The Effects of Masai Barefoot Technology Footwear on Posture: An experimental designed study

Ethics Number: U05/111

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2,698 Words
Abstract

**Objectives:** To assess the anatomical changes in posture that occur as a result of wearing Masai Barefoot Technology (MBT) footwear in quiet standing and walking.

**Method:** A video motion analysis using the Peak Motus Version 8.5 system was used to compare the kinematics of posture wearing MBT shoes and a control condition.

**Results:** Standing in MBT footwear showed a statistically significant increase in plantarflexion at the ankle joint (P = 0.025) [Mean 3.02 degrees, 95% Confidence Interval (CI) -5.6 to -0.4]. At heel strike, walking in MBT’s showed a significant decrease in;

- Trunk flexion (P = 0.007) [Mean 1.44 degrees, 95% CI -2.4 to -0.4]
- Hip flexion (P = 0.003) [Mean 3.26 degrees, 95% CI -5.2 to -1.3]
- Anterior pelvic tilt (P = 0.003) [Mean 3.20 degrees, 95% CI -5.06 to -1.35]

**Conclusion:** MBT footwear changes certain characteristics of posture in quiet standing and walking. These findings could have positive implications for the management of conditions such as osteoarthritis and back pain, however further research is needed.
Introduction

Back pain is a major public health problem in western societies [1]. It is the most common cause of physical disability in the working age population of the United Kingdom [2] and physiotherapists within the National Health Service treat around 1.3 million people for low back pain each year [3]. Conventional therapies are often regarded as being futile in dealing with the problem and treatment remains an area of controversy [4].

Masai Barefoot Technology (MBT) claim that their innovative unstable shoe construction (see figure 1), which simulates walking barefoot on soft undulating ground can promote a more upright posture in which musculature is strengthened and joint wear reduced [5].

According to Romkes et al [6] MBT shoes are widely used across Europe by physiotherapists within rehabilitation medicine to treat a variety of back related complaints. Vernon et al [7] states that if the MBT shoe can be demonstrated to alter loading or posture of the lumbo-sacral spine its application as a tool in the treatment of low back pain will be significant.

Flexion of the vertebral column produces compression anteriorly and stretching or tension posteriorly, increasing the risk of disk damage, nerve compression and
degeneration of the posterior longitudinal spinal ligament [8]. Clinically, most back pain is related to strain and dysfunction [2]. Correction of postural faults and preservation of good alignment as described by Kendall et al [9] have become important aspects of care in the treatment and prevention of back pain [10]. Sahrmann [11] states that ideal alignment facilitates optimal movement and reduces the chance of micro-trauma causing damage to joints and supporting structures.

Poor posture with a greater forward lean of the trunk increases compressive and shearing forces placed on the low back [4]. A shoe which improves posture by promoting a more upright trunk position, for example MBT footwear may reduce stress on the lumbar spine and could be helpful in the prevention and management of mechanical back pain.

The literature states anecdotal evidence suggesting that wearing MBT shoes can produce many beneficial effects [5][6][7][12][13], however scientific research is limited to only 2 published studies [6][12].

Kalin and Segesser [12] inform of the training effect produced by the MBT shoe after a six week period of use. The study does not state for how long each day the shoes were worn or how much walking was performed by the participants to achieve this effect.

A small study of eight subjects by Nigg et al [13] found that the MBT shoe increased the excursion of the centre of force and speculate that MBT footwear maybe useful as a training device for stability and muscle strengthening. Subjects were instructed to
wear the shoes as much as possible for two weeks but no standardised protocol regarding activity level or daily use was stated.

Vernon et al [7] report in a detailed motion analysis of twenty two subjects that MBT shoes promote less forward lean of the trunk during locomotion. The authors do not report setting a standardised procedure for the daily use of the shoe or the level of activity undertaken by participants.

Romkes et al [6] have shown that walking in MBT shoes significantly reduces hip flexion at heel strike; but subjects were given a second instruction session on the correct use of the shoe prior to data collection, this could have added bias to the results.

