Gait & Posture 29 (2009) 582–586

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Differences in plantar loading between flat and normal feet during different athletic tasks

Robin M. Queen [a,b,*], Nathan A. Mall [b,c], James A. Nunley [b], Bavornrit Chuckpaiwong [a,b,d]

[a] Michael W. Krzyzewski Human Performance Laboratory, Duke University, Durham, NC, United States
[b] Division of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, United States
[c] Department of Orthopaedic Surgery, Washington University, St. Louis, MO, United States
[d] Orthopaedic Surgery Department, Siriraj Hospital, Mahidol University, Bangkok, Thailand

ARTICLE INFO

Article history:
Received 25 October 2008
Received in revised form 4 December 2008
Accepted 8 December 2008

Keywords:
Plantar pressure
Foot type
Sports injuries
Flat foot
Athletic tasks

ABSTRACT

The purpose of this study was to determine if foot type (flat or normal) resulted in loading differences during four sport-specific tasks (cross-cut, side-cut, shuttle run, and landing from a simulated lay-up). Twenty-two healthy subjects (12 normal feet and 10 flat feet) completed five trials in each condition, while in-shoe pressure data was collected at 50 Hz. Contact area, maximum force, and the force time integral were analyzed under the entire foot and in eight-foot regions. Foot type was determined by examining navicular height, arch angle, rearfoot angle, and a clinical score. A series of independent sample *t*-tests were used to determine statistical differences ($\alpha < 0.05$). During the cross-cut, flat feet demonstrated an increase in medial midfoot contact area. During the side-cut, flat feet demonstrated an increase in contact area, force time integral and maximum force in both the medial and lateral midfoot. During the shuttle run, flat feet demonstrated an increase in force time integral in the lateral midfoot and increases in maximum force in both the medial and lateral midfoot. During the landing task, flat feet demonstrated an increase in maximum force in the medial midfoot. However, flat feet demonstrate a decrease in middle forefoot maximum force. All results were statistically significant ($p < 0.05$). Therefore, individuals with a normal foot could be at a lower risk for medial and lateral midfoot injuries such as metatarsal stress fractures, indicating that foot type should be assessed when determining an individual's risk for metatarsal stress fractures.

1. Introduction

The risk of injury in sports is dependent on both the sport being played as well as the player's position [1]. Many risk factors have been reported for foot and ankle injuries such as age, gender, skeletal alignment, bone density, competition level, shoe type, playing surface, muscle strength and imbalance, and foot morphology [2]. A consensus has not been reached in the literature regarding the effect of foot type and arch structure on foot and ankle injuries in athletics. Previous literature has reported that individuals with a flat foot are at increased risk for sustaining ankle sprains, knee injuries, and other overuse injuries such as metatarsal stress fractures and patellofemoral pain syndrome [3–6]. Simkin et al. examined the influence of foot type on stress fracture injury risk and reported that individuals with a high arch were at increased risk for femoral and tibial stress fractures, while individuals with a low arch were at increased risk for developing metatarsal stress fractures [5]. Additionally, Williams et al. examined stress fractures in runners and reported that runners with high arches were at increased risk for developing fifth metatarsal stress fractures, while runners with low arches were at increased risk for developing second and third metatarsal stress fractures [6]. In contrast, other authors have stated that no association exists between arch height and lower extremity injury risk [3,7].

In the literature few studies exist that examine plantar pressure distribution patterns during athletic tasks. Sneyers et al. examined the differences in plantar pressure patterns in pes planus, pes cavus, and normal foot types during barefoot running, however, this is the only study in the literature to examine the influence of foot type on plantar loading during an athletic task [8]. The results of this study indicated that the relative loads under the midfoot were decreased in the pes cavus foot type due to the lack of foot deformation that exists in the rigid pes cavus foot [8]. In addition, Sneyers et al. reported that in patients with a pes planus foot no significant medial shift existed in forefoot loading [8]. Sneyers et al.

* Corresponding author at: Michael W. Krzyzewski Human Performance Laboratory, 102 Finch Yeager Building, DUMC 3435, Duke University, Durham, NC 27710, United States. Tel.: +1 919 684 1853; fax: +1 919 681 7067.
E-mail address: robin.queen@duke.edu (R.M. Queen).

0966-6362/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.gaitpost.2008.12.010