Effect of Symptom Duration on Injury Severity and Recovery in Patients With Achilles Tendinopathy

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Background: Achilles tendinopathy is a common overuse condition. Distinguishing between early- and late-stage tendinopathy may have implications on treatment decisions and recovery expectations.

Purpose: To compare the effects of time and baseline measures of tendon health on outcomes among patients with varying symptom durations after 16 weeks of comprehensive exercise treatment.

Study Design: Cohort study; Level of evidence, 3.

Methods: Participants (N = 127) were categorized into 4 groups based on the number of months since symptom onset: ≤3 months (n = 24); between >3 and ≤6 months (n = 25); between >6 and ≤12 months (n = 18); or >12 months (n = 60). All participants received 16 weeks of standardized exercise therapy and pain-guided activity modification. Outcomes representing symptoms, lower extremity function, tendon structure, mechanical properties, psychological factors, and patient-related factors were assessed at baseline and at 8 and 16 weeks after the initiation of exercise therapy. Chi-square tests and 1-way analysis of variance were used to compare baseline measures between groups.Time, group, and interaction effects were evaluated using linear mixed models.

Results: The mean age of the participants was 47.8 ± 12.6 years, 62 participants were women, and symptoms ranged from 2 weeks to 274 months. No significant differences were found among symptom duration groups at baseline for any measure of tendon health. At 16 weeks, all groups demonstrated improvements in symptoms, psychological factors, lower extremity function, and tendon structure, with no significant differences among the groups ($P > .05$)

Conclusion: Symptom duration did not influence baseline measures of tendon health. Additionally, no differences were observed among the different symptom duration groups in response to 16 weeks of exercise therapy and pain-guided activity modification.

Keywords: achilles tendon; acute tendinopathy; chronic tendinopathy; overuse; rehabilitation; tendinosis

Achilles tendinopathy is a common overuse condition characterized by Achilles tendon pain and loss of function related to mechanical loading.[37] The understanding of the pathological process and progression of Achilles tendinopathy in various domains of tendon health remains incomplete. This has sparked interest in recent years to better understand how change unfolds between symptom onset and the later stages of Achilles tendinopathy.[25,27,41] Tendinopathic tendons often demonstrate altered mechanical properties and structure.[4] Structural alterations—including fibril disorganization, tendon thickening, and neovascularization—have historically been considered long-term consequences of tendinopathy.[2,3,20] However, research interest in early tendinopathy has recently challenged whether these are truly chronic adaptations. A recent study by Tran et al[42] reported increased neovascularization, tendon size, and elevated tissue metabolism within the first 3 months of symptom onset compared with healthy controls. This advocates the need to investigate whether these alterations arise chronologically with symptom duration or whether they precede symptom onset.[12,19,26]

In clinical practice, cases deemed chronic are characterized based on several factors, including symptoms lasting >12 weeks with degenerative tendon findings on imaging (calcifications, collagen degeneration, scar formation, and neovascularization).[16] These so-called degenerative findings have since been identified in asymptomatic tendons as well, suggesting that tendon degeneration may not progress chronologically.[10,45] Recent evidence[18] suggests that tendon degeneration may be well underway before symptom onset. Heinemeier et al[18] demonstrated that tendinopathy may indeed be preceded by years of abnormally high collagen turnover. Nonetheless, labeling Achilles tendinopathy as early or chronic based on the time course of symptoms remains commonplace in clinical practice.

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Distinguishing between early- and late-stage tendinopathy may have implications on treatment decisions and recovery expectations. The most recent clinical practice guidelines from the American Physical Therapy Association recommend 12 weeks of exercise therapy as the first line of treatment.[29] If symptoms remain, surgical options are often indicated.[36] However, it is more likely for injection therapy or surgery to be offered when a case is chronic.[9,36] The guidelines also suggest different treatment considerations between acute and nonacute tendinopathy and acknowledge that the majority of studies describe interventions for chronic Achilles tendinopathy.[29]

The broader impact of Achilles tendinopathy can be described by the tendon health model.[17,39] The tendon health domains include symptoms, lower extremity function, tendon structure, mechanical properties, psychological factors, and patient-related factors. Clinical management of Achilles tendinopathy may be better informed by leveraging the tendon health model to investigate how tendon health is influenced by symptom duration. The purpose of this study was to (1) explore whether baseline measures of tendon health differ among 4 patient groups with Achilles tendinopathy with ranging symptom duration and (2) compare changes over time in tendon health measures among groups after 16 weeks of standardized exercise therapy and pain-guided activity modification.

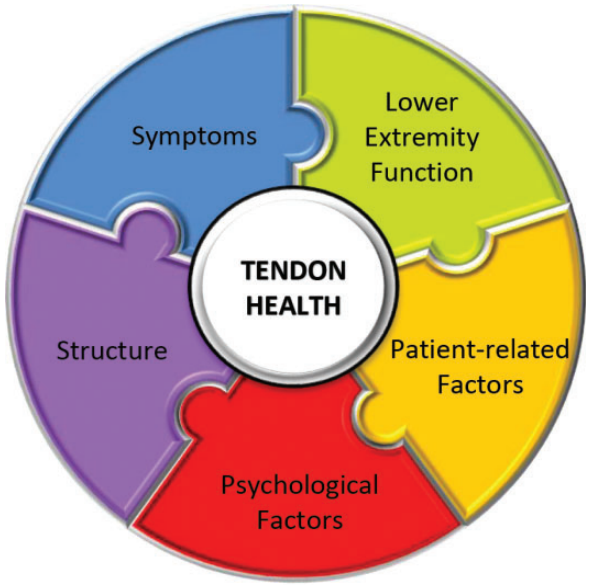

Figure 1. The tendon health model.

