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Original Research

Comparison of the sonographic features of the Achilles Tendon complex in patients with and without achilles tendinopathy: A case-control study

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ABSTRACT

Aim: The aim of the present study was to evaluate and quantify with ultrasound imaging (USI) the Achilles tendon thickness, cross-sectional area (CSA), Kager's fat pad length and gastrocnemius-soleus pennation angle (PA) between chronic mid-portion Achilles tendinopathy (AT) and healthy subjects.
Methods: A total sample of 143 individuals (age: 41.3 ± 12.0 y; height: 1.74 ± 0.0 m; weight: 75.0 ± 11.4 kg; body mass index, BMI: 24.4 ± 2.6 kg/m^2) was recruited and divided in two groups: chronic mid-portion AT group (n = 71) and a healthy group (n = 72).
Results: The thickness and CSA at 4 cm and 6 cm from the calcaneus was increased showing statistically significant differences ($P < .01$) in favor the tendinopathy group. For the gastrocnemius-soleus PA and Kager's fat pad length, significant differences ($P < .01$) were observed for a decrease in favor of the tendinopathy group.
Conclusions: This study reported an increase of Achilles tendon thickness and CSA at 4 cm and 6 cm from the calcaneus as well as a decrease in gastrocnemius-soleus PA and Kager's fat pad length in patients with chronic mid-portion AT.

1. Introduction

The Achilles tendon is the strongest and largest tendon in the whole human body. This structure is subject to modifications depending to the tensile loads during its contraction or elongation, make it susceptible to overuse injuries (Nadeau, Desrochers, Lamontagne, Larivière, & Gagnon, 2016).

Achilles tendinopathy (AT) is a clinical disease characterized by pain, swelling, morning stiffness and a lack of functionality in the lower limb (Lopes, Hespanhol Junior, Yeung, & Costa, 2012). This syndrome reported an incidence rate of 2.35 and 2.16 per 1000 in general population (Albers, Zwerver, Diercks, Dekker, & Van den Akker-Scheek, 2016). Overuse is the primary cause of AT, starting with lightly tendon adaptations and finishing with degenerative processes (Cook & Purdam, 2009). Degeneration is very common in the mid-portion in this population (van Dijk, van Sterkenburg, Wiegerinck, Karlsson, & Maffulli, 2011), and specially this area seems to present a blow flow decrease (Chen et al., 2009).

Structural alterations have been identified in individuals with AT, Shaikh et al. (Shaikh et al., 2012) showed an increased tendon thickness in runners with AT symptoms. Arya and Kulig (8) reported an increase in cross sectional area (CSA) in tendinopathic tendons. In addition, Docking and Cook observed a greater Achilles CSA compared with healthy individuals. Padhiar et al. (Padhiar, Al-Sayeagh, Chan, King, & Maffulli, 2008) observed that subjects with AT are more likely to have a decreased pennation angle (PA) of the soleus fibers in the pathologic side.

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Several authors reported a reduced mechanical properties in weight-bearing tendons in subjects with AT (Arya & Kulig, 2010). Kongsgaard et al. (Kongsgaard et al., 2010) showed a higher tendon strain and a lower tendon stiffness in subjects with AT compared with controls. In addition, Wang et al. (Wang, 2006) argued that these reduced mechanical features are a consequence of changes in the tendon cellular structure.

Ultrasound imaging (USI) have been widely used to quantify the length, thickness and CSA of the tendon, muscular and connective tissues in different structures. B- mode is considered superior to magnetic resonance imaging (MRI) for assess structural changes in AT (Fredberg & Stengaard-Pedersen, 2008). USI is considered as a non-invasive, safe, rapid and relatively inexpensive technique which provides a complete examination of the tendon and surrounding structures (Shaikh et al., 2012) (8) (Padhiar et al., 2008) Several authors described by USI healthy Achilles tendons with well-organized and parallel collagen fibers with hyperechoic bright bands and hypoechoic dark bands from the extracellular matrix (Khan, Cook, Bonar, Harcourt, & Astrom, 1999) ((Sharma & Maffulli, 2006)) Sharma and Maffulli ((Sharma & Maffulli, 2006)) reported a disorganization areas of the collagen fibers and a thickened and hypoechoic portion in tendons from individuals with AT. Nadeau et al. (Nadeau et al., 2016) reported that the use of the USI has evolved in the last recent years, being able to provide high quality images to quantify structures and angles. For example, the maximum thickness from a tendon is relatively easy to measure with a two-point digital caliper function on the USI machine. In addition, Hertzberg et al. (Hertzberg et al., 2000) indicated that these measurements are influenced by the evaluator's experience to recorded and interpret the images.

