

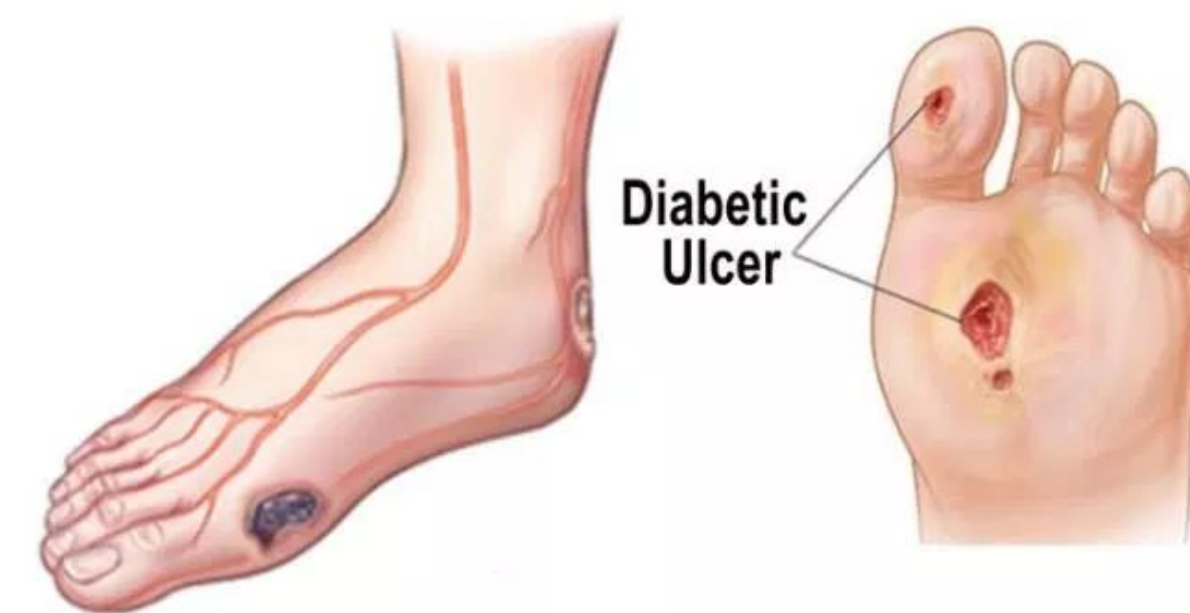
Walking Boot Design Influences Offloading

Andrew R. Hillier, Seth C. Huber, Dylan J. Parry, Amy Mitchell Hayward, Jordan K. Grover, Dustin A. Bruening

Background

Clinical Motivation

- Nearly 14% of individuals in the U.S. suffer from diabetes¹
- 15-25% of these individuals will suffer from a diabetic related ulcer in their lifetime¹
- More than 85% of foot ulcers are diabetes related¹
- As ulcers worsen, infection, gangrene, and amputation become more likely



Current Treatment

- Controlled Ankle Motion (CAM) boots to offload plantar pressure while ulcers heal

Clinical Problem

- CAM boots offload forefoot well, but not heel²
- Recurrence is common (40% in a median of 126 days)³
- CAM boots immobilize joints and change gait

Proposal

- Test offloading ability of a novel spring-loaded walker boot (SB)
- Compare offloading among the traditional CAM boot (CB) with SB and a hinged walker boot (HB)

Hypotheses

- SB would reduce plantar pressure at the hindfoot compared to the CAM boot (due to greater offloading from foot to lower leg)
- HB would increase forefoot plantar pressure compared to CB (due to a more natural forefoot push-off)



Figure 1: Walking boots. All boot contained an air bladder to aid in offloading as well as a slightly rockered sole.

