Prospective Study of Structural and Biomechanical Factors associated with the Development of Plantar Fasciitis in Female Runners

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INTRODUCTION

Plantar fasciitis is one of the 5 most common injuries that runners sustain (vanMechelen, 1992). It is believed that this injury is a result of repetitive strain to the plantar fascia. Warren at al. (1987) reported that runners, either currently or formerly experiencing PF, exhibited greater pronation of the foot while in a loaded stance position than runners with no history of this injury.

In a retrospective study of runners with a history of plantar fasciitis, we reported that these runners exhibited significantly greater peak eversion compared to the controls (Davis et al, 2003). A trend towards greater eversion velocity was also noted. Plantar fasciitis is also often associated with limitations in ankle dorsiflexion range of motion. It is believed that this limitation may lead to a compensatory excessive pronation. This excessive pronation, noted at both the rearfoot and midfoot, leads to increased strain of the plantar fascia.

Finally, it is possible that excessive loading, in terms of peak forces and rates of loading, may be associated with the development of plantar fasciitis. However, these loading variables have yet to be examined in runners who develop this injury.

Therefore, the purpose of this prospective study was to compare foot structure and mechanics in a group of female runners who develop plantar fasciitis (PF) to a group of healthy controls (CON). It was hypothesized the PF group would exhibit decreased peak ankle dorsiflexion, increased rearfoot eversion, and increased vertical ground reaction forces and load rates. Structurally, it was expected that the PF group would have lower arches, greater calcaneal eversion in stance and limited ankle dorsiflexion range.

METHODS

These data are part of an ongoing, prospective study of female distance runners. Female runners, aged 18 to 40 yrs., and running at least 20 miles per week are recruited into a 2-year longitudinal study. A gait analysis is performed on entry into the study. Subjects run overground at 3.7m/s in standard laboratory running shoes. Five trials are recorded using a 6-camera motion capture system at 120 Hz (Vicon, Oxford Metrics, UK) and a force platform (Bertec, OH, USA). 3D kinematics and kinetics were calculated for both lower extremities (Visual 3D, C-Motion, MD, USA). In addition to the motion analysis, a structural assessment of the runner's lower extremities is performed by an experienced physical therapist. Included in these measures are arch index (Williams et al, 2000), dorsiflexion range of motion with the knee extended, and calcaneal valgus during stance.

The subjects are then followed monthly for two years. Running mileage and injuries are tracked. To date, 10 runners, aged 32 ± 8 years, and running an average of 28 ± 12 miles per week have developed plantar fasciitis (PF). These were compared to a control (CON) group of 10 uninjured runners matched for age (31± 11 yrs) and mileage (28 ± 6 miles per week).

Variables of interest were compared between groups statistically using an independent, one-tailed t-test. Due to the preliminary nature of these data, a p value of 0.10 was used for statistical significance.

RESULTS AND DISCUSSION

Comparison of the variables of interest between groups is presented in Table 1.

Table 1: Structural and Dynamic Measures

	PF	CON	p
Peak EV (deg)	7.1	8.6	0.22
DF exc (deg)	17.8	20.8	0.12
Peak DF (deg)	25.7	27.7	0.15
Imp. Peak (BW)	1.81	1.65	0.15
Inst. Load Rate (BW/s)	124.5	109.3	0.19
Avg. Load Rate (BW/s)	86.7	77.9	0.22
Stance Calc. VAL (deg)	5	2	0.03
Arch Index (unitless)	0.339	0.353	0.19
DF rom (deg)	1	3	0.18

Surprisingly, no difference was noted in peak rearfoot eversion (EV). This is in contrast to our previous retrospective study of plantar fasciitis (Davis et al, 2003), where the injured subjects exhibited significantly greater EV than the controls. While not statistically significant, there was a trend towards a decrease in peak dorsiflexion (DF) and DF excursion. This was not associated with increased rearfoot EV in this group. However, the reduction in DF may have resulted in a compensation in the midfoot (not readily measured with standard motion analysis techniques). It is this midfoot pronation that is believed to most directly increase the strain of the plantar fascia.

All loading variables were higher in the PF group, with impact peak showing the strongest trend. Instantaneous vertical load rate was 15% higher in the PF group. Higher load rates may mean greater strain rates on soft tissues, such as the plantar fascia. These loading variables have not been previously examined in this group and may be important in the development of plantar fasciitis.

Structurally, the PF group had slightly lower arches. In addition, they presented with less ankle dorsiflexion range of motion. This may have resulted in the decreased peak dorsiflexion and dorsiflexion excursion seen during running. Finally, the PF group exhibited significantly greater calcaneal EV in stance, consistent with Warren et al. (1987). It was expected that this would be associated with greater rearfoot EV during running. While the structural measure was taken from markers placed directly on the skin, the dynamic measures were from markers placed on the shoe. This factor may have added unexplained variance to the dynamic rearfoot EV angle.

SUMMARY

Results of these preliminary, prospective data suggest that there may be predisposing structural and mechanical factors to the development of plantar fasciitis. These results may be strengthened as additional subjects are added. With additional subjects, regression analyses, utilizing both structural and mechanical variables will be performed. It is hoped that, as this research progresses, we will gain further insight into the cause of plantar fasciitis in runners. This will help us to develop optimal treatment interventions for this common injury.

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