months showed the strongest association with new-onset AT; this was also the risk factor with the strongest association for the subcategories, insertional and midportion AT. For developing new-onset AT, and specifically for midportion AT, registering for an event of 10/10.55 km resulted in a negative association with new-onset AT when compared with registering for a marathon. Younger age was significantly associated with the onset of insertional AT.

Table 3
Logistic regression analyses of potential risk factors associated with new-onset AT and subcategories of AT.

	New-onset AT (n = 141)		Insertional (n = 39)		Midportion (n = 90)	
	Univariate	Multivariate	Univariate	Multivariate	Univariate	Multivariate
Demographics						
Sex (male)	1.92 (1.30−2.85)**	1.65 (0.99−2.76)	2.11 (1.00−4.48)	2.14 (0.97−4.72)	1.96 (1.20−3.20)**	1.49 (0.90−2.50)
Age (years)	1.00 (0.99−1.02)		0.98 (0.95−1.00)	0.97 (0.94−1.00)*	1.01 (0.99−1.03)	
Weight (kg)	1.01 (1.00−1.03)	1.00 (0.98−1.02)	1.01 (0.98−1.04)		1.01 (0.99−1.03)	
SQUASH	1.00 (1.00−1.00)		1.00 (1.00−1.00)		1.00 (1.00−1.00)	
Training						
Years of training (years)	1.01 (1.00−1.03)	1.00 (0.99−1.02)	0.98 (0.94−1.01)		1.02 (1.00−1.04)	1.01 (0.99−1.03)
MYDR	1.02 (0.93−1.12)		0.78 (0.48−1.28)		1.04 (0.96−1.13)	
MYSR	0.37 (0.02−6.33)		0.97 (0.92−1.02)		1.00 (0.97−1.04)	
Use of training schedule (yes)	1.15 (0.80−1.66)		0.65 (0.34−1.23)	0.61 (0.31−1.20)	1.63 (1.00−2.63)*	1.33 (0.79−2.22)
Running ≥80% on paved road (yes)	0.83 (0.56−1.23)		1.86 (0.72−4.8)	1.75 (0.67−4.60)	0.85 (0.52−1.39)	
Use of compression socks (yes)	1.32 (0.88−1.97)	0.92 (0.60−1.41)	1.07 (0.49−2.35)		1.43 (0.88−2.32)	0.94 (0.56−1.59)
Landing type						
Hindfoot	Reference		Reference		Reference	
Midfoot	0.90 (0.58−1.38)		1.57 (0.70−3.53)		0.75 (0.44−1.30)	
Forefoot	0.72 (0.39−1.30)		0.92 (0.29−2.95)		0.65 (0.30−1.37)	
Unknown	0.88 (0.56−1.37)		1.14 (0.47−2.75)		0.92 (0.54−1.57)	
Event distance						
10/10.55 km	0.50 (0.31−0.81)**	0.59 (0.36−0.97)*	0.84 (0.39−1.78)	0.86 (0.38−1.95)	0.37 (0.19−0.72)**	0.47 (0.23−0.93)*
15/16.1 km	0.63 (0.37−1.07)	0.62 (0.35−1.08)	0.70 (0.26−1.87)	0.64 (0.23−1.77)	0.57 (0.29−1.14)	0.59 (0.29−1.21)
Half marathon	0.63 (0.37−1.07)	0.65 (0.38−1.13)	0.28 (0.07−1.2)	0.28 (0.07−1.22)	0.86 (0.48−1.54)	0.94 (0.51−1.72)
Marathon	Reference	Reference	Reference	Reference	Reference	Reference
Previous injuries						
AT in the previous 12 months (yes)	6.71 (4.50−10.02)**	6.47 (4.27−9.81)**	5.10 (2.43−10.71)**	5.45 (2.51−11.81)**	7.40 (4.6−11.89)**	6.96 (4.24−11.40)**
An RRI, except AT, in the previous 12 months (yes)	1.15 (0.81−1.64)		1.04 (0.54−2.01)		1.07 (0.69−1.66)	

Note: Data are presented as OR (95%CI). The combined type of AT is not included in this analysis due to the low number of cases in this subclassification. Only variables with p < 0.20 in univariate analyses were entered in the multivariate model.
* $p < 0.05$, ** $p < 0.01$.
Abbreviations: 95%CI = 95% confidence interval; AT = Achilles tendinopathy; MYDR = month:year distance ratio; MYSR = month:year speed ratio; OR = odds ratio; RRI = running-related injury; SQUASH = the Short Questionnaire to Assess Health.

