KINETIC ANALYSIS OF GAIT ON INCLINED SURFACES

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INTRODUCTION

Walking on a level surface usually takes minimal effort and is a daily occurrence. Access to areas on different levels, however, may become a barrier to the injured, elderly or disabled persons. Adding ramps or inclined surfaces is one means of permitting access to different levels of a building. Little data are available concerning the efforts required to negotiate different inclines. Prentice *et al.* [1] analyzed various inclines but only examined the swing phase while Post & Robertson [2], looked at ramp descent at one gradient. The purpose of this investigation was to quantify the moments of force and powers produced in the lower extremity during ascent of inclines of various gradients compared to those of level gait.

METHODS

Twelve subjects (6 female, 6 male) between the ages of 20 and 30 volunteered. Sagittal plane kinematics from a 60 Hz video camera and ground reaction forces from a force platform placed on the ramp were collected. The participant's ascended four different ramp inclinations, five times each (level, 3-deg, 6-deg and 9-deg). The motion data were digitized using the APAS. Kinematic, inverse dynamic and power analyses were done with the Biomech Motion Analysis System [3].

RESULTS AND DISCUSSION

Ankle moments and powers were similar for the level and 3-deg inclined conditions. There were no significant differences in the peak moments of force for any of the four conditions but there was a steady increase in peak power between 3, 6, and 9 degrees of incline. There was a 21% increase in peak power between the 9-degree incline and then level and 3-degree incline (2.99 vs. 2.45 W/kg).

Figure 1 illustrates the average knee moments of force and moment powers for all four conditions. The power burst at K0 was equal for all the inclines excepting for 9-deg, which was significantly less. Other major differences with the 9-deg incline occurred after foot-strike (FS) at K1 where the knee extensors produced almost no negative work compared to the other grades and at K2 where substantially more work and power were required.

There were sequential reductions in the peak eccentric power bursts of the knee extensors at K3 prior to toe-off (TO) and by the knee flexors prior to FS (K4). Thus, the energy demands of ascending inclines are met by reducing the amounts of energy dissipated by knee eccentric muscle contractions.

The peak moments of force at the hip were not significantly different across the four gradients. The peak powers were also similar but there were differences in the extensor work done immediately after FS (H1). Here there was a gradual increase of 138% from level to 9-deg incline (0.29-0.69 W/kg).

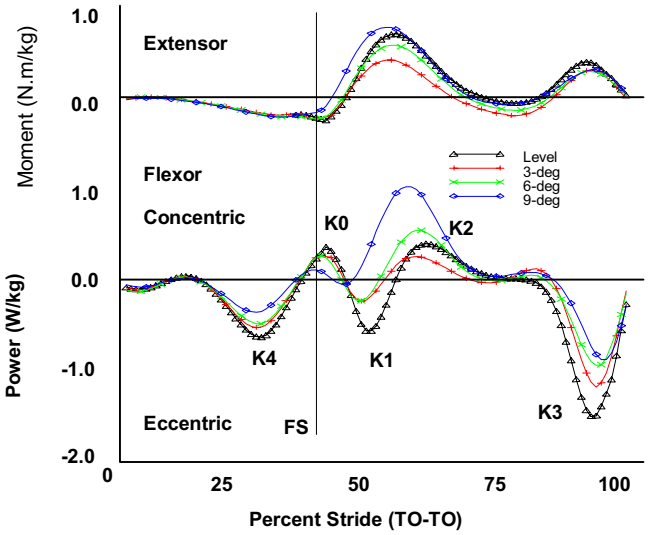

Figure 1: Grand ensemble averages (n=12x5) of the knee moments of force (top) and their powers (bottom) for level, 3, 6 and 9-degree inclines normalized to body mass. Abscissa is percent of stride from toe-off to toe-off.

CONCLUSIONS

There were few differences in the peak moment and power demands between level and 3-deg incline. The demands for 9-deg inclined ascent were significantly greater especially at the knee as compared to level and 3-deg of incline with the 6-deg incline being of intermediate demand.

REFERENCES

1. Prentice SD, et al. *Gait Posture* **20**, 255-65, 2004.
2. Post A & Robertson DGE *Proceedings of CSB XIII,* Halifax, Canada, 2004.
3. Biomech Motion Analysis System, http://www.health.-uottawa.ca/ biomech/software/biomech.