

ARE ASYMMETRIES IN JOINT KINETICS RELATED TO LIMB DOMINANCE?

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INTRODUCTION

Bilateral asymmetries have been documented for kinematic, kinetic, and electromyographic data during normal gait, yet their causes remain unclear (Sadeghi et al., 2000). One explanation for these asymmetries has been termed functional asymmetry. According to this explanation, the non-dominant (ND) leg contributes more to supporting the center of mass, while the dominant (D) leg contributes more to propulsion of the center of mass (Sadeghi et al., 2000). Impulses due to vertical and propulsive ground reaction forces are symmetrical during normal gait (Seeley et al., In Press), indicating that, at a global level, the ND and D legs contribute similarly to support and propulsion. However, these symmetrical impulses do not necessarily imply symmetry for “local” measures, such as joint kinetics. Asymmetries in joint kinetics may be related to different functional roles of the ND and D legs, in a manner that is consistent with the functional asymmetry perspective.

The purpose of this study was to determine if joint kinetic asymmetries during normal gait are related to these hypothesized functional differences between the ND and D legs (support and propulsion, respectively). We formulated three hypotheses that were based upon this idea of functional asymmetry: 1) joint mechanical work associated with support during gait would be greater for the ND leg than for the D leg, 2) joint work associated with propulsion would be greater for the D leg, relative to the ND leg; and 3) with increases in walking speed, propulsion-related

joint work would increase disproportionately for the D leg, when compared to the ND. This limb \times speed interaction was not predicted for support-related work because, although propulsive requirements increase as walking speed increases, support requirements remain relatively steady due to the constancy of gravity.

METHODS AND PROCEDURES

The gaits of 20 healthy subjects (age = 25 ± 3 yr; ht = 1.7 ± 0.1 m; mass = 70 ± 14 kg) were evaluated at three walking speeds: preferred (1.49 ± 0.20 m/s), -20% (1.24 ± 0.15 m/s), and +20% (1.78 ± 0.20 m/s). We quantified joint mechanical work associated with support and propulsion by integrating joint mechanical power, with respect to time, during specific power bursts that are associated with support or propulsion (Eng & Winter, 1995; Allard et al., 1995). Power bursts associated with support included the first ankle sagittal (A1S), combined first and second knee sagittal (K1S/K2S), first hip sagittal (H1S), and second hip frontal (H2F). Propulsion-related bursts included the second ankle sagittal (A2S) and third knee sagittal (K3S). Power was the product of joint angular velocity and net joint moment. Work was normalized to body weight \times limb length. A repeated measures ANOVA ($\alpha = 0.05$) was performed (SPSS) to detect the effects of limb and speed on joint work. Variables exhibiting a limb \times walking speed interaction were bilaterally compared at each speed via *post hoc* analyses. All other data were pooled from each speed and compared bilaterally.

RESULTS

For mechanical work associated with support: 1) significantly more work was performed by the ND leg during the A1S (data were pooled from each speed) and K1S/K2S (preferred and fast speeds) power bursts; and 2) significantly more work was performed by the D leg during the H2F power burst (data pooled from each speed; Table 1). Regarding propulsion-related work, significantly more work was performed by the ND leg during the A2S (data were pooled from each speed) and K3S (fast speed) power bursts (Table 1).

DISCUSSION

The data did not consistently support our hypotheses, indicating that asymmetries in joint work during walking are probably not related to different functional roles of the ND and D legs, as conceptualized within the functional asymmetry framework. Mechanical work performed during the A1S, K1S/K2S, H1S, and H2F joint power bursts is associated with center of mass support. As expected, the work performed during two (A1S and K1S/K2S) of these bursts was greater for the ND. However, there was no difference for work performed during the H1S burst, and work performed during the H2F burst was

significantly greater for the D, which was in opposition to our first hypothesis. Propulsion-related work (A2S and K3S) consistently contradicted our second hypothesis, as both were greater for the ND. Finally, the walking speed manipulation described in the third hypothesis was not supported, as the only limb \times speed interaction observed for propulsion-related work, was in a direction that was opposite to the third hypothesis.

SUMMARY

Bilateral asymmetries for joint mechanical work are probably not related to limb dominance in a manner that is consistent with the functional asymmetry idea, which states that the ND and D legs contribute more to support and propulsion, respectively. Other causes of asymmetries in joint kinetics should be explored, as clarification of this issue will advance our understanding of normal gait.

REFERENCES

- Eng J & Winter D (1995). *J Biomech*, 28: 753-758.
 Allard P et al. (2004). *Hum Mov Sci*, 15: 327-346.
 Sadeghi H et al. (2000). *Gait Post*, 12: 34-45.
 Seeley M et al. (In Press). *Gait Post*.

Support	Mean Work $\times 10^{-3}$				
	ND	D	Propulsion	ND	D
A1S * ($p < 0.001$)	17 \pm 5	10 \pm 4	A2S * ($p < 0.001$)	26 \pm 6	15 \pm 5
K1S/K2S (slow)	13 \pm 7	12 \pm 5	K3S (slow)	11 \pm 6	12 \pm 5
K1S/K2S (preferred) * ($p = 0.008$)	19 \pm 6	15 \pm 5	K3S (preferred)	14 \pm 8	14 \pm 5
K1S/K2S (fast) * ($p < 0.001$)	28 \pm 8	22 \pm 6	K3S (fast) * ($p < 0.001$)	22 \pm 6	17 \pm 5
H1S	21 \pm 12	21 \pm 13			
H2F * ($p < 0.001$)	3 \pm 4	10 \pm 6			

Table 1. Work, normalized to body weight \times limb length, performed at the ankle, knee, and hip joints of the non-dominant (ND) and dominant (D) legs during specific joint power bursts (see text for details) during normal gait. * Asterisks indicate statistical significance.