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PROLONGED PRONATION IN RUNNERS WITH ACHILLES TENDINOPATHY

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SUMMARY

This study examines whether runners currently symptomatic with Achilles tendinopathy demonstrate prolonged durations of pronation as opposed to the commonly cited excessive amounts or velocities of pronation. The results suggest that compared to healthy controls, injured runners do not differ in the amount or velocity of pronation. However, injured runners have longer durations of pronation during stance, meaning they initiate push off while the foot is still in a pronated position. Implications for muscle force requirements and injury potential are discussed.

INTRODUCTION

Achilles tendinopathy (AT) is one of the most common overuse running injuries, a fact which has not changed in over thirty years of research [1,2]. Frequently cited biomechanical parameters for the development of AT include excessive amounts or velocities of foot pronation [3]. However, while several studies suggest there is a relationship between the amount or velocity of pronation and injuries, an equal number of authors report no such relationship exists [3]. Therefore, an alternative theory regarding the relationship between foot pronation and injury may be warranted.

One such theory suggests it may be the duration the foot remains in a pronated position throughout stance, and not necessarily the amount or velocity of pronation, which is more important to consider for injury development [1]. While pronation is desirable early during stance, the foot should start supinating prior to push off, as supination will cause the axes of the transverse tarsal joints to diverge turning the foot into a rigid lever. Prolonging pronation past mid-stance would result in the foot being an inefficient lever during push-off, theoretically requiring greater muscular effort to stabilize the foot and generate sufficient propulsive impulse [1]. However, there are currently no reports in the literature which have examined the duration of pronation in runners with AT.

Therefore the purpose of this study was to compare the duration of pronation in runners currently symptomatic with AT with matched healthy control subjects. It was hypothesized that compared to healthy controls, runners with AT would demonstrate a longer duration of pronation but not excessive amounts or velocities of pronation.

METHODS

Thirteen runners currently symptomatic with AT and 13 healthy control subjects (CON) participated in this study (Table 1). The diagnosis of AT was made by one of the two clinicians participating in the study (SJ or RW). All CON subjects were healthy at the time of testing and had not history of AT. Subjects first underwent a clinical exam measuring 10 variables documenting general lower limb alignment, flexibility, and mobility [1].

Table 1. Subject characteristics. RFS = rearfoot strike. MFS = midfoot strike.

Variable	AT	Control
Sex	9M, 4F	9M 4 F
Weekly mileage	50.1 (± 15.1)	52.3 (± 14.7)
Foot strike pattern	7 RFS, 6 MFS	7 RFS, 6 MFS
Age	37.6 (± 15.9)	32.6 (± 12.4)

After the clinical exam subjects participated in a 3D motion analysis of their running gait. Their whole body motion was recorded by a 10-camera motion capture system (Motion Analysis Corp.) sampling at 200 Hz while they ran continuous laps around a short track in the laboratory. Ground reaction forces were recorded with three force plates (AMTI) sampling at 1000 Hz. Foot strike patterns were characterized as rearfoot strike (RFS) or mid/forefoot strike (M/FFS). Filtered marker trajectories were used to calculate 17 variables describing orientations and movement of the leg segments. Propulsive forces and impulses were calculated from the filtered anterior-posterior ground reaction force curves. The position of the center of pressure (COP) relative to the anatomic structures of the foot was examined by transforming the COP from the lab coordinate system to a local foot coordinate system at each frame during stance.

Differences between groups in descriptive characteristics (Table 1) were assessed using independent *t*-tests. Independent *t*-tests were also used to examine differences between AT and CON groups on clinical exam measures. Differences between groups in kinematic and kinetic variables were assessed using a 2X2 ANOVA (injury group x foot strike pattern). This allowed the inclusion of variance due to using different foot strike patterns. Running speed and arch height were included as covariates in the analysis. A binary logistic regression was used to examine the influence of the period of pronation (Per_P) on group assignment. Finally, the position of the COP in the anterior-posterior (A/P) and medio-lateral (M/L) directions were analyzed, also using a 2x2 ANOVA. Starting at contact, positions were analyzed in increments of 10% stance through toe off.

RESULTS AND DISCUSSION

No differences were observed for any of the descriptive characteristics between groups (Table 1). Compared to CON group, the AT group demonstrated higher standing tibia varus angle, reduced passive dorsiflexion range of motion, and a longer period of pronation (Figure 1).

