LOWER EXTREMITY JOINT MOMENT ASYMMETRY DURING SPLIT-BELT TREADMILL WALKING

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INTRODUCTION

Several diseased populations, including stroke and Parkinson’s disease (PD), are characterized by asymmetric motor deficits. Asymmetry in important gait-related variables have been described in these populations, including diminished ability to generate sufficient propulsive forces on the side most affected by disease or neurologic insult. Diminished unilateral lower extremity joint moment production has also been described in persons post-stroke [1] and with PD [2].

During split-belt treadmill walking (SBTW), the lower limbs each walk at a different speed simultaneously, thus externally altering symmetry patterns in the walker’s gait. Consequently, SBTW has been utilized to rehabilitate gait asymmetries. Acute SBTW has been shown to temporarily restore symmetry in step length and double-limb support time in persons post-stroke [3]. However, the potential for SBTW to similarly rehabilitate asymmetry of joint moment production remains unknown. Therefore, in this study, we have investigated changes in peak sagittal joint moment production in the hip, knee, and ankle bilaterally during acute SBTW as compared to normal, tied-belt treadmill walking in healthy young adults.

METHODS

Twelve participants (age 22.6 ± 3.6 yr, 167.6 ± 8.9 cm, 62.8 ± 9.5 kg, 6 male, 6 female) participated in this study. None of the participants had ever walked on a split-belt treadmill prior to participation in this study. Additionally, all participants were free of lower-extremity orthopedic injury for at least one year.

Sixteen passive reflective markers were attached to the lower body in accordance with the Vicon Plug-in-Gait marker system. Kinematic data, time-synchronized to the kinetic collection, were collected using a 7-camera motion capture system (Vicon Nexus, Oxford, UK) collecting at 120Hz. Force plate data from the instrumented treadmill (Bertec Corporation, Columbus, OH) were collected at 960 Hz.

Initially, participants began by walking on an instrumented split-belt treadmill while both belts moved together at the same speed. The speed was gradually increased until the participants reported being at the “fastest speed they felt comfortable walking for 15 minutes”. This speed was set as the “fast” walking speed, while 50% of this speed was designated as the “slow” walking speed. Participants then walked for two minutes at the “slow” speed and two minutes at the “fast” speed, followed by a two-minute washout period at the “slow” speed. The last 30 seconds of the first “slow” speed trial, the “fast” speed trial, and the “split” trial were collected.

At the conclusion of the washout period, the belt under the nondominant leg was sped up to the “fast” speed while the belt under the contralateral leg remained at the “slow” speed. Participants walked under these conditions for 10 minutes. Following this “split” condition, participants were given 5 additional minutes with both belts at the “slow” speed to eliminate any after effects of the SBTW.

Lower extremity sagittal joint moments were calculated using inverse dynamics techniques. Change scores were calculated by comparing the magnitudes of the peak joint moments produced during SBTW and the average of the peak joint moments produced during the “slow” and “fast” trials.

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% \text{Change} = \left(1 - \frac{\text{moment}_{\text{split}}}{\left(\frac{\text{moment}_{\text{fast}} + \text{moment}_{\text{slow}}}{2}\right)}\right) \times 100\%
\]
Paired samples t-tests were run on the change scores in peak sagittal ankle angle production between limbs during SBTW.

RESULTS AND DISCUSSION

Analysis of the peak sagittal joint moments during SBTW showed that the “fast” limb ankle produced a significantly higher torque than the “slow” limb ankle at push-off (p < .001, figures below).

Interestingly, the change in peak flexion/extension moments of the knee and hip were not significantly different between the “fast” and “slow” limbs during SBTW. These results suggest that SBTW places a greater demand on the ankle of the “fast” limb, requiring the walker to generate a stronger plantarflexor torque.

CONCLUSIONS

While walking on an instrumented split-belt treadmill, all subjects produced a larger sagittal plantarflexor joint torque in the “fast” limb ankle when compared to the contralateral limb. This information may be useful in rehabilitating asymmetries in gait in populations, such as stroke, in which the ability to generate plantarflexor torque is diminished unilaterally.

REFERENCES