MUSCLE ACTIVATION PATTERNS DURING GAIT INITIATION

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INTRODUCTION

Gait initiation is a temporary movement between upright posture and steady-state gait. The activation of several postural muscles has been identified to precede changes observed in the ground reaction force. Although previous research has focused on the lower limb, few studies have examined recruitment patterns of the thigh and trunk musculature. This study was conducted to determine the phasic patterns of several muscles of the lower limbs and trunk for the duration from quiet stance to trail leg toe-off.

METHODS

Eleven healthy participants initiated gait with their right legs. Two force platforms (Kistler) were used to measure vertical ground-reaction forces, at 1040 Hz, from quiet stance to toe-off of the trail limb. In addition, electromyographic data (Bortec) were collected at 1040 Hz beginning at quiet stance to the end of the third step. EMG electrodes were placed bilaterally over the erector spinae, the tensor fasciae latae, the adductor magnus and the tibialis anterior muscles. All analog signals were synchronously recorded by SIMI Motion.

Participants were asked to stand with one foot on each of the force plates, distributing their weight equally onto both limbs. Each participant began walking briskly, after the researcher gave a "go" command. Ten trials were collected for each subject. Force platform data were filtered with a zero-lag, second-order, critically-damped, low-pass filter with a cut-off frequency of 20 Hz. To remove low frequency motion artefacts, the raw electromyographic data were high-pass filtered with a cut-off frequency of 8 Hz (Robertson & Dowling, 2003). Electromyographic data were then full-wave rectified and filtered by a second-order, critically-damped, low-pass filter with a cut-off frequency of 5 Hz, producing a linear envelope (Robertson & Dowling, 2003).

The determination of the start and end of muscle activity was obtained by an amplitude threshold criterion. The amplitude threshold was based on three times the standard deviation of the resting EMG baseline for each muscle, estimated from the quietest 100 ms periods of each EMG trace. This was obtained from the beginning of the trial while the participant was in quiet stance. Timings of all eight muscle onsets and offsets were recorded from the time-normalized, ensemble-averaged data for each subject for the period beginning 1.5 seconds before trail leg toe-off until trail leg toe-off.

RESULTS AND DISCUSSION

The patterns of muscle activity across subjects were generally consistent. The muscle onset times for nine subjects are given in Table 1. The earliest activation was consistently found to be the lead limb tibialis anterior, followed by the lead limb tensor fasciae latae. The trail limb tibialis anterior, trail limb tensor fasciae latae and the trail limb adductor magnus were next to become active, respectively. The muscle activity during the middle of the gait initiation process was more variable. Specifically, there were notable inconsistencies between subjects for the order of the fifth and sixth muscle activations. The last two muscles to become active were consistently found to be the erector spinae of the trail limb side followed by the erector spinae of the lead limb.

Table 1: Muscle onset times during gait initiation

	L-ES	T-ES	L-TFL	T-TFL	L-ADD	T-ADD	L-TA	T-TA
Subject1	51	84	18	22	49	35	16	19
Subject2	43	25	20	35	79	24	13	15
Subject3	51	75	21	36	50	39	17	30
Subject4	45	36	12	18	17	30	11	20
Subject5	41	35	20	28	24	34	19	23
Subject6	63	40	16	12	18	19	32	28
Subject7	46	35	11	16	33	18	10	15
Subject8	41	39	15	34	26	28	12	17
Subject9	48	32	14	39	21	18	17	13
Mean	47.7	44.6	16.3	26.7	35.2	27.2	16.3	20.0
St Dev	7.35	20.4	3.64	9.94	20.5	7.92	6.63	5.94

Presumably the two tibialis anterior muscles with the simultaneous release of the gastrocnemius/soleus muscles cause the posterior movement of the centre of pressure, whereas the lead leg tensor fasciae latae (Figure 1) contributes to the initial lateral shift toward the lead limb reported by Winter (1995). The delayed activation of the erector spinae muscles confirm the kinetic analysis of gait initiation conducted by Robertson *et al.* (2005) that showed a brief period of falling prior to lead-leg heel contact.

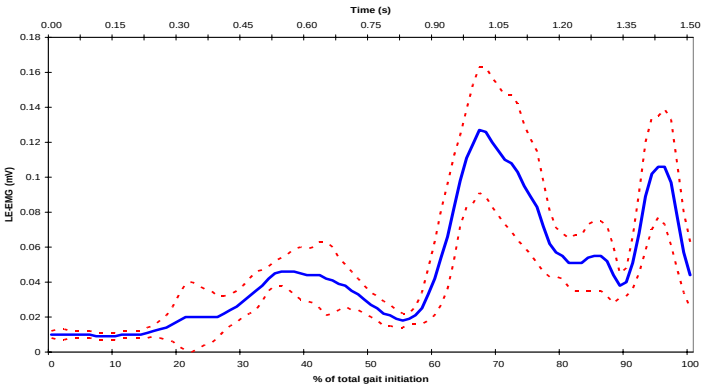

Figure 1: Ensemble mean (±SD) of the lead tensor fasciae latae from 10 trials for one subject. Time normalized linear envelope EMG throughout gait initiation.

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