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Effect of shoes with rounded soft soles in the anterior–posterior direction on the center of pressure during static standing

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HIGHLIGHTS

- Static standing posture becomes more unstable when wearing the MBT or SW with curved rocker bottom soles than when wearing more conventionally soled shoes with a typical toe-spring or when barefoot.
- In addition, the MBT has lower stability in the front–back direction than the SW.

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ABSTRACT

Shoes with curved rocker bottom soles may induce an unstable standing posture. This study was aimed to mainly examine the effect of such shoes on the center of pressure (COP) during static standing. Ten healthy young male adults had their COP measured during static standing with four types of shoe conditions (Stretch Walker®: SW (shoes with curved rocker bottom soles), Masai Barefoot Technology®: MBT (similar to SW in form and material), more conventionally soled shoes with a typical toe-spring: MCS, and bare feet: BF) for 60 s. The mean path length and mean velocity of *Y* (front-back) axis were significantly greater when wearing the MBT than when wearing the SW, and when wearing the SW than when BF or when wearing the MCS. In addition, mean velocity of *X* (left-right) axis, area surrounding root mean square, root mean square, and root mean square of *Y*-axis were significantly greater when wearing the MBT than when wearing the SW, MCS, or when BF. In conclusion, when wearing the MBT or SW with rounded sole, static standing posture becomes unstable because of their characteristics as compared with wearing MCS or when BF, but the MBT has a larger sway in the front-back direction than the SW.

1. Introduction

According to Nigg et al. [1], posture stability is very important for walking and it is necessary to wear appropriate shoes that support gait and enforce leg strength for enhanced walking stability. Shoes used for walking or exercise are generally designed to aim at stability of posture and gait. However, it is feared that long-period use of such shoes induces a decrease in leg strength [2,3].

Recently, training devices which aimed at enhancement or decrease-prevention of leg strength have been developed. A wobble board is used as a representative device. It has been reported to improve proprioception of the ankles and knees in addition to increasing leg strength [2,3]. Shoes with rounded and soft soles made with special materials, called Masai Barefoot Technology (MBT), are based on a similar idea. It was reported that wearing these shoes significantly changes gait [1] and provides special stimulation to the leg muscles and leg joints [4]. In addition, it was reported that when wearing these shoes, the sway of center of pressure (COP) during static standing increases in the anterior–posterior and lateral directions [1].

Furthermore, in Japan, "Stretch Walker" (SW) shoes with a curved rocker bottom sole and a soft cushion material in the heel portion of the outsole and forepart have been developed and are currently available on the market. Demura et al. [5] reported that wearing these shoes change gait properties. The SW has characteristics similar to the MBT but has greater stability because the heel

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Fig. 1. Stretch Walker (Nosaka, Japan).

Fig. 2. Masai Barefoot Technology (MBT, Switzerland).

portions are somewhat flat (Figs. 1 and 2). Hence, it was hypothesized that the COP differs when standing while wearing SW and MBT.

It has been reported that static standing posture becomes more unstable because of a curved rocker bottom sole and a soft heel pad when wearing unstable shoes as represented by MBT [1,6–8].

In addition, Lord et al. [9] reported that COP during static standing differed with different types of shoes; however, Wilson et al. [10] and Brenton-Rule et al. [11] reported no significant difference. In short, contradictory results have been reported. Wearing shoes with very special soles such as MBT affects COP during static standing; however, few studies have examined how the degree of round sole angle affects COP during static standing. Hence, the above, in short, the shoes with the different sole round angle would be necessary to examine.

The degree of the round angle of the sole is related to the stability of standing posture and the muscle activity of the legs while walking. In addition, it is assumed that the effect of the above-stated special soles differs between elderly and young individuals with different leg strengths. Shoes with curved rocker bottom soles have been developed for walking. However, a large body sway, even during static standing in elderly individuals with poor leg strength or leg muscle fatigue after walking, entails a risk of falling when wearing the shoes. The results presented here will be useful for the optimal selection of shoes according to individual physical fitness levels. The results will also aid shoe selection for young individuals with the goals of strength training via gait for a short time, or of keeping a comfortable gait for a long time.

This study is aimed to compare the COP during static standing with BF (bare feet) and while wearing SW, MBT, and MCS (more conventionally soled shoes with a typical toe-spring).

2. Materials and methods

2.1. Subjects

Ten healthy young male adults without extremity disorders and with regular exercise habits participated in this study (age: 23.9 ± 3.6 years, height: 171.8 ± 4.1 cm, body mass: 67.6 ± 4.9 kg). Before the experiment, the purpose and procedure of this study were explained to all subjects in detail and an informed consent was obtained. However, subjects were not informed about the characteristics of the shoes. In addition, this study was approved by the Ethics Committee on Human Experimentation of the Faculty of Human Science, Kanazawa University (Ref. No. 2012-08).

Fig. 3. More Conventionally soled Shoes with a typical toe-spring (MCS).

2.2. Materials

2.2.1. Shoe conditions

In this study, three types of shoes were used to examine the effect of rounded soles in the anterior–posterior direction on gait (Figs. 1–3). Shoe with sizes from 24 to 29 cm (US size: 6–11) at intervals of approximately 0.5 cm were prepared, and the subjects selected preferred shoe size after trying on the shoes.

2.2.1.1. Stretch Walker (SW; Nosaka Ltd., Japan). The "Stretch Walker®" (SW) shoes manufactured by Nosaka, Ltd. were used for this study as the shoes with curved rocker bottom soles (Fig. 1). In the case of a 26 cm (US size: 8) size shoe, the height from the ground was 3.8 cm anteriorly and 3.0 cm posteriorly (Fig. 1).

2.2.1.2. Masai Barefoot Technology (MBT; Masai Marketing & Trading AG, Switzerland). The "Masai Barefoot Technology®" (MBT) shoes in which the soles have an ungrounded area while standing upright, with surface area wider than SW, were used for this study as another pair of curved rocker bottom soles (Fig. 2). In the case of a 26 cm (US size: 8) size shoe, the height from the ground was 2.9 cm anteriorly and 4.3 cm posteriorly (Fig. 2).

2.2.1.3. More conventionally soled shoes with a typical toe-spring (MCS). We used more conventionally soled shoes with a typical toe-spring as the control (Fig. 3). In the case of a 26 cm (US size: 8) size shoe, the height from the ground was 2.3 cm anteriorly and 0.2 cm posteriorly (Fig. 3).

2.2.1.4. Barefeet (BF). Posture stability of subjects with BF was measured for the control condition.

2.2.2. Measurement of COP

The measurement instrument was a stabilometer G5500 (Anima, Japan). This instrument can calculate the COP of vertical loads from the values of three vertical load sensors, which are located at the corners of an isosceles triangle on a level surface. The data sampling frequency was 20 Hz.

2.3. Testing protocol

The measurement procedure followed a method prescribed in the standardized stabilometry test [12]. Subjects maintained a