Gait Energy Efficiency in Children with Cerebral Palsy

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Introduction

Children with Cerebral Palsy (CP) expend up to three times the energy required for ambulation as compared to typically developed children of the same age. Measuring the metabolic energy required to execute a task is an intuitively appealing way to quantify task efficiency. Task energy demand is often quantified through pulmonary tests that measure oxygen consumption. Although providing an accepted measure of energy demand, these tests are technically demanding and staff intensive. For this reason, we sought a measure of gait efficiency based on spatiotemporal and kinematic parameters that would be reflective of the energy cost during ambulation in children with CP. Given the complex nature of ambulation in children with cerebral palsy, it is likely that singular approaches to model or predict gait energy efficiency could fall short. Kinematic parameters as well as parameters from models developed by Kerrigan et al., 1,2 Fonseca et al. 3 and Kuo et al. 4 were calculated and analyzed to find those parameters that most highly correlate with energy cost.

Methods

• Data from 18 children with spastic diplegic CP (7-13 years old) who underwent both gait analysis and energy expenditure testing in the motion analysis laboratory were used in this analysis.
• Gait data were collected and processed using a 7-camera motion analysis Vicon system (Vicon, Oxford Metrics, Lake Forest, CA).
• Energy expenditure during steady state walking was assessed via gas dilution method utilizing a SensorMedics® VMax metabolic cart and software.
• Spatiotemporal, kinematic as well as parameters of the various biomechanical models were calculated using the Vicon system and a Matlab program (The Mathworks Inc. 6.5, Natick MD).
• Once all variables were calculated, the results were averaged, for each subject’s side, left and right, for a total of 60 gait strides (left heel strike to left heel strike) and data sets. Statistical (Statistica 6.1, Tulsa OK) relationships between energy cost and the other gait variables were analyzed using Pearson product moment correlation coefficients with a significance criterion of alpha < 0.05. Based on the correlation results, a regression model was run on chosen variables with oxygen cost as the dependent variable.

Results

Presented are the statistical analysis results for 18 subjects with CP for a total of 60 gait cycles:

Discussion

The results of this work provide insight into the relationship between mechanical and metabolic efficiency of gait in children with Cerebral Palsy. This work provides a conceptual basis for the development of improved computational models and monitoring devices that accurately assess the energy efficiency of gait in this population without the need for explicit measurement of metabolic expenditure. Such devices could utilize wearable sensor technology to measure kinematic variables. The computational model of gait energy efficiency can also be used to investigate the impact of clinical interventions to improve gait efficiency.

References: