HOPPING OVER GROUND AND ON A TREADMILL: BIOMECHANICAL DIFFERENCES

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Introduction

To our knowledge no study has tested if hopping is biomechanically identical when performed at the same gait velocity over ground (OG) or on a treadmill (TM). When hopping, a decrease followed by an increase of the center of mass (COM) forward velocity can be observed OG indicating a fluctuation of energy during each step cycle [Blickhan 1989]. The aim of this study was to analyse if the mechanical energy fluctuation and the muscle activity are altered when hopping is performed at equal velocity and frequency on a TM.

Methods

Ten experiences healthy male runners (age, 36.5±13.2 years; mass, 68.1±4.5 kg; height, 174.5±4.6 cm) participated in the experiment. They had to perform hopping OG at self-selected gait velocity and frequency, which was subsequently conducted at the same speed and frequency on the TM.

We measured body segment kinematics (Vicon Plug-in-Gait) and surface EMG of both legs of tibialis anterior (TA), soleus (SOL), gastrocnemius medialis/lateralis (GM/GL), rectus femoris (RF), vastus medialis/lateralis (VM/VL) and biceps femoris (BF).

The contact phase and the heel-toe delay was determined. Based on the heel marker and the COM we determined the landing angle. The COM in sagittal plane was used to estimate the potential energy (Ep) and kinetic energies in forward and vertical directions (Ekf, Ekv). The sum of these energies resulted in a total external mechanical energy (Em). For each step we determined the relative energy fluctuation (ΔE) as the ratio of the absolute fluctuation with the mean of the energy extreme. The surface EMG was processed as discussed in a previous study [Staudenmann, 2007]. For each contact and flight phase the average and maximal EMG amplitudes were determined in order to assess the difference in EMG amplitude between OG and TM hopping.

Results

The toe-heel delay and the landing angle showed a significant reduction on the TM ($p<0.009$). ΔEkf and ΔEm showed also a significant reduction ($p<0.012$) whereas ΔEkv and ΔEp showed no significant difference ($p>0.132$). Maximal EMG amplitudes were significantly reduced on the TM during the contact phase ($p=0.014$). The mean during contact phase ($p=0.174$) and mean / max during flight phase showed no significant differences between OG and TM ($p>0.517$).

Discussion

OG and TM hopping have not been compared so far. A reduction of ΔEkf and ΔEm was observed over TM but no difference for ΔEkv and ΔEp. These results indicate some mechanical similarities in vertical direction between OG and TM hopping but highlight biomechanical differences in the anteroposterior direction. These differences were accompanied by a systematic reduction of the maximal muscle activity during the stance phase of TM hopping, which was highest for GM/GL and RF. The lower activity of GM/GL on the TM may be related to the slightly different movement execution. It was observed that the landing angle showed a systematic reduction on the TM, which is expected to be associated with the reduction in ΔEkf. The small step frequency increase (+2.8%) and the larger ΔEm decrease (-5%) on TM indicate a better energy efficiency for TM hopping compared to OG.

References

Blickhan *et al*, J Biomech, 22:11-12, 1989
Staudenmann *et al*, J Biomech, 40:900:909, 2007
Farley et al, J Biomech, 32:267-273