1. PLoS One. 2018 Jun 21;13(6):e0199645. doi: 10.1371/journal.pone.0199645.
eCollection 2018.

Achilles tendon structure is negatively correlated with body mass index, but not influenced by statin use: A cross-sectional study using ultrasound tissue characterization.

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INTRODUCTION: Statins are widely used to inhibit cholesterol production in the liver among people with hypercholesterolemia. A recent epidemiological study in the UK has shown that statin use (unlike elevated BMI) is not associated with an increased risk of Achilles tendon rupture. However, because of laboratory reports suggesting a negative influence of statins on tenocyte metabolism, we decided to directly compare the Achilles tendon structure (cross-sectional area and longitudinal collagen organization) in regular statin users compared to non-users.
METHODS: We conducted ultrasound tissue characterization (UTC) of the Achilles tendon in statin users and a comparison group of similar age and gender. Statin users and control participants were recruited from May 10 2015 to February 17 2017 through a cardiovascular health centre and from the general community. Cross-sectional area of the Achilles tendon and longitudinal collagen organization (% type I echoes) were assessed using quantitative ultrasound tissue characterization by a blinded observer at a predetermined location (2 cm proximal to the calcaneus).
RESULTS: Sixty-six individuals who were either taking statins for at least one year (ST, n = 33) or a comparison group who had never taken statins (CG, n = 33) were included in the study. The Achilles tendon cross-sectional area (ST 59.7 (13) mm2, CG 59.9 (8.5) mm2) and proportion of echo-type I patterns [ST 70 (10)%, CG 74 (13)%] were equivalent in the two groups. In contrast, there was a negative correlation between BMI (rs = -0.25, p = 0.042) and type I echo values. Obese individuals demonstrated a significantly lower percentage of type I echoes (62 (11)%) than individuals of normal body mass index (73 (10)% p<0.05).
CONCLUSION: These findings demonstrate that there is no evidence of a negative statin influence on Achilles tendon structure. Given earlier reports that the risk of Achilles injury is equivalent in statin users and non-users, weightbearing exercise may be prescribed without placing the Achilles tendon at a higher risk of injury than among the general population. The results of this study are consistent with the known negative effects of elevated BMI on tendon structure, suggesting that an assessment of the Achilles tendons prior to prescribing weightbearing exercise may be prudent in obese individuals.

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Conflict of interest statement: The authors have declared that no competing interests exist.

2. Scand J Med Sci Sports. 2018 Jun 4. doi: 10.1111/sms.13235. [Epub ahead of print]

Quantifying proximal patellar tendon changes during adolescence in elite ballet dancers, a 2-year study.

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PURPOSE: Patellar tendon pathology appears to develop in young athletes. It is not known how this tendon develops through adolescence. This longitudinal study investigated proximal patellar tendon development during the adolescent growth spurt in young ballet dancers, and identified if puberty (estimated by maturity offset) had an effect on tendon development.
METHODS: 52 dancers (32 female and 20 male dancers, ages 11-18 at baseline) had ultrasound images of their tendons every 6 months for 2 years. Changes in tendon size (anterior-posterior diameter) on greyscale images and echogenicity, as quantified using ultrasound tissue characterization, were recorded each time. Maturity offset was calculated used to estimate peak height velocity (adolescent growth spurt).
RESULTS: Maturity offset did not affect effect tendon composition before peak height velocity, however after participants passed peak height velocity, maturity offset increased the composition of stable echopattern ($p<0.05$); a 4% differential increase in type I echopattern, indicative of normal tendon structure, and a decrease in type III echopattern (more disorganized echopattern) by 0.7% per year. Anterior-posterior thickness increased by 0.2mm/year ($p<0.05$) measured 2cm below the patella.
CONCLUSIONS: Following peak height velocity, the proximal patellar tendon attachment increased in thickness and demonstrated a more stable echopattern representative of aligned fibrillar structure. Future research is required to further understand this normal maturation and the factors that support this process, with the aim of reducing the development of patellar tendon pathology in the adolescent jumping athlete. This article is protected by copyright. All rights reserved.

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3. Scand J Med Sci Sports. 2018 Apr 15. doi: 10.1111/sms.13095. [Epub ahead of print]

Proximal patellar tendon pathology can develop during adolescence in young ballet dancers-A 2-year longitudinal study.

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Patellar tendinopathy (tendon pain and dysfunction), or jumper's knee, is prevalent in adult jumping athletes. Pathology in the proximal patellar tendon is a key risk factor for developing patellar tendinopathy. When pathology develops in the proximal patellar tendon is not known, although it is reported to exist in adolescent athletes. The aim of this study was to follow young jumping athletes (ballet dancers) through adolescence to identify whether pathology develops and its relation to the adolescent growth spurt. Fifty-seven elite ballet students between ages 11 and 18 were monitored for 2 years. Data were collected every 6 months, including an ultrasound scan on their left tendons using ultrasound tissue characterization (UTC) to quantify intratendinous changes, anthropometric data to calculate peak height velocity (adolescent growth spurt), participant reports of any injuries or dance modifications, and a VISA-P and single leg decline squat for patellar tendon pain. Nine percentage of adolescent dancers developed pathology during this study, and development was not associated with growth spurt. Peak height velocity and dance participation/volume both at the start and throughout the study were similar in those who did develop pathology and those who did not. Only 2 of 5 participants who developed pathology reported pain associated with their tendon. Pathology in the proximal patellar tendon can develop during adolescence.

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PMID: 29658150

4. Am J Phys Med Rehabil. 2018 Apr 11. doi: 10.1097/PHM.0000000000000951. [Epub ahead of print]

Clinical improvements are not explained by changes in tendon structure on UTC following an exercise program for patellar tendinopathy.

