DECREASED DYNAMICAL COMPLEXITY DURING QUIET SITTING IN CHILDREN WITH AUTISM SPECTRUM DISORDERS

1 Kimberly Fournier, 2Shinichi Amano, 3Hyo Kuen Lee and 3Chris Hass

1 The University of Rhode Island, Kingston, RI, USA
2 Ohio University, Athens, OH, USA
3 The University of Florida, Gainesville, FL, USA
email: kimfournier@uri.edu

INTRODUCTION

Movement impairments are a ubiquitous symptom in children diagnosed with Autism Spectrum Disorders (ASD) [1]. Purposeful movements necessary for functional independence, first require an ability to control one’s posture. Children with ASD have been reported to exhibit impairments in their control of posture [2] and non-linear analyses of the center of pressure (COP) data during quiet stance has revealed their control to be more regular or restrictive [3]. In an effort to further explore the link between postural control and the characteristic repetitive and stereotyped behavior associated with this population, detrended fluctuation analysis (DFA) was applied to quiet, unsupported sitting posturography data in children with ASD.

METHODS

Posturographic data for sixteen children diagnosed with ASD (age: 6 ± 1 years, height: 1.2 ± 0.1 m, mass: 23.8 ± 6.2 kg, Leiter-R Brief IQ: 81.5 ± 25.0) and sixteen age-matched typically developing (TD) children (age: 6± 1 years, height: 1.2 ± 0.1 m, mass: 20.6 ± 2.90 kg, Leiter-R Brief IQ: 115.2 ± 13.9) were analyzed. Ground reaction forces (GRF) and moments were recorded (360 Hz) from a forceplate (Type 4060-10, Bertec Corp., Columbus, OH). During quiet sitting trials, children sat on a stool that was positioned on the forceplate. During each trial, children viewed a video that contained vibrant images and music for 120 s. Each 120 s trial was subdivided into smaller 20 s trials. Trials where the participant was moving and not attending to the video were discarded. GRF and moments were used to calculate the location of the COP in a time-series and these data were then filtered using a second order, low pass frequency Butterworth filter (cut-off frequency of 20 Hz). The filtered locations of the COP were then outputted for further analyses.

The time-dependent structure of sway variability during sitting was examined by means of DFA. This approach provides a measure of the rate of growth in the fluctuation of variance as a function of increasing time scales, and the slope of this rate of growth (α-value) provides an index of the breadth of fluctuations across the range of time scales [4]. The robustness of this technique to non-stationarity underscores the appropriateness of its use for postural sway data [5]. A larger rate of growth or steeper slope (larger α-value) indicates fluctuations occur over relatively few time scales indicating a more predictable system (decreased complexity). A smaller growth rate or gradual slope (smaller α-value) indicates fluctuations dispersed more evenly across a range of time scales and thus indicative of a more random system (increased complexity) [5]. In general, the motor patterns of mature, healthy adults are represented with an α-value of approximately 1. Alternatively, α-values for less mature systems, such as those of children, would likely be greater than 1 and would gradually decrease over their development [4].

Growth rates in the fluctuation of variance (α-value $\alpha_x$, $\alpha$-value $\gamma$) were calculated for the anteroposterior and mediolateral directions based on previous methodology [4]. Additionally, the movement present in the COP time series was characterized by the traditional linear measures of COP range in the anteroposterior and mediolateral directions and the elliptical sway area containing 95 % of the COP data (COP$_{\text{range-x}}$, COP$_{\text{range-y}}$, and Area$_{CE95}$). Independent t-tests were used to identify differences in the dependent variables (Linear: COP$_{\text{range-x}}$, COP$_{\text{range-y}}$, Area$_{CE95}$, Nonlinear: α-value $\alpha_x$, α-value $\gamma$).
between children diagnosed with ASD and TD children. An a’ priori alpha level of 0.05 was set for all statistical tests and all statistical tests were performed using SPSS 16.0 for Windows (Chicago, Illinois).

RESULTS AND DISCUSSION

Children with ASD exhibited significantly larger $\alpha$-values in both the anteroposterior and mediolateral directions ($p < 0.05$). The $\alpha$-values were 14.5% larger in the anteroposterior direction ($\alpha$-value $X$) and 16.8% larger in the mediolateral direction ($\alpha$-value $Y$). Additionally, the three linear measures for movement present in the COP time series were significantly larger in children with ASD when compared to TD children (76.4% larger, 135.5% larger, and 271.9% larger for COP RANGE-$X$, COP RANGE-$Y$, and AreaCE95 respectively, $p < 0.05$ for all 3 measures) (Table 1).

Linear and nonlinear analyses of the COP time series during quiet, unsupported sitting support previous postural control findings reported in the literature. As hypothesized, children diagnosed with ASD displayed larger linear measures (COP RANGE-$X$, COP RANGE-$Y$, AreaCE95) when compared to TD children [2]. Similar to previous findings for quiet stance [3], DFA analyses revealed that children with ASD had a more predictable control of posture. Growth rates in the fluctuation of variance approached values previously reported for behavior with predictive patterns or reduced complexity [4].

Unsupported sitting, when compared to quiet stance, is believed to require less control and/or coordination (fewer degrees of freedom). Previous reports suggest postural impairments may be the result of abnormalities and dysfunction in the underlying neural networks responsible for coordinated activity [3]. However, abnormalities in these same areas have also been associated with restricted, repetitive behaviors (RRBs), a cardinal feature of ASD [6]. While quiet sitting is more readily accomplished as a research task in this population, the restricted control of posture observed during the less coordinated task lends support to a global impairment associated with ASD and an underlying central rigidity that result in a lack of complexity in the control of a broad range of stereotypic behavior, including motor behavior [3].

CONCLUSIONS

The main finding of this work is that children with ASD exhibit reduced dynamical complexity in their control of posture, over a range of behaviors that now includes unsupported sitting. Results further support the links between restricted control of posture, stereotypic behavior and the neurobiology of ASD.

REFERENCES


Table 1: Means and standard deviations (SD) for measures of COP variability during quiet, unsupported sitting.

<table>
<thead>
<tr>
<th>Measure of Variability</th>
<th>ASD (n=16)</th>
<th>TD (n=16)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$-value$X$</td>
<td>1.26</td>
<td>(0.13)</td>
<td>1.10</td>
</tr>
<tr>
<td>$\alpha$-value$Y$</td>
<td>1.25</td>
<td>(0.16)</td>
<td>1.07</td>
</tr>
<tr>
<td>AreaCE95</td>
<td>12.31</td>
<td>(10.10)</td>
<td>3.31</td>
</tr>
<tr>
<td>COP RANGE-$X$</td>
<td>4.57</td>
<td>(2.43)</td>
<td>2.59</td>
</tr>
<tr>
<td>COP RANGE-$Y$</td>
<td>3.98</td>
<td>(2.79)</td>
<td>1.69</td>
</tr>
</tbody>
</table>

*Significant at p<0.05