METHODS

The protocol for this study received institutional review board approval. This cohort study comprised participants with clinically diagnosed midportion Achilles tendinopathy[25,44] who were part of a larger ongoing clinical trial (ClinicalTrials.gov identifier: NCT03523325) evaluating recovery from Achilles tendinopathy over 1 year. All participants were evaluated at baseline, then at 8 and 16 weeks after initiation of the same exercise therapy protocol and pain-guided activity modification program.[40] Outcome measures representing tendon health (Figure 1) were evaluated at each time point and included the following domains: symptoms, lower extremity function, psychological factors, patient-related factors, and tendon structure.[39] Data for this study were collected between July 2018 and December 2021.

Participants

To be eligible for inclusion, participants had to be between the ages of 18 and 65 years, be clinically diagnosed with midportion Achilles tendinopathy, and have no other injury that impaired their ability to perform the data collection tests or the exercise protocol. The diagnosis was confirmed based on the presence of Achilles tendon pain during loading activities and pain with palpation at the midportion of the Achilles tendon (2-6 cm proximal to the calcaneus).[25,44] Participants were excluded if they had a previous Achilles tendon rupture, received an injection to the Achilles tendon in the past 6 months, or had any other injury that prevented participation in the exercise treatment program. Study recruitment consisted of advertising through paper flyers, social media posts, email blasts, and referrals from local physicians and physical therapists.

Classification of Symptom Duration Groups

After recording participants' date of injury, they were categorized into 4 groups based on the number of months since symptom onset: 3 months or less, between >3 and ≤6 months, between >6 and ≤12 months, or 12 months or longer. Henceforth, the groups will be referred to as "≤3 months," "3-6 months," "6-12 months," and ">12 months."

Exercise Therapy Protocol

All participants received supervised exercise therapy (Silbernagel protocol)[40] with a licensed physical therapist. The

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Ethical approval for this study was obtained from the University of Delaware (ref No. 1090153-23).

protocol details are described in Appendix Figure A1. Participants were instructed to use the pain monitoring model to monitor their symptoms with activity and that tolerable pain (<5/10) was not detrimental to recovery.[40] Participants also completed daily training diaries to record their exercises, physical activity, and Achilles tendon pain. These were reviewed weekly with their physical therapist. The treating physical therapist determined the frequency of supervised visits and treatment progression. Participants were instructed to complete bodyweight exercises once daily. Heavy external loads were prescribed (phase 2 and onward) at least twice per week and bodyweight exercises on all other days to ensure adequate recovery after heavy loading.

Tendon Health Measures

Symptoms. Symptoms were assessed using the Victorian Institute of Sport Assessment–Achilles (VISA-A)[33] questionnaire and self-reported maximum tendon pain with tendon loading activity. The VISA-A is a valid and reliable instrument with 8 questions that span the domains of pain, functional status, and activity specific to Achilles tendinopathy.[33] Scores range from 0 to 100, with a lower score indicating worse pain and symptom severity. We evaluated the minimal clinically important difference (MCID) in the VISA-A score as 14 points at 12 weeks after treatment initiation, as determined by Lagas et al[21] specifically for physically active patients with midportion Achilles tendinopathy. Participants were asked to complete the VISA-A for each limb. Participants were asked to rate pain on a Numeric Pain Rating Scale[11] immediately after 25 single-leg hops, ranging from 0 (no pain) to 10 (worst imaginable pain).[11]

Participant-Related Factors and Psychological Factors. Participants' medical history, age, height, body mass index (BMI), weight, sex, medications, physical activity level, quality of life, and injury laterality (unilateral or bilateral symptoms) were collected at baseline.[32] Physical activity was quantified using the Physical Activity Scale,[15] a Likert scale that has participants rate[15] their physical activity from 1 to 6. A rating of 1 corresponds to regularly performing minimal physical activity and a rating of >5 indicates performing vigorous physical activity ≥3 days per week. The Tampa Scale for Kinesiophobia[13,24] (TSK-17) was administered to measure fear of movement. Scores range between 17 to 68, with a higher score indicating greater kinesiophobia. The Foot and Ankle Outcomes Score–Quality of Life (FAOS-QoL) subscale was used as a joint-specific assessment of the quality of life–related limitations of the foot and ankle.[14,35] The Patient Reported Outcome Measurement System–29 (PROMIS) was used as a universal assessment of quality of life,[5] and the PROMIS Social Roles and Activities and PROMIS Pain Interference subscales were included in data analysis. For each PROMIS subscale, a *T* score of 50 points represents the normative score for the general population, with an SD of 10 points. Each respective subscale is scored so that a higher score indicates greater presence of the construct (ie, more pain interference or more social activity).