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OBJECTIVES: The aim of this study was to investigate the effects of a 4-week in-season exercise program of isometric or isotonic exercises on tendon structure and dimensions as quantified by Ultrasound Tissue Characterization (UTC).
DESIGN: Randomized clinical trial. Volleyball and basketball players (16-31 years, n=29) with clinically diagnosed patellar tendinopathy were randomized to a 4-week isometric or isotonic exercise program. The programs were designed to decrease patellar tendon pain. A baseline and 4-week UTC scan was used to evaluate change in tendon structure.
RESULTS: No significant change in tendon structure or dimensions on UTC was detected after the exercise program, despite patellar tendinopathy symptoms improving. The percentage and mean cross-sectional area (mCSA) of aligned fibrillar structure (echo-types I+II) (Z=-0.414,p=0.679) as well as disorganized structure (echo-types III + IV) (Z=-0.370,p=0.711) did not change over the 4-week exercise program. Change in tendon structure and dimensions on UTC did not differ significantly between the groups.
CONCLUSION: Structural properties and dimensions of the patellar tendon on UTC did not change after a 4-week isometric or isotonic exercise program for athletes with patellar tendinopathy in-season, despite an improvement of symptoms. It seems that structural improvements are not required for a positive clinical outcome.

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PMID: 29649012

5. Am J Sports Med. 2018 Mar;46(4):947-954. doi: 10.1177/0363546517750854. Epub 2018 Jan 26.

The Role of the Vascular and Structural Response to Activity in the Development of Achilles Tendinopathy: A Prospective Study.

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BACKGROUND: Several risk factors have been suggested in the development of Achilles tendinopathy, but large-scale prospective studies are limited.
PURPOSE: To investigate the role of the vascular response to activity of the Achilles tendon, tendon thickness, ultrasound tissue characterization (UTC) of tendon structure, and foot posture as possible risk factors in the development of Achilles tendinopathy.
STUDY DESIGN: Cohort study; Level of evidence, 2.
METHODS: The study began with 351 first-year students at Ghent University. After 51 students were excluded, 300 were tested in the academic years 2013-2014 and 2014-2015 and were followed prospectively for 2 consecutive years by use of a multilevel registration method. Of those, 250 students were included in the statistical analysis. At baseline, foot posture index and UTC were investigated bilaterally. Blood flow and tendon thickness were measured before and after a running activity. Cox regression analyses were performed to identify significant contributors to the development of Achilles tendinopathy.
RESULTS: During the 2-year follow-up, 27 of the included 250 participants developed Achilles tendinopathy (11%). Significant predictive effects were found for female sex and blood flow response after running (P = .022 and P = .019, respectively). The risk of developing Achilles tendinopathy increased if the blood flow increase after running was reduced, regardless of sex, foot pronation, and timing of flow measurements. The model had a predictive accuracy of 81.5% regarding the development of Achilles tendinopathy, with a specificity of 85.0% and a sensitivity of 50.0%.
CONCLUSION: This prospective study identified both female sex and the diminished blood flow response after running as significant risk factors for the development of Achilles tendinopathy. UTC of tendon structure, Achilles tendon thickness, and foot posture did not significantly contribute to the prediction of Achilles tendinopathy. A general evaluation of tendon structure by UTC, measurement of tendon thickness, or determination of the foot posture index will not allow clinicians to identify patients at risk for developing Achilles tendinopathy. Furthermore, it may be possible to improve blood flow after activity by using noninvasive techniques (such as prostaglandins, compression stockings, heat, massage, and vibration techniques). These techniques may be useful in the prevention and management of Achilles tendinopathy, but further research is needed.

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PMID: 29373799

6. Muscles Ligaments Tendons J. 2017 Sep 18;7(2):306-314. doi: 10.11138/mltj/2017.7.2.306. eCollection 2017 Apr-Jun.

Characterising the proximal patellar tendon attachment and its relationship to skeletal maturity in adolescent ballet dancers.

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Background: It is unknown how and when the proximal attachment of the patellar tendon matures; puberty may be key in ensuring normal tendon formation. The aim of this study was to investigate the features of the proximal patellar tendon attachment at different stages of skeletal maturity, to help gain an understanding of how and when the tendon attachment matures.
Methods: Sixty adolescent elite ballet students (ages 11-18) and eight mature adults participated. Peak height velocity (PHV) estimated skeletal maturity. Ultrasound tissue characterisation (UTC) scan was taken of the left knee and analysed for stability of echopattern. An image-based grading scale for greyscale ultrasound was developed to describe the tendon appearance. Anterior-posterior thickness was measured at the inferior pole of the patella, 1 and 2 centimetres distally. Outcomes were compared with skeletal maturity.
Results: Mid-portion patellar tendon thickness increased with skeletal maturity ($p=0.001$ at 1 cm and $p=0.007$ at 2 cm). There was more variance in structural appearance (greyscale classification and UTC echopattern) in pre and peri-PHV participants. Tendon attachment one-year post PHV appeared similar to mature tendons.
Conclusions: Early adolescence was associated with highly variable tendon appearance, whereas the tendon appeared mature after PHV. Adolescence may be a critical time for the formation of normal tendon attachment.
Level of evidence: IIb individual cohort study.

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PMCID: PMC5725180
PMID: 29264342

7. Scand J Med Sci Sports. 2018 Feb;28(2):436-445. doi: 10.1111/sms.12930. Epub 2017 Aug 4.

Impact of rest duration on Achilles tendon structure and function following isometric training.

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Intervention programs are often sought to strengthen the Achilles tendon (AT) due to its high injury rate. Long rest periods between loading cycles have been found to increase collagen synthesis by tenocytes, suggesting rest duration may be important for tendon adaptation in vivo; however, exercise programs comparing long and short rest duration have not been directly compared. Fourteen adults completed a 12-week progressive training intervention; training sessions consisted of 5×10 isometric plantarflexion contractions each of 3-s duration performed at 90% of MVC three times weekly. Each leg was randomly allocated to long (LRT, 10-s rest) or short rest training (SRT, 3-s rest). We hypothesized that the leg allocated to LRT would demonstrate superior AT collagen organization compared to the leg receiving SRT, which would be related to improved biomechanical function. AT collagen organization and morphology were measured using ultrasound tissue characterization. AT properties were assessed before and after the intervention using a combination of dynamometry, ultrasound imaging, EMG, and motion capture. Contrary to our hypothesis, collagen organization did not improve following either training protocol; conversely, an unexpected decrease in echotype I proportion was seen after SRT ($P<.001$) but not LRT ($P=.58$), indicating an apparent protective effect of rest on collagen organization during isometric training. In contrast, AT adaptation was not appreciably enhanced by increasing intercycle rest duration; both protocols were equally effective at inducing significant strength gains and AT mechanical and material adaptation ($P\leq.001$). Further research is necessary to identify optimal loading characteristics for injury prevention and rehabilitation.

