Assessment of postural control system in autistic patients

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Received 20 August 2011
Accepted 24 September 2011

The Egyptian Journal of Otolaryngology
2012, 28:44–48

Introduction
Studies using clinical tests have reported abnormal postural balance in children with autism generally but it was only clinically significant when somatosensory input was disrupted alone or in combination with other sensory challenges.
Objective
To assess the postural control system in autistic children and correlate their age and Child Autism Rating Scale (CARS) score with their postural control.
Methods
Computerized dynamic posturography was performed in 20 autistic children with (IQ > 70) between the ages of 5 and 15 years and 15 age-matched healthy children.
Results
There was a statistically significant positive correlation between age in both the study and the control groups and the Sensory Organization Test (SOT) results in all SOT conditions. As regards the degree of autism, this study included 20 autistic children diagnosed by CARS and their CARS values ranged from 30 to 46, with a mean (33.7 ± 3.22). In our study, we found that there was a statistically significant negative correlation between the CARS score in the study group and SOT results in all conditions, except in SOT condition 1.
Conclusion
The evidence from this study suggests the more general involvement of neural circuitry beyond the neural systems for social behavior, communication, and reasoning, all of which share a high demand on neural integration of information.

Keywords:
autism, autism spectrum disorder, children, development, postural control, sensory analysis, sensory organization test

Egypt J Otolaryngol 28:44–48

1012-5574

Introduction

Autism is a disorder of neural development characterized by impaired social interaction and communication, and by restricted and repetitive behavior. These signs all begin before a child is 3 years old. Autism affects information processing in the brain by altering how nerve cells and their synapses connect and organize; how this occurs is not well understood [1]. Autism spectrum disorders (ASDs) are a group of neurodevelopmental disorders (autistic disorder, Asperger's syndrome, and pervasive developmental disorder – not otherwise specified) diagnosed according to impairments in communication, reciprocal interaction, and stereotypic behavior [2]. Unusual responses to sensory stimulation may also be a feature of autism and this is mainly observed with regard to the auditory or tactile systems. The child may display extreme reactions to neutral stimuli (such as screaming in response to a gentle touch) or neutral reactions to extreme stimuli (preference for high-pitched sounds). This hypersensitivity or hyposensitivity is a reflection of poor sensory integration – that is, problems with the way sensory information is being transmitted to and interpreted by the brain. This is yet another symptom of developmental delay. Another common resultant is that fine and gross motor skills are often very poor and cognitive ability is lower than normal. The majority of autistic children have significant intellectual impairment but some autistic children are unusually talented in specific areas in which language is not required, such as mathematics or music [3].

One of the fundamental scientific issues in autism research concerns the root causes of the psychological impairments. Several cognitively oriented theories, such as executive dysfunction theory and weak central coherence theory, postulate that cognitive impairments are the underlying cause of autistic symptomatology [4]. Socially oriented theories propose that abnormalities in social perception, social cognition, and social motivation cause subsequent failures of language and cognitive development in autism [5,6].

Studies using clinical tests have reported abnormal postural balance in children with autism generally but it was only clinically significant when somatosensory input was disrupted alone or in combination with other sensory challenges [6,7]. Histopathological studies have revealed

abnormalities of the cerebellum, raising the possibility of motor dysfunction as the cause of postural instability in autism [6,8]. Abnormalities in postural control were suggested to be related to a deficit in sensoryneural integration that depends on multimodal systems involving the basal ganglia, the supplementary motor cortex, the anterior cingulated cortex, and other subcortical areas [8].

The primary goal of this study is to assess the postural control in autistic children and to determine whether it is correlated to age and degree of autism (according to Child Autism Rating Scale; CARS).

Patients and methods

Participants

The study group included 20 participants diagnosed with different degrees of autism of both sexes (13 boys and seven girls). Their age ranged between 5 and 15 years. The control group included 15 participants of the same age range of both sexes (nine boys and six girls). Patients were recruited from the Phoniatric and Psychiatry clinics of Kasr Al-Eini Hospital, Cairo University. The study took place in the Audiology clinic of Kasr Al-Eini Hospital, Cairo University, in the period between March 2010 and March 2011.

In the study group, we excluded patients with mental retardation (IQ < 70) and otitis media with effusion (type B curve tympanogram). A CARS score of 30 or higher was used as a threshold point for the diagnosis and inclusion of autistic children. In the control group, we excluded participants with otitis media with effusion, as well as participants with general medical diseases as birth or developmental abnormalities, acquired brain injury, a learning or language disability, a current or past history of psychiatric or neurologic disorder, a medical disorder with implications for the central nervous system or requiring regular medication use, or a family history in first-degree relatives with developmental cognitive disorder, learning disability, mood disorder, anxiety disorder, or autism in first-degree, second-degree, or third-degree relatives.