Lower Extremity Function. Participants completed a functional test battery using the MuscleLab (Ergotest Innovation) measurement system. Testing consisted of the single-leg countermovement jump (CMJ), single-leg hopping, single-leg drop countermovement jumping (drop CMJ), and the heel-rise endurance test.[38] The CMJ is a single-leg jump for maximal height while keeping the hands behind the back. The drop CMJ involved dropping down off a 20-cm box and then quickly rebounding upward for maximal height. Three trials were attempted for each jump test and the mean height (in cm) was used in data analysis. The hopping test required the completion of 2 trials of 25 single-leg hops at a self-selected cadence. For the hopping and jumping tests to register, participants needed to have a vertical movement of ≥1 cm. For the heel-rise endurance test, participants were instructed to stand on a slant board (10° incline) and to lift the heel to the maximum height for as many repetitions possible until fatigued to a set cadence of 30 heel-rises per minute using a metronome. A MuscleLab linear encoder was attached to the heel to measure heel-rise height for each repetition. Heel-rise work (J) was calculated by multiplying heel-rise height (cm) by the number of repetitions by body mass (kg). Data analysis was performed using data from the most symptomatic limb for all tests. For those participants with bilateral symptoms, their most symptomatic limb was determined by the lowest baseline VISA-A score.

Tendon Structure and Mechanical Properties. B-mode ultrasound with a linear transducer set at a frequency of 10 MHz and a depth of 3.5 cm (GE LOGIQ e; GE Healthcare) was used to assess the structural and mechanical properties of the Achilles tendon. Participants were positioned in prone position with their feet relaxed off the end of the table. Using previously described procedures, images of the Achilles tendon cross-sectional area were taken in the section with the greatest amount of tendon thickening present (Figure 2A).[45] Achilles tendon thickening was measured by obtaining an extended field-of-view image from the calcaneus proximally past the soleus musculotendinous junction (Figure 2B). Tendon thickening was assessed as a measure of the within-limb degree of tendon pathology and was calculated by subtracting the thinnest portion (healthy tendon) from the thickest portion along the free tendon.[6]

The mechanical properties of the Achilles tendon were measured using continuous shear-wave elastography (Figure 2C). Using an external actuator to generate shear waves[7,8] at 11 frequencies, 2 mechanical properties can be calculated post hoc: (1) shear modulus (ie, stiffness; in kPa) and (2) viscosity (rate-dependent stiffness; in kPa·s) (Figure 2D). Lower shear modulus and viscosity have been observed in injured tendon tissue.[8] This method is valid and reliable for evaluating changes in tendon viscoelastic properties caused by injury.[8] The frequency of Achilles tendon structural abnormalities was recorded during the ultrasound examination and included the presence of calcifications, retrocalcaneal bursitis, and neovascularization.[31]

Statistical Analysis

Baseline data were compared among symptom duration groups using 1-way analysis of variance and chi-square tests. Change over time among groups was evaluated using

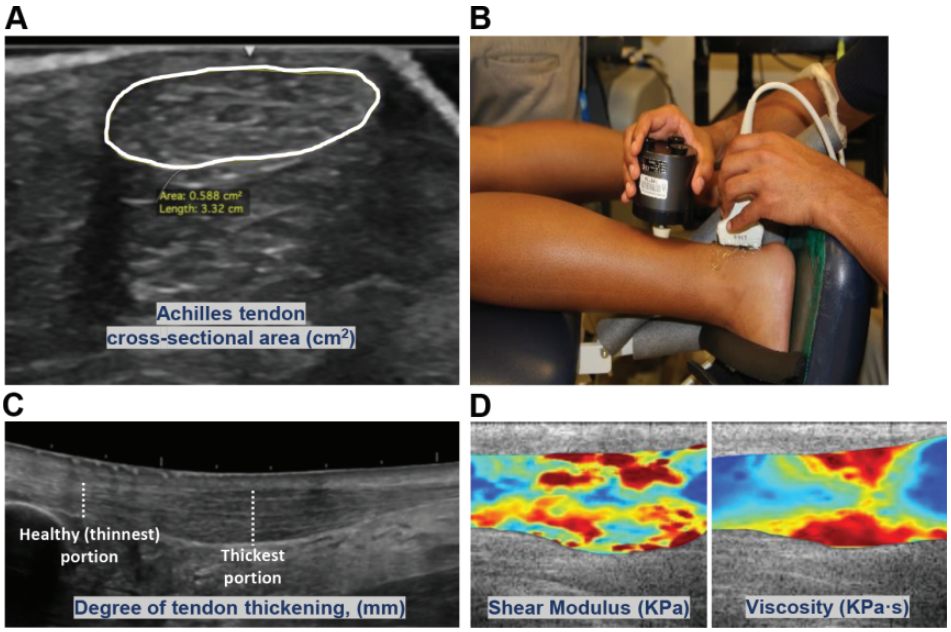

Figure 2. (A) Cross-sectional area of the Achilles tendon. (B) Degree of tendon thickening. (C) Continuous shear wave elastography application. (D) Region of interest for the calculation of shear modulus and viscosity.

linear mixed models. Effects of time, group, and interaction (time × group) were evaluated. Pairwise comparisons were performed post hoc with a Bonferroni adjustment for significant main effects. Sex was a covariate in the final analysis for CMJ height and drop CMJ height to control for potential confounding differences in muscle volume and associated differences in jump height ability. Residual values were tested using Shapiro-Wilk tests to assess for normality and identify outlier observations. Data analysis was completed using SPSS Version 28 (IBM). For all comparisons, the threshold for significance was set at $P < .05$.

