The Contribution of Frontal Hip Power to Slope Walking

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INTRODUCTION

- More than 30% of the older population aged above 65 in the USA fall at least once during a year [1].
- The risk of falling in the elderly is increased when facing increased challenges to balance control while walking on uneven terrains such as up stairs and slopes [2].
- The task demands for slope walking result in changes in lower limb kinematics and kinetics, but little is known about how power in the frontal plane changes with slope. During level walking, 23% of the total hip work is done in the frontal plane [3].
- It is reasonable to expect that slope walking will place greater demands on the hip in the frontal plane to control the pelvis and trunk against gravitational forces in downslope walking, and to help lift the trunk in upslope walking.

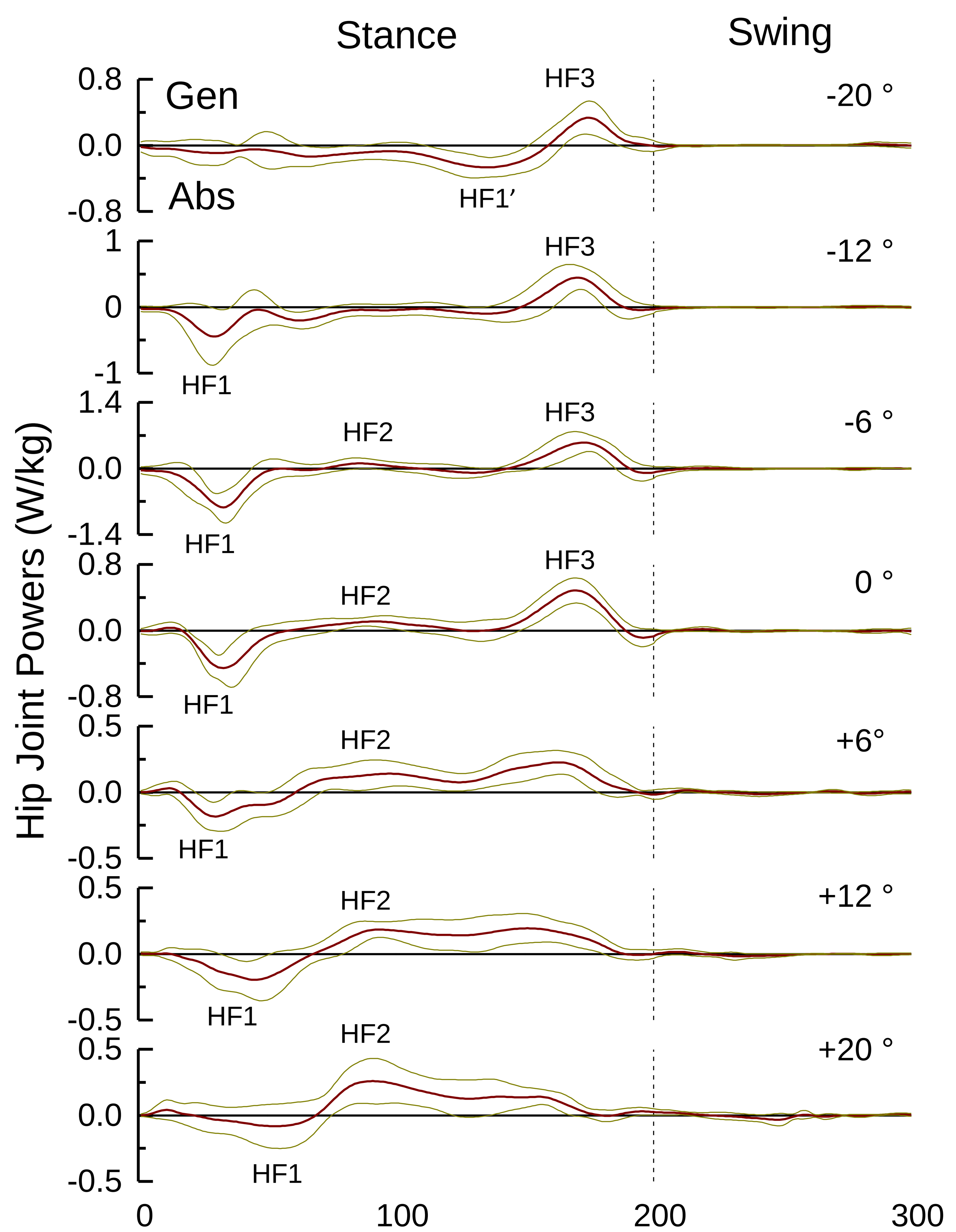

Fig. 1 *Frontal hip powers as a function of slope averaged for nine subjects.*

PURPOSE

- To fully describe the change with the frontal of hip joint powers during slope ascent and descent, and to quantify total work done in the frontal plane by the hip joint.

METHODS

- Subjects：Nine healthy male adults (23.8±1.1 yrs).
- Marker Set：29 retroreflective markers (Helen Hayes Marker Set).
- Overground Slopes: +20°，+12°，+6°，0°，-6°，-12°，-20°; slopes was 3.2 m long; 3 trials each.
- Self-selected speed with at least two steps on the slope before and after contacting the force platform.
- Mounted force-platform (Kistler 9281CA, Switzerland) and 8 camera 3D Optical Capture system (Motion Analysis Raptor-4, USA).
- Gait events (heel strike and toe off) identified from vertical ground reaction force with a 10 N threshold. Kinetic data were filtered using a 4th order zero-lag Butterworth filter at 15 Hz [4].
- The time integral of the power curves (i.e. work) was calculated (a) over one stride and (b) for each phase of the hip frontal power (HF1, HF2 and HF3; Fig. 1). The total work over the stride was the sum of the positive work and the negative work [3].
- This paper focused on the comparisons within the upslope and downslope conditions (including level condition), but not between upslope and downslope.
- Statistics：A one-way ANOVA was used to determine differences of hip frontal work within upslope and downslope, with Tukey post hoc tests; alpha level was set at 0.05.

