USE OF HIGH-RESOLUTION ULTRASOUND TO MEASURE CHANGES IN PLANTAR FASCIA THICKNESS RESULTING FROM TISSUE CREEP IN RUNNERS AND WALKERS

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ABSTRACT

Objective: This study sought to use high-resolution ultrasound to measure changes in plantar fascia thickness as a result of tissue creep generated by walking and running.

Methods: Independent samples of participants were obtained. Thirty-six walkers and 25 runners walked on a treadmill for 10 minutes or ran for 30 minutes, respectively. Standardized measures of the thickness of the plantar fascia were obtained in both groups using high-resolution ultrasound.

Results: The mean thickness of the plantar fascia was measured immediately before and after participation. The mean plantar fascia thickness was decreased by 0.06 ± 0.33 mm SD after running and 0.03 ± 0.22 mm SD after walking. The difference between groups was not significant.

Conclusion: Although the parameters of this study did not produce significant changes in the plantar fascia thickness, a slightly higher change in the mean thickness of the plantar fascia in the running group deserves further investigation. (J Manipulative Physiol Ther 2015;38:81-85)

Key Indexing Terms: *Fascia; Ultrasonography; Running; Walking*

The plantar fascia is a tissue band that runs along the inferior aspect of the foot. The fascia is composed of 3 bundles with the central bundle being the most structurally important and also the most common bundle involved in disease processes and injury.[1] The central bundle arises from the medial tubercle of the calcaneus and divides into 5 separate bands that blend into the deep fascia of the foot before ultimately inserting on the metatarsal heads.[1] The plantar fascia is functionally the most important structure maintaining the longitudinal arch of the foot.[2]

The plantar fascia is histologically a fibrous structure composed of dense collagen fibers.[3] Fibrous structures such as the plantar fascia demonstrate viscoelastic biomechanical behaviors.[4] Viscoelastic tissues demonstrate creep, stress relaxation, and stress-strain hysteresis.[4] Creep is described as lengthening or resultant laxity of a tissue as a result of repetitive loading.[5-7] It has been shown that the results of creep are more pronounced with higher repetition and more robust loading of fascial structures.[5-7] The effects of creep will be the primary focus of this investigation.

The plantar fascia is tensioned and relaxed throughout the gait cycle. The most longitudinal tension is exerted at the toe-off phase of the cycle.[1] A maximum fascial elongation of 9% to 12% occurs just before the toe-off phase of the gait with the fascia returning to its resting length in the relaxation phase.[3,8] The amount of force being transmitted across the plantar fascia during ambulation has also been studied, although the results are somewhat inconclusive. In a finite element model proposed by Giddings et al, peak loading of the plantar fascia reached 1.8 times body weight with walking and 3.7 times body weight during running.[9] Erdemir et al[10] reported peak

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plantar fascia loading of 538 ± 193 N or an average of 0.96 ± 0.36 times body weight with walking. In the same study, a failure range of 916 to 1743 N (2.12-2.80 times body weight) was reported by Erdemir et al,[10] whereas another study reported a failure range of 1189 ± 244 N.[11] As a result of these forces and repetitive loading and stretching of the plantar fascia during ambulation, microtears of the fascia occur, even in conditions of normal mechanical usage.[1,5,7]

According to the "creep compensation" mechanism proposed by Frost,[7] a reparative process occurs after a repetitive loading event. In low-frequency, low-force loading conditions, the residual creep within a viscoelastic tissue is within 5% of baseline within 7 hours of rest. In higher frequency, higher force conditions, residual creep may be as high as 25% to 30% above baseline within 7 hours.[5] The repair of damaged tissues, even subclinical damage, prevents accumulation of microtears and eventual elongation or failure of the structure. If this reparative mechanism is overcome by repetitive microtrauma, fibrous structures can degenerate and/or fail.[5,7] This same mechanism results in chronic damage to the plantar fascia known as plantar fasciosis.

