IMPACT FORCES, REARFOOT MOTION AND THE REST OF THE BODY IN HEEL-TOE RUNNING

[1] Uwe G. Kersting, [2]René E.D. Ferdinands
[1]Department of Sport and Exercise Science, The University of Auckland, New Zealand,
[2]Department of Physics and Electronic Engineering, The University of Waikato, New Zealand
e-mail: u.kersting@auckland.ac.nz , web: http://www2.auckland.ac.nz/tmk/ses/

INTRODUCTION

The high incidence of overuse injuries in heel-toe running has inspired numerous researchers to identify their mechanical causes. High internal stresses experienced during the impact phase and excessive ranges of rearfoot motion have been the focus of interest in the past [1]. Recently a new paradigm has been proposed [2] which states that muscular activities being modulated by foot-shoe-ground interactions may play an important role in the development of overuse syndromes. If this is the case it can be expected that a variation in muscular activities would affect joint powers, energy transfer between body segments and therefore movement efficiency. Only a limited number of studies have taken into account full body mechanics in comparing effects shoe modifications.

The purpose of this study was to apply a three-dimensional model of the human body to heel-toe running. Systematic variations of rearfoot movement were compared with regard to their effect on torques and powers at various joints of the body.

METHODS

Twelve trained distance runners served as subjects for this study. They were equipped with reflective markers to represent body segments and determine joint centers using static markers on anatomical landmarks. Runners had to run for 1.5 km in a standard running shoe (Nike Pegasus) prior to the collection of ground reaction forces (GRF) and kinematic data while running through the laboratory. Three versions of a heel insert were applied in randomized order (8 deg varus, neutral, 8 deg valgus). For each shoe insert runners had to hit the force platform five times with each foot.
Using an 8-camera 240 Hz motion analysis system (Motion Analysis Corp.) markers placed on the runner were recorded and tracked. A force plate (Bertec, 1200 Hz) was used to collect ground reaction forces. Ratings of perceived comfort and efficiency were recorded using visual analogue scales.

An inverse dynamics model of the runner was created using *Mathematica's Mechanical Systems Pack*. This is a set of packages designed for the analysis of spatial rigid body mechanisms by implementing a dynamics formulation with Lagrangian multipliers. The computer model gives a 3D representation of the human body as a system of fifteen rigid body segments with mass and inertia properties (Fig. 1). Joint kinematics, torques and joint powers were derived.

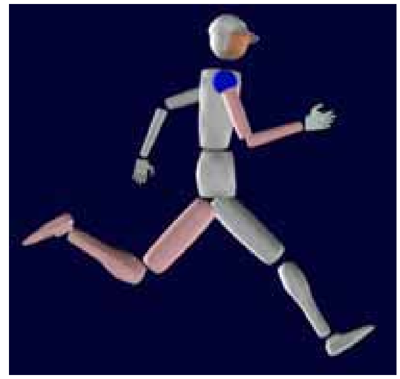

Figure 1: Graphical representation of the 15 segment model.

RESULTS AND DISCUSSION

Results show that rearfoot movement varied systematically and consistently with the insert being used. However, GRF did not vary according to a frontal plane model proposed by Denoth [3]. In 58% of the subjects ankle flexion kinematics showed significant differences between shoe conditions. Thirty-three per cent of the runners demonstrated modified knee joint kinematics in this comparison. These differences were accompanied by significant variations in joint kinetics and power flows up the hip and trunk joints.

CONCLUSIONS

The results of this study suggest that relatively subtle kinematic changes in foot placement and GRFs may be accompanied by considerable variations in segmental kinetics and energy transfer at the joints of the human body. It is likely that these variations will affect running efficiency and may therefore influence fatigue and overloading in distance running.

REFERENCES

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