Factors Governing Temporal Symmetry in Hemiparetic Gait:
Improvement on the Treadmill with Harness Support

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Introduction

Treadmill training with harness support is a promising, task-oriented approach to restoring locomotory ability in individuals with post-stroke hemiparesis. With harness support, many hemiparetic individuals are able to walk with improved swing time or, equivalently, improved single-leg stance time symmetry, which has been regarded as a positive training stimulus in the achievement of a more functional gait [1]. The improvement in swing/stance time symmetry is generally accompanied by an increase in stance time on the paretic limb, which presumably demands a higher level of performance from the paretic limb during stance. In hemiparetic individuals, swing/stance time asymmetry may result from shortened swing time of the non-paretic limb, perhaps, due to weakness or poor balance during weight acceptance of the paretic limb, and/or from prolonged swing time of the paretic limb, perhaps, due to inadequate acceleration of the limb during pre-swing. To examine these possibilities, we assessed swing times and kinetic energies of the paretic and non-paretic limbs at toe off in hemiparetic subjects during treadmill walking with and without harness and compared these values with those in healthy controls walking at matched treadmill speeds.

Clinical Significance

A better understanding of temporal asymmetry in hemiparetic gait, and its improvement on the treadmill with harness support, can support or challenge the view that improved swing time symmetry and/or increased stance time on the paretic limb is a positive training stimulus on the treadmill. Such clarification may suggest better approaches to treadmill training with harness support, or the use of supplementary gait training interventions, which may optimize functional outcome.

Methodology

Bilateral kinematics and insole pressure data were collected in 5 hemiparetic subjects and 5 age- and size-matched healthy controls as they walked on a treadmill at speeds comfortable for the hemiparetic subjects (range = 0.13-0.45 m/s). The hemiparetic subjects walked both unsupported and with 50% of their body weight supported by a harness. The healthy subjects walked unsupported. The kinematic data were fit to subject-specific, inertial models to quantify the kinetic energy of the leg segments (i.e., thigh, shank, and foot/shoe) at toe off. The insole pressure data were used to determine the periods of stance and swing of each limb.

Results

Without harness support, swing time was prolonged for the paretic limb (40±4% of gait cycle in hemiparetic vs. 32±11% in healthy subjects) and shortened for the non-paretic limb (23±4% of gait cycle in hemiparetic vs. 32±9% in healthy subjects) relative to values for corresponding limbs (right/left matched) in healthy controls (Figure 1). With 50% body weight support, swing time was even more prolonged for the paretic limb (46±9% of gait

cycle). However, swing time for the non-paretic limb or, equivalently, stance time of the paretic limb (33±6% of gait cycle) was about equal to that in the control subjects, resulting in a net improvement in swing time symmetry.

Without harness support, leg kinetic energy at toe off was very low for the paretic limb (1.6±0.9 cJ/kg in hemiparetic vs. 4.6±2.4 cJ/kg in healthy subjects) and relatively high for the non-paretic limb (7.0±4.0 cJ/kg in hemiparetic vs. 4.8±3.0 in healthy subjects). With 50% body weight support, leg kinetic energy at toe off was even lower for the paretic limb (1.1±0.6 cJ/kg). However, non-paretic limb kinetic energy (4.9±3.1 cJ/kg) was about equal to that in the control subjects.

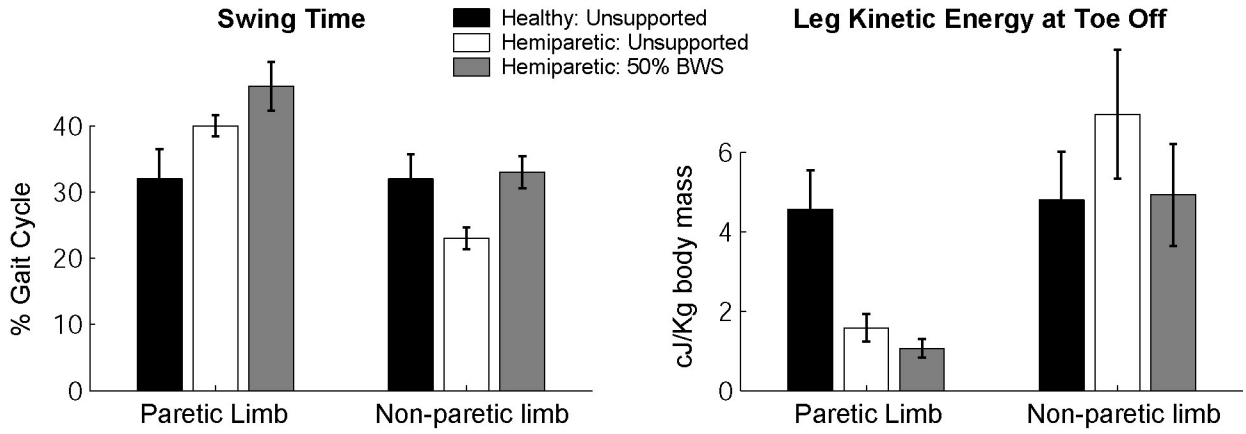

Figure 1 Swing time and leg kinetic energy at toe off for paretic and non-paretic limbs in hemiparetic subjects and for corresponding limbs (right/left matched) in healthy controls (± SEM)

Discussion

Without harness support, the relatively high kinetic energy of the non-paretic limb at toe off, resulting in shortened swing time, could be a consequence of weakness or poor balance during paretic limb stance. With harness support, swing time and kinetic energy of the non-paretic limb at toe off were similar to values in healthy subjects, resulting in improved swing time symmetry and increased stance time on the paretic limb. However, the abnormally low kinetic energy of the paretic limb at toe off, consistent with inadequate push off by the plantarflexors, was not improved with harness support, and swing time of the paretic limb was prolonged even more. Increased stance time on the paretic limb may be a positive training stimulus on the treadmill with harness support, but supplementary gait intervention to improve swing initiation of the paretic limb may be needed for optimal functional outcome.

References

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Acknowledgments

This work was supported by a Pre-Doctoral Associated Health Rehabilitation Research Fellowship and the Rehabilitation R&D Service of the U. S. Department of Veterans Affairs (VA); and a Whitaker Foundation Predoctoral Fellowship.