Left: Spring-loaded boot (SB)

Middle: Traditional CAM boot (CB)

Right: Hinged boot (HB)

Methods

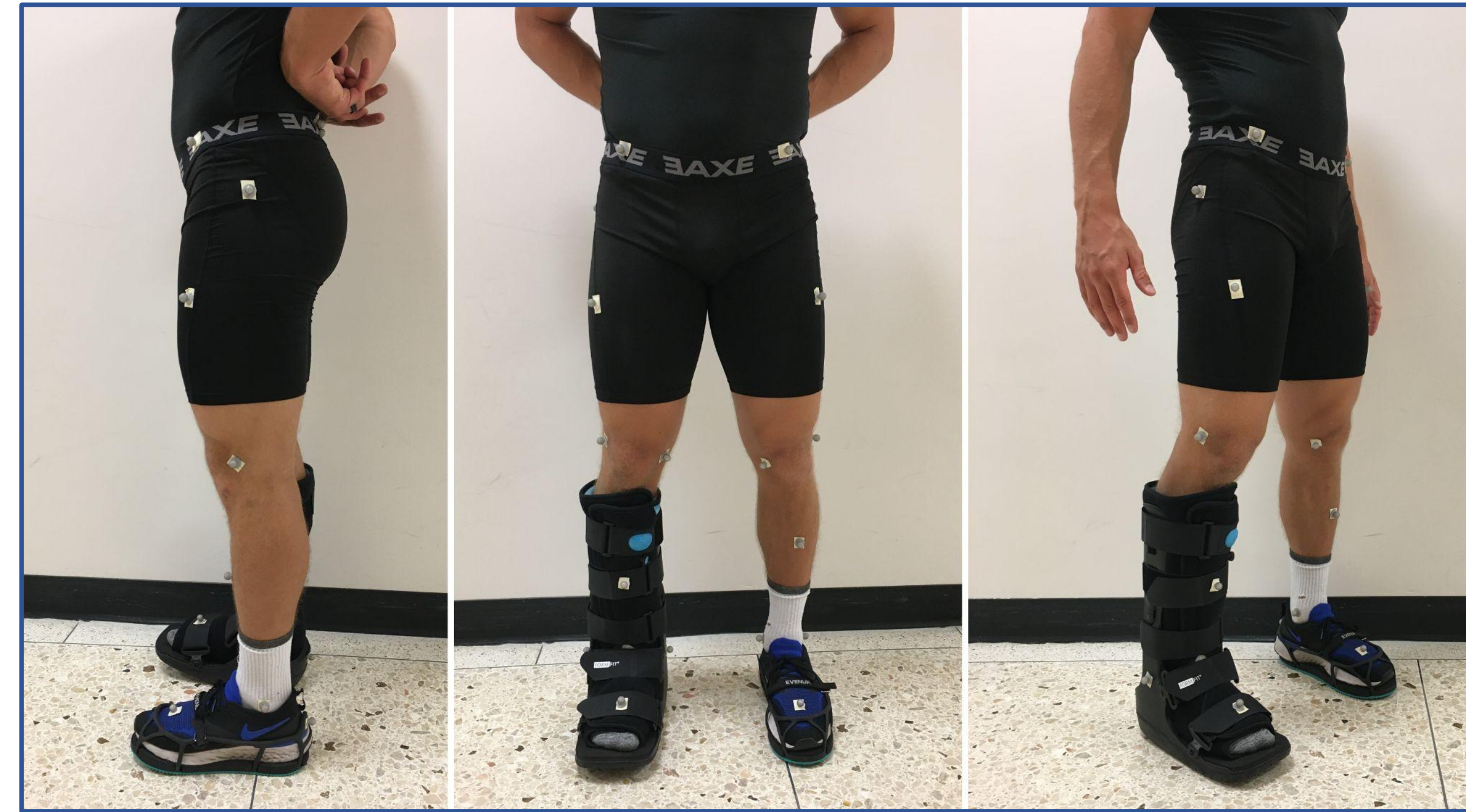


Figure 2: Experimental setup showing CAM boot, shoe leveler, and motion capture marker set (data not used in this analysis)

Participants

- 10 healthy male participants (age= 26.6 ± 7.5, height = 180.1 ± 5.0 cm, mass = 81.5 ± 8.8 kg)

Protocol

- Participants tested 4 conditions (Fig 1) in random order:
 - 1- CAM boot (CB), 2- Hinged-boot (HB), 3- Spring-loaded boot (SB), 4- Tennis shoes (SH)
- Unilateral R foot tested - shoe lifts used on L foot to maintain leg length symmetry
- After acclimation, participants forces were measured while walking:
 - Instrumented insoles measured pressure distributions inside boots
 - In-ground force platforms measured total force