Little is known about ultrasound measurement of tissue creep in runners and walkers. Therefore, this study sought to use high-resolution ultrasound to measure changes in plantar fascia thickness as a result of tissue creep generated by walking and by running. We hypothesized that the fascial creep caused by repetitive longitudinal stress placed on the plantar fascia would result in thinning of the fascia. Comparing walking and running at differing durations aimed to stratify the load placed on the plantar fascia. We further hypothesized that the plantar fascia would thin to a greater extent with the stress produced by running as compared with walking.

Methods

In this experiment, thickness of the plantar fascia was used as a potential marker of fascial creep. In theory, lengthening of the plantar fascia as a result of creep would cause the plantar fascia to thin in cross section. Therefore, we used high-resolution sonographic imaging to measure plantar fascia thickness. The thickness was measured before and immediately after repetitive stress generated by walking compared with running.

After approval by the Logan University Institutional Review Board, a nonrandom convenience sample of 61 asymptomatic individuals, 32 males and 29 females, with a mean age of 25.70 ± 6.21 years (range, 21-51 years) was recruited following an inclusion and exclusion criteria questionnaire and obtaining informed consent. Participants were screened before participation by a third-year radiology resident. Inclusion criteria were ages between 18 and 55 years and ability to walk on a treadmill for 10 minutes or run on a treadmill for 30 minutes. Exclusion criteria were current heel pain, a current diagnosis of plantar fasciitis (plantar fasciopathy), previous foot injury or surgery, pregnancy, or an inflammatory arthritide diagnosis. All participants were required to wear traditional athletic footwear such as walking or running shoes. The sample was divided into 2 independent groups based on the physical fitness ability of the participants (Table 1). Those subjects who indicated that they were unable to run on a treadmill for 30 minutes were placed in group 1. Those able to run on a treadmill for 30 minutes were placed in group 2. The subjects in group 1 (n = 36; 22 females; mean age, 25.02 ± 4.53 years), which served as a baseline for comparison, were required to walk on a treadmill at a pace of 3.5 miles per hour for 10 minutes. The subjects in group 2 (n = 25; 7 females; mean age, 26.68 ± 7.89 years) were required to run on a treadmill for 30 minutes at a pace of 6.5 miles per hour. The treadmill settings were maintained at a constant pace for the duration of the walking or running periods.

Table 1. *Characteristics of Assigned Groups*

	Group 1	Group 2
n	36	25
Sex	22 females, 14 males	7 females, 18 males
Age	25.02 ± 4.53 (20-42)	26.68 ± 7.89 (22-51)

Subjects were imaged bilaterally immediately before and after their participation using a Logiq e (GE Healthcare, Milwaukee, WI) ultrasound system and a high-frequency 12-MHz linear transducer probe. The central bundle of the plantar fascia was measured in the sagittal plane at the distal plantar cortex of the calcaneus (Figure 1)[12] from where the plantar fascia could be distinguished from the adjacent fat to the cortical calcaneal surface,[13] perpendicular to the orientation of the plantar fascia fibers. All participants were imaged in the seated position with the knee extended and the foot in the dorsiflexed position. The participants were examined by a third-year radiology resident with 2.5 years of experience in musculoskeletal ultrasound imaging. Comparison of preparticipation and postparticipation plantar fascia thickness measures was performed within the groups using paired-samples *t* tests. Interexaminer reliability analyses were conducted with 2 examiners measuring the same set of images using a 2-way random-effects interclass correlation coefficient (ICC). Examiner 1 and examiner 2 had 2.5 years and 6 years of experience with musculoskeletal ultrasound imaging, respectively. The reliability of acquiring images of the plantar fascia was previously demonstrated by Rathleff et al.[14] Image acquisition reliability was not performed in this study.

Results

Group 1 consisted of 36 participants that were imaged bilaterally for a total of n = 72. The mean plantar fascia