Regarding the literature, several studies have shown a moderate to good test-retest reliability of the Achilles tendon (O'Connor et al., 2004) ((Fredberg, Bolvig, Andersen, & Stengaard-Pedersen, 2008)) Provide information about the tendon structure, such as thickness or CSA is becoming essential to the clinicians and researches for the diagnosis and to observe the evolution to the different treatments.

The aim of the present study was to evaluate and quantify with USI the Achilles tendon thickness, CSA, Kager's fat pad length and gastrocnemius-soleus PA between chronic mid-portion AT and healthy subjects. It was hypothesized that in presence of tendinopathy, structural alterations were observed and quantify with USI, such an increase of CSA and a decrease of the gastrocnemius PA.

2. Methods

2.1. Design

A cross-sectional observational study has been carried out from January to December 2017, following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations (Welch et al., 2015).

2.2. Sample size calculation

A sample size calculation was performed by the difference between two groups with the G*Power 3.1.9.2 software and based on the thickness (mm) at 4 cm from the calcaneus variable of a pilot study ($n = 42$) with 2 groups (mean ± SD), 21 subjects with chronic mid-portion AT (7,64 ± 2.69 mm) and 21 healthy controls (6.28 ± 0.9 mm). Indeed, 1-tailed hypothesis, and effect size of 0.67, an α error probability of 0.05, a power (1-β error probability) of 0.80 and an allocation ratio (N2/N1) of 1 were applied for the sample size calculation. Therefore, a total sample size of 56 individuals was calculated. In addition, we could recruit a sample of 143 subjects.

2.3. Participants

A sample of 143 individuals (age: 41.3 ± 12.0 y; height: 1.74 ± 0.0 m; weight: 75.0 ± 11.4 kg; body mass index, BMI: 24.4 ± 2.6 kg/m^2) was recruited and divided in two groups: chronic mid-portion AT group ($n = 71$) and a healthy group ($n = 72$). Participants inclusion criteria comprised aged of 18–65 years, had pain

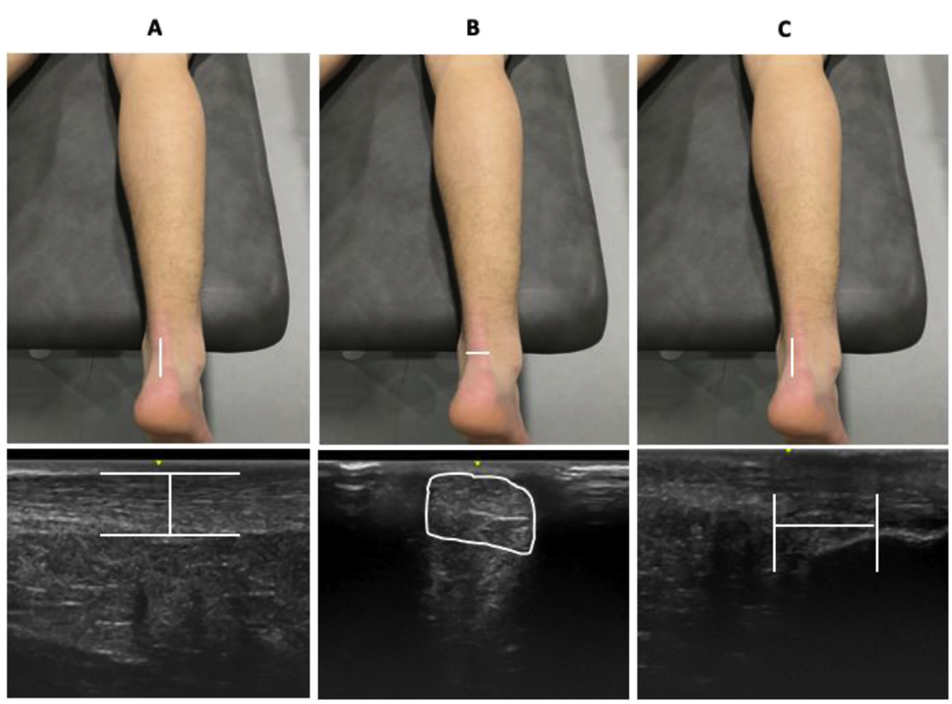

Fig. 1. Transducer places during ultrasound evaluation of the thickness, cross-sectional area and Kager's fat pad.

