The Effect of Hindfoot and Forefoot Positions on Posterior Tibialis Muscle Length

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INTRODUCTION

Posterior Tibial Tendon Dysfunction (PTTD) is a primary cause of flat foot deformity. The flat foot deformity seen in PTTD is expected to produce increased strain on the posterior tibial (PT) tendon causing eventual rupture. A recent in-vivo study suggests subjects with PTTD show hindfoot (HF) eversion as well as significant forefoot (FF) abduction compared to controls [1]. However, current management of PTTD focuses on relieving strain with orthotics by supporting the HF and medial longitudinal arch, without directly influencing forefoot position. [2]. The differential effects of HF eversion and FF abduction on PT muscle length remain unclear, making it difficult to judge the relative importance of forefoot abduction. The purpose of this study was to describe differential changes in PT muscle length due to non-weight bearing foot positions of FF abduction and HF eversion at three different angles of ankle motion.

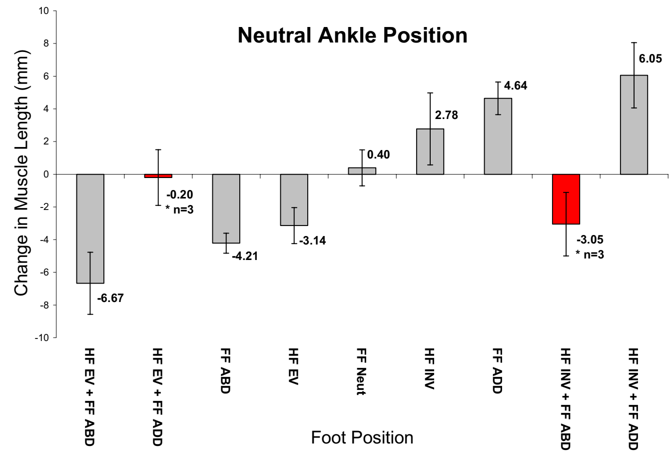

Figure 1: Muscle Length for 9 Neutral Ankle Tests with standard deviation bars.

METHODS

Four fresh frozen human cadaver limbs were potted and mounted on a platform. The PT tendon was dissected proximal to the medial malleolus and a 5 kg weight was sutured to the tendon via a string. Bone pins were inserted into the tibia, calcaneous, navicular, and first metatarsal to track motion of each bone. A 6 camera Optotrak Motion Analysis System (Northern Digital Inc, CAN) was used to track 3 infrared emitting diodes (IREDs) mounted to each bone pin. The platform was arranged so vertical displacement of an IRED on the 5 kg weight tracked PT muscle length. Using Motion Monitor Software (Innsport Training Inc, USA) online feedback of 3D angles (Z-X'-Y'' sequence) were used to achieve reproducible 3D FF and HF positions. After neutral foot position was determined, the foot was moved into 9 specified testing positions designed to stretch and shorten the PT muscle (listed in Table 1). These 9 positions were repeated at 30º of ankle plantarflexion, neutral ankle, and 10º of ankle dorsiflexion, resulting in 27 tested positions. PT muscle length was recorded at each foot position. Data were averaged across limbs for each position to describe differences across positions.

RESULTS AND DISCUSSION

Across ankle positions isolated FF abduction and HF eversion produced muscle lengthening while FF adduction and HF inversion produced muscle shortening (Table 1). FF adduction neutralized the effect of HF eversion in the HF EV + FF ADD position (Figure 1). This effect occurred to an even greater extent in the HF INV + FF ABD position where FF motion surpassed the effect of the HF and produced lengthening. These results demonstrate a trend where the FF produces an equal or greater change in muscle length to that of the HF (Figure 1).

CONCLUSIONS

The results from this study suggest FF abduction and HF eversion play an integral role in determining length of the PT muscle. If replicated in weight bearing studies, this would suggest that controlling the FF and HF during gait is necessary to decrease strain on the PT muscle. This may require designing braces to control the FF after heel off, when only the FF is in contact with the ground, in addition to controlling the HF during early stance.

REFERENCES

1. Tome, J., et al. *The Effect of Posterior Tibial Tendon Dysfunction on Dynamic Foot Motion*. GCMAS 10th Annual Meeting. Portland, OR, 2005.
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Table 1: PT muscle length relative to neutral expressed in millimeters ±1 standard deviation for each position tested. Negative values indicate lengthened position, positive values indicate shortened position. Hindfoot (HF), Eversion (EV), Inversion (IV), Forefoot (FF), Abduction (ABD), Adduction (ADD).

	HF EV + FF ABD	HF EV + FF ADD	FF ABD	HF EV	Neutral	HF INV	FF ADD	HF INV + FF ABD	HF INV + FF ADD
Plantarflexion	-2.0±2.2	5.8±1.0	-0.7±1.8	0.4±2.6	2.9±1.9	5.0±2.3	6.8±1.2	-0.4±1.2	10.1±1.9
Neutral	-6.7±1.9	-0.2±1.7	-4.2±0.6	-3.1±1.1	0.4±1.1	2.8±2.2	4.6±1.0	-3.1±1.9	6.1±2.0
Dorsiflexion	-9.3±3.1	-2.6±2.9	-6.7±2.0	-2.0±1.8	-2.6±3.5	1.3±2.7	3.1±3.4	-5.3±1.7	3.6±3.5