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Tibialis posterior EMG activity during barefoot walking in people with neutral foot posture

George S. Murley [a,c,*], Andrew K. Buldt [a], Philip J. Trump [a], James B. Wickham [b,c]

[a] Department of Podiatry, Faculty of Health Sciences, La Trobe University, Victoria 3086, Australia
[b] School of Human Biosciences and Faculty of Health Sciences, La Trobe University, Victoria 3086, Australia
[c] Musculoskeletal Research Centre, Faculty of Health Sciences, La Trobe University, Victoria 3086, Australia

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Abstract

The aim of this study was to characterize the electromyographic (EMG) profile of tibialis posterior during barefoot walking in order to establish a reference database for neutral foot posture. Fifteen participants had their foot posture screened using the six-item Foot Posture Index. Bipolar intramuscular electrodes were inserted into tibialis posterior and peroneus longus utilizing ultrasound guidance. Surface electrodes were placed over medial gastrocnemius, peroneus brevis and tibialis anterior. EMG and footswitch gait characteristics were recorded whilst participants completed 10 barefoot walking trials. Individual and grand ensemble averages were used to characterize the intensity profiles for each muscle. Results indicated that for most of the participants, tibialis posterior displayed two bursts of EMG activity, with the first burst during the initial contact phase and the second burst during midstance. However, there was significant variability between participants. The grand ensemble average for tibialis posterior was comparable to peroneus longus which displayed similar temporal and intensity characteristics. It is suggested that this may reflect a synergistic relationship between these muscles during stance phase, although this was not consistent for all participants. Further research is required to determine if this relationship is altered in abnormal foot posture and whether it is clinically important. In conclusion, the EMG profile of tibialis posterior during the gait cycle appeared to be highly variable among participants. However, the authors believe that EMG findings from the participants with neutral foot posture in this study may be used for comparison to EMG patterns in people with abnormal foot posture and individuals affected by musculoskeletal disease.

Keywords: Foot posture; Muscle activity; Gait; Normal

1. Introduction

The tibialis posterior muscle originates deep within the posterior compartment of the leg from the interosseous membrane and proximal adjacent surfaces of the tibia and fibula, inserting into the navicular, medial cuneiform, cuboid and bases of the second, third and fourth metatarsals (Sarrafian, 1993). These muscle attachments enable the tibialis posterior tendon to have the largest 'inverter' moment arm acting on the subtalar joint (Perry, 1992), thus the muscle is considered a strong supinator of the hind foot (Moore and Dalley, 2006).

The most common method for evaluating tibialis posterior muscle activity during walking is using electromyography (EMG) with intramuscular electrodes. Although there are several studies which have evaluated tibialis posterior muscle EMG in neurological conditions such as cerebral palsy (Perry and Hoffer, 1977; Barto et al., 1984; Wills et al., 1988; Michlitsch et al., 2006), few studies have investigated EMG in participants without disease or dysfunction during walking (Sutherland, 1966; Gray and Basmajian, 1968; Ambagtsheer, 1978; Ringleb et al., 2007). These studies describe quite dissimilar profiles of

* Corresponding author. Address: Department of Podiatry, Faculty of Health Sciences, La Trobe University, Victoria 3086, Australia. Tel.: +61 3 9479 5776; fax: +61 3 9479 5784.
E-mail address: g.murley@latrobe.edu.au (G.S. Murley).

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tibialis posterior activity during the stance phase. The earlier studies of tibialis posterior EMG report only the raw signals which showed the muscle activity to range from; a single burst throughout the whole stance phase (Sutherland, 1966), to low biphasic activity (Ambagtsheer, 1978), or only very slight activity (Gray and Basmajian, 1968).