or soreness in mid-portion of the Achilles tendon for at least 3 months (Alfredson & Cook, 2007), had a visual analog scale (VAS) pain intensity score of at least 3 out of 10 points, had no received any intervention or treatment. Exclusion criteria were patients with skin diseases or systematic disorders (Alfredson, Pietila, Jonsson, & Lorentzon, 1998), previous fractures (19) and a lower limb pathology the last 12 months.

2.4. Ethical considerations

This study was approved by Hospital de la Princesa Ethics Committee, Madrid, Spain (2828A). This study also adhered to the Declaration of Helsinki for Human experimentation. All the participants signed the informed consent form.

2.5. Ultrasound imaging assessment

The UI examination was performed using a LogiQ P7 system (GE Healthcare; UK) with a 4 to 13 linear transducer (38-mm footprint with a L6-12-RS type). All evaluations were carried out by a single operator (P.M.L), who was 3 years of RUSI experience. Ultrasound measurements of the thickness, CSA and Kager's fat pad were carried out in the prone position, with both feet dangling over the end of the table. In this position the Achilles tendon enthesis on the calcaneus was located by ultrasonography and made marks in the skin at 4 and 6 cm from the calcaneus for recording the ultrasound images for the tendon thickness and CSA. For the thickness measurement the evaluator aligned the transducer in the precise location marks and recorded three images in longitudinal view placing the caliper on the upper and lower edges of the Achilles Tendon (Nadeau et al., 2016) (Fig. 1A).The tendons CSA corresponds to the area delimited by the tendon's outline and the evaluator aligned the transducer in the same location marks in transversal view (Nadeau et al., 2016) (Fig. 1B).The mean of 3 repeated values was collected for each measurement. For each image the transducer was removed and repositioned again on the skin marks. Several studies indicated that the incidence of AT is higher at this level (Alfredson & Lorentzon, 2000) ((Jarvinen, Kannus, Maffulli, & Khan, 2005)) Kager's fat pad measurements were carried out aligned the transducer on the calcaneus enthesis and recorded three images with the transducer in longitudinal view and pacing the caliper on the upper and lower edges of the fat pad (Fig. 1C). Following Narici et al. (Narici et al., 1996) guidelines for gastrocnemius-soleus PA measurement, patients were placed in prone position with the foot inside the table with a passive plantar flexion. The probe was located on the gastrocnemius medialis central region oriented along the medial longitudinal axis determined by the soleus fibers. (Fig. 2) Measures were calculated with an angle calculator software from the UI device. The mean of 3 repeated values was recorded for each measurement.

2.6. Statistics

Statistical package for social sciences, version 22.0 for Windows (IMB SPSS Statistics for Windows; NY: IBM Corp.) was used for the analysis data. An α error of 0.05 (95% confidence interval) and a desired power of 80% (β error of 0.2) were used for all statistical tests. First, the Kolmogorov-Smirnov test was utilized to assess the normality. Second, a descriptive analysis was performed for the total sample, as well as both groups separately. Finally, a comparative analysis between both groups was developed. Mean, standard deviation (SD) and Student's *t*-test for independent samples were used for the parametric data. Median, interquartile range (IR) and Mann-Whitney *U* test were applied for non-parametric data.

