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Energetics of the intrinsic foot muscles in plantar fasciitis

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Introduction

Intrinsic foot muscles and the plantar fascia provide mechanical support for the medial longitudinal arch in gait [1]. In an injury to the plantar fascia (i.e. plantar fasciitis), there may be an increase in load on the intrinsic foot muscles resulting in increased metabolic demand. Phosphorus magnetic resonance spectroscopy (^{31}P MRS) has shown that the ratio of inorganic phosphate to phosphocreatine ([Pi]/[PCr]) within a muscle increases proportionately with muscle work at low to moderate levels [2]. The purpose of this study was to determine whether walking elicits a relatively higher increase in activity of the intrinsic foot muscles of feet with plantar fasciitis relative to healthy feet.

Methods

Three female subjects (mean age: 43 yrs; arch index: 0.299) with unilateral chronic plantar fasciitis (>3 months) participated.

A 4-Tesla MRS system (Bruker, Germany) was used to obtain concentrations of [PCr] and [Pi] before (PRE) and after (POST) walking. Subjects were positioned supine in the MRS system with a ^{1}H and ^{31}P coplanar surface coil under the medial arch. ^{31}P free induction decays (FIDs) were captured for 3 mins (100 μs, 60° nominal flip angle, TR = 2 s, 2048 data points, spectral width = 8000 Hz).

Subjects walked barefoot on a treadmill for 7 mins at 1.35 ms^{-1}. To preserve the intracellular metabolic state of the intrinsic foot muscles induced by walking, a cuff was inflated around the ankle within the last step. In less than 4 min, subjects were repositioned into the magnet for POST measurement. Both the healthy (H) and plantar fasciitis (PF) feet were studied with > 25 min between tests. Pi and PCr peaks were integrated and [Pi]/[PCr] was calculated.

Results

Walking caused a depletion of [PCr] and an accumulation of [Pi] (Figure 1) which resulted in an increased [Pi]/[PCr] with walking (Table 1). The increases in [Pi]/[PCr] from PRE to POST were similar in PF and H.

Conclusion

In this novel approach to the study of intrinsic foot muscles, we used MRS to measure metabolic activity non-invasively and *in vivo*.

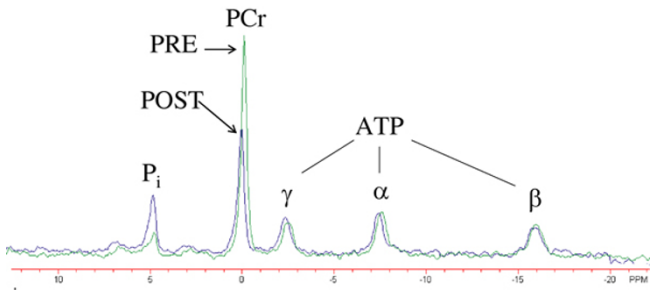

Figure 1
Exemplar PRE and POST spectra.

Table 1: [Pi]/[PCr] before (PRE) and after (POST) walking

	PF		Healthy	
Subject	**PRE**	**POST**	**PRE**	**POST**
S1	0.12	0.17	0.12	0.18
S2	0.10	0.25	0.14	0.18
S3	0.11	0.45	0.10	0.46
Mean	0.11	0.29	0.12	0.27

The data showed that walking caused an increased use of ATP in the intrinsic foot muscles, indicating that these muscles were activated to produce force along the plantar aspect of the foot. Although increases in [Pi]/[PCr] of PF and H were similar, more information is required to conclude that both feet performed equal force output. Subsequent studies will examine whether there is PF and H asymmetry in forefoot-rearfoot kinematics, muscle size and mitochondrial function.

Acknowledgements

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