CHILDREN WITH CEREBRAL PALSY HAVE INCREASED VARIABILITY IN THEIR STEPPING PATTERN AND INCREASED CORTICAL ACTIVITY DURING GAIT

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INTRODUCTION

Children with cerebral palsy (CP) display balance and walking impairments that are commonly provoked by damage to the periventricular white matter during birth or shortly after. Although it has been previously shown that these children have an increased amount of variability in their stepping pattern [1], it is currently unknown if these variations are a result of an aberrant brain-body connection. Due to recent computational and hardware advances in the technique of functional near-infrared spectroscopy (fNIRS), we are now able to quantify the amount and location of the cortical activation that occurs during gait [2]. Our recent fNIRS investigation has demonstrated that the amount of cortical activation is related to the difficulty of the walking task [2]. Moreover, we have shown that the amount of cortical activation is also positively related to the amount of variation present in the gait pattern of adults [2]. Based on these insights, we suspect that the increased variability seen in the gait pattern of children with CP will be reflected in their cortical activity during gait. The purpose of this investigation was threefold: 1) To further substantiate that children with CP have a more variable stepping pattern, 2) To determine if there is positive relationship between the amount of cortical activity and the variation in the gait patterns of children, 3) To determine if children with CP have an altered amount of activity across the cortical network during gait.

METHODS

Children with spastic diplegic CP (n= 4; Age = 11 ± 4 yrs.) who had a Gross Motor Function Classification Score (GMFCS) of II-III and TD children (n= 8; Age = 13.2 ± 3 years) participated in this investigation. A GMFCS of II indicates that the children have notable walking impairments but do not require an assistive mobility device to walk, while a GMFCS III indicates that the child requires an assistive mobility device (e.g., forearm crutches, wheeled walker) to walk.

The children walked on a programmable treadmill for two sessions that consisted of five alternating blocks of standing still for 30 seconds and 30 seconds of walking at 0.45 m/s. Cortical activation was measured using a 24-channel fNIRS system. fNIRS quantifies the concentration of deoxygenated and oxygenated hemoglobin (oxyHb) in the neural tissues beneath the array, which is closely linked to the amount of neuronal activity. We focused on oxyHb measurements in this study. The optodes of the system were positioned on the child’s head using the International 10/20 system for EEG recording, with Cz located beneath the center of the front two rows of optodes (i.e., between channels 5-6). The full 24-channel array was separated into smaller 5-channel arrays that were located over the supplemental motor area (SMA), precentral gyrus, postcentral gyrus, and superior parietal lobe (SPL).

Concurrently, a two-dimensional sagittal plane video was collected at 60 Hz and was used to determine temporal kinematics. The respective stride, stance and swing times were determined from the video using the SIMI motion capture software. The coefficient of variation of the respective temporal kinematic measures was calculated to quantify the amount of variability present in the gait pattern.
RESULTS AND DISCUSSION

The children with CP had a greater amount of variability in their stance and stride times (Figures 1 A & B). The greater variability suggests that the children with CP had more errors in the execution of the stepping motor command. This result concurs with what has been previously reported for the over ground walking patterns of children with CP [1].

We additionally found positive correlations between the amount of variability in the temporal kinematics and the amount of cortical activation seen during the gait of the children. Specifically, strong positive correlations were found between the variability in the stride (r=0.77) and stance time intervals (r=0.76) and the SPL (p<0.05). We also found moderate correlations (p<0.05) between variability in the stride time intervals and the postcentral gyrus (r=0.55). Additionally, moderate correlations (p<0.05) were found between the stance time intervals and the precentral gyrus (r=0.56) and postcentral gyrus (r=0.62). These results further confirm that an increased amount of gait variability is associated with an increased amount of cortical activity [2].

Our results also showed that the amount of activation across the cortical network was higher for the children with CP (Figure 2). For children with CP, activity was significantly greater in the precentral gyrus, postcentral gyrus, and SPL (p<0.05). Conversely, activations in the SMA were not significantly different (p>0.05). These results infer that walking presents a greater burden on the cortical networks for children with CP than TD children. We suspect that the increased burden may be partly related to the damage present in the corticospinal and thalamocortical tracts of the children with CP [3]. Effectively, the damage may diminish the efficiency of the neuronal groups that are involved in the formulation and correction of the stepping motor command.

CONCLUSIONS

The results of our experiment are three fold: 1) Children with CP have greater variability, 2) Increased gait variability is associated with increased activity across the cortical network, 3) Children with CP have an increased amount of cortical activation during gait. These results are the first to evaluate the link between the brain and biomechanics in children with CP during walking. Further exploration of this connection will enhance our understanding of the movement impairments seen in children with CP, and may enhance our ability to assess the efficacy of therapeutic strategies that are directed at improving the motor control and learning of children with CP.

REFERENCES