COMPARISON OF ANKLE, KNEE AND HIP MOMENT POWERS DURING STAIR DESCENT VERSUS LEVEL WALKING

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INTRODUCTION

The purpose of this project was to investigate the mechanics of descending stairs to that of level walking. Recognizing that descending stairs was more difficult and dangerous than ascending stairs and that falls from stair descent especially in the elderly can be fatal (Winter 1995), the idea behind this project was to determine how descending stairs differed kinetically from level walking.

METHODS

Ten subjects (4 females, 6 males) between the age of 20 and 35 participated in the study. They first descended stairs at their own pace for five trials then repeated the descent five times at a slower pace. The stairs (20 cm rise, 30 cm tread) were equipped with Kistler force platforms on the last two steps and on the landing. A digital camera filmed one side of the subject at 60 fps while stair forces were collected at 200 Hz. Sagittal planar, inverse dynamics was applied to obtain the forces and moments of force at the ankle, knee and hip joints. Only the data from the second last step will be presented. Moment powers were then computed from the products of the joint angular velocities and the moments of force: $\boldsymbol{P_j} = \boldsymbol{M_j} \,.\, w_j$. Each subject's moments and powers were body mass normalized and ensemble averaged to create a grand ensemble (GE).

RESULTS AND DISCUSSION

Other than an increase in the stance-to-swing phase ratio, there were no significant differences between normal and slow speed stair descent trials. Only the normal speed trials will be analyzed and compared with "natural cadence" walking reported by Winter (1991).

Figure 1 shows the grand ensemble averages (n=10 subj. × 5 trials) for the ankle moments and powers. The label TO indicates toe-off and the start of swing phase. Three major differences between level walking were apparent. First, no initial dorsiflexor phase was exhibited and instead an eccentric plantar flexor eccentric phase (A0) occurred to permit a controlled lowering of the heel to the step. Second, both plantar flexor bursts A1 and A2 were considerably reduced compared to level walking. In particular, less concentric work (A2) was necessary for stair descent presumably because of the reduction in step distance compared with a walking stride.

Figure 2 shows similar curves for the knee moments and powers. The major significant difference ($P<0.001$), compared with walking, was the doubling of the eccentric power of the extensors prior to TO (K3). This likely constitutes the most significant difficulty for people with disabilities to overcome because of the heavy loading that must occur to the patellar tendon. Notice that the K2 power reported for level walking did not occur during stair descent. The two other power bursts K1 and K4 were not significantly different from level walking.

The hip moments and powers were relatively smaller then those of the ankle and knee and were highly variable compared to level walking. They appear to not have a major role during the swing phase presumably due to the short step distance (60 cm).

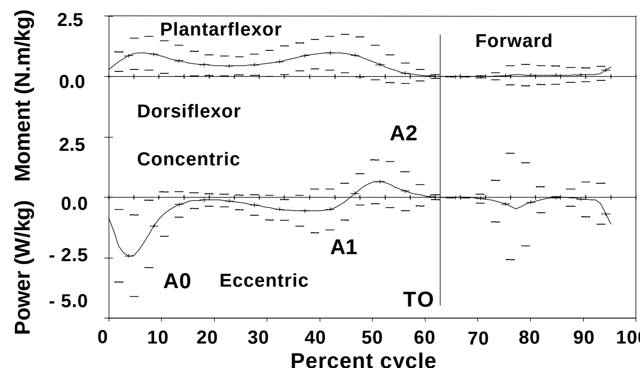

Figure 1. Ensemble averages ±95th% confidence intervals of the ankle moment and powers during forward stair descent.

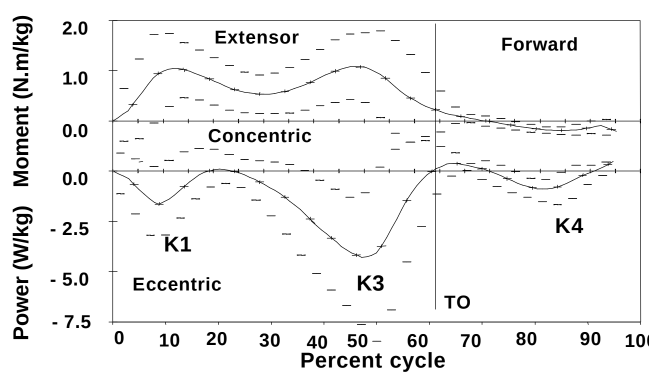

Figure 2. Ensemble averages ±95th% confidence intervals of the knee moment and powers during forward stair descent.

SUMMARY

The major differences between stair descent and level walking was the doubling of the eccentric knee extensor power burst immediately before toe-off and the presence of an additional burst of eccentric power by the ankle plantar flexors immediately after foot contact.

REFERENCES

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