Gait & Posture 46 (2016) 142–146

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Does "transition shoe" promote an intermediate biomechanical condition compared to running in conventional shoe and in reduced protection condition?

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ARTICLE INFO

Article history:
Received 6 February 2015
Received in revised form 9 March 2016
Accepted 10 March 2016

Keywords:
Biomechanics
Ground reaction force
Kinematic
Barefoot
Minimalist

ABSTRACT

This study evaluated if running in a "transition shoe" commercially available results in intermediate mechanical load upon lower extremities compared to conventional shoe and minimalist shoe/barefoot. Kinematic and kinetic parameters while running in different shoe conditions were compared. Fourteen runners (12 men, 2 women; age = 28.4 ± 7.3 years), inexperienced in minimalist shoes and barefoot running, ran on an instrumented treadmill within four experimental conditions (conventional shoe – CS, transition shoe – TrS, minimalist shoe – MS, and barefoot – BF). Running was performed at 9 km/h for 10 min in each experimental condition. Vertical ground reaction force (VGRF) and two-dimensional kinematic variables of lower limbs (both legs) were recorded. Nine data acquisitions (10 s) were conducted for each footwear condition. Transition shoe lead to significant changes in VGRF variables related to impact control, while kinematic parameters were little affected. The TrS had smaller first peak of VGRF (Fy1) than CS ($p \leq 0.001$) and higher than MS ($p = 0.050$) and BF ($p \leq 0.001$). Time to first peak of VGRF (tFy1) of TrS was smaller than CS ($p \leq 0.001$) and higher than MS ($p \leq 0.001$) and BF ($p \leq 0.001$). The TrS and MS induced to lesser knee flexion ($p < 0.001$) and greater dorsiflexion ($p < 0.001$) than CS and BF. Thus, results suggest the transition shoe (TrS) tested seem to promote an intermediate mechanical load condition only for VGRF parameters, presenting values of impact forces between those found for conventional shoe and minimalist shoe/barefoot. Such knowledge could be useful for the transition process from conventional running shoe to minimalist shoe/barefoot.

1. Introduction

Despite footwear industry efforts to develop modern running shoes and protective elements, the incidence of running injuries is still high. About 20–80% of runners suffer lower-extremity injuries over the course of a year [1], predominantly stress injuries and usually in the knees [1,2]. Running in conditions characterized by minimal external protection (barefoot/minimalist shoes) [3,4] has been suggested as training approach to improve performance [5–8], to attenuate mechanical load [4,9–11] and to minimize injury rate [12,13] in regular running.

Minimalist/barefoot running seem to decrease joint power [11,14,15], to change parameters of vertical ground reaction force (VGRF) related to impact [4,9–11], and to alter parameters of running technique, as spatiotemporal variables and foot-strike pattern [9,10,16–18]. Improvements in impact forces control, as less incidence of first peak of VGRF (Fy1) or smaller magnitude of Fy1 and loading rate (LR) are reported [9,10]. Also, minimal running led to forefoot-strike pattern, while heel-strike pattern is observed for shod running [9,10], increased stride frequency, reduced stride length and changed joint angles [3,11,16]. Believing these improvements on impact regulation and protective mechanisms could reduce injury risk [4,10,12], many runners (31–34% of runners) have adopted minimalist/barefoot running seeking to prevent injuries [12,19].

However, no sufficient evidence is available to fully support that reduced protection running prevents injuries. Other evidences suggest minimalist/barefoot running has no influence [20] or increases injury risk [21–26]. Recent studies reported increased impact forces [22], peak of plantar pressure under almost the entire foot [26] and joint power [7,11,14,15] during running under these conditions. Moreover, stress fractures have been reported by minimalist runners [23–25,27].

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http://dx.doi.org/10.1016/j.gaitpost.2016.03.008
0966-6362/

A critical point between benefits and harms of reduced protection running seems to be the transition to this mechanical condition. Injured runners presented an abrupt transition to reduced protection running [23–25,27]. How the transition from conventional shoe to minimalist/barefoot condition is done must concern [17,23–25,27] and should be considered an important factor to get the benefits of minimal running [25,27]. However, how to develop the transition appropriately is not clear. Considering the wide variety of minimalist shoes, a practical way of transitioning is by footwear.

