Re-Education of Injured Nervous Systems: Infant Spontaneous Kicking Study (CNS-0932015)

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Infants with perinatal brain injury are delayed in their locomotor development. We have only a limited understanding of the process by which brain injury impedes the process of infant motor learning. Primary injury to neural subsystems as well as secondary changes to skeletal, joint, and tissue subsystems may limit the process by which infants modify hip, knee, and ankle joint rotations in order to explore how their legs function in a gravitational field. These limitations in self-produced kicking experience may result in reduced range of motion, excessive stiffness, and abnormal postures. To examine this possibility, we are undertaking a longitudinal study of spontaneous supine kicking in typically developing infants and infants with perinatal brain injury at risk for neuromotor delay. Here, we present the methodology for acquiring kinematic and EMG data from the typically developing infants. We use these data to gain a better understanding of the process by which dissociation of joint rotations are used to explore the kinematics of the entire limb. We present a set of tools for displaying and analyzing time-locked kinematic and EMG signals of each limb. By comparing these data with kicking data from brain-injured infants, we will be able to develop rehabilitation strategies that use assistive devices to increase the opportunity for infants to explore their own leg motions.

The infant's motion is captured using an optical motion capture system (VICON), which tracks the position trajectories of individual IR markers on the body. Using these marker positions and the infant's anatomical dimensions, a biomechanical model can be constructed, and accurate inverse kinematics (IK), i.e., joint angles, produced during the infant's movement may be derived. In order to study the coordination of leg movement during kicking, surface EMG sensors with accelerometers are placed on the muscles of the leg segments to record the agonist and antagonist muscle groups electric activity and limb accelerations during movement. Our analysis of data from five typically developing infants indicates that during early spontaneous kicking:

1. Flexion and extension motions during kicking are achieved by simultaneous activation of quadriceps and hamstring muscles, a pattern called co-contraction.
2. The hip and knee joints rotate in phase during flexion-extension.
3. Muscle activations and joint rotations occur synchronously.

Thus, when infants initially explore the properties of their limbs moving in a gravitational field, the three segments of each limb are controlled as a single degree of freedom, and that the muscle activations are not taking advantage of the effects of gravity on the leg. We know from other research that there is a gradual dissociation of joint rotations as typically developing infants have the opportunity to kick and explore their leg motion. Brain injured infants may produce fewer spontaneous kicks and have limited learning opportunities for dissociating limb movements. This suggests that a device that provides brain-injured infants with the opportunity to explore the multiple degrees of freedom of their rotating limb segments may promote learning and the possibility of restoration of function.