GROUND REACTION FORCES DURING DOWNHILL AND UPHILL RUNNING

Jinger S. Gottschall and Rodger Kram
Locomotion Laboratory
University of Colorado, Boulder, USA
gottscha@ucsu.colorado.edu

INTRODUCTION

Ground reaction force (GRF) data have been essential to our understanding of locomotion biomechanics for over 70 years. Many researchers have quantified GRF values for running on the level (e.g. Fenn, 1930, Cavagna, 1975, Cavanagh & Lafortune, 1980, Munro, et al., 1987). In most geographic locations, runners encounter substantial hills, yet there are no published GRF measurements for running on declines or inclines. This is likely due to the difficulty of constructing a force platform runway on a hill. Buczek and Cavanagh (1990) did secure a force platform to a ramp, at one angle, to evaluate joint moments and powers during downhill running but they did not report GRF data.

The goal of this study was to investigate the effects of both decline and incline on the normal and parallel ground reaction forces during running. We tested four general hypotheses: (1) normal impact force peaks would increase during downhill running and decrease during uphill running, (2) normal active force peaks would not change, (3) parallel braking force peaks would increase during downhill running, and (4) parallel propulsive force peaks would increase during uphill running.

METHODS

We measured ground reaction forces for five males and five females running at 3 m/s. Subjects ran on the level, downhill and uphill on a force treadmill mounted to 3, 6 and 9 degree wedges. We analyzed the data with a repeated measures analysis of variance.

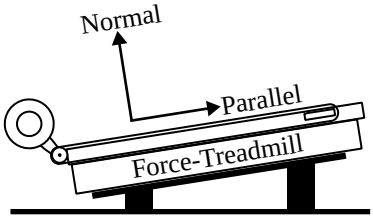

Figure 1. Force measuring treadmill mounted on 9 degree wedges.

RESULTS AND DISCUSSION

The normal impact force peaks increased for downhill running and decreased for uphill running. Specifically, the normal impact force peak increased by 44% on the 9 degree decline compared to level and decreased progressively such that no subjects had impact peaks on the 9 degree incline. In contrast, the normal active force peaks did not change during downhill or uphill running.

At steeper declines, parallel braking force peaks systematically increased while parallel propulsive force peaks decreased. Conversely, on steeper inclines, parallel braking force peaks decreased as parallel propulsive force peaks systematically increased. On the 9 degree incline, parallel braking force peaks were 78% less than for level running.

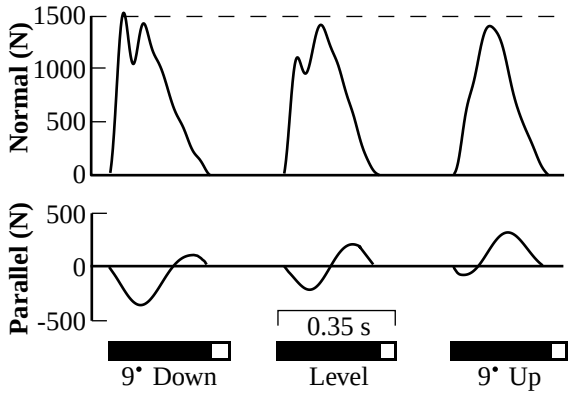

Figure 2: Normal and parallel ground reaction force traces for a typical subject (63 kg). Bars indicate stance phase duration (solid) and aerial phase duration (open).

SUMMARY

We conclude that downhill running increases normal impact force peaks and parallel braking force peaks. In contrast, uphill running decreases normal impact force peaks and increases parallel propulsive force peaks.

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ACKNOWLEDGEMENTS

We thank Sid Gustafson for helpful advice on the construction of the force treadmill wedges.
Supported by a United States National Institute of Health Grant AR44688.