Data Analysis

- Metrics:
 - Peak vertical force on foot (from insoles)
 - Peak vertical force on boot (from force plate)
 - Peak pressure under forefoot
 - Peak pressure under hindfoot
- Statistics
 - Comparisons among the four conditions
 - 1-way ANOVAs ($\alpha=0.05$) with Holm post-hoc tests

Results

Peak pressure (Figure 3):

- Hindfoot
 - SB 65% lower than SH
- Forefoot
 - SB 41% lower than SH

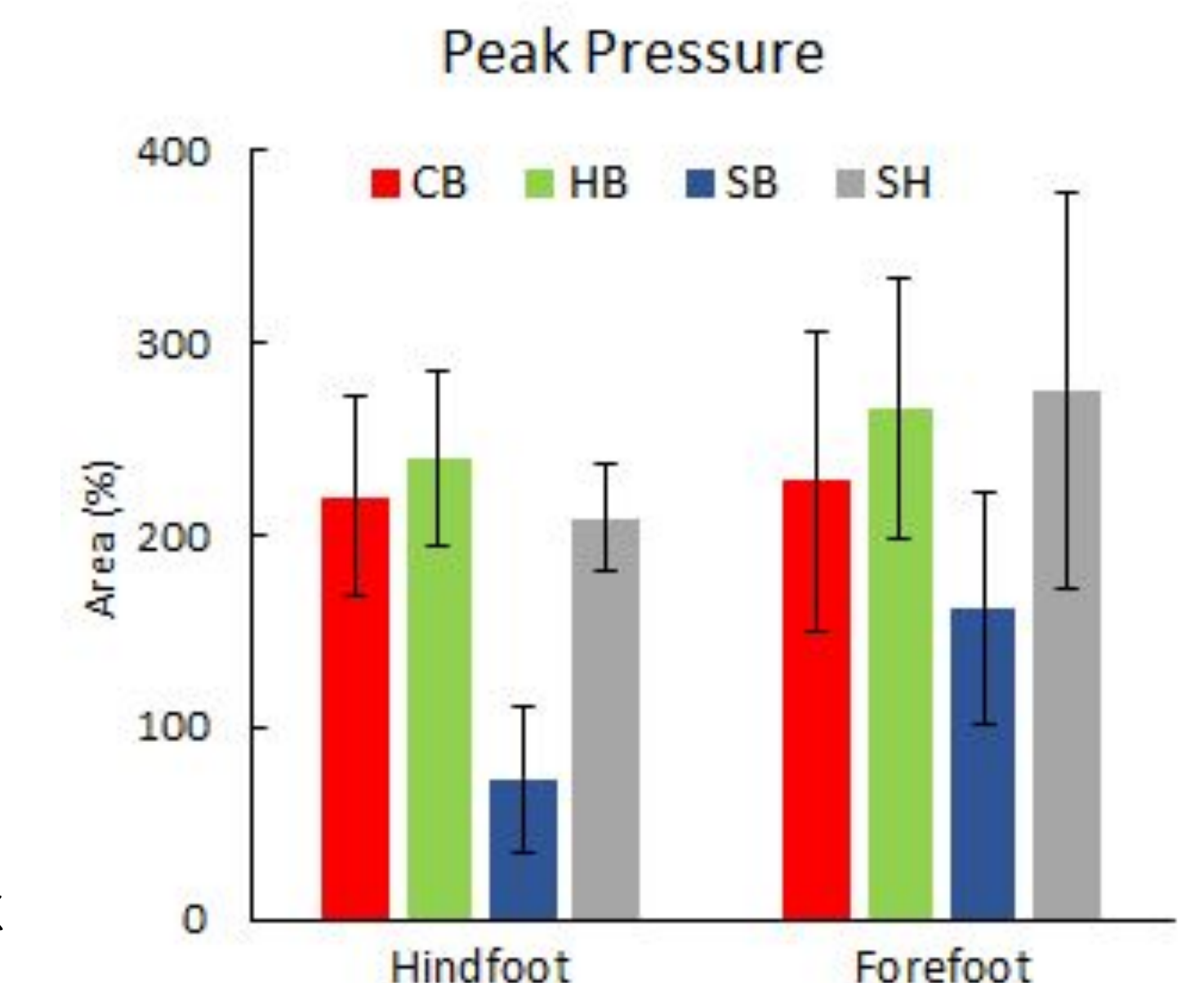


Figure 3: Peak pressure

Insole vertical forces (Figure 4A):