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8. Stem Cell Res Ther. 2017 Jun 5;8(1):129. doi: 10.1186/s13287-017-0564-8.

Effect of single intralesional treatment of surgically induced equine superficial digital flexor tendon core lesions with adipose-derived mesenchymal stromal cells: a controlled experimental trial.

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BACKGROUND: Adipose tissue is a promising source of mesenchymal stromal cells (MSCs) for the treatment of tendon disease. The goal of this study was to assess the effect of a single intralesional implantation of adipose tissue-derived mesenchymal stromal cells (AT-MSCs) on artificial lesions in equine superficial digital flexor tendons (SDFTs).
METHODS: During this randomized, controlled, blinded experimental study, either autologous cultured AT-MSCs suspended in autologous inactivated serum (AT-MSC-serum) or autologous inactivated serum (serum) were injected intralesionally 2 weeks after surgical creation of centrally located SDFT lesions in both forelimbs of nine horses. Healing was assessed clinically and with ultrasound (standard B-mode and ultrasound tissue characterization) at regular intervals over 24 weeks. After euthanasia of the horses the SDFTs were examined histologically, biochemically and by means of biomechanical testing.
RESULTS: AT-MSC implantation did not substantially influence clinical and ultrasonographic parameters. Histology, biochemical and biomechanical characteristics of the repair tissue did not differ significantly between treatment modalities after 24 weeks. Compared with macroscopically normal tendon tissue, the content of the mature collagen crosslink hydroxylysylpyridinoline did not differ after AT-MSC-serum treatment ($p = 0.074$) while it was significantly lower ($p = 0.027$) in lesions treated with serum alone. Stress at failure ($p = 0.048$) and the modulus of elasticity ($p = 0.001$) were significantly lower after AT-MSC-serum treatment than in normal tendon tissue.
CONCLUSIONS: The effect of a single intralesional injection of cultured AT-MSCs suspended in autologous inactivated serum was not superior to treatment of surgically created SDFT lesions with autologous inactivated serum alone in a surgical model of tendinopathy over an observation period of 22 weeks. AT-MSC treatment might have a positive influence on collagen crosslinking of remodelling scar tissue. Controlled long-term studies including naturally occurring tendinopathies are necessary to verify the effects of AT-MSCs on tendon disease.

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PMCID: PMC5460527
PMID: 28583184 [Indexed for MEDLINE]

9. Br J Sports Med. 2017 May 10. pii: bjsports-2017-097827.4. doi: 10.1136/bjsports-2017-097827.4. [Epub ahead of print]

Subcategories of tendinopathy using ultrasound tissue characterization (utc): dorsal mid-portion achilles tendinopathy is more severe than ventral achilles tendinopathy.

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AIM: To evaluate the association between tendon structure and clinical severity. Looking specifically at location of pathology, comparing ventral versus dorsal tendinopathy.
METHODS: Patients were recruited from a tertiary tendinopathy center between Jan 2015 - June 2016. Inclusion criteria included patients with midportion Achilles tendinopathy, aged between 1870. Patients with insertional Achilles tendinopathy or other suspected etiology were excluded. Patients were assessed using ultrasound tissue characterization (UTC) scanning. UTC software was used to analyse a 2 cm block 24 cm from the calcaneum for percentage of echo type I, II, III and IV. With percentage echo type I+II used as the primary outcome. A doctor also categorised patients into predominately dorsal or ventral pathology based on UTC imaging. VISAA and VAS scores were used for clinical outcome measures. Statistics were undertaken using SPSS, data was not normally distributed RESULTS: Overall 33 tendons with mid portion Achilles tendinopathy were analysed, the overall percentage echo type I+II showed no correlation to either VISAA (p=0.745, r=0.0600) or VAS (p=0.157, r=0.248). When divided into dorsal and ventral Achilles tendinopathy there was a significant difference between baseline VISAA scores with a lower VISAA score 35 (SD±19) in dorsal group compared with the ventral group 60 (SD±17.1) (p=0.009). There was also a higher VAS score in the dorsal group (mean = 6, SD±2.28) at baseline compared with ventral (mean = 5, SD±3.07), although this was not significant (p=0.416).
CONCLUSIONS: This highlights the possibility of using UTC to subcategories patients into ventral and dorsal which seems to correlate to increased clinical severity in the dorsal group. This is perhaps due to increased tension and stretching acting through this part of the tendon on loading and thus more nociceptive stimulation and greater dysfunction of the tendon. This could be used to help determine differing rehabilitation interventions in future with differing intensities for the two groups. It further highlights as previous studies1,2 have that there is no direct correlation between overall structure and clinical severity.

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PMID: 28490458

10. Scand J Med Sci Sports. 2018 Jan;28(1):303-310. doi: 10.1111/sms.12903. Epub 2017 Jun 19.

Achilles tendon adaptation in cross-country runners across a competitive season.

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Ultrasound tissue characterization (UTC) is an imaging tool used to quantify tendon structural integrity. UTC has quantified Achilles tendon (AT) acute response to load in athletes; however, AT response to cumulative load over a season is unknown. The purpose of this study was to evaluate AT response across a four-month competitive season in collegiate cross-country (XC) runners. Participants (n=21; male=9, female=12; age=19.8±1.2 years; height=171.9±8.9 cm; weight=60.2±8.5 kg) were imaged using the UTC device with a 10-MHz linear-array transducer mounted in a tracking device. The device captures images at 0.2 mm intervals along the AT. UTC algorithms quantified the stability of pixel brightness over every 17 contiguous transverse images into four echo types (I-IV). A total of 168 scans (n=21, bilateral limbs) were performed monthly across the four-month season (Aug=M1, Sep=M2, Oct=M3, Nov=M4). Echo-type percentages (%) were calculated from each scan. Generalized estimating equations (GEE) linear regression models evaluated echo-type % change (β) over the season (M1=reference). Type I increased from M1 to M4 (β=9.10, P<.01; 95%CI: 7.01, 11.21) and Type II decreased from M1 to M3 (β=-2.71, P=.018; 95%CI: -4.96, -0.47) and M1 to M4 (β=-10.19, P<.01; 95%CI: -12.22, -8.17). Type III increased from M1 to M3 (β=0.42, P=.003; 95%CI: 0.19, 0.65) and M1 to M4 (β=0.49, P=.002; 95%CI: 0.18, 0.81), Type IV increased from M1 to M4 (β=0.57, P<.01; 95%CI: 0.29, 0.84). A positive adaptation in AT structural integrity was observed over the XC season, with a ~10% shift from Type II to Type I UTC echo types, suggesting AT resilience to a competitive season of repetitive loading in highly trained runners.

