

Site-Specific Loading at the Fifth Metatarsal Base in Rehabilitative Devices: Implications for Jones Fracture Treatment

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Background: Fractures of the fifth metatarsal base are a relatively common injury. Whether treated surgically or nonsurgically, injury rehabilitation typically involves immobilization in a rigid sandal or short controlled ankle movement (CAM) walker boot.

Objective: To determine the peak pressure, contact pressure, and impulse at the base of the fifth metatarsal in 3 common footwear devices during common gait activities.

Design: This was a retrospective comparative study.

Setting: Research was conducted in a sports performance laboratory at a university.

Participants: Twenty subjects without a recent history of foot injuries volunteered to participate.

Methods: Each subject performed 3 common gait activities (walking, heel walking, and pivoting) in 3 footwear devices (short CAM walker boot, postoperative sandal, running shoe). Pressure data were sampled (100 Hz) using individually sized plantar pressure insoles and software (Tekscan). Walking trials were collected at 1.0 m/s \pm 5% (FusionSport Timing Gates).

Outcome Measurements: Peak pressure, contact pressure, and impulse at the fifth metatarsal base region were determined for all trials for all subjects. Mixed-effect regression models were used to compare pairwise differences in outcome variables between footwear devices.

Results: The CAM walker boot resulted in significantly lower peak pressure at the fifth metatarsal during walking and heel-walking relative to the postoperative sandal ($P < .01$) and during heel-walking ($P < .01$) relative to the standard athletic shoe. The CAM walker boot significantly reduced contact pressures at the fifth metatarsal during walking and heel-walking relative to the postoperative sandal ($P < .01$), and during heel-walking relative to the standard athletic shoe ($P < .001$).

Conclusions: Our results suggest that the short CAM walker boot more effectively offloads the fifth metatarsal during common gait activities than a postoperative sandal or a standard athletic shoe. A short CAM walker boot may be a beneficial rehabilitative tool for patients undergoing rehabilitation after treatment of Jones fractures and other base of fifth metatarsal fractures.

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INTRODUCTION

Fractures of the fifth metatarsal base are a relatively common injury, particularly in active populations. These include fractures of the metaphysis (ie, Jones fractures), and avulsion fractures from the base of the fifth metatarsal (ie, dancers fracture) [1]. Although both types of fracture can occur acutely, Jones fractures often occur with clinical and radiological characteristics of overuse (ie, stress) fractures. Jones fractures in athletes are most often treated surgically, as nonsurgical management results in a high incidence of non-union [1-5]. However, nonsurgical treatment can produce successful results for certain injuries and in some populations [6]. Avulsion fractures typically are successfully treated nonoperatively [7].

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A primary goal of rehabilitation after treatment of a fifth metatarsal fracture, whether nonoperative or operative, is to reduce loading of the lateral foot and fifth metatarsal while avoiding periods of prolonged cast immobilization, which can lead to muscle atrophy and deconditioning [8]. The optimal postoperative or rehabilitative device would allow the patient to ambulate without assistance, protecting the fifth metatarsal from excessive loads. Common devices used during rehabilitation include a rigid, wooden-sole postoperative sandal (sandal) or a controlled ankle movement (CAM) walker boot (boot) (Figure 1). The magnitude and distribution of force at the base of the fifth metatarsal in these devices has important implications toward modifying pathomechanics and optimizing rehabilitation during treatment of proximal fifth metatarsal fractures [9]. The peak pressure, contact pressure, and impulse at the fifth metatarsal during normal gait activities in a CAM boot, sandal, and shoe are currently unknown.

Recent clinical studies have demonstrated little difference in clinical outcomes in various orthotics including elastic wrap, open-toed shoes, short-leg orthoses, and crutches in the nonoperative treatment of fifth metatarsal fractures in patients in whom time to return to full activities was not critical [10,11]. Nevertheless, in the treatment of patients hoping to return to full activity sooner (athletes, military personnel), an understanding of the biomechanical

differences in various rehabilitation devices may guide treatment decisions.

Plantar pressure distributions in various shoe devices have been investigated using pressure-mapping systems [12,13]. These systems generally consist of a thin film insole that fits into the shoe and is fitted with multiple pressure sensors. Sports scientists commonly use pressure mapping to compare the effect of different shoe types and movement patterns on the plantar pressure [14,15]. It has been suggested that pressure insole technology might change the state of prescription of therapeutic shoes, braces, and orthoses [16], as it gives clinicians an objective measurement of the load on the foot. Plantar pressure measurements have been used to investigate the efficacy of treatments for osteoarthritis [17,18]. Brophy et al [19] also used pressure mapping systems to examine the risk factors for turf toe, and found that patients with a history of turf toe injury had higher great toe plantar pressures. Kavros et al [12] recently concluded that off-the-shelf rocker-bottom provisional footwear with plastizote are effective at reducing the mean peak plantar pressure at the GT. In addition, using pressure-mapping systems, rocker sole shoes are well documented in literature to reduce forefoot pressure [20-22]; however, to our knowledge, this is the first study to compare a running shoe, a CAM boot, and a postoperative sandal under various movement conditions.

The goal of the present study was to determine the peak pressure, contact pressure, and impulse (force-time integral) at the fifth metatarsal during 3 movement tasks in 3 different devices: a rigid postoperative sandal, a CAM walker boot, and a standard athletic shoe (shoe). We hypothesized that a CAM walker boot would result in lower peak pressure, contact pressure, and impulse at the fifth metatarsal compared to those with other devices. The goal is to implement a rehabilitative device that will reduce pressure at the fracture site while minimizing the risks associated with prolonged non-weight bearing.



Figure 1. Photograph of the CAM walker boot and rigid postoperative sandal used in this study.

METHODS

After obtaining approval from our institutional review board, we recruited 10 healthy males and 10 healthy females to participate in this study. The age of participants ranged from 19 to 38 years. All subjects were confirmed free of lower extremity injury for at least 1 year before participation, had never been treated for a major foot injury, and did not require or use orthotic devices. Data were collected on each subject's self-defined dominant foot. Of the 20 subjects in our study, 19 self-defined themselves as right-foot dominant, whereas 1 subject self-defined as left-foot dominant.

Foot Assessment

A physical therapist examined the dominant foot of each subject and classified the mobility of each subject's foot as

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