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The incidence rate of AT in the general population was reported as 1.85 per 1000 registered patients in Dutch general practice networks[22] and 1.7 per 1000 registered patients in a Danish general practice.[23] In runners, the incidence reported in the literature varied from 5.2% to 10.9%.[17,24,25] In the current study, the incidence among all participants and those who registered for a marathon were 4.2% and 5.0%, respectively, both lower than in a comparable study population (5.2% and 7.4%).[17] Coronavirus disease 2019 pandemic restrictions could at least partially explain the differences in incidence. A previous study reported that the peak incidence of AT emerged in the period between 2 weeks before and 1 day after the event,[17] while the peak of onset in the current study emerged during the period between 44 and 15 days prior to the event. The current peak of onset might be related to the cancellation of the Nationale-Nederlanden marathon Rotterdam event (50% of participants in this study), which was due to the coronavirus disease 2019 pandemic and was announced 24 days before the originally scheduled event date.[26] The suspension of the event probably disturbed the training schedule of the participants, thereby preventing the high peak of injuries that may have emerged later. Both studies demonstrated a relatively high risk for developing a new-onset AT in the final training stage before a marathon, suggesting this is a crucial time frame for AT prevention in recreational marathon runners.

AT has always been regarded as an "overuse injury".[27] We found that participants registered for a marathon had a higher incidence of AT than any other race distance, and participants who registered for a 10-km race had significantly lower chances of having new-onset AT or midportion AT. However, there is currently no convincing evidence for change in absolute training load as a risk factor for AT.[2] Hence, the attention shifted to the sudden change in training volume.[9] Hulin et al.[28] developed a parameter to measure to the relative change of workload: acute: chronic workload ratios (ACWR), which was defined as the ratio of the latest 1-week workload to the average workload of the previous 4 weeks. The significant association between high ACWR and overall injury occurrence was shown recently in various sports.[28−31] Nakaoka et al.[32] were the first to report on the ACWR and injury risk in runners, and they found a significant association between higher ACWR and lower injury risk among recreational runners. Nevertheless, no studies have used this tool to focus on the onset of AT. With the concept of ACWR in mind, this study uses the month:year distance ratio and the month:year speed ratio to detect recent adjustments in training volume and running performance from long-existing patterns. To our knowledge, this is the first prospective cohort study investigating the association between the change of training load and the risk of AT, though no significant association was found. Future studies should use more advanced serial measures of training load to identify whether overuse is a risk factor for AT.

Having a history of AT in the past 12 months before baseline is the predominant risk factor for new-onset AT, which is a finding that agrees with previous literature.[14,17,24] In the current study, 31% of the new-onset AT were recurrent injuries, suggesting the importance of preventing recurrence. Gajhede-Knudsen et al.[33] reported a 27% recurrence rate of AT among professional football players. A significantly higher recurrence risk was found after a short recovery time (less than 10 days) as opposed to a longer recovery. While these data suggest that more time for recovery is an effective prevention for recurrent AT, there are still many questions regarding this specific subgroup.[33]

Subclassification of AT is common practice.[2] AT has been divided into insertional and midportion (non-insertional) subtypes since Clain and Baxter's 1992 study.[34] These subtypes have varied etiology, histopathological features,[35] and macroscopic findings during surgery.[36] Midportion AT is localized more than 2 cm above the tendon insertion and occurs in or around the tendon substance.[34] Previous studies speculated that localized torque stresses from the tendon or pathologic alterations in the paratenon might lead to midportion AT.[37] Degeneration of the tendon substance[38] or acute/chronic inflammation in the paratenon could be found in histopathological studies.[39] Insertional AT is localized within 2 cm of the tendon insertion and involves the tendon−bone interface. Researchers contend that insertional AT is the result of the Achilles tendon being abraded by the bony prominence at the posterior superior tuberosity of calcaneus. In addition, the insertional part of the Achilles tendon could also be chemically eroded when there is chronic inflammation of retrocalcaneal bursa.[34] Histopathological features of insertional AT include ossification of enthesial fibrocartilage and degeneration of soft tissue at the tendon−bone junction.[40] Retrocalcaneal bursitis and Haglund morphology are pathologies that can be present in conjunction with insertional AT.[36] According to the current internationally published guidelines,[2] these subtypes are treated with different exercise programs, as the insertional region is regarded to be more subjected to compressive forces than the other region.[41] There are limited data available on the proportion of AT subtypes in the general population, and the origin of these figures can be traced back to 2 cross-sectional studies of injured athletes from the 1990s.[42,43] However, due to the inconsistent use of terminology throughout the years, researchers have subclassified Achilles tendon injuries in different ways. Kvist et al.[43] examined 455 athletes with Achilles tendon overuse injuries in a sports medicine clinic and found that 23% had insertional pain, 66% had midportion AT (referred to as paratenonitis), and 8% had complaints of the myotendineal junction. Leppilahti et al.[42] diagnosed 330 cases of Achilles tendon injuries (including tenalgia, tendinosis, peritendinitis, partial rupture, and retrocalcaneal bursitis) in 273 athletes. Thirty-three (10%) of the injuries were insertional problems and 56 (17%) were retrocalcaneal bursitis. It should be noted that both studies focused on a specific population attending a secondary clinic, which may induce selection bias. Based on the terminology and subclassifications in the latest guidelines,[2] our data showed that 28% of the new-onset AT was insertional and 64% was midportion. It is likely that this is a better representation of the proportion of AT subtypes in the athletic population than the previous studies and could provide a more up-to-date reference for clinical practice nowadays.