RESULTS

Overall, 127 participants met the inclusion criteria. Results of participants' characteristics and demographics overall and according to symptom duration group are presented in Table 1. Sex distribution differed significantly among groups as follows: ≤3 months: 29% women; 3-6 months: 80% women; 6-12 months: 56% women; ≥12 months: 42% women; $P = .018$. All groups reported similar symptom severity based on the VISA-A score, similar high kinesiophobia (TSK-17 scores ≥37), and similar poor foot- and ankle-related quality of life based on the FAOS-QoL score. The mean T scores for the PROMIS Social Roles and Activities and PROMIS Pain Interference subscales were also similar between groups, suggesting that symptoms did not affect social roles and activities, nor did pain interfere with daily life.

All groups performed similarly on the CMJ height ($P = .463$), drop CMJ height ($P = .632$), and heel-rise work ($P = .552$). There were no differences among groups in baseline measures of Achilles tendon thickening ($P = .444$), tendon cross-sectional area ($P = .064$), shear modulus ($P = .115$), or viscosity ($P = .788$).

Marginal means for all groups are presented in Tables 2 and 3, and changes over time are displayed graphically in Figure 3. Similar significant changes over time were observed among the groups for VISA-A scores and pain with hopping (both $P < .001$). All groups met or exceeded the VISA-A MCID (14 points)[21] at 8 weeks. TSK-17 scores reduced similarly for all groups ($P < .001$) to low kinesiophobia at 16 weeks. FAOS-QoL scores improved similarly for all groups ($P < .001$); however, scores indicated continued deficits in foot- and ankle-related quality of life at 16 weeks. All groups demonstrated similar changes over time in CMJ height ($P = .006$) and improved heel-rise work ($P < .001$). Adjusting for sex resulted in a significant interaction effect for drop CMJ height among groups ($P = .048$), with only the 3-6 months and 6-12 months groups demonstrating significant increases from baseline to 16 weeks ($P = .012$ and $P = .005$, respectively).

A significant interaction effect was observed for tendon thickening ($P = .034$), with only the 3-6 months group demonstrating significant changes between baseline and 16 weeks (2.6-2.1 mm; $P = .032$) (Table 3). Shear modulus significantly increased ($P = .003$) for all groups over the 16-week period, suggesting similar improvements in tendon stiffness. Slight increases in the Achilles tendon cross-sectional area were observed over time ($P = .003$) for all groups.

DISCUSSION

The purpose of this study was to determine how tendon health presents among patients with symptoms ranging

TABLE 1
Baseline Characteristics and Clinical Findings[a]

		Symptom Duration Group				
	Pooled Sample (N = 127)	≤3 Months (n = 24)	3-6 Months (n = 25)	6-12 Months (n = 18)	>12 Months (n = 60)	P^b
Age, y						.313
Mean ± SD	47.8 ± 12.6	49.4 ± 12.7	48.4 ± 13.6	42.4 ± 14.6	46.3 ± 11.7	
Range	18-65	25-65	20-65	19-65	18-64	
Sex, M:F, n	65:62	17:07	5:20	8:10	35:25	**.018**
Height, cm						.124
Mean ± SD	174.1 ± 23.5	184.1 ± 50.7	169.3 ± 7.9	172.4 ± 9.7	172.4 ± 8.6	
Range	151.1-419.1	151.1-419.1	157.5-188	158.1-188	151.1-194.3	
Body Mass, kg						.848
Mean ± SD	83.8 ± 19.4	83.9 ± 21.1	82.3 ± 18.1	81 ± 11.4	85.2 ± 21.2	
Range	27.7-167.3	27.7-123.2	52.3-121.8	62.7-101.6	54.1-167.3	
BMI, kg/m^2						.869
Mean ± SD	28.4 ± 6	28.5 ± 4.5	28.8 ± 6.4	27.3 ± 3.6	28.6 ± 7	
Range	19-53.3	21-36.4	19-42.9	20.1-33.8	19.5-53.3	
Symptom duration, mo						NT
Mean ± SD	30.7 ± 48.3	1.9 ± 0.7	4.3 ± 0.9	8.3 ± 1.6	60 ± 57.8	
Median [IQR]	10 [3.9-32.6]	2.1 [1.3-2.4]	4.1 [3.6-5.2]	8.1 [7.1-9.3]	35 [22.9-72.8]	
Range	0.5-274.1	0.5-3	3.1-5.9	6.1-11.5	12.8-274.1	
Bilateral symptoms, n/N (%)	53/74 (41.7)	6/18 (25)	9/16 (36)	6/12 (33.3)	32/28 (53.3)	.077
Calcifications, n/N (%)	82/42 (64.6)	15/9 (62.5)	18/7 (72)	9/9 (50)	40/20 (66.7)	.622
Neovascularization, n/N (%)	50/77 (39.4)	12/12 (50)	11/14 (44)	5/13 (27.8)	22/38 (36.7)	.465
History of Achilles tendinopathy, n/N (%)	23/104 (18.1)	9/15 (37.5)	3/22 (12)	2/16 (11.1)	9/51 (15)	.053
Previously sought medical attention, n/N (%)	67/127 (52.8)	7/24 (29.2)	16/25 (64)	10/18 (55.6)	34/60 56.7)	.07
Medication history, n/N (%)						
Statins	13/114 (10.2)	4/20 (16.7)	4/21 (16)	1/17 (5.6)	4/56 (6.7)	.465
Fluroquinolones	7/120 (5.5)	0/24 (0)	2/23 (8)	1/17 (5.6)	4/56 (6.7)	.053
Steroids	4/123 (3.1)	0/24 (0)	2/23 (8)	0/18 (0)	2/58 (3.3)	.07
VISA-A						.068
Mean ± SD	52 ± 18	55 ± 17	47 ± 19	44 ± 18	54 ± 18	
Range	1-88	24-80	1-80	19-83	8-82	
Physical Activity Scale[c]						.121
Mean ± SD	5 ± 1	5 ± 1	4 ± 2	5 ± 1	5 ± 1	
Range	1-6	2-6	1-6	3-6	1-6	
TSK-17						.78
Mean ± SD	38 ± 5	37 ± 5	39 ± 5	38 ± 7	38 ± 5	
Range	26-53	26-48	29-48	26-50	29-53	
FAOS-QoL						.544
Mean ± SD	40 ± 18	43 ± 16	36 ± 19	39 ± 21	41 ± 18	
Range	0-81	19-69	0-69	0-69	0-81	
PROMIS Social Roles and Activities						.806
Mean ± SD	55.4 ± 8.3	56 ± 7.2	53.6 ± 9.6	55.1 ± 9.9	55.9 ± 7.6	
Range	27.5-64.2	44.2-64.2	27.5-64.2	27.5-64.5	37.3-64.2	
PROMIS Pain Interference						.129
Mean ± SD	53.7 ± 7.4	53.9 ± 6.4	57 ± 6.9	53.9 ± 9.1	52.2 ± 7.2	
Range	41.6-75.6	41.6-66.6	41.6-75.6	41.6-75.6	41.6-66.6	

