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ORIGINAL ARTICLE

Heel lifts stiffness of sports shoes could influence posture and gait patterns

La rigidité des talonnettes à plan incliné des chaussures de sport pourrait affecter les paramètres de la marche et de posture

S. Hessas [a,b], **M. Behr** [a], **M. Rachedi** [b,*], **I. Belaidi** [b]

[a] *Laboratoire de biomécanique appliqué, IFSTTAR, faculté de médecine, Aix-Marseille université, secteur Nord boulevard Pierre-Dramard, 13916 Marseille cedex 20, France*
[b] *LEMI, équipe de recherche mécanique et ingénierie des systèmes et procédés, université Boumerdes, Algeria*

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KEYWORDS
Stiffness;
Heel lift;
Plantar pressure;
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Comfort

Summary
Purpose. — The aim of this study was to investigate how different commercial heel lift stiffness could affect gait and posture patterns, in order to propose to athletes the most appropriate which can reduce injury risk by moderating the effects of repeated impacts, plantar pressure and excessive pronation or supination.
Methods. — Ten healthy young male volunteers were asked to wear successively three pairs of heel lifts, with identical geometry but different stiffness. Static tests consisted in measuring plantar pressure distribution and center of mass position. Dynamic tests consisted of kinematics and reaction force measurements at both imposed and preferred frequency.
Results. — No significant anterior-posterior displacement of the center of mass was found. Peak pressure on the calcaneus was found significantly different, although metatarsal pressures were found unaffected. Dynamic tests revealed significant modifications in the reaction forces. Heel lift stiffness was found to significantly modify posture and gait patterns and should therefore be considered in the insole design process. Our findings suggest that low stiffness insole is not necessarily the most appropriate to reduce plantar pressure levels.

* Corresponding author.
E-mail address: medrachedi@yahoo.fr (M. Rachedi).

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MOTS CLÉS
Rigidité des talonnettes inclinées ;
La pression plantaire ;
Centre de pression ;
Confort

Résumé
Objectif. — Le but de cette étude était d'étudier comment les différentes raideurs des talonnettes pourrait affecter les paramètres de la marche et de la posture, afin de proposer aux athlètes la semelle la plus appropriée qui peut réduire le risque de blessures en modérant les effets de chocs répétés, les pressions plantaires et la pronation, ou supination excessive.
Méthodes. — Dix volontaires sains de sexe masculin ont été invités à porter successivement trois paires de semelles a talon incliné, avec géométrie identique mais à rigidité différente. Les essais statiques ont consisté à mesurer la distribution des pressions plantaires et la position du centre de masse. Les tests dynamiques consistaient de la cinématique et les mesures de force de réaction à la fois en fréquence imposée et préférée.
Résultats. — Il n'a pas été trouvé de déplacement significatif du centre de masse dans la direction antéropostérieure. Le pic de pression sur le calcanéum a été trouvé significativement différent, bien que des pressions du métatarse restent invariables. Les tests dynamiques ont révélé qu'en termes de force de réaction, les modifications sont significatives. La rigidité du talon incliné modifie de manière significative les paramètres de posture et la marche, cependant elle doit être prise en compte par les athlètes et aussi dans le processus de fabrication de semelle.

1. Introduction

Designing footwear to improve performance and comfort is a complex process involving athletes, designers, medical practitioners and scientists. In recent years, footwear has evolved dramatically. Sports shoes now include a wide range of materials that are selected for their properties to support the lower limb and assist with locomotion. These features include plastic reinforced heel counters, wedge shaped midsoles of varying densities and height, and air or gel insoles. Shoes sport manufacturers offer different grades of shoe properties, ranging from less to more support and cushioning, designed to match individual foot types through the use of different combinations of these features. This is a human engineering problem involving knowledge on how footwear geometrical and mechanical characteristics may alter the biomechanical parameters of human posture and gait such as kinematics, kinetics and electromyography. The characteristics of a shoe are numerous, starting with vertical outsole thickness, width and architecture of the plantar support, and materials used. Each of these parameters may have an impact on comfort, safety, and performance.

Heel lifts play a major role in footwear design and their influence on human walking has been widely investigated. There is an overall agreement that, to some reasonable height, the influence on posture and gait is positive. Heel lifts limited to 20 mm were reported to have a protective effect for the muscles of the posterior muscle chain (triceps of the leg, hamstrings, muscles of the back) that are significantly involved in the function of gait [1]. Heel lifts were also reported as being possibly more effective in restoring gait speed, standing and walking symmetry and balance than any conventional treatment programme [2]. Higher heel lifts, that is over 45 mm, are more questioned and pointed out in literature as possible factors of gait troubles. They can affect muscle balance [3] up to muscle overuse and strain injuries [4—6] and lead to the development of postural disorders and altered temporospatial gait parameters [7], depending on age of wearers [8—11] and experience [12].

The use of a total-contact inserts or cushioning insoles in running shoes were reported to improve comfort rating and footstability [13], as well as to favor posturalbalance and control [14]. Interactions between running shoes and different types of ground were also investigated, pointing out possible active adaptation strategies in users [15—17]. To our knowledge, besides heel lift geometry, other characteristics such as plantar support stiffness, whatever the shoe type or the heel lift height, has received insufficient focus and should be investigated further.

The objective of the present study was to determine the effect of heel lifts material stiffness (soft, medium and hard) on posture and gait patterns with particular attention paid to plantar pressure distributions, ground reaction forces and displacement of the body center of pressure.

2. Methods

2.1. Subjects and test configurations

Ten healthy young male volunteers (age: 23.8 ± 44 years, height: 175.5 ± 7.1 cm, mass: 70.9 ± 8.7 kg), free from injury for at least 12 months prior to participation, took part in this study. All volunteers provided written informed consent prior to participation. They were asked to wear successively three pairs of different heel lifts, all of them having the same geometry but different stiffness. As illustrated in Fig. 1, these lifts were all built with one same rigid lower wedge associated on top of it with a layer of foam material of 3 different hardness properties, i.e. respectively 10, 35 and 65 shore A. The thickness of each upper layer was adjusted so as to end with the same resulting lift height of 20 mm once compressed by the volunteers weight, considering an average weight of 71 kg. In these conditions, heel lift supper layer stiffness can be considered as the only parameter that changes from one configuration to another.