Journal of Mechanics in Medicine and Biology
Vol. 15, No. 1 (2015) 1550014 (14 pages)

DOI: 10.1142/S0219519415500141

FOOT LOADING PATTERNS WITH DIFFERENT UNSTABLE SOLES STRUCTURE

QICHANG MEI*, NENG FENG†, XUEJUN REN‡,
MAK LAKE§ and YAODONG GU*,¶

*Faculty of Sport Science
Ningbo University, Zhejiang 315211, P. R. China

†Rehabilitation Center
Ningbo Ninth Hospital, Zhejiang 315020, P. R. China

‡School of Engineering
Liverpool John Moores University
Liverpool, L3 3AF, UK

§School of Sport and Exercise Sciences
Liverpool John Moores University
Liverpool, L3 2ET, UK
¶guyaodong@hotmail.com

Received 19 December 2013
Revised 24 June 2014
Accepted 28 July 2014
Published 26 August 2014

Foot loading patterns can be changed by using different unstable sole structures, detailed quantification of which is of great significance for research and technological development in falling prevention and lower limb disorders rehabilitation. In this study, unstable soles constructions are adjusted through unstable elements in heel and medial, neutral and lateral forefoot and the foot loading patterns are comparatively studied. A total of 22 healthy male subjects participated in this test. Subjects are asked to walk over a 12 m walkway with control shoes and experimental shoes in self-adapted speed. Significant peak pressure, contact area and pressure-time integral differences in middle foot are found between control shoes and experimental shoes. In addition, peak pressure and pressure-time integral are found to increase significantly with unstable elements adding to center forefoot. The results showed that adjusting the unstable elements in coronal plane of forefoot could effectively alter the distribution of plantar pressure, this could potentially offer a mechanism for preventing falling of elderly and rehabilitation of lower extremity malfunctions. This study also demonstrates a novel concept that unstable element could be effectively adjusted in terms of position to meet different functional requirement.

Keywords: Stability; walking; unstable soles construction; plantar pressure; falling; lower limb disorders.

¶Corresponding author.

1. Introduction

Stability during locomotion is a fundamental factor as part of a healthy and happy lifestyle. However, the risk of falling would increase significantly due to different unstable factors in human body, environment and footwear leading to falling injuries, such as ankle sprain, lower limb contusion or even fracture.[1,2] People constantly encounter both internal perturbations and external perturbations that directly influence stability. Internal perturbations frequently occur in daily life with different orientations of body posture, like basic movement of turning, reaching, bending, etc.[3] External perturbations often comes from external circumstances, like uneven ground, stairs, ramps, unstable training device or unstable shoes.[4–7] In general, the whole body balance could be treated as an integration of both internal perturbations and external perturbations. As to the dynamic stability, the ability of keeping gait balance could be divided into the local stability and the global stability.[8]

Falling because of aging is an issue that should not be neglected as the world population constantly expanding, people are living longer and physically more active. A large quantity of studies have been conducted on the injuries of the elderly through different research works, a large proportion of injuries are associated with falling. One in three community dwelling people (aged > 65 years old) experience at least one falling each year and more than 30% of subjects of falling sustain severe injuries that require medical attention.[1,9] Most of the falling injuries were found to be due to tripping with weak muscle strength. The technical explanation for more frequent falling in elderly may be loss of strength, decreased response time, reduced cognition and neuronal noise.[10,11]

The plantar pressure distribution while locomotion is another issue to be considered which directly influence the foot mechanics with different footwear.[12] Based on the previous studies, the pressure distribution and COP (center of pressure) vary remarkably due to different design in certain area of soles in footwear.[13,14] Recently, some specific shoes featuring unstable sole constructions have been introduced in some footwear products to induce neuromuscular stimuli similar to balance training. Typical footwear products include Masai Barefoot Technology (MBT) shoes, it is characterized by a rounded sole in the anterior–posterior direction with a soft pad underneath the rear foot, which are supposed to increase microscopic movement variability during standing[15] and walking,[16] thus enhancing sensory feedback to the locomotor system.[17] Goryachev *et al.*[18] held that manipulations of COP in the sagittal or coronal plane could instantly lead to significant sEMG changes of lower limb muscle, such as coronal shifts of COP relating to activation changes of lateral and medial muscles, or sagittal shifts of COP relating to activation changes of anterior and posterior muscles. Landry *et al.*[19] maintained that the muscles (FDL: flexor digitorum longus; PR: peroneus group; AC: anterior compartment group) activation level is higher than wearing stable shoes or barefoot after conducting a test of before and after a 6-week accommodation period of wearing MBT. This kind