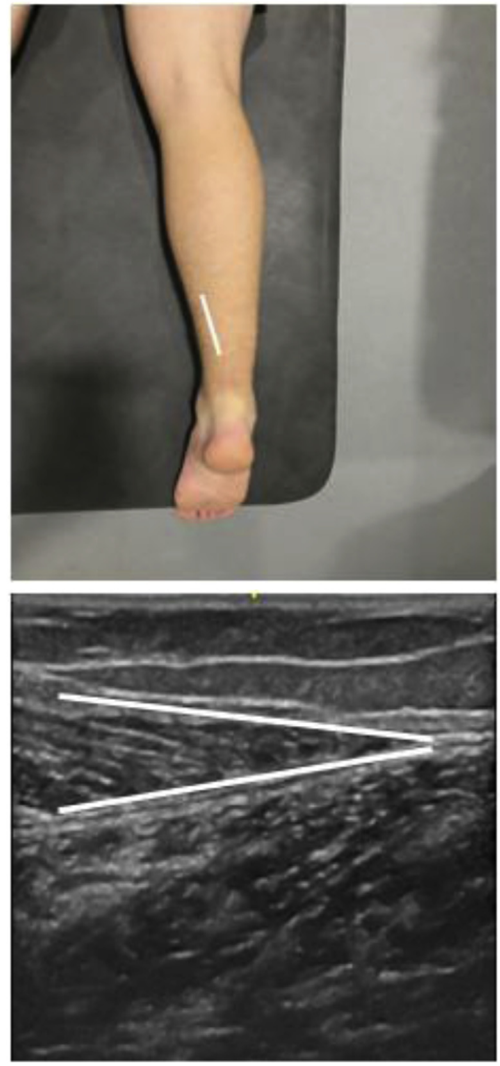

Fig. 2. Transducer places during ultrasound evaluation of the gastrocnemius-soleus pennation angle.

3. Results

Regarding the Table 1, sociodemographic data showed statistically significant differences ($P < .05$) for the body mass index (BMI) between groups and did not show statistically significant differences ($P > .05$) for the age, weight and height between groups. Considering the Table 2, ultrasound measurements of the thickness and CSA at 4 cm and 6 cm from the calcaneus increased showing statistically significant differences ($P < .01$) in favor the tendinopathy group. For the gastrocnemius-soleus PA and Kager's fat pad length significant differences ($P < .01$) were observed for a decrease in favor the tendinopathy group.

4. Discussion

This research provides useful information regarding the Achilles tendon complex in individuals with AT and controls. Conventional ultrasound evaluations, such Achilles tendon thickness and CSA, were considered valid and reliable measures for patients with AT. Syha et al. (Syha et al., 2007) suggested that B-mode USI could be a new gold standard for quantification alterations in chronic Achilles

Table 1
Sociodemographic data, pain scores and VISA-A scale of the sample.

Data	Tendinopathy (n = 71)	Controls (n = 70)	*P*-value Cases vs Controls
Age, y	45.11 ± 12.75[a]	37.61 ± 11.91[a]	.200[b]
Weight, kg	76.00 ± 12.00[c]	75.00 ± 18.50[c]	.412[d]
Height, m	1.76 ± 0.11[c]	1.76 ± 0.12[c]	.566[d]
BMI, kg/m2	24.81 ± 2.13[c]	23.88 ± 3.67[c]	.012[d]
VAS	2.00 ± 3.00[c]	N/A	N/A
VISA-A	56.00 ± 14.00[c]	N/A	N/A

Abbreviations: VAS, visual analogue scale.
[a] Mean ± standard deviation (SD) was applied.
[b] Student's *t*-test for independent samples was performed.
[c] Median ± interquartile range (IR) was used.
[d] Mann-Whitney *U* test was utilized.

Table 2
Ultrasound imaging measurements.

Measurement	Tendinopathy (n = 71)	Controls (n = 72)	P-value
Degrees (o)			
Pennation angle	15.09 ± 4.35 (8.25–19.11)[c]	18.96 ± 3.56 (14.46–26.63)[c]	0.000[d]
Distance (mm)			
CSA 4 cm	176.89 ± 93.07 (79.04–410.26)[c]	121.72 ± 27.29 (78.62–198.16)[c]	0.000[d]
CSA 6 cm	210.91 ± 110.07 (109.81–527.90)[c]	134.53 ± 35.17 (87.41–206.62)[c]	0.000[d]
Thickness 4 cm	6.40 ± 1.62 (4.12–14.14)[c]	5.78 ± 0.80 (4.65–8.93)[c]	0.001[d]
Thickness 6 cm	7.68 ± 4.40 (5.02–17.91)[c]	5.94 ± 0.90 (4.84–10.85)[c]	0.000[d]
Kager	11.25 ± 2.00 (4.78–17.87)[a]	13.74 ± 1.93 (10.31–19.23)[a]	0.000[b]

Abbreviations: CSA, cross sectional area.
[a] Mean ± standard deviation (SD) (minimum–maximum) was applied.
[b] Student's *t*-test for independent samples was performed.
[c] Median ± interquartile range (IR) (minimum–maximum) was used.
[d] Mann-Whitney *U* test was utilized.

tendons. Moreover, this research contemplates a new approach to measure and quantify the gastrocnemius-soleus PA variable in AT subjects.

