A TEST OF THE FUNCTIONAL ASYMMETRY HYPOTHESIS IN WALKING

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INTRODUCTION

Subtle kinematic, kinetic, and electromyography (EMG) asymmetries have been well documented in able-bodied gait, yet the causes of these asymmetries remain unclear (Sadeghi et al. 2000). One prominent theory is that these bilateral discrepancies represent what are commonly referred to as *functional asymmetries*. Functional asymmetry has been defined as the consistent task discrepancy between the non-dominant (ND) and dominant (D) lower limbs (Sadgehi et al. 2000). It is purported that the ND limb is primarily responsible for providing support (vertical acceleration of the center of mass), while the D limb is primarily responsible for propulsion (forward acceleration of the center of mass). Preliminary evidence suggests that gait asymmetries may also be speed-dependent (Goble et al. 2003).

Some studies have provided provisional support for the hypothesis of functional asymmetry, yet many of these studies contain important limitations. As part of a larger effort to evaluate kinematic, kinetic, and EMG asymmetries, we report here on asymmetries in impulses due to the vertical and anterior-posterior (AP) ground reaction forces (GRF) during gait. It was hypothesized that if functional asymmetry is a reasonable explanation for able-bodied gait asymmetries, then: 1) impulses due to the VGRF (V) would be greater for the ND limb, and 2) impulses due to the propulsive portion of the APGRF (P) would be greater for the D limb. Also, it was expected that there would be no speed effect on V impulses (due to the constancy of the gravitational force), but that P impulses would increase with speed disproportionately on the D side.

METHODS

Two force platforms were used to measure bilateral GRF during simultaneous gait cycles in 20 young adults walking at three different speeds: preferred, slow (20% slower than preferred), and fast (20% faster than preferred). Five satisfactory trials were recorded at each speed. Trials were time normalized to the gait cycle, normalized to body weight, and then ensemble averaged for each limb, for each speed. V impulse was calculated as the time integral of the normalized VGRF during stance. P impulse was calculated as the time integral of the normalized APGRF, while the APGRF was directed in the anterior direction (approximately the second half of stance).

A repeated measures ANOVA ($p = 0.05$) was utilized to detect effects of limb and walking speed on the dependent variables. Bonferroni adjusted post hoc analyses were performed to detect bilateral differences at each walking speed.

RESULTS AND DISCUSSION

There was no significant main effect of limb for V impulse ($p = 0.219$), but there was a significant limb × speed interaction ($p < 0.001$). Post hoc analyses revealed no significant bilateral differences at the slow ($p = 0.334$) or preferred ($p = 0.523$) speeds. However, V impulse was 2% greater in the

ND limb (p = 0.009) at the fast speed (Figure 1). Similarly, there was no significant main effect of limb for P impulse (p = 0.753), but there was a significant limb × speed interaction (p = 0.001). However, there were no significant bilateral differences at the slow (p = 0.212), preferred (p = 0.675), or fast (p = 0.130) walking speeds (Figure 1).

The lack of a bilateral difference in V or P impulses at the slow and preferred speeds does not support the hypothesis of functional asymmetry as an explanation for able-bodied gait asymmetries. However, results at the fast walking speed offered modest support for functional asymmetry. As predicted, V impulses were greater for the ND limb at the fast speed, and there was also a trend towards greater P impulses for the D limb at the fast speed. Perhaps, if subjects had been required to walk faster, still larger bilateral differences may have been observed. However, given the results obtained at the preferred and slow speeds, present support for the concept of functional asymmetry as a general phenomenon is weak at best.

The absence of a limb effect at the preferred speed indicates that the gross kinetics of able-bodied gait are generally symmetrical. This supports the assumption of symmetry that is often made in studies of able-bodied gait. However, this does not guarantee that joint kinetics or neuromuscular patterns will be symmetrical.

SUMMARY/CONCLUSIONS

The present results, based on impulses generated against the ground, do not support functional asymmetry as a valid explanation for able-bodied gait asymmetries, while walking at or below a preferred speed. Future efforts to clarify this issue should consider joint kinematics, joint kinetics, and EMG data, and more closely examine the issue of walking at speeds greater than preferred.

REFERENCES

Goble, D. et al. (2003). *Hum Mov Sci*, 22, 271-283.

Sadeghi, H. et al. (2000). *Gait and Posture*, 12, 34-45.

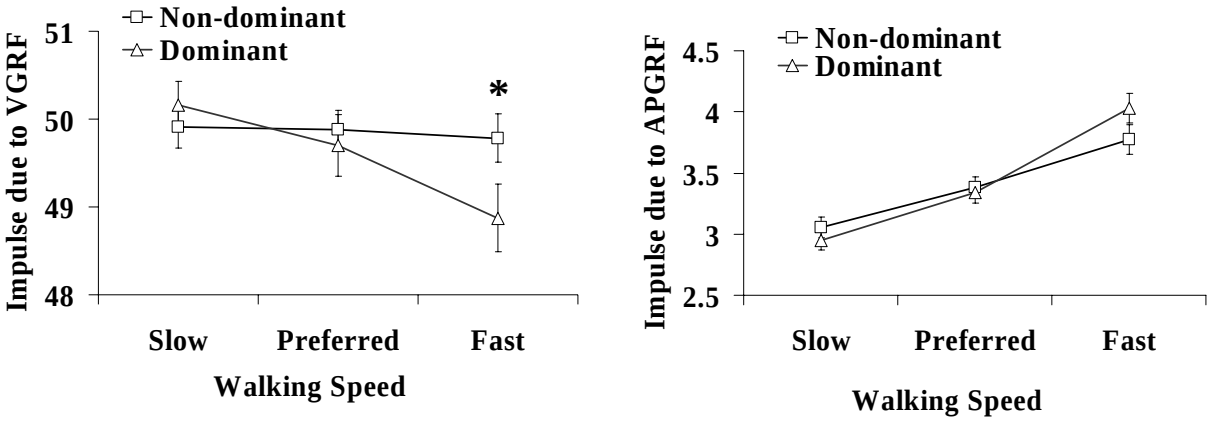

Figure 1: Mean impulses due to the VGRF and APGRF for non-dominant and dominant limbs during gait at three different walking speeds; ordinate values are reported as the product of force (N/body weight) and time (% of the gait cycle); the asterisk indicates statistical significance.