INTRODUCTION

Manual-assisted, body-weight supported gait training is a promising neurorehabilitation intervention for restoring walking ability following stroke and spinal cord injury (Wernig, 1992, Visentin, 1989). Recent advances in robotics are attempting to overcome the limitations associated with this therapy, such as therapist fatigue, training inconsistencies, and the duration of training sessions. One of the potential limitations with robotic-assisted gait training is the necessary limitation of the degrees of freedom through which the patient can move. Such restrictions may influence natural muscle recruitment patterns in both the temporal and spatial sense, which in turn may influence the effectiveness of the therapy.

The objective of this study was to investigate whether there are differences in muscle activation patterns between unrestricted and robotic-assisted treadmill ambulation.

METHODS

A single healthy subject participated in this study. Surface EMGs were recorded differentially from the gastrocnemius, rectus femoris, vastus medialis and lateralis, adductor longus, hamstrings, and gluteus medius and maximus muscles using a DelSys (Boston, MA) Bagnoli-8 EMG system. Knee and hip angles were measured using twin-axis goniometers (XM100, Motion Labs, Baton Rouge, LA), while foot-switches (MA151, Motion Labs, Baton Rouge, LA) were placed on the subject’s heel to detect heel-strike.

The subject first walked on a treadmill at a self-selected walking speed during which 60-seconds of stepping was recorded. The subject was then placed into the Lokomat (Figure 1) with no body-weight support. The Lokomat restricts motion of the lower limbs to the sagittal plane and has a single DOF in the vertical direction. Small DC motors actuate the hip and knee joints through a kinematic pattern that is adjustable. Foot straps are placed on the subject’s forefoot to assist with dorsiflexion during swing. The leg kinematics of the Lokomat were adjusted to match the subject’s natural kinematic pattern.

The subject was allowed to walk in the Lokomat at the same self-selected speed for up to 5 minutes to acclimate to the device. Data was then recorded for 60-second step sequences. EMG patterns during both conditions were broken up into individual steps, time-normalized, and the RMS was calculated using a 10 ms window.

Figure 1: Lokomat robotic-orthosis (Hocoma, Inc, Zurich, Switzerland)
RESULTS AND DISCUSSION

Comparisons between unrestricted treadmill ambulation and Lokomat treadmill ambulation found that there were significant differences in the spatial and temporal muscle activation patterns across nearly all muscles. For example, during Lokomat stepping, there was minimal activity in the gastrocnemius, presumably because the foot straps prevent significant plantarflexion and push-off (Figure 2). Conversely, there was over-activity in the adductor longus in Lokomat stepping, perhaps attributable to the leg being restricted to the sagittal plane as well as the inability to weight shift.

Mean RMS values were compared at 0, 20, 40, 60, and 80% of the gait cycle for each muscle, where it was found that at each phase across a number of muscles, there were statistical differences between the two walking conditions.

SUMMARY

While robotic-assisted gait training overcomes many of the limitations associated with manual-assisted gait therapy, restrictions in the walking patterns appear to influence muscle activation patterns from what would normally be observed in over-ground walking. These changes include over-activity and under-activity, as well as shifts in the phase of burst patterns. We are currently running more subjects, and investigating whether the changes described here are affected by walking speed as well as the foot-strap used to provide dorsiflexion.

REFERENCES


ACKNOWLEDGMENTS

We would like to thank the National Rehabilitation Hospital for sponsoring this work.

Figure 2: Muscle activation patterns in the gastrocnemius (upper trace) and rectus femoris (lower trace) during treadmill stepping and Lokomat stepping.