This is the first prospective study to explore risk factors for specific subtypes of AT. We found that younger age was a risk factor for insertional AT only. Previous reviews often regarded advancing age as a risk factor for Achilles disorders,[44,45] though these conclusions were drawn from cross-sectional studies that did not separate insertional AT from the whole group.[42,43] On the

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other hand, the pain at the insertion site of the Achilles tendon could be caused by enthesitis, as a result of axial spondylarthritis.[46] Axial spondylarthritis is known to have its onset in early adulthood (median age 26 years[47]). Enthesitis, as one of the axial spondylarthritis features, could cause insertional Achilles tendon pain on relatively younger individuals, which might explain this identified risk factor. Midportion AT was more frequently observed in participants who were preparing for the marathon event. However, this was not significantly associated with insertional AT, which might suggest that midportion AT is caused by higher training loads compared to insertional AT. We should, however, be cautious with this conclusion. Even though statistical differences were found in our analyses, their clinical significance needs further confirmation. The average age of participants who had new-onset insertional AT and midportion AT were in the same stage of life, 40 years and 45 years, respectively. Unlike midportion AT, the onset of insertional AT was not significantly associated with the event registered, but the number of insertional AT subjects was not even a half of midportion cases, which limited the statistical power. Our findings on different risk factors for insertional and midportion AT warrant future research into the etiology of these 2 subtypes. Although, it should also be noted that the observed differences in risk factors between midportion and insertional AT are limited. It remains opens to discussion whether there is solid ground for regarding them as distinct subcategories from a clinical perspective.

The biggest strength of the current study is that it was based on the largest prospective cohort of recreational runners to date and included runners of a wide range of ages and backgrounds. Hence, the results are potentially applicable to the general running population. We included 14 risk factors in the model and were able to detect moderate associations due to the high number (141) of cases of new-onset AT occurrences during follow-up. Risk factors for insertional and midportion subtypes were explored separately with the intention of revealing any discrepancies between them.

Limitations also exist in the present study. Statistical differences in age, weight, and years of training were found between responders and non-responders. However, the differences seem to be a result of the large sample size and are small enough that they are unlikely to be of clinical relevance. It is possible that misdiagnosis of Achilles tendon injury occurred since onset was self-reported. To improve diagnostic accuracy, a standardized pain map was used in the present study. A previous study confirmed a 93% agreement between patient-reported AT with the assistance of the pain map and a physician-established diagnosis.[21] Moreover, 82% of the subcategories of AT (insertional/midportion) reported by patients coincided with their diagnosis by the physician.[21] This increases the likelihood that self-reported AT is consistent with the clinical diagnosis of AT in the vast majority of cases. Finally, the training-load data from the baseline questionnaire might be imprecise due to recall bias, and no training-load data was collected during follow-up. Despite these limitations, our study took the first step toward understanding the association between new-onset AT and changes in training load over a lengthy timespan prior to a running event.

Future prospective studies should focus on the role of change in load as a risk factor for both insertional and midportion AT. To better understand the association between AT and overload, global positioning systems or devices estimating local Achilles tendon load should be equipped to collect more precise data for change in training load. Factors associated with metabolic disorders[48] should also be explored to verify their role in the onset of injury.

5. Conclusion

The incidence of AT was 4.2% during 20 weeks of follow-up among recreational runners. Incidence of insertional and midportion AT was 28% and 64%, respectively (combined type 8%). As AT in the past 12 months was the predominant risk factor for the onset of AT, this emphasizes the need for effective prevention of recurrent AT. Insertional AT was associated with younger age, and midportion AT was more frequently observed in participants who trained for the marathon. It remains undetermined whether these differences are of clinical significance.

Authors' contributions

KLAC performed the data collection and data analysis, and WbC conducted data analysis and wrote the manuscript under the supervision of SMABZ, MvM, and RJdV. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interest

The authors declare that they have no competing interests.

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Supplementary materials

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