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Review

The effect of Masai Barefoot Technology (MBT) footwear on lower limb biomechanics: A systematic review

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ABSTRACT

This systematic review evaluated the available evidence for the effects of Masai Barefoot Technology (MBT) footwear on lower limb biomechanics during gait. Electronic databases (MEDLINE, EMBASE, CINAHL, SPORTDiscus, and PubMed) were searched in January 2015. Methodological quality of included studies was evaluated using the Quality Index. Standardised mean differences and 95% confidence intervals were calculated, and meta-analysis was conducted where possible. 17 studies satisfied the inclusion criteria; 16 cross-sectional studies and one randomised control trial (RCT). Quality Index scores ranged from 7 to 12 (out of 15). All 17 studies investigated walking gait only. Evidence showed that MBT footwear caused asymptomatic individuals to walk with a shorter stride length, *reduced* peak hip flexion, *increased* peak knee extension, and *reduced* hip and knee range of motion throughout gait. All kinematic effects occurred in the sagittal plane. There was a trend towards a *decrease* in internal and external joint moments and power, except for the foot, where *increases* in force were observed. There were only a small number of changes to lower limb muscle amplitude and timing. No statistically significant effects were observed in symptomatic individuals with knee osteoarthritis or following total knee replacement, but there was an *increase* in cadence and a *decrease* in step length in individuals following tibiotalar arthrodesis. These findings suggest that MBT footwear does change lower limb biomechanics in both asymptomatic and symptomatic individuals during gait. However, further clinical trials need to be undertaken to determine whether these changes are therapeutically beneficial.

1. Introduction

Shoes have traditionally been used to protect the foot, but more recently, the function of shoes has evolved to improve foot and lower limb function. There are several shoes types which are now commercially available that are able to control and potentially change lower limb biomechanics. The Masai Barefoot Technology (MBT) shoe, constructed with a shock-absorbing cushioned heel and rounded sole in the anterior–posterior direction (known as a rocker sole), is designed to improve walking by transforming a flat, hard, surface into an unstable surface [1].

MBT footwear has been reported to improve upright walking posture [2], reduce lower limb joint motion and loading [2–5], increase tactile sensory feedback [6] and alter muscle activation patterns [2,3]. These effects have been shown to be useful for the prevention and treatment of a number of musculoskeletal conditions including lower back and knee pain [1].

Several studies have investigated the effect of MBT shoes on lower limb biomechanics predominantly in asymptomatic populations, with few studies investigating symptomatic populations, such as those with knee osteoarthritis [6,7], knee implants [8] and

Abbreviations: MBT, Masai Barefoot Technology; ROM, range of motion; GRFs, ground reaction forces; COP, centre of pressure; EMG, electromyography; SMD, standardised mean difference; CI, confidence interval; QI, Quality Index; RCTs, randomised controlled trials; ICC, intra-class correlation coefficient; "Foot force minima", minimum force generated by the entire foot during the midstance phase of gait.

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those with tibiotalar arthrodesis [9]. However, to date, no study has systematically reviewed the effects of MBT footwear on lower limb biomechanics. Therefore, the aims of this systematic review were to (i) identify, appraise and summarise the available evidence for the effects of MBTs on lower limb biomechanics in asymptomatic and symptomatic populations, and (ii) provide guidance for further research in this area.

2. Methods

This systematic review was developed and reported in accordance with guidelines provided by the Preferred Reporting of Systematic Reviews and Meta-Analysis (PRISMA) statement [10].

2.1. Eligibility criteria

Studies included in this review were obtained from English peer-reviewed journals evaluating the effects of MBT footwear on spatiotemporal (cadence, double support time, velocity, step length and stride length), lower limb (hip, knee, ankle, foot) kinematic (joint range of motion [ROM] and angles) kinetic (ground reaction forces [GRFs], joint moments and power, impulse), centre of pressure (COP) and plantar pressure variables, as well as muscle function (electromyography [EMG]) during walking. Additionally, inclusion criteria were; (1) human participants aged over 18 years or older; (2) experimental design with a control group (either cross-sectional or longitudinal); (3) specifying the use of MBT footwear; (4) asymptomatic or symptomatic participants (such as those with osteoarthritis or post-surgery). Studies were excluded if they used rocker sole shoes that were not MBTs; were a case-series design (study with no control group); and non-peer reviewed publications. Additionally, we excluded reviews, non-English publications, letters and opinion articles.