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PMID: 28455943

11. Scand J Med Sci Sports. 2017 Dec;27(12):1942-1949. doi: 10.1111/sms.12820. Epub 2016 Dec 28.

Pain duration is associated with increased muscle sympathetic nerve activity in patients with Achilles tendinopathy.

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Tendinopathy is a common condition, which has been linked to surrogate measures of sympathetic nervous system (SNS) activity and insulin resistance. This study aimed to compare in vivo measures of the SNS and insulin resistance between individuals with and without Achilles tendinopathy. This case-control study compared Achilles tendinopathy sufferers to healthy controls. SNS activity was quantified using muscle sympathetic nerve activity (MSNA), while metabolic status was assessed via a modified glucose tolerance test and fasting lipid panel. Ultrasound tissue characterization assessed tendon structure. Resting MSNA did not differ between the 15 cases and 20 controls. Tendon pain duration in tendinopathy patients was correlated with burst frequency (R2 =.32, P=.02) and burst incidence (R2 =.41, P=.01) of MSNA. After adjusting for multiple comparisons, there was a trend suggesting fasting glucose was greater in cases (median 4.80, IQR .70 in cases vs 4.51, .38 in controls) and correlated with pain severity (R2 =.14, P=.03), but no other metabolic measures were associated with tendon pain/structure. This study indicates that SNS activity is associated with tendon pain duration, building on previous data indicating the SNS is involved in recalcitrant tendinopathy. Metabolic parameters had little relationship with Achilles tendinopathy in this metabolically homogenous sample. Prospective studies are required to uncover the precise relationship between SNS activity, insulin resistance, and tendinopathy.

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PMID: 28028840 [Indexed for MEDLINE]

12. Int J Sports Physiol Perform. 2017 Apr;12(Suppl 2):S2122-S2126. doi: 10.1123/ijspp.2016-0397. Epub 2016 Dec 5.

Effects of Training Load and Leg Dominance on Achilles and Patellar Tendon Structure.

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PURPOSE: Detrimental changes in tendon structure increase the risk of tendinopathies. The aim of this study was to investigate the influence of individual internal and external training loads and leg dominance on changes in the Achilles and patellar tendon structure.
METHODS: The internal structure of the Achilles and patellar tendons of both limbs of 26 elite Australian footballers was assessed using ultrasound tissue characterization at the beginning and the end of an 18-wk preseason. Linear-regression analysis was used to estimate the effects of training load on changes in the proportion of aligned and intact tendon bundles for each side. Standardization and magnitude-based inferences were used to interpret the findings.
RESULTS: Possibly to very likely small increases in the proportion of aligned and intact tendon bundles occurred in the dominant Achilles (initial value 81.1%; change, ±90% confidence limits 1.6%, ±1.0%), nondominant Achilles (80.8%; 0.9%, ±1.0%), dominant patellar (75.8%; 1.5%, ±1.5%), and nondominant patellar (76.8%; 2.7%, ±1.4%) tendons. Measures of training load had inconsistent effects on changes in tendon structure; eg, there were possibly to likely small positive effects on the structure of the nondominant Achilles tendon, likely small negative effects on the dominant Achilles tendon, and predominantly no clear effects on the patellar tendons.
CONCLUSION: The small and inconsistent effects of training load are indicative of the role of recovery between tendon-overloading (training) sessions and the multivariate nature of the tendon response to load, with leg dominance a possible influencing factor.

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13. BMC Vet Res. 2016 Sep 7;12(1):191. doi: 10.1186/s12917-016-0826-1.

Effect of intralesional platelet-rich plasma (PRP) treatment on clinical and ultrasonographic parameters in equine naturally occurring superficial digital flexor tendinopathies - a randomized prospective controlled clinical trial.

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BACKGROUND: Regenerative and anti-inflammatory effects on tendinopathies have been attributed to blood-derived biologicals. To date the evidence for the efficacy of autologous platelet-rich plasma (PRP) treatment of naturally occurring equine tendinopathies is limited. The purpose of this placebo-controlled clinical trial was to describe the effect of a single treatment of equine superficial digital flexor tendon (SDFT) disease with PRP on clinical and ultrasonographic parameters. Twenty horses with naturally occurring tendinopathies of forelimb SDFTs were randomly assigned to the PRP-treated group (n = 10) or control group (n = 10) after clinical and ultrasonographic examination. The SDFTs received an intralesional treatment with autologous PRP or were injected with saline, respectively (day 0). All horses participated in a standardized exercise programme and were re-examined clinically, with B-mode ultrasonography (5 times at regular intervals) and ultrasound tissue characterization (week 12 and 24 after treatment) until week 24. Long-term performance was estimated via telephone inquiry.
RESULTS: Compared to day 0, lameness decreased significantly by week 8 after treatment with PRP and by week 12 in the control group. Ultrasonographically there was no difference in the summarized cross sectional area between the groups at any time point. Ultrasound tissue characterization showed that echo types representing disorganized matrix decreased significantly throughout the observation period in the PRP-treated group. Echo type II, representing discontinuous fascicles, not yet aligned into lines of stress was significantly higher 24 weeks after PRP treatment. Eighty percent of the PRP treated horses reached their previous or a higher level of performance after 12 months compared to 50 % in the CG. After 24 months these proportions were 60 % and 50 %, respectively.
CONCLUSIONS: A single intralesional treatment with PRP up to 8 weeks after onset of clinical signs of tendinopathy contributes to an earlier reduction of lameness compared to saline treatment and to an advanced organization of repair tissue as the fibrillar matrix is getting organized into fascicles while remodelling continues. Long term, PRP treatment has the potential to increase the number of horses reaching their previous level of performance. Earlier treatment of tendinopathy with PRP should be considered to enhance these effects.