Multiple footwear manufacturers offer self-described "minimalist shoes". Despite the lack of an industry standard or formal definition, they typically contain reduced cushioning, lower heel height, lower heel-forefoot offset, high flexibility, lack stabilizing device and are lighter than conventional shoes. Minimalist shoes can vary in design characteristics from very minimalistic to more structured shoes [15]. Some of them have heel height and heel-forefoot offset lower than conventional shoes, but higher than minimalistic shoes, being classified as "transition shoes". Market establishes transition shoe would promote an intermediate mechanical condition compared to conventional shoe and minimalist/barefoot running. Recently, Squadrone et al. [28] observed the magnitude of acute adaptations in heel-foot strikers varies across the different types of minimalist shoe models. Thereby, a transition shoe could be an effective and useful option for transitioning appropriately from conventional shoe to barefoot/ minimalist shoe. Nevertheless, this is still an assumption and must be tested. As far as we know, there are no studies about the effectiveness of transition shoe, neither how to transition from conventional shoe to minimal running.

Thus, the purpose of this study was to test the effect of different footwear conditions upon kinetic and kinematic parameters of running, and evaluate if a "transition shoe" commercially available promotes an intermediate mechanical condition when compared to conventional shoe and reduced protection running. It is hypothesized the transition shoe will present values of biomechanical parameters between those found for conventional shoe and minimalist shoe/barefoot.

2. Methods

Fourteen recreational runners (12 men, 2 women; age = 28.4 ± 7.3 years; mass = 72.7 ± 7.8 kg; height 1.74 ± 0.06 m) were recruited for the study. Inclusion criteria were: participants should be 18–40 years old; be experienced in running, but without experience in minimalist/barefoot running; be habitual rearfoot strike pattern; had a minimum of 6 months in regular running training and of experience in running on treadmills. Our runners had 7.7 years of experience in running, average weekly volume of 88.3 km accomplished in 4–5 training sessions (22.1–17.7 km per session) and average training speed of 12 km/h. Participants were excluded if they had suffered any orthopedic injury in the last 12 months or had any experience in barefoot running or in minimalist shoes. Additionally, participants who presented habitual forefoot strike pattern were excluded. Physical condition and perception of effort were qualitatively monitored throughout the test by an adapted Rated Perceived Exertion (RPE) Scale to check fatigue. In case of exhaustion, the test was interrupted and participant was excluded. The cut-off value of RPE Scale used to define exhaustion was 17. Information about running experience, volume training and injury history were self reported. All participants read and signed an informed consent form. The experimental design was approved by the local ethics committee.

Participants ran under four experimental conditions: conventional shoe (CS), transition shoe (TrS), minimalist shoe (MS) and barefoot (BF). Three different models from New Balance® were used for shod conditions (Fig. 1). The New Balance® models were chosen because NB Minimus is reported as one of the most adopted minimalist shoes by runners [19]. Information about shoes characteristics is provided in Table 1.

To standardize measurements of shoes characteristics, all reference values refer to the size 43 EUR. All running shoes were new, without any structural damage that could change or limit the motion execution.

Test session started with sixteen reflexive markers being attached to the right and left lower limbs. Standing position was adopted as neutral position. Thus, 90° and 0° were established as neutral ankle and knee/hip angles, respectively. Markers were attached in sagittal plane, at the following anatomical points: 5th metatarsal, lateral malleolus, lateral condyle, greater trochanter and iliac spine anterior-superior. For shod conditions, 5th metatarsal was identified by touching the participant wearing shoe and set a mark on the footwear where the marker should be attached.

Then, participants performed a 5-min warm-up and familiarization to experimental environment at self-selected speed on treadmill. After this procedure, participants ran for 10 min in each

Fig. 1. In addition to barefoot, the shoes tested in the study were: conventional (A), transition (B) and minimalist (C) running shoes.

Table 1
Information about construction and characteristics of each shoe model tested.

	Conventional shoe	Transition shoe	Minimalist shoe
Shoe model	NB 759	NB 890	NB Minimus MR10BG
Heel height (mm)	45	40	25
Heel-forefoot offset (mm)	18	12	4
Weight (g)	280	250	209
Shoe construction	Upper: nylon (polyamide) polyvinyl chloride (PVC) – "mesh" technology; Inner sole: ethylene vinyl acetate (EVA); Midsole: viscoelastic materials (EVA, fiber of carbon polyoxymethylene); Outsole: rubber	Upper: nylon (polyamide) polyvinyl chloride (PVC) – "mesh" technology (made of synthetic materials); Midsole: viscoelastic material, 30% lighter; Outsole: rubber	Upper: nylon (polyamide) polyvinyl chloride (PVC) – "mesh" technology (made of synthetic materials); Midsole: viscoelastic material, 30% lighter; Outsole: rubber (All materials used in smaller amount)