Research in Autism Spectrum Disorders 40 (2017) 13–23

Contents lists available at ScienceDirect

Research in Autism Spectrum Disorders

journal homepage: www.elsevier.com/locate/rasd

Spatial and temporal analysis of postural control in children with high functioning Autism Spectrum Disorder

Nathalie Goulème[a,*], Isabelle Scheid[b,c], Hugo Peyre[b,c], Anna Maruani[b,c], Julia Clarke[b,c], Richard Delorme[b,c], Maria Pia Bucci[a]

[a] UMR 1141 Inserm, Université Paris Diderot, Robert Debré Hospital, 48 Boulevard Sérurier, 75019, Paris, France
[b] Child and Adolescent Psychiatry Department, Robert Debré Hospital, Paris, France
[c] High Functioning Autism Expert Center, Fondamental Foundation, Paris, France

A R T I C L E I N F O

Keywords:
Autism spectrum disorder
Children
Postural control
Wavelet transformation
Sensorial inputs

A B S T R A C T

Background: Children with autism spectrum disorders (ASD) have poor postural stability. The objective of our study was to explore further postural capabilities in ASD children by measuring spatial as well as temporal displacement of the center of pressure using wavelet analysis.
Method: Thirty children with ASD (12.1 ± 2.9 years) and 30 sex-, age- and IQ-matched typically developing children participated in the study. We recorded postural control using Multitest, also called Balance Quest, Equilibre from Framiral® in three viewing conditions (eyes open, eyes closed and with perturbed vision) and in two postural conditions (stable and unstable).
Results: Our results show that children with ASD displayed a deficit in postural stability in comparison with typically developing children, especially when sensory inputs are not all available.
Conclusion: Such poor postural control in children with ASD could be due to both an impairment in using sensorial inputs appropriately and a deficit in the ability to compensate for sensorial changes.

1. Introduction

Autism Spectrum Disorders (ASD) are neurodevelopmental disorders that are characterized by deficits in social communication and social interaction, as well as by the presence of restricted, repetitive behaviors (as classified in the DSM-5 – APA, 2013). Children with ASD often display deficits in fine and gross motor skills, lack coordination and show poor postural stability (Pozzo et al., 2006).

Postural control involves an intricate relationship between several sensorial inputs from the vestibular, visual and proprioceptive senses (Brandt, 2003). All these sensory inputs are used to adapt motor command and maintain postural stability to a specific motor task and as suggested by Mergner and Rosemeier (1998), multisensory integration system develops through experience during the daylife.

In the literature, motor impairment in ASD subjects has been extensively described, more particularly in situations in which sensory inputs are not always available. Kohen-Raz (1991) were the first to evaluate postural control in several conditions (eyes open, eyes closed, on foam). They reported that ASD subjects had poorer postural control than typically developing children and featured an increase in medio-lateral postural sway particularly in conditions with misleading sensory information. Gepner and Mestre (2002) hypothesized that Asperger children, like autistic children, could experience hyporeactivity to visual motion, and they observed that

* Corresponding author.
E-mail address: gouleme.nathalie@gmail.com (N. Goulème).

http://dx.doi.org/10.1016/j.rasd.2017.05.001
Received 14 September 2016; Received in revised form 14 April 2017; Accepted 3 May 2017

their postural control was poorer than that of control children. Moreover, these authors recorded postural oscillation during a visual motion condition and they found that postural sway was significantly more adapted to the visual motion stimuli in both control and Asperger children but not in children with ASD. These results suggest a sensorimotor deficit in children with ASD, who are not able to adapt their postural stability when visual inputs are changed, which indicates poor cerebellar activity in response to environmental changes. Indeed, cerebellum is involved in integration and reweighting of sensory inputs (visual, somesthesic and vestibular) (Peterson, Christou, & Rosengren, 2006) and several authors (Gepner, Mestre, Masson, & de Schonen, 1995; Gepner and Mestre, 2002; Gowen and Miall 2005; Rinehart et al., 2006; Stoodley 2016) suggested that postural difficulties in ASD children could be due to poor cerebellar activity. Molloy et al., (2003) compared postural control in children with ASD and typically developing children when sensory information is perturbed (visual and somatosensory inputs) and they reported that in these perturbed conditions children with ASD showed poorer postural control than typically developing children. Thus, these authors suggested that ASD children had a deficit in sensory multimodal integration, the latter being necessary to maintain postural control.

