WALKING AND RUNNING ON PLACE

Andre Seyfarth and Susanne Lipfert
Locomotion Laboratory, University of Jena
email: oas@uni-jena.de, web: www.lauflabor.de

INTRODUCTION

A central question in locomotion research is to understand how leg movements are generated. In the last decade a number of experimental and analytical approaches were undertaken to reveal basic mechanisms for stable leg operation in running and hopping. As a result of this research we do believe that the leg function can be compared to a mechanical spring [1]. This means that leg forces during contact increase with the amount of leg shortening. A similar description of the leg operation in walking will be presented at this conference (Geyer et al.).

To improve our understanding of leg operation, we ask whether the well-known shape of the force patterns (Fig. 1) could be a result of the gait-specific longitudinal leg shortening and extension rather than an effect of the leg rotation (retraction during stance).

To approach this issue we investigate the leg behavior during walking and running on place. Here, the backward rotation of the stance leg (retraction) can not contribute to the leg force generation.

Our hypothesis is that the leg force patterns are primarily dependent on gait-specific leg compression dynamics and therefore similar to forward locomotion when walking and running on place.

TREADMILL WALKING **TREADMILL RUNNING**

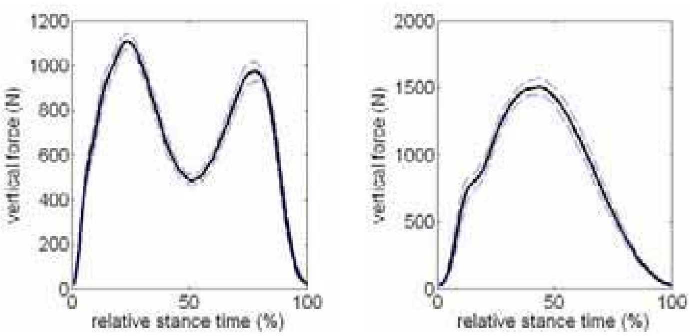

Figure 1: Vertical ground reaction forces (mean ± S.D.) in treadmill walking and running at preferred walk-run transition speed (1.9 m/s).

METHODS

Three subjects (body mass m=54, 73, 67kg; body height h=167, 182, 182 cm) were asked to walk and run on two adjacent KISTLER force plates. The kinematics of the right toe, ankle, knee, hip and shoulder were recorded using a high-speed camera system (QUALISYS).

First, subjects were asked to select their preferred gait at frequencies between 1 and 4 Hz. Then, they were required to change gait every 10 contacts at their preferred gait transition frequency. Using the marker data the inner leg joint angles (ankle and knee) were calculated.

RESULTS

The analysis of walking and running on place shows a high similarity in the ground reaction force patterns (Fig. 2) compared to forward locomotion (Fig. 1). In *running*, a single force peak (circle **3**) is observed. For *walking* on place, a double humped (circles **1** and **2**) force pattern - similar to forward walking - is present. In comparison with forward walking, however, the second hump (circle **2**) is slightly reduced in magnitude.

Walking kinematics: During stance, large extension-flexion cycle of the knee (ca. 135-175 deg) and two ankle flexion-extension cycles (ca. 105-115 deg) are observed.

Running kinematics: Leg shortening during stance is mainly achieved by the ankle joint (125-100 deg).

WALKING ON PLACE **RUNNNING ON PLACE**

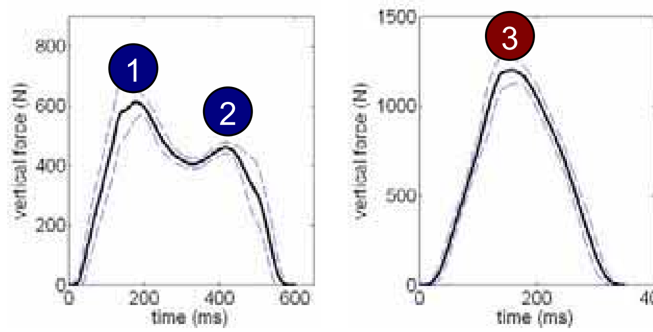

Figure 2: Vertical ground reaction forces (mean ± S.D.) during walking and running on place at preferred transition frequency (2.8 Hz).

DISCUSSION

Both, walking and running on place keep general features of forward locomotion, such as *maximum leg force* at midstance in running and *two local force maxima* and *one local minimum at midstance* in walking. On the joint level, a clear distinction of knee and ankle operation between walking and running can be found.

In conclusion, we suggest that the organization of the leg behavior during stance does primarily rely on the longitudinal dynamics of leg compression and extension. Further research needs to be done to evaluate the effects of forward movement on the leg function during locomotion.

REFERENCES

1. Blickhan, R. *J. Biomech.* **22**, 1217-1227, 1989.

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