Roesch et al. (Roesch, Milanese, Osborne, Spurrier, & Thoirs, 2018) carried out an examination with USI of the morphological changes in asymptomatic tendons in response to an eccentric and concentric exercise program. They observed a significant increase of the CSA at 2 cm and at the calcalneus enthesis immediately 3-day post-exercise in both groups. According to these findings, our study shows how by USI it can be assessed the mid-portion of Achilles tendons and quantify objectively the CSA and thickness tendon. Additionally, Grigg et al. (Grigg, Wearing, & Smeathers, 2009) investigated the acute effects of calf concentric (A group) and eccentric (B group) exercise in asymptomatic Achilles tendons. Eccentric group showed a significant decrease in tendon thickness immediately after exercise but similar results between groups regarding the recovery of the tendon morphology. USI is useful to carry out a follow up of the tendon morphology in response to different exercise programs. Regarding the quantify by USI of the tendon thickness in tendinopathic populations Ohberg et al. (Ohberg, Lorentzon, & Alfredson, 2004) reported that tendon thickness decrease significantly post eccentric calf muscle training. Coinciding with our findings it can be seen a tendon thickness increase in AT populations, being able to modify in presence or absence of load requirements.

The tendon remodeling in response to different stimulus, such exercise or in pathological populations, can be assessed and monitored more accurately with the advances in USI. Jhingan et al. (Jhingan et al., 2011) reported a thicker baseline in mid-portion thickness as a risk indicator for the production of AT in elite soccer players. Several authors showed physical changes to body tissues during running, for example Neves et al. (Neves, Johnson, Hunter, & Myrer, 2014) reported a significant decrease in Achilles tendon CSA in uphill and downhill runners. In addition, Magnusson and Kjaer ((Magnusson & Kjaer, 2003)) observed a greater CSA in runners compared with no-runners in response to the habitual training, quantify the hypertrophy region by USI in the Achilles tendon. In his line of work, Perry et al. (Perry, Tillett, Mitchell, Maffulli, & Morrissey, 2012) founded a greater longitudinal tendon thickness in the skaters compared with non-skaters individuals, which it involves a greater risk of Achilles tendon problems. To date, there is no evidence that changes in the tendon images are related with tendinopathy symptoms. However, the assessment of the tendon structures with USI would be of great interest to clinicians and researchers to complement a diagnosis and developing a follow up.

In this study, following Narici et al. (Narici et al., 1996) guidelines for assessment gastrocnemius-soleus PA, we found a significant PA decrease ($P > .01$) in subjects with AT compared with controls. According to these findings, this type of assessment could be complement to conventional USI examinations and together with the clinical symptoms be a part of a set of diagnostic tests to improve the AT diagnosis.

Kager's fat pad showed lower means values in a length assessment by USI in patients with AT respect to controls. Theobald et al. (Theobald et al., 2006) reported that this adipocyte structure protects nerves and blood vessels during the ankle plantar-flexion. Therefore, our findings could be related with an increase of the tendon symptoms. In addition, Benjamin et al. indicated that Kager's fat pad is an important part of the Achilles enthesis organ. Therefore, it should be studied and understood in static and dynamic situations.

4.1. Limitations

Several limitations should be considered in this study. First, all the measures have been conducted in not weight-bearing situations. Second, an inter-rater reliability analysis has not been performed. At last, USI M-mode and color elastography may be useful for the study of Achilles tendon complex.

5. Conclusions

This study reported an increase of Achilles tendon thickness and CSA at 4 cm and 6 cm from the calcaneus as well as a decrease in gastrocnemius-soleus PA and Kager's fat pad length in patients with chronic mid-portion AT.

