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

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ARTICLE INFO

Article history:
Received 12 November 2018
Accepted 4 December 2018

Keywords:
Ultrasoundography
Achilles tendon
Diagnostic Imaging
Tendinopathy

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/m²) 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.

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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. Padhia et al. (Padhia, 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.
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) (Padniar 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/m²) 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...
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 Ultrasound 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 (IBM SPSS Statistics for Windows; NY: IBM Corp.) was used for the analysis data. An z 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.

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
measure and quantify the gastrocnemius-soleus PA variable in AT tendons. Moreover, this research contemplates a new approach to assessing gastrocnemius-soleus PA, we found a significant decrease in mid-portion Achilles tendon CSA in runners compared with non-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 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 compared 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.

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