

Introduction

- Foot function, in respect to the gait cycle, is important in determining the presence of an ongoing pathologic condition. Through clinical observation, information obtained during stance phase of the gait cycle can assist the physician in monitoring effective treatments in patients with plantar fasciitis (PF).
- Stance phase is separated into four events: heel strike, toe down, heel off, and toe off (Figure 1). During heel strike, forward momentum is maintained as the heel engages the floor and pretibial muscles contract, resulting in a rate-controlled foot drop with advancement of the heel rocker phase.² At toe down the momentum is controlled through gastrocnemius and soleus activation, resulting in advancement of the ankle rocker phase. At heel off, the momentum increases due to forward ground reaction forces under the forefoot, leading to the toe off events and conclusion of the toe rocker phase.²
- Due to plantar fascia involvement during all rocker phases, pathologic changes associated with PF are likely to alter the stance phase support patterns during the gait cycle.

Purpose

- The purpose of this study was to: (1) identify if changes occur in the foot support duration measurements in patients with PF; (2) Describe a clinical method to evaluate the timing of stance phase and foot support pattern events as related to monitoring treatment outcomes in PF.

Methods

- Twelve (12) plantar fasciitis patients and twenty (20) control subjects performed three walking trials at a self-selected speed along a 10-m walkway.
- 3-dimensional motion capture was performed on the subjects to analyze stance phase pattern tendencies during gait utilizing heel and toe markers.
- Collected data was evaluated using MATLAB to identify vertical kinematic features of the subjects heel strike, toe down, heel off, and toe off events. Stance phase parameters were evaluated to determine the percentage of duration spent in heel (heel support), ankle (foot-flat support), and toe (forefoot support) rockers.

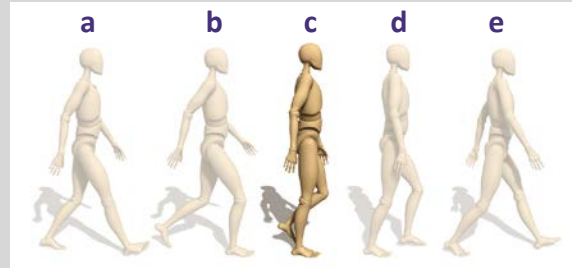


Figure 1. Kinematic breakdown of stance foot support phases at a) heel strike, b) toe down, c) mid-stance, d) heel off, and e) toe off with heel rocker occurring at a-b, ankle rocker at b-d, and toe rocker at d-e.

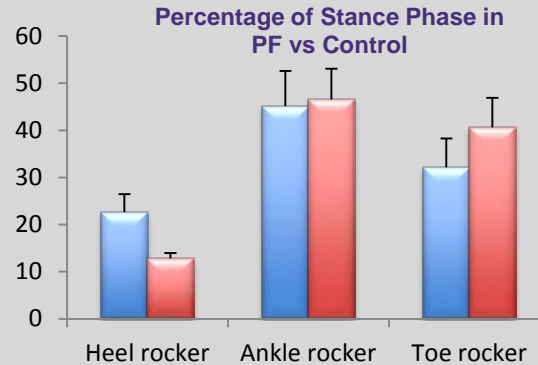


Figure 2. PF vs Control percentage of foot support rockers during stance phase of gait.

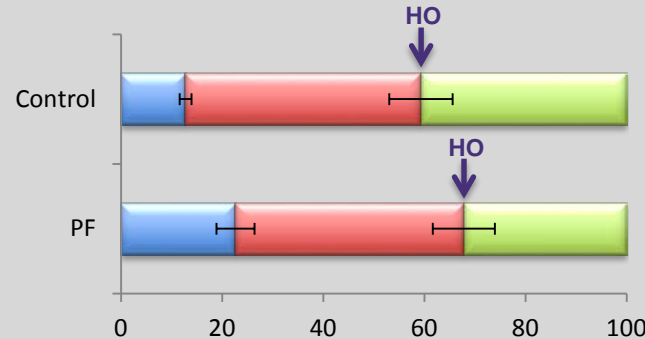


Figure 3. Percentage of heel rocker, ankle rocker, and toe rocker duration in stance phase between PF and control subjects.

Results

- Differences were observed between PF and control subjects when analyzed using two-sided paired t-tests. Self-directed walking speed presented slower in PF when compared to controls (116.23 m/s vs 126.49 m/s; $p=0.016$).
- Figure 2 shows heel rocker duration significantly longer in PF during stance phase (22.67% vs 12.79; $p=0.000$) and toe rocker duration significantly shorter in PF during stance phase (32.17% vs 40.66%; $p=0.001$). PF patients also show a delay in heel off (67.83% vs 59.34%; $p=0.001$) shown in Figure 3.
- Ankle rocker duration was found to not be affected in PF (45.16% vs 46.55%; $p=0.585$) as well as overall duration of stance phase in PF (60.48% vs 60.78%; $p=0.668$). Summary of these results is demonstrated in Table 1.

Table 1. Means (\pm Standard Deviation) comparing outcomes between PF and control subjects with t-test significance level results shown.

| Means | PF (N=12) | Control (N=20) | Significance ($\alpha < 0.05$) |
|-------------------------------|------------------------|------------------------|----------------------------------|
| Walking Speed (m/s) | 116.23 (± 10.98) | 126.49 (± 11.01) | $p=0.016$ |
| Stance Phase (%Gait Cycle) | 60.48 (± 2.16) | 60.78 (± 1.12) | $p=0.668$ |
| Heel Rocker (%Stance Phase) | 22.67 (± 3.78) | 12.79 (± 1.15) | $p=0.000$ |
| Ankle Rocker (% Stance Phase) | 45.16 (± 7.46) | 46.55 (± 6.52) | $p=0.585$ |
| Toe Rocker (% Stance Phase) | 32.17 (± 6.13) | 40.66 (± 6.24) | $p=0.001$ |
| Heel Off (%Stance Phase) | 67.83 (± 6.13) | 59.34 (± 6.24) | $p=0.001$ |

Discussion

- PF is often considered a difficult condition with multiple treatment modalities available. These alternative treatment options for PF patients when not effective put the patient at a higher risk for developing a chronic condition.
- Clinically evaluating PF stance phase gait patterns offers significant insight into the effectiveness of the current treatment modality prescribed.
- Our study finds the events of heel strike, toe down, heel off, and toe off, when measured using simple gait monitoring technology, provides clinically significant and useful information that may assist the physician in determining effective treatments for patients with PF, resulting in improved outcomes.

References

- Neumann, Donald A. "Kinesiology of Walking." Kinesiology of the Musculoskeletal System: Foundations for Physical Rehabilitation. St. Louis: Mosby, 2002. 529-32.
- Perry, Jacquelin, Judith M. Burrfield, and Lydia M. Cabico. "Basic Functions." Gait Analysis: Normal and Pathological Function. 2nd ed. Thorofare, NJ: SLACK, 2010. 33-35.