Research demonstrates that over a two to six week period the MBT shoe produced a training effect [6][7][12][13]. The subjects in all the above studies received an instruction session where they were taught how to use the shoes correctly by a qualified instructor and given a training period. It remains unclear from these studies if the reported changes in posture were as a result of the MBT shoe or the professional instruction and the training periods set, or all three in combination. The purpose of this study was to assess the anatomical changes to posture in the sagittal plane as a result of wearing MBT footwear during standing and walking, without professional instruction or a training period. The following hypothesis was tested:

H$_1$: There will be an anatomical difference in posture during quiet standing and walking when wearing MBT’s compared to a control shoe.
Method

Twelve volunteers were selected to take part in this study (6 male, 6 female), between the ages of 18 and 40. All participants were free from musculoskeletal injury for a minimum period of six months prior to testing and had never used MBT shoes before. A pilot study was conducted on two subjects to test protocol and validity prior to data collection. Written informed consent was obtained from each participant (See appendix A) and the study was approved by the University of Southampton Ethics Committee (Appendix B).

Data was collected in the biomechanics laboratory at the School of Health Professions and Rehabilitation Sciences, University of Southampton. For the control condition subjects wore their own regular training shoes as a representation of footwear available to the general population. Each participant was provided with a pair of MBT shoes, which were worn for the trial condition.

Experimental Set-up

Retro-reflective markers were attached to the right side of the body in locations consistent with a modified Helen Hayes Marker set [14]. Markers were placed over the acromion process, the highest point of the iliac crest, anterior superior iliac spine, posterior superior iliac spine, greater trochanter of the femur, lateral condyle of the tibia, lateral malleolus, posterior aspect of the calcaneum and the base of the 5th metatarsal (close approximation on the shoe) (fig. 2).
A two dimensional motion analysis was conducted using Peak Performance Version 8.5 from Vicon Peak, Oxford, UK, to record kinematic data [15] [16]. Motion analysis systems have been shown to be highly reliable and accurate in the measurement of joint angles [17] [18].

Each participant was asked to stand on a level walkway while a snapshot of quiet standing was captured to film using a Panasonic F1 5HS video camera. Subjects were then filmed as they traversed the walkway (15m) at their preferred walking speed. The test was repeated three times to ensure reliability and eliminate error.

Subjects exchanged their footwear for the MBT shoes and following brief instruction in the correct use of the shoe, as advised by the MBT Research Academy (Appendix C). Participants performed 10 minutes of walking in the laboratory until they felt comfortable in the MBT shoe.

The test was repeated as for the control condition. This was performed for all 12 study participants.
**Data Analysis**

All data was sampled at 50 Hz (50 fields per second) and transferred to computer using a Panasonic AG7350 video recorder. Data was captured to the PC using Peak Motus via a Canopus ADVC1395 video card to calculate resultant joint angles and smoothed using a Butterworth filter. Angles of the trunk, pelvis, hip, knee and ankle were then compared in both shoe conditions whilst standing and at right heel strike, mid stance and toe off during one step of the gait cycle.

**Statistical Analysis**

All statistical tests were performed using SPSS version 12.0.0. Mean and median values were calculated and compared to determine if data was normally distributed and within reasonable limits to allow the use of a parametric test. Three gait trials in each condition were averaged for all subjects and paired \( t \)-tests were applied to kinematic data to determine changes between standing and walking in both shoe conditions. The results for the pelvis at heel strike were not normally distributed and were analysed both parametrically and non-parametrically with a Wilcoxon signed ranks test [19] which produced the same significant result. The level of significance was set at \( P < 0.05 \) to reduce the risk of a type I error.
Results

Standing in MBT shoes showed a statistically significant ($P=0.025$) increase in plantar flexion at the ankle joint when compared to the control shoe. The results of the kinematic data for standing in both shoe conditions are presented in Table 1.

Table 1

Results for quiet standing.

<table>
<thead>
<tr>
<th>Joint</th>
<th>Mean Angles</th>
<th>Confidence Interval</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Own</td>
<td>MBT</td>
<td>Difference</td>
</tr>
<tr>
<td>Ankle*</td>
<td>90.86</td>
<td>93.88</td>
<td>3.02</td>
</tr>
<tr>
<td>Knee</td>
<td>176.81</td>
<td>176.86</td>
<td>0.06</td>
</tr>
<tr>
<td>Hip</td>
<td>86.87</td>
<td>88.03</td>
<td>1.16</td>
</tr>
<tr>
<td>Pelvis</td>
<td>-6.28</td>
<td>-5.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Trunk</td>
<td>90.29</td>
<td>90.66</td>
<td>0.37</td>
</tr>
</tbody>
</table>

* = Statistically significant

At heel strike walking in MBT’s showed a decreased forward lean of the trunk in ten subjects, as seen in fig. 3 ($P=0.007$) and a reduction of anterior tilt of the pelvis when compared to the X axis (fig. 4).
The effects of MBT shoes on trunk flexion at heel strike

![Graph showing the effects of MBT shoes on trunk flexion at heel strike.](image)

Fig. 3. Difference in angle of trunk flexion between MBT shoes and the control shoe.