[a]The bold *P* value indicates a statistically significant difference between groups ($P < .05$). BMI, body mass index; F, female; FAOS-QoL, Foot and Ankle Outcome Score–Quality of Life; IQR, interquartile range; M, male; NT, not tested; PROMIS, Patient-Reported Outcome Measurement System; TSK-17, Tampa Scale of Kinesiophobia–17 item; VISA-A, Victorian Institute of Sport Assessment–Achilles.
[b]Compared using the analysis of variance for continuous variables and the chi-square test for categorical variables.
[c]Before injury.

from a few weeks to several years and to investigate how these patients respond over time to a comprehensive treatment protocol. No differences in tendon health were observed at baseline among patients whose symptom history ranged from 2 weeks to 274 months. Additionally, an equivalent response to the intervention was seen in all groups, regardless of symptom duration. These findings challenge the current concept that classifies Achilles tendinopathy as acute or nonacute based on symptom duration and that symptom duration is important for guiding clinical decisions and intervention strategies.[29]

TABLE 2
Summary of Marginal Means and Main Effects for Patient-Reported Outcome Scores and Functional Tests[a]

	Symptom Duration Group				Group		Time		Group × Time	
Outcome Measure	≤3 Months	3-6 Months	6-12 Months	>12 Months	*F*	*P*	*F*	*P*	*F*	*P*
Symptoms										
VISA-A					2.094	.104	52.72	**<.001**	0.953	.458
Baseline	55 ± 17	47 ± 19	44 ± 19	54 ± 17						
8 weeks	69 ± 19	61 ± 16	62 ± 22	67 ± 17						
16 weeks	67 ± 20	61 ± 18	67 ± 24	74 ± 15						
NPRS pain with hopping					2.225	.089	29.322	**<.001**	0.776	.59
Baseline	3 [0-6]	3 [2-4]	3 [2-5]	2 [0.75-4]						
8 weeks	2.5 [0-4]	2 [0.25-3]	2 [0-4]	1 [0-2]						
16 weeks	2 [0-5]	1 [0-2]	0 [0-4]	0 [0-2]						
Psychological and patient-related factors										
TSK-17					0.321	.811	23.288	**<.001**	0.805	.567
Baseline	37 ± 5	39 ± 5	38 ± 7	38 ± 5						
8 weeks	35 ± 5	36 ± 6	36 ± 6	37 ± 5						
16 weeks	34 ± 5	35 ± 6	33 ± 6	35 ± 5						
FAOS-QoL					0.285	.836	75.618	**<.001**	1.523	.172
Baseline	43 ± 15	37 ± 19	38 ± 21	41 ± 18						
8 weeks	57 ± 19	56 ± 15	50 ± 20	53 ± 17						
16 weeks	62 ± 22	58 ± 15	66 ± 21	64 ± 18						
PROMIS Social Roles and Activities					0.327	.806	7.468	**<.001**	0.641	.697
Baseline	56 ± 7.2	53.6 ± 9.6	55.1 ± 9.9	55.9 ± 7.6						
8 weeks	57.1 ± 6.4	57.1 ± 7.7	57.1 ± 8.6	57 ± 7.2						
16 weeks	57.7 ± 7.5	56.7 ± 9.6	59.2 ± 7	59.4 ± 6.1						
PROMIS Pain Interference					1.924	.129	40.582	**<.001**	0.773	.592
Baseline	53.9 ± 6.4	57 ± 6.9	53.9 ± 9.1	52.2 ± 7.2						
8 weeks	47.4 ± 6.3	49.7 ± 6	49 ± 7.1	48.1 ± 6.5						
16 weeks	49.4 ± 7.3	50.1 ± 7.9	49.2 ± 7.8	46.5 ± 6.5						
Lower extremity function										
CMJ height, cm					0.863	.463	5.349	**.006**	0.662	.68
Baseline	7.1 ± 4.5	5.2 ± 3.5	6.5 ± 3.9	7.5 ± 3.8						
8 weeks	7.2 ± 3.6	4.9 ± 3.4	6.5 ± 4.3	6.9 ± 3.5						
16 weeks	8.3 ± 4.1	4.4 ± 2.1	7 ± 4	7 ± 3.4						
Drop CMJ height, cm					0.575	.632	7.836	**<.001**	2.175	**.048**
Baseline	6.5 ± 4.4	4.6 ± 3.9	5.5 ± 3.4	6.7 ± 3.8						
8 weeks	6.1 ± 3	5.6 ± 3.2	6.4 ± 3.9	6.7 ± 3.9						
16 weeks	7 ± 2.5	6.3 ± 2.8	7.7 ± 4.4	6.7 ± 3.3						
Heel-rise work, J					0.702	.552	10.722	**<.001**	1.381	.225
Baseline	1809 ± 995	1440 ± 697	1712 ± 827	1757 ± 832						
8 weeks	1722 ± 773	1553 ± 452	1852 ± 882	1916 ± 790						
16 weeks	2003 ± 712	1479 ± 518	2126 ± 1028	1955 ± 826						