- Similar among CB, HB, and SH
- SB had 50% lower first peak
- SB had 26% lower second peak

Boot vertical forces (Figure 4B):

- Similar among all conditions
- Slightly delayed peaks in SB

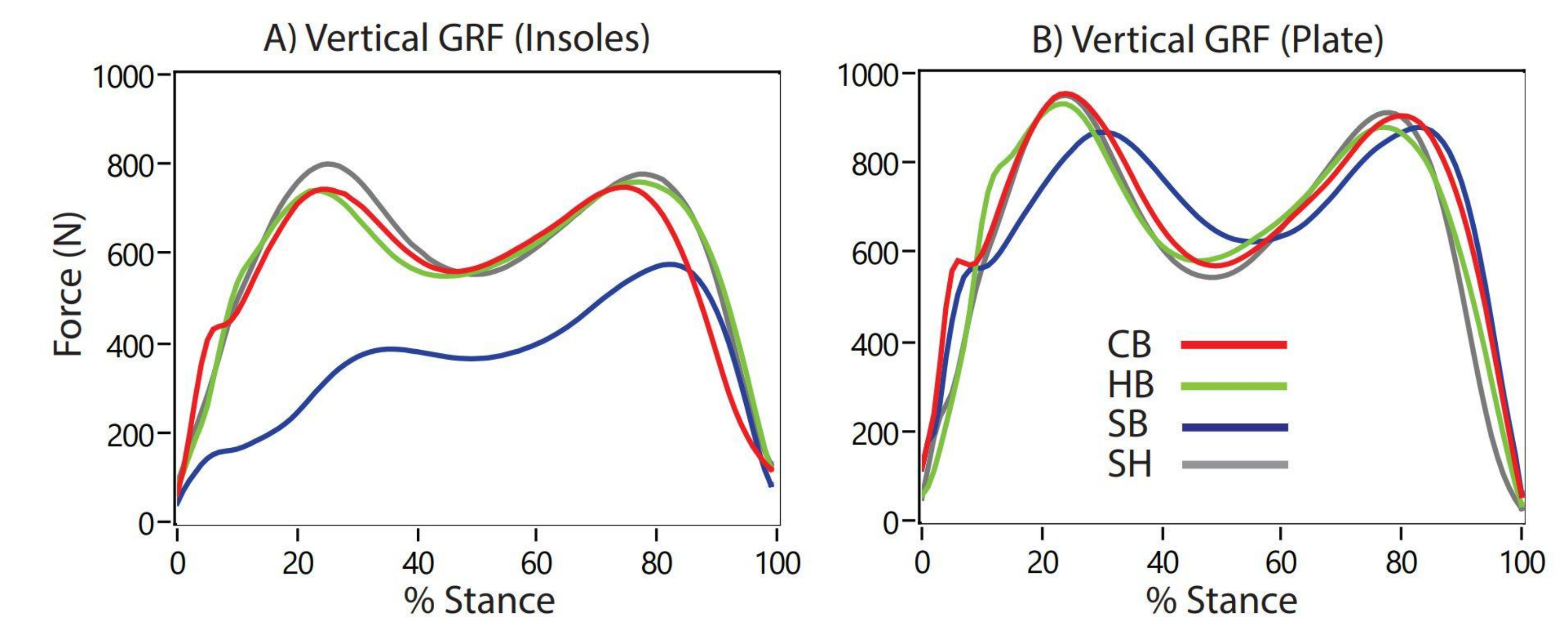


Figure 4: Mean GRF waveforms across stance phase of gait for each boot condition. A) Vertical GRF from insoles and B) Vertical GRF from force plate.

Conclusions

- The traditional CAM boot was not statistically different from shoes in our measurements, suggesting that offloading is poor.
- The hinged boot did not change loading patterns.
- The spring boot offloaded the heel effectively, but also the forefoot, showing great promise for future diabetic ulcer treatment.

References

References

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2. DiLiberto FE, Baumhauer JF, Wilding GE, Nawoczenski DA. Alterations in Plantar Pressure with Different Walking Boot Designs. *Foot & Ankle International*. 2007;28(1):55-60.
3. Pound N, Chipchase S, Treece K, Game F, Jeffcoate W. Ulcer-free survival following management of foot ulcers in diabetes. *Diabet Med*. 2005;22(10):1306-1309.