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PMCID: PMC5015224
PMID: 27604193 [Indexed for MEDLINE]

14. Scand J Med Sci Sports. 2017 Jul;27(7):746-753. doi: 10.1111/sms.12706. Epub 2016 Jul 1.

What does normal tendon structure look like? New insights into tissue characterization in the Achilles tendon.

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Recently, ultrasound tissue characterization (UTC) was introduced as a reliable method for quantification of tendon structure. Despite increasing publications on the use of UTC, it is striking that there is a lack of normative data in active adolescents. Therefore, the aim of this study was to provide normative values of the Achilles tendon as quantified by UTC. Seventy physiotherapy students (26 male and 44 female students) with no history of Achilles tendon injuries were recruited. The Achilles tendons were scanned with UTC to characterize tendon structure. This study demonstrated that Achilles tendons of active, healthy adolescents contained 54.6% echo type I, 42.8% echo type II, 2.2% echo type III, and 0.3% echo type IV at midportion. The comparison between insertion and midportion of the tendon showed more echo type II at insertion ($P < 0.001$). Furthermore, female tendons contained significantly more echo type II, in both insertion and midportion compared with male tendons ($P = 0.004$ and $P = 0.003$, respectively). The results of this study, with respect to the MDC (minimum detectable change), highlight differences in the UTC echopattern in the normal population (sex and regional location), which are important considerations for future studies.

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15. BMC Musculoskelet Disord. 2016 Feb 24;17:97. doi: 10.1186/s12891-016-0955-5.

How to diagnose plantaris tendon involvement in midportion Achilles tendinopathy - clinical and imaging findings.

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BACKGROUND: The purpose of this investigation was to evaluate if clinical assessment, Ultrasound + Colour Doppler (US + CD) and Ultrasound Tissue Characterisation (UTC) can be useful in detecting plantaris tendon involvement in patients with midportion Achilles tendinopathy.
METHODS: Twenty-three tendons in 18 patients (14 men, mean age: 37 years and 4 women: 44 years) (5 patients with bilateral tendons) with midportion Achilles tendinopathy were surgically treated with a scraping procedure and plantaris tendon removal. For all tendons, clinical assessment, Ultrasound + Colour Doppler (US + CD) examination and Ultrasound Tissue Characterisation (UTC) were performed.
RESULTS: At surgery, all 23 cases had a plantaris tendon located close to the medial side of the Achilles tendon. There was vascularised fat tissue in the interface between the Achilles and plantaris tendons. Clinical assessment revealed localised medial activity-related pain in 20/23 tendons and focal medial tendon tenderness in 20/23 tendons. For US + CD, 20/23 tendons had a tendon-like structure interpreted to be the plantaris tendon and localised high blood flow in close relation to the medial side of the Achilles. For UTC, 19/23 tendons had disorganised (type 3 and 4) echopixels located only in the medial part of the Achilles tendon indicating possible plantaris tendon involvement.
CONCLUSIONS: US + CD directly, and clinical assessment indirectly, can detect a close by located plantaris tendon in a high proportion of patients with midportion Achilles tendinopathy. UTC could complement US + CD and clinical assessment by demonstrating disorganised focal medial Achilles tendon structure indicative of possible plantaris involvement.

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PMCID: PMC4765029
PMID: 26912241 [Indexed for MEDLINE]

16. Foot Ankle Int. 2016 Apr;37(4):386-93. doi: 10.1177/1071100715619989. Epub 2015 Dec 4.

Plantaris Excision and Ventral Paratendinous Scraping for Achilles Tendinopathy in an Athletic Population.

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BACKGROUND: Achilles tendinopathy is a frequent problem in high-level athletes. Recent research has proposed a combined etiologic role for the plantaris tendon and neovascularization. Both pathologies can be observed on ultrasound imaging.(1,13) However, little is known about the change in structure of the Achilles tendon following the surgical treatment of these issues. The purpose of the study was to assess if excising the plantaris and performing ventral paratendinous "scraping" of the neovascularization improved symptoms of Achilles tendinopathy and whether there was a change in the fibrillar structure of the tendon with ultrasound tissue characterization (UTC) following this operation.
METHODS: This prospective consecutive case series included 15 professional/semiprofessional athletes (17 Achilles tendons) who underwent plantaris excision and paratendinous scraping to treat noninsertional Achilles tendinopathy. The plantaris tendon was excised if adherent to the Achilles tendon, and the area of neovascularization for scraping was demarcated on preoperative imaging. Preoperative and postoperative Victorian Institute of Sports Assessment-Achilles (VISA-A) scores were taken. UTC was performed on 11 of 17 tendons preoperatively and postoperatively. The mean follow-up was for 25 months.
RESULTS: Fourteen of 15 patients had a successful outcome after the surgery. The mean VISA-A improved from 51 to 95 (p=.0001). There was a statistically significant (p=.04) improvement in the aligned fibrillar structure of the tendon confirmed with UTC scanning following surgery from 90% (±8) to 96% (±5).
CONCLUSION: This group of high-level athletes derived an excellent clinical result from this operation. Furthermore, UTC scanning offered an objective method to evaluate the healing of Achilles tendons.
LEVEL OF EVIDENCE: Level IV, case series.

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PMID: 26637273 [Indexed for MEDLINE]

17. BMC Musculoskelet Disord. 2015 Nov 10;16:345. doi: 10.1186/s12891-015-0803-z.

Does type 1 diabetes mellitus affect Achilles tendon response to a 10 km run? A case control study.

