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Men with unilateral Achilles tendinopathy have impaired balance on the symptomatic side

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ABSTRACT

Objectives: To investigate single leg standing balance in males with mid-portion Achilles tendinopathy (AT).
Design: Cross sectional case study.
Methods: Centre of pressure (COP) path length was measured using a Wii Balance Board (WBB) in 21 male participants (20–60 years) with unilateral mid-portion AT during single-limb standing on each limb with eyes open and closed. Ultrasound imaging of both Achilles tendons was also performed by one blinded assessor, and the anteroposterior (AP) thickness and presence of pathology was determined. Comparisons were made between symptomatic and asymptomatic sides for key outcomes, and correlation between COP path length and variables of interest were investigated.
Results: Symptomatic Achilles tendons demonstrated significantly increased AP tendon thickness ($p < 0.001$). Participants with AT demonstrated increased COP path length (sway amplitude) on their affected side during the eyes closed task ($p = 0.001$). Increased tendon thickness was associated with increased sway amplitude during the eyes open task on both the affected (rho = 0.44, $p = 0.045$) and unaffected sides (rho = 0.62, $p = 0.003$).
Conclusions: In males with AT, single-leg standing balance with eyes closed is impaired on the symptomatic side. This indicates that neuromuscular deficits affecting functional ability may be present in people with AT during more challenging balance activities. It is unclear if this deficit precedes the onset of symptoms, or is a consequence of tendon pain. Work is now needed to understand the mechanisms that may explain standing balance deficits among people with AT.

1. Introduction

Achilles tendinopathy (AT) is characterised by activity related pain localised to the Achilles tendon, which can affect both daily activities and sporting performance.[1] People with painful Achilles tendons often have intratendinous pathology, but asymptomatic pathology is also common, demonstrating an unclear relationship between structural pathology and pain.[2] The prevalence rate of AT in runners is reported as 6.2–9.5%, and as high as 18.5% in an ultra-marathon running population.[3]

Motor deficits including reduced plantarflexion torque have been reported in people with, and preceding the onset of, Achilles tendon pain.[4,5] However, the mechanism behind this impaired motor function in people with Achilles tendon pain is not clear. In patellar tendinopathy, Rio et al.[2] recently reported an increase in both motor cortex inhibition and corticospinal excitability of the rectus femoris muscle, providing some insight into potential explanations for impaired motor function in lower limb tendinopathy. Furthermore, two recent studies found reduced proprioceptive function (i.e. decreased movement and load sensing ability) associated with patellar tendinopathy.[6,7] This impaired motor control during functional loading tasks in lower limb tendinopathy may alter tendon loading, and subsequently result in pain development and persistence.[2]

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Table 1
Descriptive data (mean (SD) or frequency (proportion)) pertaining to participants (n = 21).

	Mean (SD) or frequency (%)
Age (years)	45.2 (13.3)
Height (m)	1.76 (0.1)
Weight (kg)	77.9 (14.9)
BMI	25.1 (4.3)
Kicking leg right	16 (76%)
Active in sports	18 (86%)

Single leg standing balance is a potential motor deficit that has received very little attention in lower limb tendinopathy. The advantage of single leg standing balance compared to other measures of motor performance in the literature (e.g. proprioceptive measures such as joint position sense or threshold to detection of a passive movement) is that it is easily and quickly measured in clinical practice. Standing balance requires a coordinated motor output that involves the integration of feedforward motor prediction, as well as feedback proprioceptive input.[8] Proprioceptive information about force, effort and balance are provided principally by mechanoreceptors in the skin, muscle spindle and the intra-tendinous golgi tendon organ (GTO).[9] It is possible that pathological changes to tendon structure with lower limb tendinopathy, including the Achilles, may impact on GTO function and proprioception, resulting in impaired sensorimotor control during single leg standing balance. Identification of potential motor deficits, such as impaired standing balance in tendinopathy, may help to monitor the effect of current interventions on motor output.

The aim of this study was to investigate single leg standing balance by assessing COP path length in males with unilateral AT. We hypothesised that participants would have reduced single leg standing balance on their affected side compared with the unaffected side.

