BIOMECHANICAL DIFFERENCE BETWEEN OVER GROUND AND TREADMILL WALKING AND RUNNING

Didier Staudenmann[1], Jacques Robadey[1], Silvio Lorenzetti[2], Wolfgang Taube[1]
[1] Movement and Sport Science, Department of Medicine, University of Fribourg, Switzerland;
[2] Institute for Biomechanics, ETH Zurich, Switzerland

Introduction

Is walking and running biomechanically identical when performed over ground (OG) or on a treadmill (TM)? When walking or running, a decrease followed by an increase of the center of mass (COM) forward velocity can be observed [Cavagna, 1976]. The aim of this study was to compare the mechanical energy fluctuation and the muscle activity between OG and TM locomotion.

Methods

Ten experienced 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 walk and run OG at self-selected velocity before walking/running at the same velocity 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).

Contact phase and the heel-toe delay were assessed. Using 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.

Results

The heel-toe delay showed no significant effect for walking ($p=0.143$) but a significant reduction for TM running ($p=0.013$). The landing angle showed a significant reduction for TM locomotion (-9% walk, -20% run; $p<0.046$). A significant reduction on ΔEkf was found for walking (-6%; $p=0.012$) and running (-9%; $p<0.001$) whereas ΔEm showed only a significant reduction for running (-9%; $p=0.001$) but not for walking ($p=0.644$). ΔEkv and ΔEp were not significantly altered ($p>0.28$). EMG amplitude showed no significant effect for walking ($p>0.123$) whereas muscular activity was significantly reduced during the contact phase of TM running ($p<0.019$). Especially TA, BF, SOL, GM showed a reduction between 7-11%.

Discussion

For walking and running, reduction (6% and 9%, respectively) in kinetic forward energy fluctuation (ΔEkf) could be observed on the TM compared to OG. This can be related to a reduced landing angle for TM locomotion. The total mechanical energy fluctuation (ΔEm) was reduced of about 9% for TM running but not for walking. The EMG amplitudes showed no significant effect for walking, whereas a systematic reduction could be observed during the stance phase of running. Changes in TA appear to be related to the reduction in heel-toe delay in TM running [cf. Nigg, 1995], and changes in BF, SOL, and GM appear to be related to the reduction in ΔEkf during the contact phase of TM running [cf. Hamner, 2010]. These results imply that the fluctuation of the total mechanical energy is comparable for TM and OG walking. However, running on the TM is associated with lower ΔEm fluctuations and is therefore, mechanically less demanding than OG running.

References

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