

Comparison of Ankle and Foot Joint Kinetics after Heel-Off Between Individuals with Posterior Tibial Tendon Dysfunction and Controls

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INTRODUCTION

Posterior tibial tendon dysfunction (PTTD) is associated with loss of muscle function and acquired flatfoot deformity.^{1,3,4} These deficits are associated with decreased ankle power at push off.⁴ Kinematic studies suggest that the decreased ankle power at push off is not accompanied by significant changes in kinematic *patterns* of the 1st metatarsal¹ or forefoot³ in plantar flexion. This suggests that angular velocity of the forefoot may be normal, and that midfoot power *generation* may also be normal. Simplified kinetic foot models (two segment – forefoot, hindfoot) are able to reveal whether the forefoot power *generation* at push off, identified in previous studies,² is maintained or decreased due to deficits in muscle control as a result of PTTD and/or loss of midfoot stability as a result of acquired flatfoot deformity. The purpose of this study was to compare midfoot and ankle kinetics (moment, angular velocity and power) between individuals with stage II PTTD and matched controls at the push off phase of stance.

METHODS

Thirteen individuals with PTTD (3 male, 10 female; age=57 ± 10; body mass index = 31 ± 6) and 9 control participants (1 male, 8 female; age= 54 ± 7; body mass index = 32 ± 3) volunteered for this study. The Foot Function Index average score of 27 ± 12 % for the individuals with PTTD suggested moderate limitations in function and pain. The arch height index, used to document the medial longitudinal arch, was significantly lower ($p < 0.01$) in the individuals with PTTD (PTTD = 0.308 ± .019 vs Control = 0.350 ± 0.015) verifying the presence of a lower arch and suggestive of acquired flatfoot.

An Optotrak Movement Analysis System (Northern Digital, Inc, Waterloo, CANADA) and force plate (Kistler, Amherst, NY) integrated with The Motion

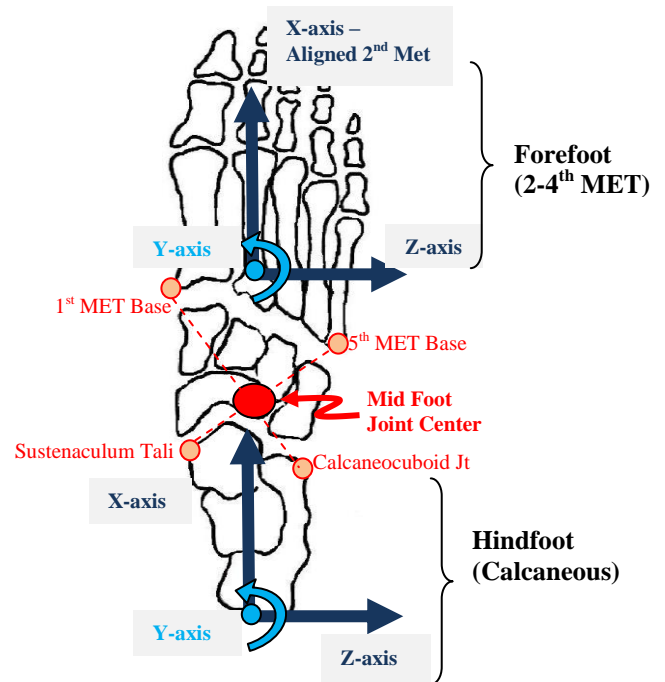


Figure 1: The midfoot joint center, forefoot segment (markers placed on 2-4 metatarsals [MET]) and hindfoot (calcaneus) are shown.

Monitor (Innsport, Inc, Chicago, IL, USA) was used to measure movement and force data from a multi-segment foot model during walking.¹ Walking speed was controlled at 1.0 m/s using timing gaits. Force data was collected at 1000 Hz and kinematic data at 60 Hz. The two segment kinetic foot model (**Figure 1**) consisted of the forefoot and hindfoot. The forefoot was defined by placing 3 infrared emitting diodes (IRED's) on the 2-4th metatarsals. The hindfoot was defined by placing a triad of three IRED's on the skin over the lateral calcaneus. The midfoot joint center was the midpoint between the sustentaculum tali, 1st metatarsal base, calcaneocuboid joint, and 5th metatarsal base. On dried skeletons this joint center approximated the lateral aspect of the talonavicular joint (**Figure 1**). An inverse dynamics solution was calculated for each segment (Forefoot, Hindfoot) at the point of peak ankle plantarflexion angular velocity of walking. At this point of stance the heel is off the

ground and the center of pressure is located between the 2nd and 4th metatarsal heads. Two sample t tests were used to compare the moments, angular velocity and powers (midfoot and ankle) at this point of stance between PTTD and controls.