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BACKGROUND: Achilles tendon structure deteriorates 2-days after maximal loading in elite athletes. The load-response behaviour of tendons may be altered in type 1 diabetes mellitus (T1DM) as hyperglycaemia accelerates collagen cross-linking. This study compared Achilles tendon load-response in participants with T1DM and controls.
METHODS: Achilles tendon structure was quantified at day-0, day-2 and day-4 after a 10 km run. Ultrasound tissue characterisation (UTC) measures tendon structural integrity by classifying pixels as echo-type I, II, III or IV. Echo-type I has the most aligned collagen fibrils and IV has the least.
RESULTS: Participants were 7 individuals with T1DM and 10 controls. All regularly ran distances greater than 5 km and VISA-A scores indicated good tendon function (T1DM = 94 ± 11, control = 94 ± 10). There were no diabetic complications and HbA1c was 8.7 ± 2.6 mmol/mol for T1DM and 5.3 ± 0.4 mmol/mol for control groups. Baseline tendon structure was similar in T1DM and control groups - UTC echo-types (I-IV) and anterior-posterior thickness were all $p > 0.05$. No response to load was seen in either T1DM or control group over the 4-days post exercise.
CONCLUSION: Active individuals with T1DM do not have a heightened Achilles tendon response to load, which suggests no increased risk of tendon injury. We cannot extrapolate these findings to sedentary individuals with T1DM.

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PMCID: PMC4641391
PMID: 26556589 [Indexed for MEDLINE]

18. Am J Sports Med. 2015 Dec;43(12):2950-8. doi: 10.1177/0363546515605077. Epub 2015 Oct 13.

The Tendon Structure Returns to Asymptomatic Values in Nonoperatively Treated Achilles Tendinopathy but Is Not Associated With Symptoms: A Prospective Study.

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BACKGROUND: Tendinopathy is characterized by alterations in the tendon structure, but there are conflicting results on the potential of tendon structure normalization and no large studies on the quantified, ultrasonographic tendon structure and its association with symptoms.
PURPOSE: To determine whether the tendon structure returns to values of asymptomatic individuals after treatment with 2 substances injected within the tendon, to assess the association between the tendon structure and symptoms, and to assess the prognostic value of the baseline tendon structure on treatment response.
STUDY DESIGN: Cohort study; Level of evidence, 2.
METHODS: This study was part of a randomized trial on chronic midportion Achilles tendinopathy using eccentric exercises with either a platelet-rich plasma or saline injection. Symptoms were recorded using the Victorian Institute of Sports Assessment-Achilles (VISA-A) questionnaire. The tendon structure was quantified with ultrasound tissue characterization (UTC); echo types I + II (as a percentage of total tendon types I-IV) are structure related. Follow-up was at 6, 12, 24, and 52 weeks. A control group of asymptomatic subjects (similar age) was selected to compare the tendon structure. Patient symptoms were correlated with the tendon structure using a linear model.
RESULTS: Fifty-four patients were included in the symptomatic group. The mean (± SD) echo types I + II in the symptomatic group increased significantly from 74.6% ± 10.8% at baseline to 85.6% ± 6.0% at 24-week follow-up. The result for echo types I + II at 24 weeks was not significantly different (P = .198) from that of the asymptomatic control group (87.5% ± 6.0%). In 54 repeated measurements at 5 time points, the adjusted percentage of echo types I + II was not associated with the VISA-A score (main effect: β = .12; 95% CI, -0.12 to 0.35; P = .338). The adjusted baseline echo types I + II were not associated with a change in the VISA-A score from baseline to 52 weeks (β = -.15; 95% CI, -0.67 to 0.36; P = .555).
CONCLUSION: In symptomatic, tendinopathic Achilles tendons, the ultrasonographic tendon structure improved during nonoperative treatment and normalized after 24 weeks to values of matched asymptomatic controls. There was no association between the tendon structure and symptoms. The percentage of echo types I + II before treatment was not associated with change in symptoms over time. This study demonstrates that restoration of the tendon structure is not required for an improvement of symptoms.

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19. J Orthop Sports Phys Ther. 2015 Nov;45(11):842-52. doi: 10.2519/jospt.2015.5880. Epub 2015 Sep 21.

Tendinopathy: Is Imaging Telling Us the Entire Story?

Docking SI, Ooi CC, Connell D.

Synopsis Tendinopathy is frequently associated with structural disorganization within the tendon. As such, the clinical use of ultrasound and magnetic resonance imaging for tendinopathy has been the focus of numerous academic studies and clinical discussions. However, similar to other musculoskeletal conditions (osteoarthritis and intervertebral disc degeneration), there is no direct link between tendon structural disorganization and clinical symptoms, with findings on imaging potentially creating a confusing clinical picture. While imaging shows the presence and extent of structural changes within the tendon, the clinical interpretation of the images requires context in regard to the features of pain and the aggravating loads. This review will critically evaluate studies that have investigated the accuracy and sensitivity of imaging in the detection of clinical tendinopathy and the methodological issues associated with these studies (subject selection, lack of a robust gold standard, reliance on subjective measures). The advent of new imaging modalities allowing for the quantification of tendon structure or mechanical properties has allowed new critical insight into tendon pathology. A strength of these novel modalities is the ability to quantify properties of the tendon. Research utilizing ultrasound tissue characterization and sonoelastography will be discussed. This narrative review will also attempt to synthesize current research on whether imaging can predict the onset of pain or clinical outcome, the role of monitoring tendon structure during rehabilitation (ie, does tendon structure need to improve to get a positive clinical outcome?), and future directions for research, and to propose the clinical role of imaging in tendinopathy. J Orthop Sports Phys Ther 2015;45(11):842-852. Epub 21 Sep 2015. doi:10.2519/jospt.2015.5880.

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PMID: 26390270 [Indexed for MEDLINE]

20. Scand J Med Sci Sports. 2016 Jun;26(6):675-83. doi: 10.1111/sms.12491. Epub 2015 Jun 9.

Pathological tendons maintain sufficient aligned fibrillar structure on ultrasound tissue characterization (UTC).

