PELVIC EXCURSION DURING WALKING POST-STROKE

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INTRODUCTION

Dyscoordination and atypical muscle activation patterns are hallmarks of stroke-related walking dysfunction. While these impairments can readily be attributed to disruptions of neural control, skeletal malalignment, specifically at the pelvis, is also a prominent, and underappreciated, sequela post-stroke. Biomechanical malalignment places muscles at disadvantageous length-tension relationships impairing muscle activation and movement efficiency [1,2]. The direct consequences of biomechanical malalignment on walking function remain poorly understood. The magnitude of altered pelvic excursion and how these alterations affect the coordination and control of walking have not been studied in persons post-stroke. Of note, activation and coordination deficits are revealed in both the paretic and nonparetic limbs post-stroke [3-6].

We hypothesized that excessive pelvic excursion during gait would correspond with: 1) impaired ankle plantarflexor and hip flexor power in late stance/early swing, and 2) disrupted muscle activation patterns.

METHODS

Here we studied 19 participants (59.4±13.9yrs; 15 male) with chronic (40.7±34.4mo) post-stroke hemiparesis compared to 19 non-disabled controls (54.32±8.21yrs; 10 male). Participants walked on an instrumented split-belt treadmill at self-selected walking speed while biomechanical variables were assessed including: pelvic excursion, magnitude of hip (H1, H3) and ankle (A2) powers, peak hip extension range of motion, and activation patterns (EMG) of the tibialis anterior (TA), medial gastrocnemius (MG), and soleus (SO). Clinical data including gait speed and Fugl-Meyer scores were also obtained.

Pelvic excursion was defined as pelvic motion with respect to the lab reference frame; quantified in three planes. Hemiparetic participants were allocated to pelvic excursion deviation categories based on the magnitude of deviation in pelvic excursion relative to controls.

ANOVA was used to determine if pelvic excursion deviation categories identified differences in clinical data, biomechanical gait parameters, and temporal muscle activation patterns (EMG).

RESULTS AND DISCUSSION

Classification based on pelvic excursion identified three distinct groups: Types I, II, and III, representing progressively increased magnitudes of deviation relative to controls.

Clinical Data
All participant groups presented with slower gait speed (Type I: 0.54 m/s, Type II: 0.41 m/s, Type III: 0.43 m/s; \( p < 0.001 \)) than the control group (0.96 m/s). However, no differences in gait speed, age (\( p = 0.70 \)) or Fugl-Meyer synergy score (\( p = 0.32 \)) were detected between Types I, II and III.

Biomechanical parameters
Differences in peak hip extension were revealed by classification on pelvic excursion deviation. The magnitude of peak hip extension was significantly lower for the paretic than the nonparetic leg for the Type III group (\( p = 0.03 \)).

Joint powers responsible for the stance-to-swing transition also demonstrated disrupted patterns across groups (Fig. 1). Nonparetic and paretic
differences were detected between the Type I and Type III groups in A2 magnitude \((p = 0.001)\), and between the Type II and Type III groups in H1 magnitude \((p = 0.02)\). The control and Type I groups produced higher magnitudes of H3 than the Type II and Type III groups \((p < 0.0001)\).

**EMG**

All three participant groups revealed differences in MG EMG across the gait cycle. The Type I group maintained a normal MG modulation pattern through late stance, while the Type II group demonstrated a stepwise pattern through late stance, and the Type III group presented with no modulation through late stance. Additionally, during loading response, all participant categories revealed a significantly greater proportion of MG EMG activity than the control group \((p < 0.0001)\).

**Discussion**

Static pelvic position did not correlate with pelvic excursion during gait. Additionally, clinical data failed to distinguish between variables of interest. However, the classification scheme based on pelvic excursion deviation differentiated group-specific walking patterns in stroke survivors.

The Type III group, with the greatest pelvic excursion, demonstrated the most pronounced reduction in H3 in late stance/early swing and reduced A2, with the greatest asymmetry between legs. Taken together, these findings provide initial evidence in support of our first hypothesis.

All groups also showed evidence of altered EMG patterns in the medial gastrocnemius, demonstrating a significant redistribution of muscle activity across the gait cycle providing support for our second hypothesis. Many treatment approaches for so-called “foot-drop” focus on augmenting TA activity to produce foot clearance. Our data suggest more effective treatment options might target EMG timing of multiple muscles, including the deficient activity of the plantarflexors during late stance in preparation for transition to swing.

**CONCLUSIONS**

As hypothesized, excessive pelvic excursion is related to walking impairment post-stroke. Here we present first evidence of detrimental effects on joint power production and EMG patterns.

Lack of correlation between static pelvic position and pelvic excursion during walking underscores the importance of this novel assessment scheme to understanding the role of dynamic pelvic control post-stroke. Additional work is needed to further understand specific neuromechanical contributions to walking impairment post-stroke and identify appropriate, targeted interventions to engage these mechanisms and promote neuromotor recovery.

**REFERENCES**


**Figure 1:** Joint powers during the stance-to-swing transition. Black bars represent symmetric joint powers between the right and left legs of controls. Blue and red bars represent nonparetic and paretic legs of participants post-stroke, respectively. **Abbreviations:** A2 – concentric ankle plantarflexor power during pre-swing, H1 – concentric hip extensor power in early stance, H3 – concentric hip flexor power during late stance and early swing.