2.2. Search strategy

MEDLINE, EMBASE, CINAHL, SPORTDiscus, and PubMed electronic databases were searched from inception until January 2015. The search strategy used a combination of search terms derived from Medical Subject Headings (MeSH) and keywords specified to the research question (Table 1). The reference lists of all included articles were also hand searched to identify any studies meeting the inclusion criteria.

2.3. Study selection

All studies identified by the search were exported into Endnote X6 (Thomson, Reuters, Carlsbad, CA) by a single investigator (JMT), cross-referenced, and any duplicate references were deleted. Each title and abstract was evaluated for potential inclusion by two independent reviewers (JMT and MA). Any discrepancies between the two reviewers were resolved with a consensus meeting. If consensus could not be reached, a third reviewer (SEM) was consulted.

2.4. Data extraction

Two reviewers (JMT and MA) extracted data including publication details (author, year), participant characteristics (sex, height, weight, body mass index, population [e.g. university students]), and study characteristics (aim, design, style of MBT footwear used, number of participants, use of habituation periods, biomechanical variables investigated [spatiotemporal, kinematics, kinetics, and muscle function]). Means and standard deviations for lower limb biomechanical variables were extracted to allow calculation of effects, reported as standardised mean differences (SMDs) and 95% confidence intervals (95% CIs). This was done to allow comparison of effects for different biomechanical variables and also to allow for meta-analysis when the same parameter was

Table 1
Search strategy.

	Search terms	MEDLINE	EMBASE	CINAHL	SPORTDiscus	PubMed
1	spatiotemporal. mp. OR temporospatial. mp.	15,892	18,126	521	423	15,762
2	kinematic*.mp.	92,443	95,845	6006	12,196	23,791
3	kinetic*.mp. OR exp kinetics/	608,769	738,609	2087	136,561	628,305
4	biomechanic*.mp. OR exp biomechanics/	102,727	99,122	12,013	444	116,340
5	EMG.mp.	24,967	36,286	2892	26,048	80,936
6	Electromyography*.mp. OR exp electromyography/OR exp electromyogram/OR exp electromyograph/	76,165	80,415	9237	5381	80,731
7	IEMG.mp.	527	578	100	532	551
8	exp muscle/OR muscle*.mp.	893,977	1406,856	52,748	644,577	777,288
9	muscle*.mp. OR exp Muscles/AND function.mp.	118,151	236,895	7532	7763	561,602
10	muscle*.mp. OR exp Muscles/AND activity.mp.	155,582	235,602	8304	9587	156,650
11	motion.mp. OR exp motion/OR exp "range of motion, Articular"/	195,581	297,465	27,229	45,552	208,974
12	OR/1-11	1,739,254	2,355,844	88,956	166,665	910,014
13	MBT.mp.	1469	1876	43	44	1504
14	masai AND barefoot.mp.	24	25	13	26	23
15	(rocker AND shoe*).mp.	100	86	26	44	121
16	(rocker AND foot*).mp.	117	260	51	57	188
17	(rocker AND sole).mp.	55	80	20	21	62
18	(roll AND over).mp.	2644	1549	199	284	1484
19	(unstable AND shoe*).mp.	68	94	15	37	83
20	OR/13–19	4343	3758	311	409	3245
21	gait.mp. OR exp gait/	36,921	54,995	9896	10,809	39,127
22	exp walking/OR walk*.mp.	81,234	136,829	20,245	21,818	26,755
23	exp running/OR run*.mp.	135,779	191,576	15,656	95,229	62,074
24	exp jogging/OR jog*.mp.	15,078	18,377	387	5034	463
25	OR/22–25	236,281	341,189	40,657	122,766	250,144
26	12 AND 21 AND 26	230	222	43	85	128
27	limit 26 to English language	220	210	43 (42 peer reviewed)	82 (79 peer reviewed)	39