More recently Keenan et al. (1991), Perry (1992), and Ringleb et al. (2007) have published normalised EMG ensemble averages for tibialis posterior from participants with foot posture described as either 'normal' or 'non-valgus'. These studies show tibialis posterior muscle activity to have biphasic activity during the stance phase of walking. The first burst consistently occurs during the contact phase and the second burst is reported during the midstance phase (Perry, 1992; Ringleb et al., 2007) or the propulsion phase (Keenan et al., 1991). However, the generalizability of these results is questionable. For example, Ringleb et al. (2007) compared tibialis posterior EMG from only five healthy adult men to a group of five older women with tibialis posterior tendon dysfunction. Keenan et al. (1991) compared two groups of older participants with long standing rheumatoid arthritis. One group displayed a valgus foot deformity (flat foot posture) and the control group a non-valgus foot deformity (neutral foot posture). As these studies evaluated either a small sample size (Ringleb et al., 2007) or predominantly older participants (Keenan et al., 1991) there is a lack of research describing tibialis posterior EMG in people with neutral foot posture that can be generalized to the wider population.

Foot posture characteristics are considered important variables in biomechanical gait research, as variation in foot posture can affect lower limb kinematics (Redmond et al., 2006) and possibly lower limb muscle EMG during walking (Keenan et al., 1991; Hunt and Smith, 2004). As tibialis posterior EMG is reported to be highly variable during walking (Perry, 1992), we hypothesized that a lack of homogeneity between participants' physical (i.e., body mass) and biomechanical characteristics (i.e., foot posture) may be a causative factor for the high variability reported for tibialis posterior. Furthermore, recent studies of tibialis posterior activity during running and cycling have reported a loss of EMG signal during data collection in some participants (Chapman et al., 2006; O'Connor and Hamill, 2004), thus it is possible that movement of intramuscular electrode position during data collection may contribute to participant variability in the tibialis posterior EMG waveforms.

In order for future studies to accurately characterize EMG muscle activity from participants with abnormal foot posture and painful lower limb conditions, it is necessary to evaluate a larger sample of participants with neutral foot posture. Therefore, the aim of the present study was to characterize the EMG profile of tibialis posterior from participants with neutral foot posture during barefoot walking to establish a reference database.

2. Method

2.1. Participants

Fifteen participants who reported no previous cardiovascular, neurological or abnormal biomechanical conditions were recruited for the study from La Trobe University, Victoria, Australia (Table 1). All participants gave their written consent to all experimental procedures prior to testing. The experiment was approved by the La Trobe University Faculty of Health Sciences Human Ethics Committee.

2.2. Screening protocol

To ensure only participants with a neutral foot posture were included in this study, the six-item Foot Posture Index (FPI) (Redmond et al., 2006) was used to evaluate standing foot posture.

The FPI is used to quantify the degree to which standing foot posture is pronated or supinated. Six criteria are scored on a five point scale, from −2 to +2, by a single examiner. Therefore, the summated scores have the potential to range from −12 (highly supinated) to +12 (highly pronated) (Redmond et al., 2006). The FPI has been shown to be adequately reliable (Evans et al., 2003; Yates and White, 2004; Redmond et al., 2006) and valid (Keenan et al., 2007) as a screening tool in various clinical settings.

Prior to participant recruitment, FPI was recorded from a random sample of 100 undergraduate students (La Trobe University, Australia) to determine a normal distribution for this classification test. The mean score was +3.5 (interquartile range: +1 to +5). The interquartile range from this population was considered to reflect a neutral foot, thus only participants with an FPI score between +1 and +5 were recruited for EMG testing in this study (Table 1).

2.3. Instrumentation

Bipolar fine wire intramuscular electrodes, as first described by Basmajian and Stecko (1963), were used to record the EMG signal from tibialis posterior and peroneus longus. The electrodes were fabricated from 75 μm Teflon® coated stainless steel wire (A-M Systems, Washington, USA) with 1 mm of insulation stripped to form the recording surface of the two wires. The electrode wires were inserted into a 23 gauge sterilized single use hypodermic

Table 1
Participant anthropometric characteristics

	N	Age (yrs)	Height (cm)	Body Mass (kg)	Foot Posture Index (FPI) [a,b]
Male	8	28.4 ± 8.2	181.9 ± 5.0	79.5 ± 10.3	2.5 ± 0.9 (range: 0–3.5) *
Female	7	20.3 ± 1.1	166.9 ± 4.9	60.1 ± 6.4	1.5 ± 1.0 (range: 0.5–2.5) *

[a] Negative score represents supinated foot posture; positive score pronated posture. Max possible summated score is +12, minimum is −12.
[b] Participants' FPI recorded for right foot only.
* Mean FPI recorded from two different examiners.