Review

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Unstable shoe construction: influence on gait and posture

T. Masood

Department of Biology of Physical Activity, Faculty of Sport and Health Sciences, University of Jyvaskyla, Finland.

Footwear, in one form or another, have been around for millennia. The advancements in the technology have made possible the transformation of animal skin and fur wrapped around feet by our ancestors into modern-day marvels of athletic shoes. Arguably one of the most pronounced innovations in the field of footwear design is the introduction of unstable shoe construction (USC), over the last few decades. Most widely investigated shoes are the Masai Barefoot Technology (MBT) shoes. Numerous scientific studies conducted on these shoes have revealed their effects on human gait and posture in healthy and morbid populations.

Keywords: Unstable shoe construction, Masai Barefoot Technology, Gait, Posture

Walking is arguably the most primitive mean of locomotion in humans. The most natural form of walking comes in the form of barefoot walking which has been practiced by the ancestors of modern humans for millennia. However the history of foot-wear use while walking is, by no means, a recent one. Of these foot-wears, one common type has been the shoes of various types. Conventionally, the shoes have been designed to provide stability in addition to comfort but an 'unstable' form of shoes has also evolved. The concept behind such shoe construction is to strengthen the leg musculature which is nearer to the axes of rotation.

Evidence in the form of several scientific studies suggests that Unstable Shoe Construction (USC) helps in the prevention and correction of many foot problems and assists in the rehabilitation process. Not only that they are useful in population with health-related problems but can also be beneficial for people who are otherwise healthy, by strengthening the lower leg musculature, improving balance, facilitating blood flow in calf muscles etc. [1-3]

Swiss Masai or Masai Barefoot Technologies (MBT) is credited with the manufacturing of probably the most sophisticated such shoes. The philosophy behind the MBT shoes, in company's own words is; 'In the early 1990s, we realized that both shoes and backache are unknown to the Masai tribesmen - and that there is a causal connection between these two facts. By walking barefoot on the natural soft, uneven ground of their East African homeland, the Masai activate also those muscles that atrophy when on walks on hard, even surfaces wearing conventional shoes.'

Scientific investigations involving USC

Since the arrival of MBT shoes on the scene, several research studies have been undertaken to understand both their health effects and verify the manufacturer's claims. Following are some of the major aspects of MBT shoes that have been studied;

Effect on joint kinematics

MBT has been shown to induce changes in the movement pattern of the ankle joint in the form of increased dorsiflexion at the point of initial contact succeeded by plantarflexion till end of the stance phase. The changes in the movement pattern at the hip and knee level were not so profound. [3] Similar findings were found in a previous study performed on an earlier version of MBT shoes. [4] It is possible that reduced peak hip flexion at initial stance and range of motion over the gait cycle, are due to a decrease in stride length. [5] Another study showed an increase in ankle plantar flexion while standing in MBT shoes and reduced trunk flexion and anterior pelvic tilt at initial contact of gait cycle while walking in MBT foot wear. [2] Researchers compared the kinematics of MBT walking against a stable con-

trol shoe and reported that during walking the joint kinematics were not different apart from a significantly increased dorsiflexion during the first half of stance phase with MBT shoes. [6]

Effect on joint kinetics

The angular impulses have not shown any considerable changes between the MBT and stable shoe conditions for hip, knee and ankle joints during walking but they tend to be lower for the knee and hip joint. For the rotational abduction-adduction loading during take-off, the MBT shoe has shown a reduction. The rotational inversion loading was higher for the MBT for the first half of ground contact. The rotational impulses for the knee joint showed non-significant decreases (16%-83%) for the MBT shoe for all three rotational knee axes. The rotational impulses for the hip joint axes for the second half of ground contact for the MBT shoe showed slight trend towards a reduction for the internal-external rotation axis and only small changes for the abduction-adduction and the flexion-extension rotation axis. [6]

Vernon et al. 2004, concluded that MBT walking resulted in reduced joint moments at hip, knee, and ankle joints in the sagittal plane. The important result from the Ground Reaction Forces (GRF) data is the indication that normal shoes are associated with a greater incidence of transient peaks under the foot compared to MBT shoes while MBT resulted in a significant increase in the vertical impact peak. The latter finding could be directly related to the fact that MBT shoes are heavier in weight than the regular shoes. [7]

Effect on muscle activity

The muscle activity of tibialis anterior and gastrocnemius muscles with MBT has been shown to be different as compared to regular shoe both, while walking [3] and during queit standing. [6] Based on various investigations, it can be concluded that MBT have strong potential as a useful training method for muscle strengthening of the lower leg. Slightly higher muscle activity in muscles around knee could be a sign of caution for the patients with knee problems.

As the trunk leans forward to a lesser extent with MBT shoes during the early stance phase, lower muscle action is required to keep the trunk in erect position which manifests as a decreased muscle activity in the multifidus muscle of the back. [7]

Effect on spatio-temporal parameters and other aspects

MBT shoes have been associated with decreased walking speed and the step length has also been reported to be smaller compared to regular shoe walking. [3] MBT shoes produce certain changes in characteristics of quiet standing and walking posture which could be regarded as beneficial for back pain and osteoarthiritis (OA) management. [2]

Concerning center of pressure excursion, it has been shown to be substantially larger in both anterior-posterior and medio-lateral directions during quiet standing in MBT (unstable) shoes when compared to control stable shoe. [6] When it comes to pain relief, it was concluded that pain can be reduced in patients with moderate knee OA by special shoe intervention. [8]

Another study performed to investigate the plantar pressure redistributing capacity of the MBT showed that 6-week sensory-motor training with such shoes resulted in reduction of fore-foot plantar pressure which can be beneficial for diabetes. [9]

The physiological and biochemical effects of wearing unstable shoes include an improved calf blood flow, an increased concentration of lactate, an increased glycogen metabolism, and a higher nor-adrenalin secretion when compared to regular shoes. [10]

Summary

Some of the major findings regarding the use of unstable shoes can be summarized as follows;

- MBT shoe intervention can reduce pain in subjects with moderate OA [6]
- Unstable shoe produces changes that are advantageous to locomotor system [8]
- Changes posture characteristics in quiet standing and walking which could have positive implications for

management of oteoarthiritis and back pain [2]

- Changes in ankle movement patterns and increase in muscle activity [3]
- A significant shift in in-shoe pressure distribution towards the front of the foot [11]
- Improved calf blood flow, increased glycogen metabolism and higher noradrenalin secretion [10]

While most of the literature signifies more favorable view of the unstable shoe usage, it is important to take caution when using them in certain conditions such as knee OA.

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