[a]Data are expressed as mean ± SD or median [interquartile range]. Bolded *P* values indicate statistically significant differences over time ($P < .05$). CMJ, countermovement jump; FAOS-QoL, Foot and Ankle Outcome Score–Quality of Life; NPRS, Numeric Pain Rating Scale; PROMIS, Patient-Reported Outcome Measurement System; TSK-17, 17-Item Tampa Scale of Kinesiophobia; VISA-A, Victorian Institute of Sport Assessment–Achilles.

Symptom Duration and Clinical Presentation

Our results showed that patients with substantially ranging duration of symptoms present with similar characteristics and tendon health deficits at baseline assessment. These included symptoms, lower extremity function, tendon structure, mechanical properties, psychological factors, and patient-related factors. These results were surprising since we expected to see more pronounced symptom severity, tendon thickening, and psychosocial factors in patients with longer symptom duration. Partially supporting these results, the recent study by Tran et al[42] also found no difference in tendon structure in those with tendinopathy presenting with 0-1 months, 1-2 months, and 2-3 months of symptoms duration. To the best of our knowledge, however, this is the first study comparing different domains of

TABLE 3
Summary of Marginal Means and Main Effects for Tendon Structure and Mechanical Properties[a]

	Symptom Duration Group				Group		Time		Group × Time	
Variable	≤3 Months	3-6 Months	6-12 Months	>12 Months	*F*	*P*	*F*	*P*	*F*	*P*
Tendon thickening, mm					0.9	.444	4.262	**.016**	2.344	**.034**
Baseline	1.9 [0.6-3.1]	2.6 [1.2-3.7]	1.9 [0.8-3.2]	1.9 [0.8-2.7]						
8 weeks	1.5 [0.2-2.3]	2 [0.7-3.2]	1.3 [0.3-1.6]	2.4 [0.9-3.5]						
16 weeks	1.6 [0.3-3.4]	2.1 [0.6-3.4]	2.1 [0.2-4.5]	2.2 [0.5-3.2]						
Achilles tendon CSA, cm^2					2.483	.064	6.222	**.003**	1.677	.13
Baseline	0.97 ± 0.50	0.99 ± 0.41	0.93 ± 0.55	0.85 ± 0.35						
8 weeks	1.02 ± 0.63	0.90 ± 0.44	0.87 ± 0.64	0.87 ± 0.38						
16 weeks	1.18 ± 0.79	1.13 ± 0.47	0.94 ± 0.73	0.92 ± 0.38						
Shear modulus, KPa					2.024	.115	6.036	**.003**	2.083	.058
Baseline	105.7 ± 22.3	104.4 ± 18.4	104 ± 19.4	94 ± 19.4						
8 weeks	106.5 ± 19.2	87.3 ± 25	98.6 ± 13.1	98.7 ± 20.1						
16 weeks	106.8 ± 25	103.6 ± 26.2	116.1 ± 24.5	108.2 ± 18.5						
Viscosity, KPa·s					0.352	.788	2.248	.109	1.287	.266
Baseline	52.9 ± 10.5	49.5 ± 10	51.7 ± 10.5	51.8 ± 9.5						
8 weeks	54.3 ± 11.4	52 ± 12.8	55.5 ± 9.4	51.2 ± 13.2						
16 weeks	44.7 ± 10	50.6 ± 9	52.3 ± 10.6	52.4 ± 9.3						

[a]Data are expressed as mean ± SD or median [interquartile range]. Bolded *P* values indicate statistically significant differences over time ($P < .05$). CSA, cross-sectional area.

