



Original research

Electromyographic analysis of an eccentric calf muscle exercise in persons with and without Achilles tendinopathy

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ABSTRACT

Objectives: To compare surface electromyographic (EMG) activity of the gastrocnemius and soleus muscles between persons with and without Achilles tendinopathy (AT) during an eccentric muscle exercise in different knee joint positions.

Design: Repeated measures design.

Setting: Research laboratory.

Participants: Participants ($n = 18$) diagnosed with AT and 18 control subjects were recruited.

Main outcome measures: Gastrocnemius and soleus muscle activity was examined by surface (EMG) during extended and flexed knee joint conditions while performing the eccentric training technique. The EMG data were expressed as a percentage of a maximum voluntary contraction (MVC).

Results: EMG activity was notably higher (mean difference: 10%, effect size: 0.59) in those subjects with AT. Irrespective of the presence of AT, there was a significant interaction effect between muscle and joint position. The gastrocnemius muscle was significantly more active in the extended knee condition and soleus muscle activity was unchanged across joint positions.

Conclusions: The results indicated that the presence of AT influenced calf muscle activity levels during performance of the eccentric exercise. There were differences in muscle activity during the extended and flexed knee conditions. This result does support performing Alfredson, Pietila, Jonsson, and Lorentzon (1998) eccentric exercise in an extended knee position but the specific effects of the knee flexed position on the Achilles tendon during eccentric exercise have yet to be determined, particularly in those with AT.

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1. Introduction

Achilles tendinopathy (AT) is a chronic and painful condition of the Achilles tendon affecting sporting and work related activities alike (Satyendra & Byl, 2006; Sayana & Maffulli, 2007). It is more commonly seen in males between the ages of 35–45 years and most often in the mid portion of the tendon (Fahlstrom, Lorentzon, & Alfredson, 2002; Kujala, Sarna, & Kaprio, 2005; Maffulli, Wong, & Almekinders, 2003). The aetiology of Achilles tendinopathy is multifactorial, with excessive tendon loading being the most frequently reported pathological stimulus (Rees, Wilson, & Wolman,

2006). Achilles tendinopathy is usually treated conservatively with interventions often provided by physiotherapists including stretching, bracing, electrotherapy, orthotics and exercises (Alfredson & Cook, 2007). The use of eccentric loading exercises has been popularised by Alfredson et al. (1998) who developed a 12 week eccentric training regime termed “heavy-load eccentric calf muscle” (HLECM) training for the treatment of Achilles tendinopathy. This has since been extensively utilised in subsequent research (Alfredson & Cook, 2007; Fahlstrom, Jonsson, Lorentzon, & Alfredson, 2003; Ohberg, Lorentzon, & Alfredson, 2001a, 2004; Silbernagel, Thomee, Thomee, & Karlsson, 2001).

The mechanisms by which this eccentric training might generate improvements in the tendon are not known, but are based on the concept of improving the load bearing capabilities of the tendon and reversing the patho-physiological changes seen in this condition. Prospective studies have demonstrated a reduction in tendon thickening and structural abnormalities, an increase in

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collagen synthesis and reduced in-growth of neovessels in the Achilles tendon following HLECM training (Langberg, Rosendal, & Kjaer, 2001; Ohberg, Lorentzon, & Alfredson, 2001b; Shalabi, Kristoffersen-Wiberg, Svensson, Aspelin, & Movin, 2004).

The eccentric training protocol involves the performance of a modified heel drop exercise where only an eccentric contraction of the calf musculature on the symptomatic limb is permitted. In the original study, the number of repetitions was high, with 180 per day being recommended (Alfredson et al., 1998) although recently this volume has been questioned (Meyer, Tumilty, & Baxter, 2009). Furthermore, the exercises are often painful for the individual to complete and this, along with a gradual increase in weights, were considered to be essential criteria for success in the Alfredson et al. (1998) study. The technique is divided further into extended and flexed knee components and it has been proposed that these components facilitate muscle activity in the gastrocnemius and soleus muscles of the calf respectively. However, despite the widespread use of these two components in subsequent studies of persons with AT, there is little research that identifies the magnitude of differences in muscle activation levels across these limb positions during the heel drop exercise.