The effects of MBT shoes on pelvic tilt at heel strike

![Graph showing the effects of MBT shoes on pelvic tilt at heel strike.](image)

Fig. 4. Difference in angle of pelvic tilt between MBT shoes and the control shoe.

There was less flexion found at the hip joint (P=0.003) (see figure 5), and a slight increase in knee flexion (P=0.048) at heel strike when wearing MBT’s.
The effects of MBT footwear on hip flexion at heel strike

Fig. 5. Difference in hip flexion between MBT shoes and the control shoes.

At toe off a significant reduction in anterior pelvic tilt (P=0.035) was observed in the MBT shoe (fig. 6).

The effects of MBT shoes on pelvic tilt at toe off

Fig. 6. Difference in pelvic tilt at toe off between MBT shoes and the control shoes.

There was no significant difference found between the two shoe conditions at mid stance (Appendix D).
The data shows changes to upright posture in the sagittal plane have occurred as a result of wearing MBT’s, therefore the experimental hypothesis can be supported. These small but statistically significant changes in posture were seen in standing and walking when compared to the control shoe.

**Discussion**

This study shows the MBT shoe significantly increased plantarflexion at the ankle joint during quiet standing. Although somewhat expected due to the shoe’s thick wedge shaped sole it does suggest a link to the work of Nigg et al [12] and Romkes et al [6] who found that the shoe increased muscle activity of the triceps surae and improved ankle stability during stance phase. These authors propose that MBT shoes could be useful as a training tool to strengthen the muscle of the lower leg. A trend towards a reduction in hip flexion and anterior pelvic tilt was observed in standing, however these readings never reached the level of statistical significance ($P<0.05$) and therefore no further conclusions can be drawn.

In walking most of the anatomical changes to posture were seen at heel strike, which was defined as the point where the MBT’s soft heel made initial contact with the ground [20]. This is an important part of the gait cycle as it is the moment when the body’s centre of gravity is at its lowest and stability should be at a maximum [21]. Shumway-Cook and Woollacott [22] state that as stance phase begins the impact force of foot strike must be absorbed for postural stability. The large compressive impulse of heel strike must be filtered through the knee, hip and pelvis into the spine [23]. Therefore an optimal alignment of body parts assists in load transference as the stabilising limb is preparing for weight acceptance [21]. Hence there is a
biomechanical relationship between gait style and lumbar stress, where poor alignment can have a cumulative effect creating a pattern of lumbosacral strain that can lead to pain and spinal injury [24].

Greenman [25] states that the biomechanics of the pelvis are such that at right heel strike the right iliac bone rotates posteriorly with respect to the sacrum causing nutation at the sacroiliac joint (SIJ), which according to Vleeming et al [26] increases posterior ligamentous tension and compression of the SIJ [25]. These authors [25] state that although these movements are only very small, an increased nutation of the SIJ prepares the joint for the impact of heel strike. Wearing MBT shoes showed a reduction in anterior pelvic tilt at heel strike, which may suggest that the SIJ was in a position of increased nutation and therefore the joint in a more stable position. This could be an important finding for those with lower back syndromes but further research is needed.

The unstable MBT shoe construction reduced the amount of trunk flexion causing subjects to stand in a slightly more upright position. Snijders et al [27] state that people with low back pain tend to adopt a slightly stooped position reducing the lumbar lordosis and increasing loads placed on dorsal structures at the lumbopelvic level. It is however, not possible in this study to indicate where this change in trunk flexion occurred or if the MBT shoe altered loading or posture of the lumbosacral spine in anyway.