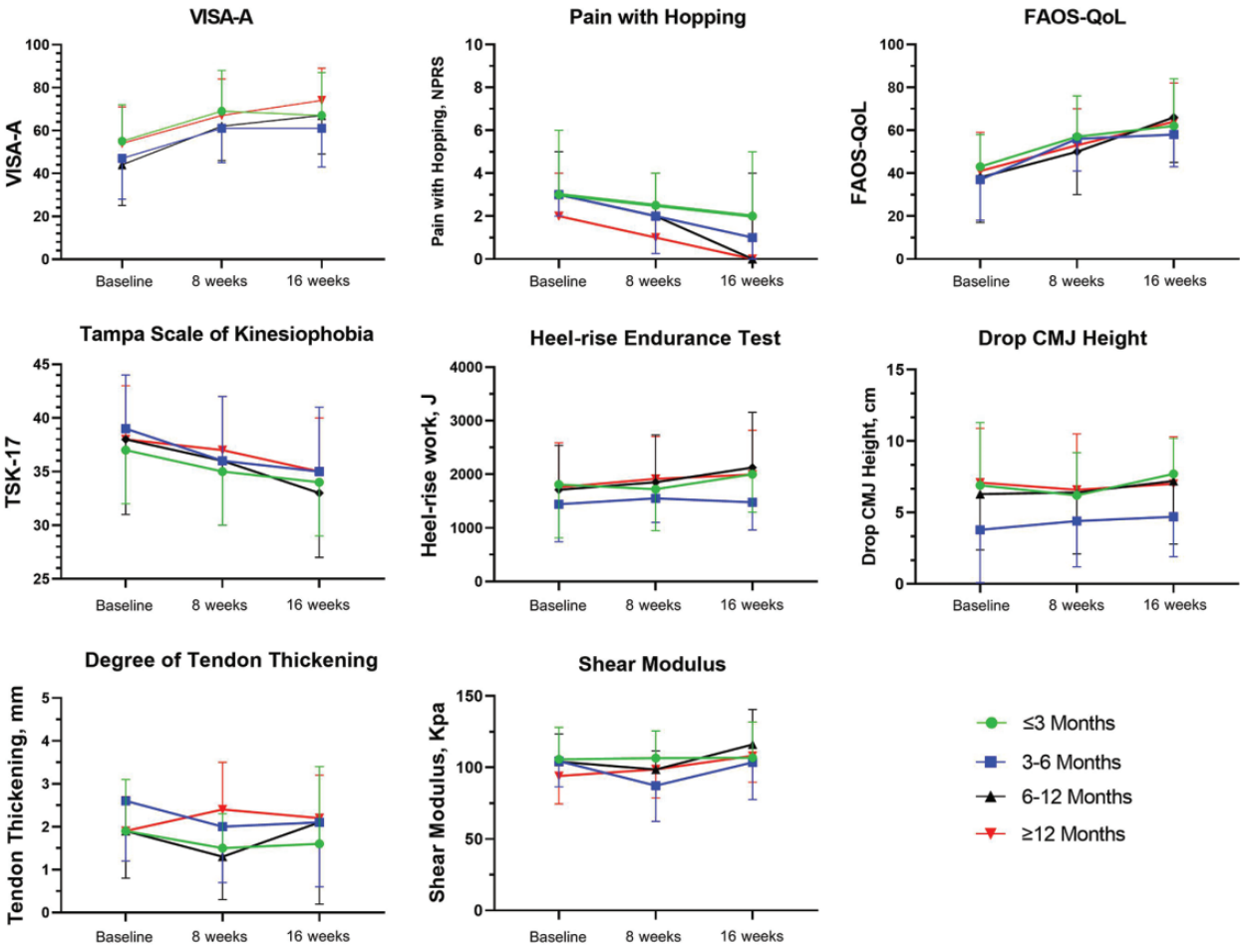

Figure 3. Summary of changes over time in outcome measures. CMJ, countermovement jump; FAOS-QoL, Foot and Ankle Outcome Score–Quality of Life; TSK-17, 17-Item Tampa Scale of Kinesiophobia; VISA-A, Victorian Institute of Sport Assessment–Achilles.

tendon health between patients at varying stages of Achilles tendinopathy.

Our findings indicate that symptom duration is not an appropriate measure for staging Achilles tendinopathy pathogenesis. At the same time, they support previous models that describe tendinopathy as a process resultant of several subclinical microtraumas that would ultimately lead to overuse, reaching the symptomatic threshold because of intrinsic and extrinsic factors associated with insufficient rest.[1,23,28,41] Once symptoms appear, the cascade of events is already in an advanced stage, which makes resolution difficult and time-consuming. This sequence of events has been compared with an iceberg, with symptoms being only the tip of the iceberg.[1] These results are also consistent with a recent model that suggests that tendinopathy would be the result of a progressive accumulation of intrinsic tissue damage that, if persisted for months/years, would lead the tendon core to reach a "metabolic tipping point," in which the metabolic demands of the tendon core exceed the available nutrient supply of the normally avascular core, leading the tissue to the pathological cascade.[41] These models are also supported by a recent study that evaluated the lifelong replacement rates of collagen using Carbon-14 bomb pulse dating in patients with Achilles tendinopathy.[17] The authors observed that 50% of the collagen matrix in the diseased Achilles tendon had undergone continuous abnormal turnover for years before the presentation of clinical symptoms of tendinopathy.[17] Collectively, these results indicate that tendinopathy is a silent disease, which is unknowingly progressed further by the patient's respective overuse mechanism. Our findings support the substantive theory of symptom onset corresponding to a late phase within a prolonged process that emerges long after cumulative tendon damage has occurred.[30]

