

# THE ROLE OF TIBIALIS POSTERIOR ON FOOT KINEMATICS DURING WALKING

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## INTRODUCTION

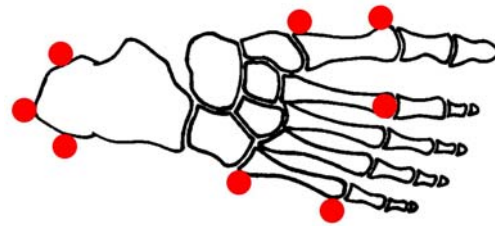
Many overuse injuries of the lower extremity are associated with excessive/prolonged pronation of the foot during gait. Pronation is a complex motion and its quantification during gait has mainly been limited to rearfoot motion. However, foot pronation also occurs across the more distal joints of the foot. Thus it is pertinent to quantify both rearfoot and forefoot motion when assessing pronation. In vitro studies suggest that the tibialis posterior muscle may play a role in preventing collapse of the medial longitudinal arch, contribute to rearfoot inversion, and adduct the forefoot [1]. In addition, patients with posterior tibial tendon dysfunction (PTTD) demonstrate increased rearfoot eversion along with increased dorsiflexion and abduction of the forefoot [2]. These studies suggest that the tibialis posterior function is important in controlling both the rearfoot and forefoot mechanics associated with pronation.

One method of assessing the role of tibialis posterior on foot mechanics may be through exercise-induced fatigue of this muscle. A decrease in power output of the muscle due to fatigue could result in altered foot mechanics, specifically in the form of excessive or prolonged pronation. However, this paradigm has only been investigated for the combined foot invertors and only rearfoot motion was measured [3]. Therefore, the aim of this study was to compare rearfoot and forefoot mechanics during walking both before and immediately after fatiguing exercise of tibialis posterior. It was hypothesized that muscle fatigue will lead to greater and prolonged rearfoot eversion and forefoot dorsiflexion, along with greater forefoot abduction.

## METHODS

The data are part of an ongoing study to understand the relationship between anatomical structure, muscular function and biomechanics of the foot. To

date, eight females and three males have participated in this study (age  $23.8 \pm 6.9$  yrs, mass  $62.4 \pm 10.2$  kg). All subjects were free from lower extremity injury and had a static standing rearfoot angle within normal limits [4]. Retroreflective markers were attached to the forefoot, rearfoot (Figure 1) and shank of the right limb.

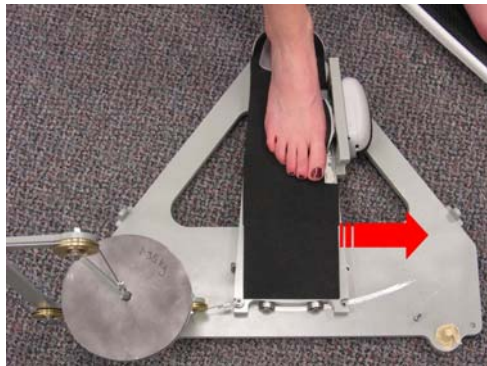


**Figure 1:** Foot marker placement.

After a standing calibration trial, subjects walked at  $1.2 \text{ ms}^{-1}$  on a treadmill while baseline (PRE) kinematic data was captured at 120Hz. Then the subject's maximum isometric contraction (MIC) was determined during isolated foot adduction using a custom built device containing a dynamometer (Figure 2). This movement was chosen as MRI studies have demonstrated the tibialis posterior is activated most selectively and effectively during foot adduction [5]. Subjects then performed multiple sets (50 reps) of fatiguing foot adduction exercises at 50% MIC. Maximum isometric contractions were measured after every two sets and subjects continued to perform fatiguing exercise until their MIC dropped below 70% of the baseline measure. A post-fatigue (POST) treadmill walking trial was subsequently collected.

