KINETIC ANALYSIS OF THE LOWER LIMBS DURING FORWARD AND BACKWARD STAIR DESCENT WITH AND WITHOUT A FRONT LOAD

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INTRODUCTION

This research investigated forward and backward stair descent with and without a 10 kg front load to determine how backwards stair descent affects the lower extremity's kinetics. The front load was used to model the changes during pregnancy that put pregnant women at greater risk of falling down stairs.

METHODS

Five healthy female students participated in this study. The subjects performed four different descent conditions: forwards, loaded forwards (LF), backwards and loaded backwards (LB). The load was a 10 litre hydration bag (10 kg) to mimic the changes during pregnancy. The staircase had five steps with 20 cm risers and 30 cm treads. Three force plates were used with one on the ground and the others on the 2nd and 3rd steps. Movement trajectories were recorded at 200 Hz by six Vicon MX-13 cameras. Visual3D computed the moments and powers.

RESULTS AND DISCUSSION

The following terminology is used to describe three sub-phases of stair descent during stance phase: weight-acceptance (WA), forward-continuance (FCN) and controlled-lowering (CL) [2]. Figure 1 holds the averaged (5 trials) flexion/extension results for a typical subject during loaded forwards descent. Figure 2 has the same subject's data for loaded backwards descent.

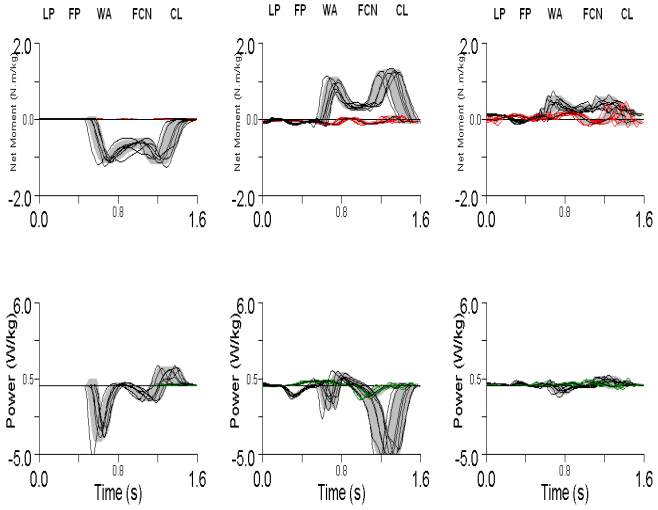

Figure 1. Moments (top) and powers of the ankle (left), knee (mid) and hip (right) joints during loaded forward stair descent

When comparing LF and LB, both conditions mimicked their unloaded conditions and were similar to those of Beaulieu *et al.* and Radka *et al.* [1,3]. During forward descent conditions, at WA the ankle performed negative work to receive body weight and to transfer of energy from the contralateral limb; this occurred from initial foot-contact until single-leg support. Although not shown, the hip abductors also performed negative work during WA to prevent the body from collapsing inwards while descending the stairs. During CL the knee flexors gradually lowered the centre of mass to control the rate of descent. In addition, ankle plantiflexors applied brief bursts of positive work to permit the foot to clear the stair edge. As expected and similar to level walking the hip flexors provided bursts of power during late stance and early swing to swing the leg forwards. The amount of work done was less than that of level walking since the stride length during stair descent was less than a walking stride [1].

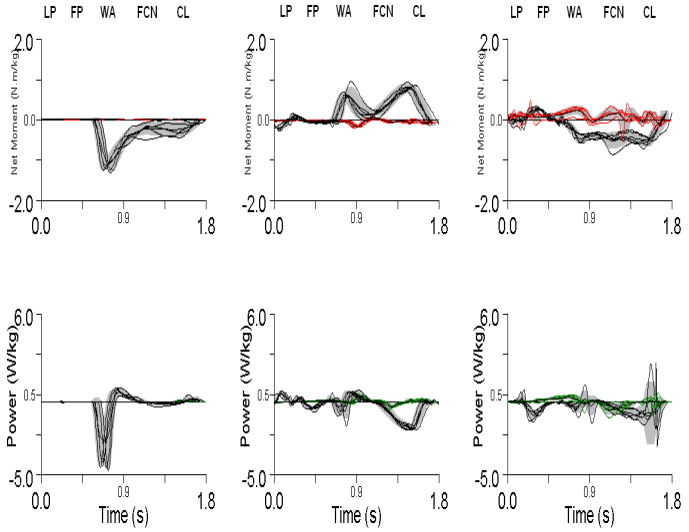

Figure 2. Moments (top) and powers of the ankle (left), knee (mid) and hip (rt.) joints during loaded backwards stair descent

Backwards descent required significantly lower knee extensor moments of force and powers during WA and particularly FCN than those of LF descent. At the ankle, the plantiflexors provided a small burst of positive power, which did not occur with forwards descent. Not surprisingly, instead of the hip flexors being active at the end of stance and early swing the hip extensors provided the positive work necessary to cause the lower extremity to swing through to the next stair (2 steps down). The most significant difference, however, was the greater than two times reduction in the peak knee extensor power during the critical lowering phase when collapse of the knee can cause a fall down the stairs. These results provide evidence that backwards stair descent is a favourable alternative to forwards stair descent for people carrying front loads or during pregnancy.

REFERENCES

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