A reduction in hip flexion was seen at heel strike when wearing the MBT shoes, which according to Romkes et al [6] is due to a decrease in stride length and a slower cadence, suggesting that MBT’s alter the gait style used by subjects in their regular
shoes. A slower pace of walking changes the pattern of joint loading so that the joints can safely cope with the high forces of gravity placed upon them and appropriately loads the antigravity muscles, thus strengthening joint protection mechanisms and reducing the risk of musculoskeletal injuries that may cause low back pain [28].

The MBT shoe demonstrated a small but statistically significant increase in knee flexion which may possibly be related to increased hamstring activity to control the limb at heel strike and prevent knee hyperextension [20]. Inman et al [29] have shown that the hamstrings become eccentrically active just before heel strike. Lee [30] states that contraction of the biceps femoris muscle increases tension of the sacro-tuberous ligament contributing to pelvic stability. This further supports the use of the MBT shoe as a training aid and suggest it may have a role in assisting the promotion of stability across the SIJ which has been identified as a primary cause of low back pain [31].

At toe off the MBT shoe again demonstrated a small reduction in anterior tilt of the pelvis. This increases the angle of hip extension relative to the pelvis and may as Whittle [20] points out put increased tension on the hip ligaments as the joint reaches its maximal position of extension in the gait cycle. Increased hip extension helps to generate a greater flexion moment as the hip flexors muscles fire to produce swing phase [20]. As a result the load placed upon the iliopsoas structure is reduced and overuse of the muscle avoided. Dananberg [32] states overuse of iliopsoas can cause disc shearing producing back pain.
Limitations

In this study the MBT shoe promoted a more ideal anatomical alignment at heel strike and toe off, however it is not possible to determine the clinical relevance of these changes to posture. Due to the small sample group used the results cannot be generalised to a wider population and the study is susceptible to a type II error.

Although every attempt was made to ensure validity and reliability it must be appreciated that the author is a novice researcher and it is therefore quite possible that a degree of operator error and bias have occurred. The study was a two dimensional motion analysis which presented problems with accuracy when markers were occluded by the upper limb while subjects were walking. The marker position had to be estimated digitally by eye and therefore reliability reduced. Although the equipment was deemed accurate by research [16] [17] [18] and every effort made to ensure markers were placed on the correct bony landmarks, there remains the possibility that movement of the skin over the landmarks could have effected data accuracy.

An interesting difference between this study and those previously conducted was that participants received neither formal instruction by a qualified instructor on the correct use of the shoe, nor was there any training period allowed. Therefore the changes seen are more likely to be as a result of the MBT shoe; but it is not known if this has prevented the shoes from demonstrating a greater effect on upright posture.
Conclusion

In summary this study has shown that wearing MBT shoes changes certain characteristics of posture in quiet standing and walking. This suggests that the footwear promote a more optimal skeletal alignment helping to oppose the forces of gravity and protect joints from injury, which could have positive implications for the treatment and management of musculoskeletal conditions such as osteoarthritis and back pain. However, no firm conclusions can be drawn from this study and further research is needed. Future investigations need to be conducted with larger sample groups on subjects who express clinical postural dysfunction and mechanical back pain.
References:


Appendix A
Appendix B
Appendix C
Appendix D
<table>
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<tr>
<th>Joint</th>
<th>Own</th>
<th>MBT</th>
<th>Difference</th>
<th>SD</th>
<th>Lower</th>
<th>Upper</th>
<th>P value</th>
</tr>
</thead>
<tbody>
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<td>98.47</td>
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<td>4.80</td>
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<td>1.70</td>
<td>0.01</td>
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<tr>
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<td>1.51</td>
<td>-2.41</td>
<td>-0.48</td>
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Table 2: Results for heel strike. * = Statistically significant

<table>
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<th>MBT</th>
<th>Difference</th>
<th>SD</th>
<th>Lower</th>
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<td>90.07</td>
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<td>2.93</td>
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<td>0.53</td>
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<td>1.50</td>
<td>-1.90</td>
<td>0.001</td>
<td>0.05</td>
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Table 3: Results for mid stance.

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<th>Joint</th>
<th>Own</th>
<th>MBT</th>
<th>Difference</th>
<th>SD</th>
<th>Lower</th>
<th>Upper</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>111.08</td>
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<td>5.77</td>
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<td>0.28</td>
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<td>1.14</td>
<td>0.60</td>
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</table>

Table 4: Results for toe off. * = Statistically significant