Conflicts of interest and Source of Funding

There are no conflicts of interest or Source of Funding.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2018.12.003.

References

Albers, I. S., Zwerver, J., Diercks, R. L., Dekker, J. H., & Van den Akker-Scheek, I. (2016 Jan). Incidence and prevalence of lower extremity tendinopathy in a Dutch general practice population: A cross sectional study. *BMC Musculoskelet Disorder England, 17*, 16.

Alfredson, H., & Cook, J. (2007). A treatment algorithm for managing achilles tendinopathy: New treatment options. *British Journal of Sports Medicine, 41*, 211–216.

Alfredson, H., & Lorentzon, R. (2000 Feb). Chronic achilles tendinosis: Recommendations for treatment and prevention. *Sports Medicine New Zealand, 29*(2), 135–146.

Alfredson, H., Pietila, T., Jonsson, P., & Lorentzon, R. (1998). Heavy-load eccentric calf muscle training for the treatment of chronic Achilles tendinosis. *The American Journal of Sports Medicine United States, 26*(3), 360–366.

Arya, S., & Kulig, K. (2010 Mar). Tendinopathy alters mechanical and material properties of the Achilles tendon. *Journal of Applied Physiology United States, 108*(3), 670–675.

Chen, T. M., Rozen, W. M., Pan, W.-R., Ashton, M. W., Richardson, M. D., & Taylor, G. I. (2009 Apr). The arterial anatomy of the achilles tendon: Anatomical study and clinical implications. *Clinical Anatomy United States, 22*(3), 377–385.

Cook, J. L., & Purdam, C. R. (2009 Jun). Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. *British Journal of Sports Medicine England, 43*(6), 409–416.

van Dijk, C. N., van Sterkenburg, M. N., Wiegerinck, J. I., Karlsson, J., & Maffulli, N. (2011 May). Terminology for Achilles tendon related disorders. *Knee Surgery, Sports Traumatology, Arthroscopy Germany, 19*(5), 835–841.

Fredberg, U., Bolvig, L., Andersen, N. T., & Stengaard-Pedersen, K. (2008 Feb). Ultrasonography in evaluation of Achilles and patella tendon thickness. *Ultraschall Medizin Germany, 29*(1), 60–65.

Fredberg, U., & Stengaard-Pedersen, K. (2008 Feb). Chronic tendinopathy tissue pathology, pain mechanisms, and etiology with a special focus on inflammation. *Scandinavian Journal of Medicine & Science in Sports Denmark, 18*(1), 3–15.

Grigg, N. L., Wearing, S. C., & Smeathers, J. E. (2009 Apr). Eccentric calf muscle exercise produces a greater acute reduction in Achilles tendon thickness than concentric exercise. *British Journal of Sports Medicine England, 43*(4), 280–283.

Hertzberg, B. S., Kliewer, M. A., Bowie, J. D., Carroll, B. A., DeLong, D. H., Gray, L., et al. (2000 May). Physician training requirements in sonography: How many cases are needed for competence? *AJR American Journal of Roentgenologynited States, 174*(5), 1221–1227.

Jarvinen, T. A. H., Kannus, P., Maffulli, N., & Khan, K. M. (2005 Jun). Achilles tendon disorders: Etiology and epidemiology. *Foot and Ankle Clinics United States, 10*(2), 255–266.

Jhingan, S., Perry, M., O'Driscoll, G., Lewin, C., Teatino, R., Malliaras, P., et al. (2011). Thicker Achilles tendons are a risk factor to develop Achilles tendinopathy in elite professional soccer players. *Muscles Ligaments Tendons Journal, 1*(2), 51–56.

Khan, K. M., Cook, J. L., Bonar, F., Harcourt, P., & Astrom, M. (1999 Jun). Histopathology of common tendinopathies. Update and implications for clinical management. *Sports Medicine New Zealand, 27*(6), 393–408.

Kongsgaard, M., Qvortrup, K., Larsen, J., Aagaard, P., Doessing, S., Hansen, P., et al. (2010 Apr). Fibril morphology and tendon mechanical properties in patellar tendinopathy: Effects of heavy slow resistance training. *The American Journal of Sports Medicine United States, 38*(4), 749–756.