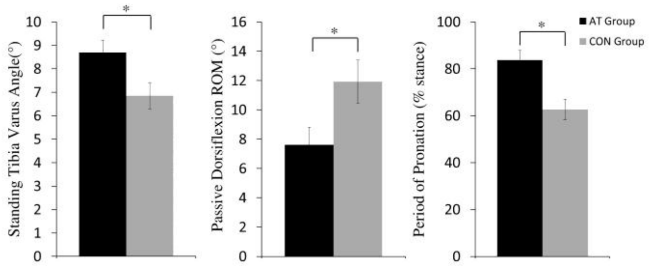

Figure 1. Standing tibia varus angle measured relative to vertical, passive dorsiflexion range of motion, and period of pronation. * indicates $p < .05$.

The time to heel off, peak propulsive force, and propulsive impulse were not different between groups (Figure 2). These results are in agreement with existing results in the literature [4,5] and suggest the overall mechanics of push off are similar between AT and CON subjects.

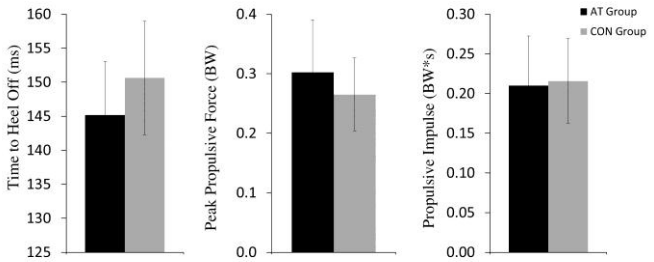

Figure 2. Time to heel off, peak propulsive force, and propulsive impulse for the AT and CON groups. None of these variables were different between groups.

There was a significant injury group x foot strike interaction for rearfoot eversion at the instant of heel off. For subjects who used a RFS, individuals in the AT group were more everted at heel off than individuals in the CON group (AT: -7.0° ± 1.3°; CON: -3.1° ± 1.5°, p <.001). However, there were no differences between AT and CON groups for runners who used a MFS.

Neither the amount of pronation (AT: 10.5° ± 3.5°; CON: 11.9° ± 2.5°; p = .383) nor the average velocity of pronation (AT: 239.7°/s ± 77.2°/s; CON: 196.8°/s ± 46.7°/s; p = .051) were different between groups.

The logistic regression model suggested each 1% stance in the AT group by 1.09 (p = .006). The overall model was significant (χ^2 = 12.36, df = 1, p < .001) and able to classify 80% of the subjects correctly.

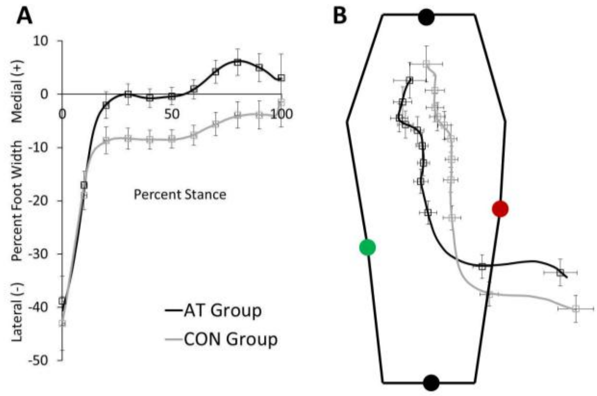

Figure 3. M/L location of the COP (A), and trajectory of the COP plotted in an outline of the foot based on marker locations (B)

Analysis of the COP trajectories revealed the COP was located significantly more medial at each time point from 30% through 90% of stance in the AT group compared to the CON group (Figure 3). In the A/P direction, there were no main effects of injury group at any time point. However, for both AT and CON groups the COP was located significantly more anteriorly in subjects who used a M/FFS compared to those who used a RFS from initial contact through 40% stance.

CONCLUSIONS

Compared to the CON group, the AT subjects had a longer period of pronation. Thus, they were achieving similar propulsive forces and impulses with the foot configured as a less efficient lever. Theoretically, this would result in less efficient force transmission. Therefore, to achieve similar acceleration of their center of mass, AT patients may need more force applied to the foot. Future work should investigate whether runners with AT are in fact producing greater muscular forces during push off. However, the results of this study suggest the duration of pronation is a variable to consider in future studies on AT, as no differences in either the amount or velocity of pronation were observed between injured and healthy subjects.

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