There are only a small number of studies that have investigated the amount of EMG activity of the calf muscles during eccentric movements in those with and without AT (Baur, Divert, Hirschmuller, Muller, & Mayer, 2004; Henriksen, Aaboe, Bliddal, & Langberg, 2009). In subjects without AT, Henriksen, Aaboe and Bliddal, and Langberg (2009) have demonstrated that gastrocnemius and soleus are activated between 10% and 5% of maximum voluntary contraction (MVC) respectively, during an eccentric lowering exercise. The authors commented that these low levels of EMG were due to reduced activation of the motor neurone pool. Baur et al. (2004) have noted that during the eccentric loading phase of gait in runners with chronic AT, that there is a 25% reduction in muscle activity when compared to those runners without AT. It is not known if these altered levels of EMG are different in those with AT during the heel drop exercise. Also if the intent of the eccentric muscle exercise is to restore the normal tensile loads through the tendon and improve the eccentric muscle action in those with AT, it would be important to know at what level the gastrocnemius and soleus muscles are working during this activity, and how these activity levels compare to those measured during typical activities of daily living and sports. Furthermore, with knowledge of these EMG activity levels, it may be that other exercise regimes could be implemented. Thus the purpose of the current study was twofold: firstly to compare EMG activity of the gastrocnemius and soleus muscles between individuals with and without Achilles tendinopathy during an eccentric movement pattern typical of that utilised by Alfredson et al. (1998). A secondary aim was to determine the effect of knee joint position on EMG activity of these muscles in persons with and without Achilles tendinopathy.

2. Methods

2.1. Participants

The participants for this study were recruited via advertisement in the local newspaper. The participants without AT had to be over 20 years of age, and without any other lower limb pathology. A set of participants with AT group was also recruited via a newspaper advertisement, and from local private physiotherapy practices and medical practitioners. The inclusion criteria for this group were: aged over 20 years, and complaining of pain in the mid portion of the Achilles tendon with recreational or activities of daily living. The clinical diagnosis of Achilles tendinopathy was a specific

painful area of the Achilles tendon 2–6 cm proximal to the calcaneal insertion point. The diagnosis was made by their treating physiotherapist, and/or the referring sports medicine doctor. The diagnosis was subsequently confirmed by one of the principal researchers (GP or SJ), qualified physiotherapists with 12 and 20 years experience in the musculoskeletal field. Participants were excluded if they had insertional Achilles tendinopathy, a previous history of Achilles tendon rupture or repair, a corticosteroid injection into the Achilles tendon or had neural signs affecting their lower limbs. Participants in the AT group were not undertaking treatment for the condition at the time of testing.

2.2. Procedures

All methods utilised in this study were approved by the Northern Regional Ethics Committee and the Auckland University of Technology Ethics Committee (AUTEC), New Zealand. Participants were provided with an information sheet and signed a document of informed consent.

2.3. Eccentric exercise performance

Participants were randomly allocated via sealed envelope with respect to the testing order of the eccentric exercise (i.e. extended knee or flexed knee). In the control subjects, the right leg was tested and in the AT group, the affected leg. A ten minute warm-up was then performed on a stationary bike at a low intensity prior to performing the eccentric exercise. The eccentric exercise was performed as described by Alfredson et al. (1998) in the HLECM training protocol. The heel drop protocol requires the subject to stand with their toes on the edge of the step with the ankle maximally plantar flexed, then lower the heel of the leg to be examined using eccentric muscle activity until they reach their maximal available dorsi-flexion range. This maximal range was substantiated by readings from the electrogoniometer.

Participants were given a demonstration and an opportunity to practise five repetitions in order to ensure their technique and speed of motion was correct. The knee was fully extended (180°) in the straight knee condition and flexed to the limit imposed by the length of the soleus muscle in the bent knee condition. Three repetitions of each condition were performed in each trial with the eccentric component of the exercise taking three seconds. Three trials were recorded for each exercise condition. During the exercise procedures body weight only was used as the load. Whilst this number of repetitions is less than the treatment protocol of Alfredson et al. (1998) (3×15), this was a sufficient number to test the level of muscle activity, which was the primary focus of the current study. Adherence to the knee angle range of motion and tempo of the exercise were assessed by the researchers (GP and SJ).

2.4. Ankle joint motion measurement

Range of movement through plantar flexion and dorsiflexion was recorded using a dual axis electrogoniometer (Model 003, Penny & Giles, Gwent, England). The measurement of ankle movement was chosen over knee motion as we deemed it important to ensure that full plantar flexion and dorsi-flexion range of motion were achieved during the exercise and to ensure synchronisation of these movements to the EMG activity. Lines between the middle of the lateral malleolus and lateral epicondyle of the fibula and head of the fifth metatarsal were marked in standing. The measurement arms of the goniometer were adhered to the skin along these lines. Prior to data collection the electrogoniometer was calibrated using a 90° calibration frame. The reliability of this method has been established by previous research (Soper, Reid, &

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