2. Materials and methods

Males with midportion AT were recruited from two sports medicine clinics in Melbourne, Australia. Given differences in standing balance between genders is unknown in AT, we only recruited men to ensure homogeneity. Inclusion criteria were similar to prior studies (e.g. Munteanu et al., 2014) and included; age 20–60 years old, fluent in written and spoken English, able to provide informed written consent, and current clinical diagnosis of midportion Achilles for >12 weeks as determined by the satisfaction of all of the following diagnostic criteria; localized midportion Achilles pain, pain with or after loading and morning stiffness, and hypoechoic regions on the Achilles tendon confirmed in both the sagittal and axial planes. People with a medical condition or other injury that would interfere with balance testing, bilateral AT, prior Achilles rupture or surgery, or injection for Achilles tendon pain in the last 6 weeks were excluded. The study was approved by the University of Melbourne Human Research Ethics Committee and all participants provided written informed consent.

Prior to testing, participants' weight, height, age, whether they participated in sport, and their dominant (kicking) leg were recorded. This descriptive data is shown in Table 1. Sports participated in included running, sprinting, triathlon, hip hop dancing, hockey and basketball.

The Victorian Institute of Sport Achilles Assessment (VISA-A) was used to measure pain and function. Scores on this eight-item questionnaire range between 0 and 100 with 100 indicating no pain and full function. The VISA-A has been shown to be reliable and demonstrate construct validity.[11]

Achilles tendon anteroposterior (AP) thickness was measured with ultrasound imaging, using a 12 MHz linear array transducer (Mindray M7, Mindray, Shenzhen, China) set at a depth of three cm. Participants were imaged in a prone position, with both feet hanging over the end of the plinth. The ankle was held in a plantergrade position by the ultrasonographer. Minimal pressure was applied to the skin to avoid compressing the tendon with the probe. AP thickness assessment was performed by one of the researchers (PM) who has had ultrasound training and has scanned more than 500 Achilles tendons. The ultrasonographer was blind to which tendon was symptomatic when imaging each participant. The maximal AP tendon thickness was measured in the sagittal and axial planes (between three and six centimetres above the tendon insertion in all cases). Measurements were recorded three times in the sagittal plane and the average was used in the analyses. This is a standard measurement protocol for AP tendon thickness that has demonstrated acceptable reliability.[12] As the Achilles tendon rotates medially from proximal to distal, tendon thickness was measured very close to but not always precisely in the sagittal plane.[13] Tendon pathology was defined as the presence of hypoechoic regions with or without Doppler flow.[14] Hypoechoic regions were confirmed in both the sagittal and axial planes, taking care to avoid anisotropy.

Participants performed two barefoot standing balance tasks on each side whilst standing on a Wii balance board (WBB), which has a usable surface of 45 × 26.5 cm. The WBB was interfaced with a laptop computer using custom-written software (Labview 8.5 National Instruments, Austin, TX, U.S.A.), and was calibrated by placing a variety of known loads at different positions on the WBB.[15] The outcome measure in this study was total centre of pressure (COP) path length (in cm) during single leg standing with eyes closed and single leg standing with eyes open, repeated on the affected and unaffected sides. The test-retest reliability of measuring COP path length during single leg stance with eyes open (ICC = 0.86 (0.70, 0.93)) and eyes closed (ICC = 0.81 (0.59, 0.91)) has been shown to be excellent.[15] Testing order (symptomatic or asymptomatic side first) was randomly assigned for each participant (selected from an opaque envelope). During each trial the participants were instructed to keep their hands placed on their hips and to remain as still as possible for the duration of the trial. Data were collected for 30 s for each trial. Three successful trials of each test were performed on each side. Participants were given at least a 30 s rest between each trial (the test was repeated on the opposite side during this time), and a 60 s rest between tasks.

In order to minimize high frequency noise contamination, balance data were interpolated to 100 Hz and low pass filtered at 12 Hz.[16] This cut-off frequency is slightly higher than the 10 Hz recommended by Salavati et al.[17] due to the higher frequency content of the signal observed in the single limb trials performed in the present study, and provided the optimal compromise between noise attenuation and maintenance of signal power. The mean of the three trials was used to provide a single value for each of the tasks (single limb eyes open or closed on the unaffected and affected side).

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc. Version 22.0, Chicago, IL, U.S.A.). Histograms were created to inspect the normality of the main outcome COP path length. The main analysis compared variables of interest between the symptomatic and asymptomatic side. This included whether there was a difference in the proportion of symptomatic right and left legs, and the proportion of people with/without ultrasound pathology in the symptomatic and asymptomatic sides (Chi-square). Paired samples t-tests and Cohen's d-effect sizes were used to compare the symptomatic and asymptomatic sides for VISA-A scores, AP diameter and COP path length. The correlation between COP path length (eyes open and closed) with AP diameter, and VISA-A scores were investigated on both the affected and unaffected side (Spearman's rho). The sig-

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