Three-dimensional kinematics were calculated for the forefoot (relative the rearfoot) and rearfoot (relative to the shank). Wilcoxon signed-rank tests were used to compare PRE and POST values for the following variables: peak rearfoot eversion (Pk RF EV), forefoot dorsiflexion (Pk FF DF) and abduction (Pk FF ABD); time to peak rearfoot eversion (time RF EV) and forefoot dorsiflexion

(time FF DF); and forefoot abduction at toe-off (FF ABD @TO).



**Figure 2:** Custom device for performing foot abduction and assessing strength.

## RESULTS AND DISCUSSION

Upon completion of the fatiguing protocol for tibialis posterior, the MIC strength dropped to  $65.2\% \pm 8.7\%$  of the PRE value.

A comparison of PRE and POST kinematic variables are presented in Table 1. In terms of rearfoot eversion, both the peak value and the time to the peak value were unchanged following the fatiguing exercises. This suggests that a 20-30% reduction in force production of tibialis posterior was insufficient to alter rearfoot kinematics. However, this is not to say that tibialis posterior does not play a role in controlling rearfoot motion. Other muscles such as the gastrocnemius and soleus may also assist in rearfoot inversion and have small inversion moment arms. Thus, it is possible that other muscles may compensate to control rearfoot motion in the absence of adequate tibialis posterior function.

Only one of the forefoot kinematic variables, peak forefoot abduction, was statistically different following the fatiguing protocol. Although peak forefoot abduction increased in 9 out of 12 patients,

it is questionable whether this small  $0.4^\circ$  mean increase is clinically relevant. As with the rearfoot, the failure to alter forefoot kinematics may be due to compensatory strategies by other muscles.

The results imply that tibialis posterior fatigue was not successful in systematically altering either forefoot or rearfoot kinematics associated with excessive or prolonged pronation of the foot. The findings contradict the results of Ness et al. [2] who reported that patients with advanced PTTD had greater rearfoot eversion, forefoot dorsiflexion and forefoot abduction compared to controls. However, the patients in the former study had progressed to the stage of a fixed pes planus deformity of the foot, where tibialis posterior was completely deficient. It is unclear whether weakness of the tibialis posterior muscle or anatomical malalignment leads to excessive pronation of the foot. It is feasible that the contribution of muscular function in controlling pronation may differ depending on foot structure. It is envisioned that this relationship will be elucidated as this study progresses.

## CONCLUSIONS

A reduction in force production of the posterior tibialis muscle following fatiguing exercise did not alter rearfoot or forefoot kinematics during walking.

## REFERENCES

- 1.Thordarson DB, et al. *Clin Orthop Rel Res* **316**, 165-172, 1995.
- 2.Ness ME, et al. *Gait Posture* **27**, 331-339, 2008.
- 3.Christina KA, et al. *Hum Mov Sci* **20**, 257-276, 2001.
- 4.Cornwall MW, et al. *Foot* **14**, 133-138.
- 5.Kulig K, et al. *Med Sci Sports Exe* **36**, 862-867, 2004.

**Table 1:** Mean (SD) kinematic measures prior to (PRE) and following (POST) fatiguing exercise.

	Pk RF EV (°)	Time RF EV (%stance)	Pk FF DF (°)	Time FF DF (%stance)	Pk FF ABD (°)	FF ABD @TO (°)
PRE	<b>2.5</b> (3.0)	<b>44</b> (8)	<b>4.0</b> (2.6)	<b>68</b> (8)	<b>10.1</b> (5.6)	<b>2.8</b> (6.1)
POST	<b>2.6</b> (2.9)	<b>43</b> (10)	<b>3.6</b> (2.1)	<b>64</b> (11)	<b>10.5</b> (5.4)	<b>2.7</b> (5.6)
p-value	0.154	0.253	0.319	0.091	0.039*	0.438

\* Indicates a significant difference between PRE and POST measures ( $p < 0.05$ ).