Symptom Duration and Improvements With Exercise Therapy

Our findings suggest that patients with presumed "chronic" Achilles tendinopathy have an equal ability to improve as those with early symptoms when treated appropriately with exercise therapy and pain monitoring. These results were surprising, as we expected to observe more pronounced improvements in patients with shorter symptom duration. Comparatively fewer improvements in patients with longer symptom durations were expected considering that symptom duration has been shown to be a relevant factor that predicts a poor outcome 5 to 8 years after the initial presentation of symptoms in other overuse musculoskeletal conditions such as patellofemoral pain.[22] This does not seem to be the case for Achilles tendinopathy, given that the participants of the present study showed similar improvements regardless of symptom duration. However, these results may not translate to other tendinopathies, such as the ones that affect the upper limb. Recent studies have suggested that symptom duration significantly influences the prognosis and outcomes of patients with lateral elbow tendinopathy.[34,43] Further research is warranted to determine the exact impact of symptom duration in other tendinopathies.

Strengths and Limitations

A strength of this study is the breadth of variables that capture tendon health and patient characteristics, although there are metabolic factors not measured that may have influenced our findings. Given the high BMI of this cohort, cholesterol, urea levels, and other metabolic factors could have influenced outcomes at 16 weeks. Baseline status may also have influenced participants' outcomes. We asked participants at baseline to disclose whether they had previously sought medical attention for their Achilles symptoms but did not inquire about timing related to study enrollment. The selected MCID for the VISA-A for this study was adopted from Lagas et al,[21] which could have influenced the results for symptoms. Last, the transitory nature of Achilles loading–induced symptoms could affect the validity of participants' reported symptom duration such that participants may underestimate their symptom onset if they interpret an asymptomatic time period followed by symptom resurgence as "reinjury." Contrarily, symptom onset could be overestimated in those with symptoms lasting >12 months because of recall bias.

CONCLUSION

Symptom duration had no impact on the clinical presentation of Achilles tendinopathy at baseline evaluation in all domains of tendon health. After 16 weeks of exercise therapy and pain monitoring, no differences were found among the symptom duration groups. These findings indicate that symptom duration may not be clinically relevant for determining prognosis for patients with midportion Achilles tendinopathy.

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APPENDIX

Symptom Management and Load Reduction Phase: Weeks 1 to 2

Patient Status
Pain and difficulty with all activities, difficulty performing 10 one-legged heel rises
Goals
Start to exercise and understanding nature of the injury and how to use the pain-monitoring model
Treatment Program
- Pain-monitoring model information and advice on exercise activity
- Circulation exercise (moving foot up/down)
- Two-legged heel rises standing on the floor (3 × 10-15 repetitions)
- One-legged heel rises standing on the floor (3 × 10 repetitions)
- Eccentric heel rises standing on the floor (3 × 10 repetitions)
- Sitting heel rises (3 × 10 repetitions)

Recovery Phase: Weeks 2 to 5

If pain at the distal insertion of the tendon, continue standing on the floor
Patient Status
Pain with exercise, morning stiffness, pain when performing heel rises
Goals
Start strengthening
Treatment Program
- Two-legged heel rises standing on edge of a step (3 × 15 repetitions)
- One-legged heel rises standing on edge of a step (3 × 15 repetitions)
- Eccentric heel rises standing on edge of a step (3 × 15 repetitions)
- Sitting heel rises (3 × 15 repetitions)
- Quick rebounding heel rises (3 × 20 repetitions)

Rebuilding Phase: Weeks 3 to 12 (or longer if needed)

If pain at the distal insertion of the tendon, continue standing on the floor
Patient Status
Tolerates the recovery phase exercise program well, no pain at the distal tendon insertion, possibly decreased or increased morning stiffness
Goals
Heavier strength training, increase or start running and/or jumping activity
Treatment Program
Perform exercises every day and with heavier load 2 to 3 times per week:
- One-legged heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Eccentric heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Sitting heel rises (3 × 15 repetitions)
- Quick rebounding heel rises (3 × 20 repetitions)
- Plyometrics training

Return-to-Sports Phase: 3 to 6 months (or longer if needed)

If pain at the distal insertion of the tendon, continue standing on the floor
Patient Status
Minimal symptoms, not morning stiffness every day, can participate in sports without difficulty
Goals
Maintenance exercise, no symptoms
Treatment Program
Perform exercises 2 to 3 times per week:
- One-legged heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Eccentric heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Quick rebounding heel rises (3 × 20 repetitions)

Figure A1. Treatment protocol.
From Silbernagel et al[39,40] protocol created by the authors.