Brazilian Journal of Physical Therapy (2017) xxx, xxx–xxx

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Associação Brasileira de Pesquisa e Pós-Graduação em Fisioterapia

Brazilian Journal of Physical Therapy

https://www.journals.elsevier.com/brazilian-journal-of-physical-therapy

ORIGINAL RESEARCH

Passive stiffness of the ankle and plantar flexor muscle performance after Achilles tendon repair: a cross-sectional study

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Received 7 December 2015; received in revised form 1 April 2016; accepted 6 April 2016

KEYWORDS
Rehabilitation;
Achilles tendon rupture;
Surgical repair;
Plantar flexors;
Muscular strength;
Joint stiffness

Abstract
Background: Deficits in ankle muscle strength and ankle stiffness may be present in those subjects who underwent surgical treatment for an Achilles tendon rupture. The presence of these long-term deficits may contribute to a lower performance during daily activities and may be linked to future injuries.
Objective: To compare the ankle passive stiffness and the plantar flexor muscle performance in patients who underwent unilateral surgical treatment of Achilles tendon rupture with non-surgical subjects.
Method: Twenty patients who underwent unilateral surgical treatment of Achilles tendon rupture [surgical (SU) group], and twenty nonsurgical subjects [non-surgical (NS) group] participated in this study. The ankle passive stiffness was evaluated using a clinical test. The concentric and eccentric plantar flexors performance (i.e. peak torque and work) was evaluated using an isokinetic dynamometer at 30°/s.
Results: The surgical ankle of the surgical group presented lower stiffness compared to the non-surgical ankle (mean difference = 3.790; 95%CI = 1.23–6.35) and to the non-dominant ankle of the non-surgical group (mean difference = −3.860; 95%CI = −7.38 to −0.33). The surgical group had greater absolute asymmetry of ankle stiffness (mean difference = −2.630; 95%CI = −4.61 to −0.65) and greater absolute asymmetry of concentric (mean difference = −8.3%; 95%CI = −13.79 to −2.81) and eccentric (mean difference = −6.9%; 95%CI = −12.1 to −1.7) plantar flexor work compared to non-surgical group. There was no other difference in stiffness and plantar flexor performance.

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http://dx.doi.org/10.1016/j.bjpt.2016.12.004

Please cite this article in press as: Borges PR, et al. Passive stiffness of the ankle and plantar flexor muscle performance after Achilles tendon repair: a cross-sectional study. *Braz J Phys Ther.* (2017), http://dx.doi.org/10.1016/j.bjpt.2016.12.004

Conclusion: Patients who underwent surgical repair of the Achilles tendon presented with long-term (1 year or more) deficits of ankle stiffness and asymmetries of ankle stiffness and plantar flexor work in the affected ankle compared to the uninjured side in the surgical group and both sides on the nonsurgical group.

Introduction

The integrity of the Achilles tendon is important for many day-to-day activities, such as during gait, in which it has the key role of transmitting the mechanical energy generated by the contraction of the triceps surae muscles during forward body propulsion.[1] Rupture of the Achilles tendon usually occurs during sports activity[2] and may result in alterations of the structural and mechanical properties of the tendon.[3] Surgical repair has been one of the treatment options for Achilles tendon rupture.[4,5] Although the surgical treatment might restore the tendon function, some evidence indicates the presence of long-term deficits.[6–8] Therefore, more studies are needed to enhance the understanding of the long-term recovery following Achilles tendon repair.

Passive ankle stiffness and the plantar flexor muscle capacity to generate strength are tissue properties that could remain affected for an extended period of time in individuals who underwent surgery due to rupture of the Achilles tendon.[8] The passive stiffness reflects the ability of the structures around the joint (i.e. capsule, ligaments, fascia, and muscles) to resist passive displacement of the joint.[9] The capacity of a muscle group to generate strength is commonly characterized by the variables peak torque and maximum work.[10,11] Both properties, passive ankle stiffness and the capacity of the plantar flexors to generate strength, could impact the stability and movement of the ankle joint.[12] Accordingly, the evaluation of these parameters in individuals having a surgical repair of the Achilles tendon would aid in the understanding of its healing process.

After the rehabilitation process and return of the individuals to their activities, it is hoped that they would exhibit tissue properties, such as stiffness and capacity to generate force, similar to asymptomatic individuals. As such, a theoretical hypothesis would be that in the long run, the surgically repaired individuals would not present deficits, or asymmetries of passive ankle stiffness and plantar flexor muscle performance compared to asymptomatic individuals with no history of tendon rupture. However, the literature suggests the possibility of deficits even after the individuals return to their activities.[3] Therefore, the objectives of this study were to evaluate the passive stiffness of the ankle and the muscular performance of the plantar flexors in individuals submitted to unilateral repair of the Achilles tendon, and compare the results to individuals with no history of injury. The findings of this study may contribute to the understanding of the long-term adaptations of the tendon due to the surgical procedure.

Methods

Sample

A convenience sample of forty individuals were selected and divided into two groups: surgical (SU) group and non-surgical (NS) group. The estimated sample size was calculated considering a statistic power of 80%, a probability of error type I of 0.05, and a moderate effect size (0.4).[13] The SU group consisted of 20 participants with a history of unilateral rupture of the Achilles tendon, at least 12 months previously, with suture of the tendon using the Kessler and Bunnell technique (i.e. without any tendon transfer), and a history of completion of a rehabilitation program. The NS group consisted of 20 asymptomatic individuals without a history of rupture in the Achilles tendon. Exclusion criteria for both groups included current presence of musculoskeletal injuries in the lower limbs and any discomfort that could limit the performance of the tests. None of the participants were excluded. The sample characteristics are shown in Table 1. This study was approved by the Research Ethics Committee of the Mater Dei Hospital, Belo Horizonte, Minas Gerais (Number CAAE 0012.0.170.000-09). All participants signed the informed consent prior to participation.

Procedures

Initially, anthropometric measures, such as body mass and height using a digital scale with altimeter (Filizola® SA, São Paulo, Brazil), were obtained. Following, clinical testing of passive ankle stiffness[14] and evaluations of the plantar flexors performance with the isokinetic dynamometer (Biodex System 3 Pro Biodex Medical Systems Inc., Shirley, USA)[15] were then conducted. Testing was done to both limbs of all subjects.

Passive stiffness of the ankle

The passive ankle stiffness was evaluated through a clinical test.[14] This test had been validated with direct measurement of passive stiffness using the isokinetic dynamometer in a previous study.[14] Therefore, it could be used as a clinical test to index the passive stiffness of the ankle.[14] To perform this clinical test, the protocol recommended by Araújo et al.[14] was used. Each participant was positioned in prone with the knee flexed at 90° for each leg to be tested.[14] In this position, markers were placed on the fibular head and lateral malleolus, and then a line was drawn using a ruler joining these two points, which afterwards served to align the fixed arm of the goniometer (Fig. 1A).[14] Then,

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