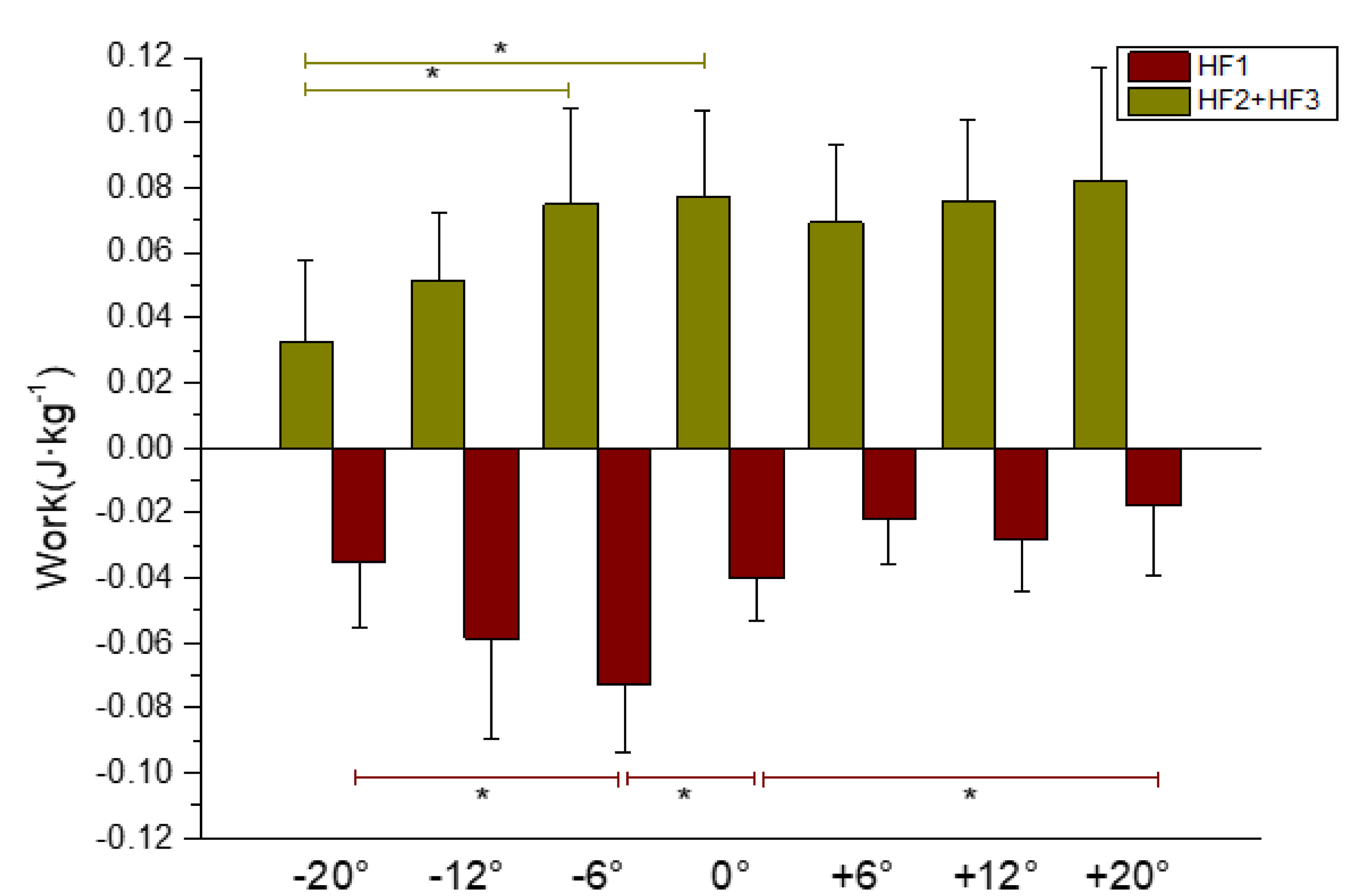

Fig. 2 *Average work for hip frontal power bursts. Asterisk (*) indicates p<0.05*

RESULTS & DISCUSSION

- During level walking, HF1 absorption is the eccentric control of the dropping pelvis during weight acceptance, and the HF2 and HF3 generation bursts raise the pelvis during midstance and push off phases [4].
- During downslope walking, HF1 absorption increased for the -6°, but was not different from level walking for the steeper slopes (Fig. 2). The increased absorption at -6° acts to control the dropping pelvis and was expected due to the greater downward distance traveled. Note HF2 generation during level walking becomes absorption (HF1') in the most extreme slope (-20°, Fig. 1). HF1' lasted from early stance phase to push-off phase; these changes are consistent with higher demands associated with dropping pelvis. However, the work of HF1 was not greater than that during level walking (Figs. 1 & 2). The power phase HF2 generation decreased as expected, but only in the most extreme slope (-20°, Fig. 1). Overall, to accomplish downslope walking, relative to level walking, there was more energy absorption on the -6°, after that, energy absorption was decreased, and less energy generation in the hip frontal plane allows the pelvis and trunk to drop.
- During upslope walking, HF1 absorption decreased as expected, but only in the most extreme slope (+20°, Fig. 2). It is interesting to note that the power phases HF2 and HF3 become one phase with increasing gradient (Fig. 1). The combined power bursts were consistent with higher demands associated with raising the pelvis to accomplish upslope walking. However, the total combined work of HF2 and HF3 was not greater than during level walking (Fig. 2). Overall, to accomplish upslope walking, relative to level walking, there was less energy absorption and similar energy generation in the hip frontal plane to elevate the pelvis and trunk.

CONCLUSION

- To accomplish upslope walking, less energy absorption in the hip frontal plane was required, for downslope walking, less energy generation was required, but more energy absorption was required on -6°.
- The power bursts changed when facing different gradient slopes, indicating complex strategies to accomplish these locomotor tasks.
- Further research should examine other joint powers and compare upslope and downslope in order to gain insight into causes of stumbles, slips and falls.
- These observations could be used to improve design of biped robots and prosthetic devices.

REFERENCE

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