RESULTS AND DISCUSSION

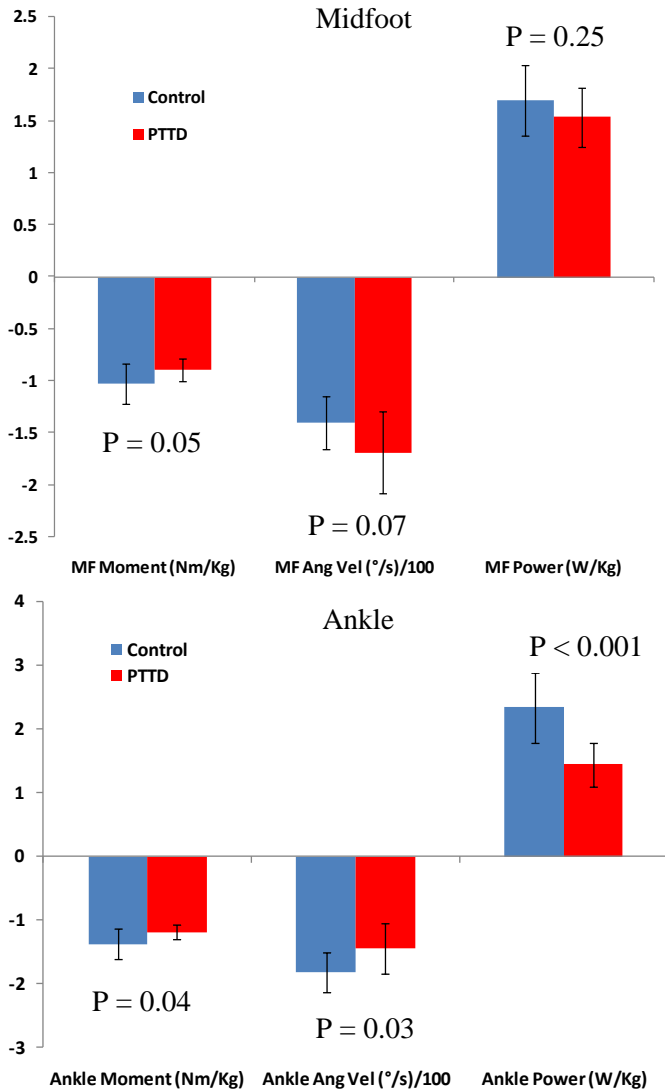


Figure 2. The midfoot (top) and ankle (bottom) joint moments, angular velocity(scaled for graphing) and powers. “-“ values for moments and angular velocity indicate plantar flexion. P values are the result of two sample t-tests.

The new findings of this study show minimal differences in the midfoot kinetics and significant differences in ankle kinetics of individuals with PTTD compared to controls (**Figure 2**). Individuals with PTTD maintained their midfoot power generation despite a significantly lower ankle power generation. The midfoot moment of the PTTD

group showed significantly lower plantar flexion moments. However, this lower moment was associated with a higher forefoot angular velocity, resulting in no difference in the midfoot powers. The individuals with PTTD maintained their midfoot power despite lower ankle powers and acquired flatfoot deformity. Maintenance of the midfoot power generation may indicate compensation via active mechanisms (ie, muscle control) to preserve foot rigidity at push off. Further, the ankle power may partially depend on the ability of subjects to stabilize their midfoot. The ankle power generation was 30 % less in the PTTD group, suggesting that push off is impaired. Clinically, this lower ankle power suggests that a solid ankle foot orthosis, which is in common use, may further restrict ankle plantar flexor function, causing further loss of power. As long as midfoot power is maintained, other alternatives like jointed ankle designs should be considered for individuals with PTTD to minimized deficits in ankle power.

CONCLUSIONS

The presence of PTTD and acquired flatfoot deformity minimally influenced midfoot kinetics. However, ankle kinetics demonstrated large differences attributable to PTTD and acquired flatfoot deformity.

REFERENCES

1. Houck, J, Neville, C; Tome, J., Flemsiter, A. Ankle and Foot Kinematics in Subjects with stage II PTTD during the Stance Phase of Gait. *Foot & Ankle International* (In Press)
2. MacWilliams BA, Cowley M, Nicholson DE. Foot kinematics and kinetics during adolescent gait. *Gait & Posture*. 2003;17: 214-24.
3. Ness ME, Long J, Marks R, Harris GF. Foot and Ankle Kinematics in Subjects with Posterior Tibial Tendon Dysfunction. *Gait & Posture*. 2008;27: 331-339.
4. Ringleb SI, Kavros SJ, Kotajarvi BR, Hansen DK, Kitaoka HB, Kaufman KR. Changes in gait associated with acute stage II posterior tibial tendon dysfunction. *Gait & Posture*. 2007;25: 555-64.

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