Walker Assisted Gait in Children with Cerebral Palsy: Instrumentation and System Design

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Introduction

Cerebral palsy (CP) is a condition characterized by a motor disorder that is usually diagnosed during the early stages of life. It occurs from brain damage and has symptoms including postural instability and abnormal muscle tone. The Centers for Disease Control and Prevention (CDC) estimates that 10,000 children in the United States develop CP each year [1]. A large number of CP patients have spastic diplegic cerebral palsy, in which the disorder affects the lower extremities more severely than the upper extremities and many use walkers. Although walkers typically support 1/3 of an adult's body weight during rehabilitation (post-stroke, post surgery, etc.), the support provided to a child with CP has not been explored. Because children with spastic diplegic cerebral palsy are asymmetric in terms of extremity involvement, so too are the forces applied to their walker handles. The purpose of this work is to develop a reliable quantitative system to analyze upper extremity (UE) kinetics in children with CP during walker assisted gait (anterior and posterior).

Statement of Clinical Significance

Several researchers have studied the effects of walkers on the lower extremity (LE) gait of patients. However, a study of the full range of upper and lower extremity dynamics with the use of a walker has not been completed. By studying upper extremity characteristics of spastic diplegic children, the effects of force distribution through the arm joints, information concerning the outcome of anterior versus posterior walkers, and quantitative measures to improve the design of pediatric walkers may be determined.

Methodology

Few studies have used an instrumented walker to analyze upper and lower extremity gait. Crosbie (1993, 1994) discussed upper extremity motion with the use of a walker in healthy adults [2,3]. Our group (2001) performed an earlier analysis with a strain gage dynamometer system to calculate the forces and moments applied to a walker by adult subjects [4]. A six DOF measurement comprised of twelve strain gage bridges was used to determine the three forces and moments applied by each hand during ambulation. In the current study, Advanced Medical Technology's AMTI (Watertown, MA) walker sensor handles, model MCW-6-500, are used in conjunction with a unique kinematic and kinetic model to measure the forces and moments applied by users of pediatric anterior and posterior walkers. The handles measure the generalized forces of contact with a series of full bridge, strain gage sensors. The handles are calibrated at eight different load locations. For the current study, two different types of walkers are used: a modified pediatric posterior walker (Kaye Products, Inc., Model W3B, Hillsborough, NC) and an anterior walker (Guardian Products Model 7749, Sunrise Medical, Simi Valley, CA). Data is recorded using two Vicon motion analysis systems (Oxford Metrics, Oxford, UK). The Vicon system at The Medical College of Wisconsin, Milwaukee, consists of a 15 camera, dual force plate system; the Vicon system at Shriners Hospital, Chicago, consists of a 12 camera, dual force plate system. The biomechanical model developed for the study includes UE and LE modules with markers placed over anatomical landmarks. The UE landmarks are: Vertebrae C7 and L1, Sternal Notch, Dorsum of Hand, Ulnar Styloid, Mid-Radius, Mid-Humerus, Olecranon, Acromion Process, and the Anterior Superior Iliac Spines. The LE landmarks are: Thigh, Lateral Knee, Tibia, Lateral Malleolus, and Dorsum of Foot (Fig.1). Data collected by the Vicon system are LPF processed. The system is outlined in Fig.2.

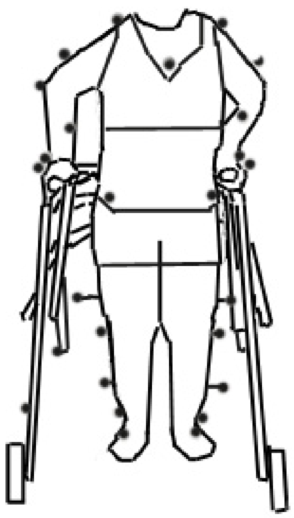

Fig.1: Posterior Walker

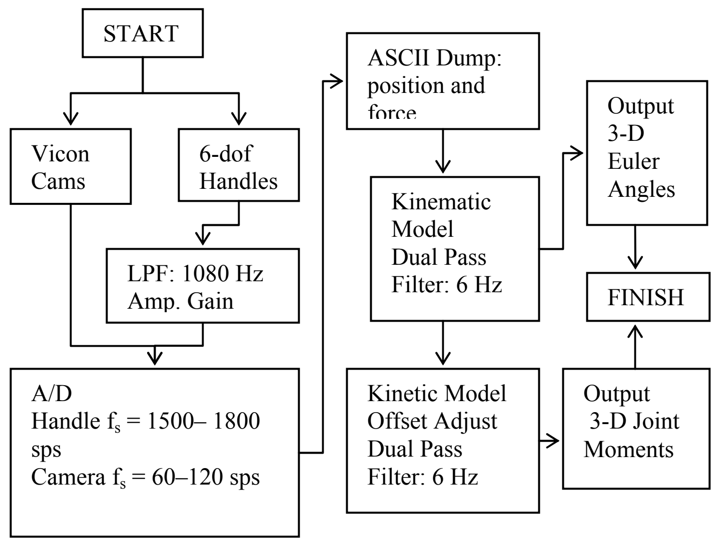

Fig.2: Data Collection System

Results

We have shown in a pilot study that the use of a pediatric posterior walker, versus an anterior walker, results in decreased trunk flexion, increased walking speed, greater energy expenditure, larger shoulder extension, and smaller elbow extension and wrist flexor demands [5]. This study expands upon these results by analyzing a larger pediatric population.

Discussion

The current system allows analysis of upper and lower extremity kinetics in a population of children with CP. Preliminary results indicate that the marker sets (UE, LE) and dynamometer configuration are appropriate for defining the complex kinematics and kinetics. Consistency with our previous adult findings supports continued development of the pediatric system.

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Acknowledgement

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