Lopes, A. D., Hespanhol Junior, L. C., Yeung, S. S., & Costa, L. O. P. (2012 Oct). What are the main running-related musculoskeletal injuries? A systematic review. *Sports Medicine New Zealand, 42*(10), 891–905.

Magnusson, S. P., & Kjaer, M. (2003 Nov). Region-specific differences in Achilles tendon cross-sectional area in runners and non-runners. *European Journal of Applied Physiology Germany, 90*(5–6), 549–553.

Nadeau, M.-J., Desrochers, A., Lamontagne, M., Larivière, C., & Gagnon, D. H. (2016). Quantitative ultrasound imaging of achilles tendon integrity in symptomatic and asymptomatic individuals: Reliability and minimal detectable change. *Journal of Foot and Ankle Research, 9*, 30.

Narici, M. V., Binzoni, T., Hiltbrand, E., Fasel, J., Terrier, F., & Cerretelli, P. (1996 Oct). In vivo human gastrocnemius architecture with changing joint angle at rest and during graded isometric contraction. *Journal of Physiology England, 496*(Pt 1), 287–297.

Neves, K. A., Johnson, A. W., Hunter, I., & Myrer, J. W. (2014 Dec). Does achilles tendon cross sectional area differ after downhill, level and uphill running in trained runners? *Journal of Sports Science and Medicine Turkey, 13*(4), 823–828.

Ohberg, L., Lorentzon, R., & Alfredson, H. (2004 Feb). Eccentric training in patients with chronic achilles tendinosis: Normalised tendon structure and decreased thickness at follow up. *British Journal of Sports Medicine, 38*(1), 8–11. discussion 11.

O'Connor, P. J., Grainger, A. J., Morgan, S. R., Smith, K. L., Waterton, J. C., & Nash, A. F. P. (2004 Nov). Ultrasound assessment of tendons in asymptomatic volunteers: A study of reproducibility. *European Radiology Germany, 14*(11), 1968–1973.

Padhiar, N., Al-Sayeagh, H., Chan, O., King, J., & Maffulli, N. (2008). Pennation angle of the soleus in patients with unilateral Achilles tendinopathy. *Disability & Rehabilitation England, 30*(20–22), 1640–1645.

Perry, M., Tillett, E., Mitchell, S., Maffulli, N., & Morrissey, D. (2012). The morphology and symptom history of the achilles tendons of figure skaters: An observational study. *Muscles Ligaments Tendons Journal, 2*(2), 108–114.

Roesch, H. J., Milanese, S., Osborne, B., Spurrier, D. J., & Thoirs, K. A. (2018 Oct). The acute effects of exercise on tendon dimensions and vascularity. An exploratory study using diagnostic ultrasound of the male Achilles tendon. *Journal of Science and Medicine in Sport Australia, 21*(10), 982–987.

Shaikh, Z., Perry, M., Morrissey, D., Ahmad, M., Del Buono, A., & Maffulli, N. (2012 May). Achilles tendinopathy in club runners. *International Journal of Sports Medicine Germany, 33*(5), 390–394.

Sharma, P., & Maffulli, N. (2006). Biology of tendon injury: Healing, modeling and remodeling. *Journal of Musculoskeletal and Neuronal Interactions. Greece, 6*(2), 181–190.

Syha, R., Peters, M., Birnesser, H., Niess, A., Hirschmueller, A., Dickhuth, H.-H., et al. (2007 Dec). Computer-based quantification of the mean achilles tendon thickness in ultrasound images: Effect of tendinosis. *British Journal of Sports Medicine England, 41*(12), 897–902. discussion 902.

Theobald, P., Bydder, G., Dent, C., Nokes, L., Pugh, N., & Benjamin, M. (2006 Jan). The functional anatomy of Kager's fat pad in relation to retrocalcaneal problems and other hindfoot disorders. *Journal of Anatomy, 208*(1), 91–97.

Wang, J. H.-C. (2006). Mechanobiology of tendon. *Journal of Biomechanics United States, 39*(9), 1563–1582.

Welch, V., Jull, J., Petkovic, J., Armstrong, R., Boyer, Y., Cuervo, L. G., et al. (2015 Oct). Protocol for the development of a CONSORT-equity guideline to improve reporting of health equity in randomized trials. *Implementation Science England, 10*, 146.