Biomechanical Effects of Different Footwear on Steady State walking

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ABSTRACT

The objective of this work is to evaluate the biomechanical effects of footwear on steady state walking of a user. An initial subjective preference of the footwear was identified which was validated biomechanically in relation to the kinetic parameters of gait. The subject underwent 3D gait analysis (using VICON Motion Capture System, UK) under four conditions: barefoot, with formal shoes, with casual shoes and with sandals. ANOVA and Paired t-test of Temporal Spatial Parameters (TSP), joint powers and joint moments (α = 0.05), for the four conditions in sagittal plane showed that there were significant differences found in TSP’s, joint moments and work done, but not in joint powers. The behaviour of formal shoes was significantly different in the frontal and transverse plane moments and had the most profound effect on the joints. Although several hypotheses on the implications of footwear on the gait parameters are proposed, these require further investigation, supplemented with electromyography (EMG) and metabolic energy measurements for a larger population.

KEYWORDS

Biomechanics, Footwear, Gait, Kinetics, Shoes, Steady State Walking, Work Done

LIST OF ABBREVIATIONS

ANOVA: Analysis of Variance
EMG: Electromyography
GRF: Ground reaction force
ISw: Initial Swing
LR: Loading Response
MS: Mid-Swing

DOI: 10.4018/IJBCE.2016010102

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INTRODUCTION

The application of motion analysis systems for investigating the effects of footwear on orthotic interventions and surgical procedures has been increasing the world over as well as in South East Asia. Several studies have been conducted to test the relationship of footwear types and their effects and have reported to have significant effects on human gait kinematics, kinetics, muscle activities, and pathogenesis. For example on, loading rates (Smith, Dyson, & Janaway, 2004), step/stride length, cadence and single/double support phases (Majumdar et al., 2006), hip and knee kinematics (Myers et al., 2006), kinematics and kinetics of ankle joint (Cikajlo & Matjačić, 2007), fore-to-rear foot eversion amplitude (Morio, Lake, Gueguen, Rao, & Baly, 2009), muscle activity (Barton, Coyle, & Tinley, 2009), net joint moments (Keenan, Franz, Dicharry, Croce, & Kerrigan, 2011), patellofemoral joint stress (Ho, Blanchette, & Powers, 2012) and amplitude of GRF and ankle joint moment (Horsak & Baca, 2013).

With such key importance of the ankle joint in normal walking, and a large population using sandals, formal shoes, and casual shoes for daily activities, an understanding of the effects of these commonly used footwear on ankle joint power and work is imperative. A better understanding would help identifying optimal footwear that facilitates the energy flows from the ankle to more proximal joints such as the knee and hip. Optimal energy flows would decrease the requirement of additional/compensatory muscle work, leading to reduced pain in musculature and allowing the user to wear it for prolonged periods with less discomfort. Therefore, the work described here is aimed to quantify the influence of joint moments in three planes, powers and work performed at the ankle by using generally used footwear. It is anticipated that the results obtained from biomechanical analysis would provide answers for subjective preference in selection of particular footwear, and would enable the user to consider which factors to consider before buying particular footwear.

METHODOLOGY

Subject

The subject volunteered for this study was a 34-year-old healthy male having no known physical or neurological impairment. A written consent was also taken from the subject. Only one subject was considered in order to reduce inter-subject variability. Table 1 presents anthropometric data of the subject.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean Value</th>
<th>Parameter</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>170</td>
<td>Left knee width (cm)</td>
<td>10.7</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>67.5</td>
<td>Right ankle width (cm)</td>
<td>6.8</td>
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<tr>
<td>Right leg length (cm)</td>
<td>87</td>
<td>Left ankle width (cm)</td>
<td>6.9</td>
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<tr>
<td>Left leg length (cm)</td>
<td>86.5</td>
<td>Inter-ASIS distance (cm)</td>
<td>23.3</td>
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<tr>
<td>Right knee width (cm)</td>
<td>10.6</td>
<td>Age</td>
<td>34</td>
</tr>
</tbody>
</table>
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