GROUND REACTION FORCE ASYMMETRIES DURING SUSTAINED RUNNING

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INTRODUCTION

Gait is a complex activity that has served as a major area of research in the biomechanics community. A common assumption in gait analysis and research is that the lower extremities behave symmetrically during able-bodied gait. This assumption may be inaccurate and have significant impact in clinical gait analysis, rehabilitation of patients, and artificial limb design.

Previous research examining running and ground reaction forces have utilized a limited number of footfalls in their analyses of symmetry, and have reached different conclusions. Hamill et al. [1] used ten-trial mean values to examine ground reaction force symmetry during walking and running and concluded that there appeared to be symmetry in ground reaction force parameters. Munro et al. [2] used six trials from each subject to examine ground reaction forces in running and indicated that right-left asymmetries were clearly present in these subjects. The purpose of this study was to examine ground reaction force symmetry during running using 700 pairs of footfalls per subject.

METHODS

Eight healthy young adult subjects with mean (sd) age 24.6 (3.5) years and body mass 627.0 (61.8) N, with no known musculoskeletal or neurological pathology volunteered for the study. The subjects were all experienced runners.

Vertical ground reaction force (VGRF) data were collected at 250 Hz using a Kistler Gaitway Instrumented Treadmill. Data were collected for two different running trials. Trial one (slow speed) consisted of running at 3, 4 or 5 $m.s^{-1}$ for 600 s for male subjects and 2, 3 or 4 $m.s^{-1}$ for 600 s for female subjects. Trial two (fast speed) consisted of running at a self-selected velocity for 600 s. Data collection began once the subject was running at the required velocity for each trial.

Data were processed with force and center of pressure data filtered with a 2nd order Butterworth filter with a cut-off of 30 Hz. The start and end of footfalls were identified using a 30 N threshold and data below this value were assumed to be noise. To quantify symmetry, a symmetry index was computed [3]. This index computed the difference between right and left limbs of a gait variable divided by the average of this variable.

Statistical differences in the following parameters were assessed using paired t tests: symmetry indices, mean impact peak VGRF, mean active peak VGRF, and mean VGRF impulse.

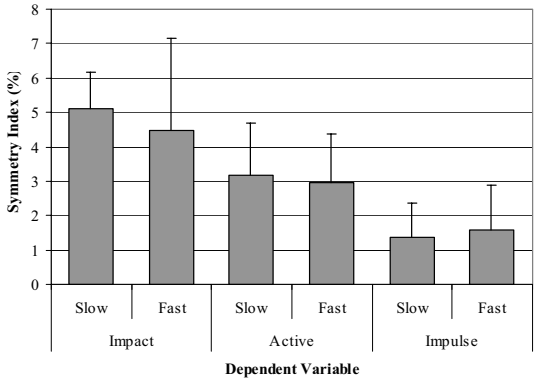

Figure 1: Mean and standard deviation o f symmetry index of mean impact VGRF, mean peak VGRF and VGRF impulse.

RESULTS AND DISCUSSION

Subjects completed an average of 1641.6 (83.2) steps per trial. Paired t-tests indicated significant differences between speeds for mean impact peak VGRF ($p < 0.001$), mean active peak VGRF ($p = 0.001$), and mean VGRF impulse ($p = 0.008$). As the speed of running was increased, there was a significant change in these variables. These results may have significance relative to injury rates in runners.

The symmetry index indicated that all of the subjects demonstrated asymmetrical behavior in mean peak VGRF, mean active VGRF and impulse across all trials. The presence of asymmetry in these variables for this period supports the concept that right and left lower extremities are not symmetrical during sustained running.

Paired t-tests indicated no significant differences ($p > 0.2$) for symmetry indices for impact peak VGRF, active peak VGRF, and VGRF impulse at different speeds (Figure 1).

CONCLUSIONS

This study provides evidence for the asymmetrical behavior of the lower extremities during running, but did not demonstrate any change in symmetry as running speed is increased.

REFERENCES

1. Hamill, J, et al. *Res Q Exerc Sport*, **55,** 289-293, 1984.
2. Munro, C, et al. *J Biomech,* **20**, 147-155, 1987.
3. Sadeghi, H, et al. *Gait Posture,* **12**, 34-45, 2000.