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Structural disorganization in the tendon is associated with tendinopathy, with little research investigating whether disorganization overwhelms the overall structural integrity of the tendon. This study investigated the mean cross-sectional area (CSA) of aligned fibrillar structure as detected by ultrasound tissue characterization (UTC) in the pathological and normal Achilles and patellar tendons. Ninety-one participants had their Achilles and/or patellar tendons scanned using UTC to capture a three-dimensional image of the tendon and allow a semi-quantification of the echopattern. The mean CSA of aligned fibrillar structure (echo type I + II) and disorganized structure (echo type III + IV) was calculated based on UTC algorithms. Each tendon was classified as either pathological or normal based solely on gray-scale ultrasound. The mean CSA of aligned fibrillar structure was significantly greater ($P \leq 0.001$) in the pathological tendon compared with the normal tendon, despite the pathological tendon containing greater amounts of disorganized structure ($P \leq 0.001$). A significant relationship was observed between the mean CSA of disorganized structure and anteroposterior diameter of the Achilles ($R(2) = 0.587$) and patellar ($R(2) = 0.559$) tendons. This study is the first to show that pathological tendons have sufficient levels of aligned fibrillar structure. Pathological tendons may compensate for areas of disorganization by increasing in tendon thickness.

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21. Scand J Med Sci Sports. 2016 May;26(5):557-63. doi: 10.1111/sms.12469. Epub 2015 May 5.

Achilles tendon structure improves on UTC imaging over a 5-month pre-season in elite Australian football players.

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Pre-season injuries are common and may be due to a reintroduction of training loads. Tendons are sensitive to changes in load, making them vulnerable to injury in the pre-season. This study investigated changes in Achilles tendon structure on ultrasound tissue characterization (UTC) over the course of a 5-month pre-season in elite male Australian football players. Eighteen elite male Australian football players with no history of Achilles tendinopathy and normal Achilles tendons were recruited. The left Achilles tendon was scanned with UTC to quantify the stability of the echopattern. Participants were scanned at the start and completion of a 5-month pre-season. Fifteen players remained asymptomatic over the course of the pre-season. All four echo-types were significantly different at the end of the pre-season, with the overall echopattern suggesting an improvement in Achilles tendon structure. Three of the 18 participants developed Achilles tendon pain that coincided with a change in the UTC echopattern. This study demonstrates that the UTC echopattern of the Achilles tendon improves over a 5-month pre-season training period, representing increased fibrillar alignment. However, further investigation is needed to elucidate with this alteration in the UTC echopattern results in improved tendon resilience and load capacity.

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PMID: 25943892 [Indexed for MEDLINE]

22. BMJ Open Sport Exerc Med. 2015 May 2;1(1):e000005. eCollection 2015.

Achilles tendinopathy-do plantaris tendon removal and Achilles tendon scraping improve tendon structure? A prospective study using ultrasound tissue characterisation.

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OBJECTIVES: The plantaris tendon has recently been described as a possible important factor in midportion Achilles tendinopathy. Ultrasound tissue characterisation (UTC) is a method to study tendon structure (matrix integrity). The effect of plantaris tendon removal on Achilles tendon structure was studied using UTC.
DESIGN AND SETTING: Prospective case series study at one centre.
PARTICIPANTS: Nine tendons in eight physically active and healthy patients (mean age 39 years) with chronic painful midportion Achilles tendinopathy were included. Preoperative two-dimensional ultrasound and UTC showed midportion Achilles tendinopathy (tendinosis) with medial tendon changes and suspected plantaris tendon involvement. Patients with previous operations to the Achilles tendon were excluded.
INTERVENTIONS: Operative treatment consisted of excision of the plantaris tendon and scraping of the ventromedial surface of the Achilles tendon under a local anaesthetic.
PRIMARY AND SECONDARY OUTCOME MEASURES: UTC examination and clinical scoring with the VISA-A questionnaire were performed preoperatively and 6 months postoperatively.
RESULTS: At 6 months follow-up, UTC demonstrated a statistically significant ($t=5.40$, $p<0.001$) increase in the mean organised matrix (echo-type I+II) and a decrease in the mean disorganised matrix (echo-type III+IV). Seven out of eight patients were satisfied, and the VISA-A score had increased significantly ($p<0.001$) from 56.8 (range 34-73) preoperatively to 93.3 (range 87-100) postoperatively.
CONCLUSIONS: Excision of the plantaris tendon and scraping of the ventromedial Achilles tendon in chronic midportion tendinopathy seem to have the potential to improve tendon structure and reduce tendon pain. Studies on a larger group of patients and with a longer follow-up period are needed.

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PMCID: PMC5117009
PMID: 27900118

23. Scand J Med Sci Sports. 2016 Feb;26(2):189-96. doi: 10.1111/sms.12426. Epub 2015 Feb 18.

Does the adolescent patellar tendon respond to 5 days of cumulative load during a volleyball tournament?

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Patellar tendinopathy (jumper's knee) has a high prevalence in jumping athletes. Excessive load on the patellar tendon through high volumes of training and competition is an important risk factor. Structural changes in the tendon are related to a higher risk of developing patellar tendinopathy. The critical tendon load that affects tendon structure is unknown. The aim of this study was to investigate patellar tendon structure on each day of a 5-day volleyball tournament in an adolescent population (16-18 years). The right patellar tendon of 41 players in the Australian Volleyball Schools Cup was scanned with ultrasound tissue characterization (UTC) on every day of the tournament (Monday to Friday). UTC can quantify structure of a tendon into four echo types based on the stability of the echo pattern. Generalized estimating equations (GEE) were used to test for change of echo type I and II over the tournament days. Participants played between eight and nine matches during the tournament. GEE analysis showed no significant change of echo type percentages of echo type I (Wald chi-square = 4.603, d.f. = 4, P = 0.331) and echo type II (Wald chi-square = 6.070, d.f. = 4, P = 0.194) over time. This study shows that patellar tendon structure of 16-18-year-old volleyball players is not affected during 5 days of cumulative loading during a volleyball tournament.

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PMID: 25694241 [Indexed for MEDLINE]

24. Br J Sports Med. 2015 Aug;49(15):995-9. doi: 10.1136/bjsports-2014-093696. Epub 2015 Jan 13.

Achilles tendons in people with type 2 diabetes show mildly compromised structure: an ultrasound tissue characterisation study.