A study by Minshew et al., (2004) on a large sample of participants with ASD subjects (aged 5–52) compared to typically developing participants established this deficit in postural stability in children as well as in adults, suggesting that ASD subjects did not achieve the adult normal level. The same authors evaluated postural control in several sensory conditions (with and without somatosensory perturbation) and suggested, in accordance with previous work, that such impairment is most likely due to a difficulty compensating changes in sensorial inputs.

Memari et al., (2013) compared postural control in ASD children and in typically developing children while they were doing a secondary task (visual searching task or auditory task) and they showed that independently to the type of the secondary task ASD children were less efficient to maintain postural stability with respect to age-matched typically developing children suggesting a difficulty of ASD children to control and integrate multimodal information.

Other studies (Downey & Rapport, 2012; Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Ming, Brimacombe, & Wagner, 2007) described poor stability, poor motor coordination and hypotonia in ASD children, and Fournier, Amano, Radonovich, Bleser, and Hass, (2014) confirmed such poor postural strategies in ASD children, showing they display a significantly greater surface of the CoP and a significant increase of postural sway in medio-lateral and antero-posterior directions during quiet stance.

Taken together, all these reports are in line with the hypothesis of poor abilities of ASD subjects at reweighting sensory inputs in order to obtain a good postural stability of the body.

One should point out that in all the studies previously cited, the center of pressure (CoP) was analyzed spatially only, and that the CoP behaviour over time is thus unknown. To our knowledge, one study only has been recently published (Wang et al., 2016) in which the postural activity of ASD subjects was measured by exploring spatial and temporal dimensions of the postural sway relative to their own postural limitation boundary. This was done using a novel virtual time-to-contact (VTC) approach. This study confirmed previous findings on poor postural control in ASD subjects, but also reported the new finding of a reduced spatial perception of postural limitation boundary towards target directions in ASD subjects. Particularly, under dynamic conditions, ASD subjects showed reduced time to correct this error and a difficulty to decouple ankle dorsi-/plantar-flexion and hip abduction/adduction processes. These results suggest an impaired perception of body movements in ASD subjects, as well as a reduced ability to decouple distinct ankle and hip movements to align their body when they are standing.

In line with this study we used new tools and new analyses by using the Multitest Equilibre also called Balance Quest, from Framiral® (www.framiral.fr) in order to explore the CoP displacement in both spatial and temporal domains. Important information on the dynamics of the CoP may be gained by applying nonlinear analysis methods such as the wavelet transformation method. Indeed, a study from Ghulyan et al., (2005) has demonstrated that a dynamic analysis of posture allows a better discrimination of pathological effects on postural control due to the possibility to mislead sensory input similarly to those involved by a disorder. Indeed, Yelnik and Bonan (2008) have shown that temporal analysis allows researchers to gain insight into the physiological and pathological mechanisms underlying postural stability impairment in patients suffering from balance disorders. Lacour et al., (2008) have also described the limitations of the traditional posturography method, suggesting that the spatial analysis of the center of pressure could lead to some misevaluations of the balance control system. Consequently, such type of analysis can reveal deficits or changes in the dynamics of the postural control system, allowing one to identify which sensory systems are implicated or altered during a given postural task. Indeed, we can test two different postural conditions – in which somesthesic inputs may be available (stable condition) or not (unstable condition) – and different visual inputs (eyes open, eyes closed or perturbed vision with opto-cinetic stimulation), see Fig. 1.

Moreover, using such platform there is the possibility to perturb one specific sensory input (vision, somesthesic or vestibular), and to analyse the displacement of the CoP for the three frequency bands: Low: 0.05–0.5 Hz, Medium: 0.5–1.5 Hz and High: higher than 1.5 Hz. The hypothetical physiological significance of the different bands is as follows: 0–0.5 Hz visual-vestibular (Kohen-Raz, Himmelfarb, Tzur, Kohen-Raz, & Shub, 1996; Paillard, Costes-Salon, Lafont, & Dupui, 2002; Nashner, 1979), 0.5–1.5 Hz cerebellar (Paillard et al., 2002) and 1.5 Hz reflexive loops (Bernard Demanze et al., 2009; Lacour, Bernard-Demanze, & Dumitrescu, 2008).

For our study, we used both static and dynamic analyses of the CoP in order to gain insight on the mechanisms involved in the postural control of children with ASD. We hypothesized that children with ASD would be globally less stable compared to typically developing children, especially in the dynamic situation with perturbed vision, in which adaptive mechanisms are needed for obtaining a good postural stability.

2. Methods

Postural capabilities were explored in 30 children with high functioning ASD (mean age 12.1 ± 2.9 years) and in 30 sex-, IQ- and