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Natural Progression of Gait in Children With Cerebral Palsy

*Katharine J. Bell, M.S., *Sylvia Õunpuu, M.Sc., *Peter A. DeLuca, M.D., and †Mark J. Romness, M.D.

Study conducted at the Center for Motion Analysis at Connecticut Children's Medical Center, Hartford, Connecticut, U.S.A.

Summary: Twenty-eight children with cerebral palsy had two gait analyses an average of 4.4 years apart with no surgical intervention between the tests. The effects of growth and age were examined using three-dimensional kinematics, temporal and stride parameters, and clinical examination measures. Kinematic changes showed decreases in hip, knee, and ankle sagittal plane ranges of motion (ROM), peak hip flexion in swing, and peak knee flexion over time. Temporal and stride parameters showed declines in timing of toe off, cadence, and walking velocity. Clinical measures showed declines in hip abduction ROM (knees flexed and extended), popliteal angle, and sagittal plane ankle ROM (knees flexed and extended). Overall results showed that gait function in these individuals with cerebral palsy decreased longitudinally with respect to temporal/stride measures, passive ROM, and kinematic parameters compared with a group of individuals who had had orthopaedic intervention. **Key Words:** Cerebral palsy—Development of gait—Gait analysis.

Children with cerebral palsy (CP) have damage to the central control system in the brain, typically a result of a static injury to the developing brain (1). This type of injury to the neurologic system commonly results in abnormal motor control, with associated delay in the onset of walking and an abnormal gait pattern. Children with spastic CP typically walk with gait patterns that reflect internal rotation, crouch, and limited sagittal plane motion. Gait abnormalities in patients with CP are typically addressed initially through a combination of conservative treatment approaches that may include therapy and bracing, followed by surgical intervention when the child is older.

Three-dimensional gait analysis techniques have been used extensively to enhance a traditional subjective evaluation of gait by providing objective information to be used for treatment decision making (4). Comparison of gait data collected both before and after surgery also allows for objective evaluation of the effects of treatment (5,6,14–16,18). The systematic evaluation of surgical protocols in groups of children using gait analysis has led to many advancements in the surgical approach to the treatment of gait abnormalities for the patient with CP. However, to fully interpret the result of treatment, the natural progression of the pathology must also be understood. Treatment that prevents a decline in the patient's function is actually a benefit if the natural progression is characterized by a decrease in function.

Little objective documentation exists on the evolution of gait in the ambulatory child with CP, with the primary exception of Johnson et al. (8), who using gait analysis documented gait in children with spastic CP. Eighteen subjects with CP were examined twice with a mean interval of 2.5 years between gait analyses. The authors found a decline in gait function in children with spastic diplegia over time, including reduced sagittal plane range of motion (ROM) and a reduction in gait stability, as indicated by stance-to-swing ratio. It was proposed that this may be a function of the inability of length changes in spastic muscle to keep up with the changes in bone length. This is consistent with the work of Ziv et al. (21), and Wright and Rang (20), using a spastic mouse model. It is clear that increased skeletal growth without simultaneous increase in muscle length will lead to relative muscle tightness, contracture, and ultimately abnormal bony torsions. Increased body weight has a negative impact on the relative forces generated by muscles, which are typically weaker than normal in children with CP.

In a cross-sectional study, Norlin and Odenrick (10) showed a decrease in cadence and an increase in stance times with age, thus creating a decrease in function over time. However, the cross-sectional design of this study with assessment restricted to temporal parameters limits definitive conclusions about the natural progression of gait in spastic CP.

The purpose of this study was to evaluate the natural

Address correspondence and reprint requests to Katharine J. Bell, M.S., Center for Motion Analysis, Connecticut Children's Medical Center, 282 Washington Street, Hartford, CT 06106, U.S.A. (e-mail: Kbell@ccmckids.org).

From *Center for Motion Analysis, Connecticut Children's Medical Center, Hartford, Connecticut, U.S.A.; and †Commonwealth Orthopaedics and Rehabilitation, Fairfax, Virginia, U.S.A.

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