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BACKGROUND: Musculotendinous overuse injuries are prevalent in people with type 2 diabetes. Non-enzymatic glycosylation of collagen resulting in tendon stiffening may play a role. In this case-control study we determined whether patients with diabetes had poorer ultrasonographic structure in their Achilles tendons compared to age-matched controls.
METHODS: People with type 1 diabetes or type 2 diabetes, and age-matched controls, had computerised ultrasound tissue characterisation of both Achilles tendons. In contiguous ultrasonographic images of the tendon, echopatterns were quantified and categorised into four echo-types. Tendon abnormality was quantified as sum of echo-types III+IV. Furthermore, skin autofluorescence (AF) of the forearm (AF-value) was gathered.
RESULTS: Twenty four type 2 diabetes patients, 24 controls, 24 type 1 diabetes patients and 20 controls were included. AF-value was higher in type 1 diabetes (1.55±0.17) than in their controls (1.39±0.18, p<0.001) and in type 2 diabetes (2.28±0.38) compared to their controls (1.84±0.32, p<0.001) Achilles tendons of type 2 diabetes patients contained more echo-types III+IV (14.1±7.9%) than matched controls (8.0±5.4%, p<0.001). There was a trend towards a difference in echo-types III+IV between type 1 diabetes patients (9.5±5.3%) and their controls (6.5±3.7%, p=0.055). In a stepwise linear regression analysis, body mass index (BMI) was moderately associated with tendon abnormality in patients with diabetes and controls (β=0.393, p<0.001).
CONCLUSIONS: Type 2, and possibly type 1, diabetes patients showed poorer ultrasonographic Achilles tendon structure that may be a risk factor for tendinopathy. Although markers for accumulation of advanced glycation end products were elevated in both diabetes populations, only BMI was associated with these abnormalities.
TRIAL REGISTRATION NUMBER: NTR2209.

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PMID: 25586910 [Indexed for MEDLINE]

25. J Sci Med Sport. 2015 Jul;18(4):383-7. doi: 10.1016/j.jsams.2014.06.004. Epub 2014 Jun 20.

Structural integrity is decreased in both Achilles tendons in people with unilateral Achilles tendinopathy.

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OBJECTIVES: A high proportion of Achilles tendinopathy patients develop bilateral symptoms with human and animal studies showing bilateral histological changes associated with overuse/pathology in one tendon. The current study examined changes in tendon structure, assessed semi-quantitatively using ultrasound tissue characterisation, in both the symptomatic and asymptomatic tendon in unilateral Achilles tendinopathy patients in comparison to individuals with no history of tendinopathy.
DESIGN: Cross-sectional case-control study.
METHODS: Participants with Achilles tendinopathy (n=21), with varying severity and length of clinical symptoms, and six participants with no history of tendinopathy were recruited. Tendons were scanned using ultrasound tissue characterisation, which captures contiguous transverse ultrasound images every 0.2mm and renders a 3-dimensional image. Ultrasound tissue characterisation quantifies tendon structure by measuring the stability of echopattern over contiguous transverse images. Four echo-types were discriminated and expressed as a percentage. Antero-posterior diameter of all tendons was measured.
RESULTS: Significant differences were observed in the proportion of normal tendon structure between all three groups ($p<0.01$), with the symptomatic tendon containing the least amount of normal tendon structure (symptomatic - 79.5%, asymptomatic - 81.8%, control - 86.4%). The asymptomatic tendon contained significantly less normal tendon in comparison to the control tendon ($p=0.008$), suggesting the asymptomatic tendon is structurally compromised despite the absence of symptoms.
CONCLUSIONS: Both Achilles tendons are structurally compromised in patients with unilateral Achilles tendinopathy. Future studies need to investigate whether these changes increase the risk of developing symptoms.

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Australian football players' Achilles tendons respond to game loads within 2 days: an ultrasound tissue characterisation (UTC) study.

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BACKGROUND/AIM: The Achilles tendon is a tissue that responds to mechanical loads at a molecular and cellular level. In vitro and in vivo studies have shown that the expression of anabolic and/or catabolic proteins can change within hours of loading and return to baseline levels within 72 h. These biochemical changes have not been correlated with changes in whole tendon structure on imaging. We examined the nature and temporal sequence of changes in Achilles tendon structure in response to competitive game loads in elite Australian football players.
METHODS: Elite male Australian football players with no history of Achilles tendinopathy were recruited. Achilles tendon structure was quantified using ultrasound tissue characterisation (UTC) imaging, a valid and reliable measure of intratendinous structure, the day prior to the match (day 0), and then reimaged on days 1, 2 and 4 postgame.
RESULTS: Of the 18 participants eligible for this study, 12 had no history of tendinopathy (NORM) and 6 had a history of patellar or hamstring tendinopathy (TEN). Differences in baseline UTC echopattern were observed between the NORM and TEN groups, with the Achilles of the TEN group exhibiting altered UTC echopattern, consistent with a slightly disorganised tendon structure. In the NORM group, a significant reduction in echo-type I (normal tendon structure) was seen on day 2 (p=0.012) that returned to baseline on day 4.
SUMMARY: There was a transient change in UTC echopattern in the Achilles tendon as a result of an Australian football game in individuals without a history of lower limb tendinopathy.

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Tendon structure changes after maximal exercise in the Thoroughbred horse: use of ultrasound tissue characterisation to detect in vivo tendon response.

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Investigations into the response of the superficial digital flexor tendon (SDFT) of the Thoroughbred horse to mechanical stimuli have been limited to in vitro cell culture studies focused primarily on gene expression of critical matrix proteins. It is uncertain how well in vitro outcomes translate to the tendon of the horse during exercise. The current study examined changes in tendon structure in response to maximal exercise using ultrasound tissue characterisation (UTC) to scan the SDFT prior to and after competitive racing. UTC uses contiguous transverse ultrasound images to assess the dynamics of the echopattern, which has a close relationship with changes in the 3-D ultra-structure of the tendon. Using UTC, it was possible to detect subtle changes in the dynamics of the echopattern, with a reduction in pixels that represent aligned and integer collagen tendon bundles on days 1 and 2 post-race when compared to pre-race ($P<0.05$). The echopattern of these tendons returned to baseline on day 3. This change in echopattern was not seen in control horses. It was concluded that short-term changes in the SDFT following maximal exercise could be detected using UTC.

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