Equipment

Computerized Dynamic Posturography (Equitest system) SMART balance master version [Sensory Organization Test (SOT)]. Immittancemeter (Garson Stadler middle ear analyzer, Eden Prairie, MN, USA) GSI 33 version 2 was calibrated according to ISO standards.

Examination and testing

Complete ENT examination and the Immittance test was performed to exclude otitis media in both groups. SOT consisted of recording the position of the center of force during 15-s trials, wherein the participant stood on either a fixed platform or a 'sway-referenced' platform that rotated to null the angle between the foot and the lower leg. Participants had their eyes closed or viewed a fixed visual surround or a 'sway-referenced' visual surround. There were six conditions: condition 1 – fixed platform, eyes open with a fixed visual surround; condition 2 – fixed platform, eyes closed; condition 3 – fixed platform, eyes open with a sway-referenced visual surround; condition 4 – a sway-referenced platform, eyes open with a fixed visual surround; condition 5 – sway-referenced platform, eyes closed; condition 6 – sway-referenced platform, eyes open with a sway-referenced visual surround. Participants performed one or two trials for sensory conditions 1, 2, and 3 and two or three trials for sensory conditions 4, 5, and 6.

Statistical analysis

The data were coded and entered using the statistical package SPSS version 15 (Chicago, Illinois, USA). The data were summarized using descriptive statistics: mean, SD, minimal, and maximum values for quantitative variables and number and percentage for qualitative values. Statistical differences between groups were tested using the χ^2-test for qualitative variables and independent-sample *t*-test for quantitative normally distributed variables. The nonparametric Mann–Whitney test was used for quantitative variables that were not normally distributed. Correlations were carried out to test for linear relations between variables. *P*-values less than or equal to 0.05 were considered statistically significant.

Results

This study was carried out on 35 children; 20 were autistic children (13 boys and seven girls) with different degrees of autism (study group) and 15 were normal children (nine boys and six girls; control group). The age of the study group ranged from 5 to 15 years, with a mean of 8.95 ± 2.98. The age of the control group ranged from 6 to 12 years, with a mean of 9 ± 1.6. There was no statistically significant difference (*P*-value > 0.05) as regards age or sex between both groups.

The autistic children were found to have reduced postural stability as shown in Table 1, especially for the conditions in which somatosensory input was disrupted, which is seen in some patients who are unable to use reliable visual or vestibular information to maintain balance.

In terms of the age of the study group, we found a directly proportional relationship between the age of the study group and the SOT results as shown in Table 2 and (Fig. 1). This was also found in the control group as shown in Table 3.

Table 1 Comparison between both the study and the control groups and their Sensory Organization Test results

	Mean ± SD		
Variable	Study group	Control group	*P*-value
SOT 1	75.94 ± 13.13	83.9 ± 6.71	0.026*
SOT 2	76.85 ± 10.63	88.13 ± 2.72	0.001*
SOT 3	73.66 ± 10.26	86.19 ± 9.96	0.001*
SOT 4	57.67 ± 15.29	73.93 ± 8.73	0.002*
SOT 5	51.29 ± 13.51	60.75 ± 13.31	0.047*
SOT 6	48.03 ± 10.79	59.79 ± 11.72	0.004*
Composite	58.97 ± 8.59	72.07 ± 4.46	0.002*

There was a statistically significant difference (*P*-value < 0.05) in both the study and the control groups, and SOT results in all SOT conditions.
SOT, Sensory Organization Test.
*Significant.

As regards the degree of autism, this study included 20 autistic children diagnosed by CARS and their scores ranged from 30 to 46, with a mean of (33.7 ± 3.22). We found a significant negative correlation between the CARS score and SOT results in the study group as shown in Table 4 and (Fig. 2); there was an inversely proportional relationship between the CARS score and SOT results of the study group.

Discussion

An effective postural control system is a necessary foundation for individuals to acquire skills inherent to functional independence. Initially, there must be an ability to maintain equilibrium during static conditions, in which the center of gravity (COG) remains within the base of support such as during a quiet stance. However, this ability must be further developed to include stability during dynamic conditions, in which the COG moves away from the base of support, such as during gait initiation (GI). During a quiet stance, the postural control system tightly couples movement of the center of pressure (COP) and COG and sway is minimized. Dynamic postural stability is often defined as the ability to tolerate separation of the COG and COP while transitioning from one posture to the next or between a static and a dynamic state [9].

In this study, we evaluated postural stability in 20 autistic children with (IQ > 70) between the ages of 5 and 15 years (mean 8.95 ± 2.89) and 15 healthy control children between the ages of 6 and 12 years (mean 9 ± 1.6).

Table 2 Pearson's correlation coefficient (*r*) between age and Sensory Organization Test results of the study group

	SOT 1	SOT 2	SOT 3	SOT 4	SOT 5		Composite
Age							
r	0.567	0.658	0.508	0.687	0.552	0.641	0.546
P-value	0.009*	0.002*	0.026*	0.519	0.027*	0.047*	0.022*

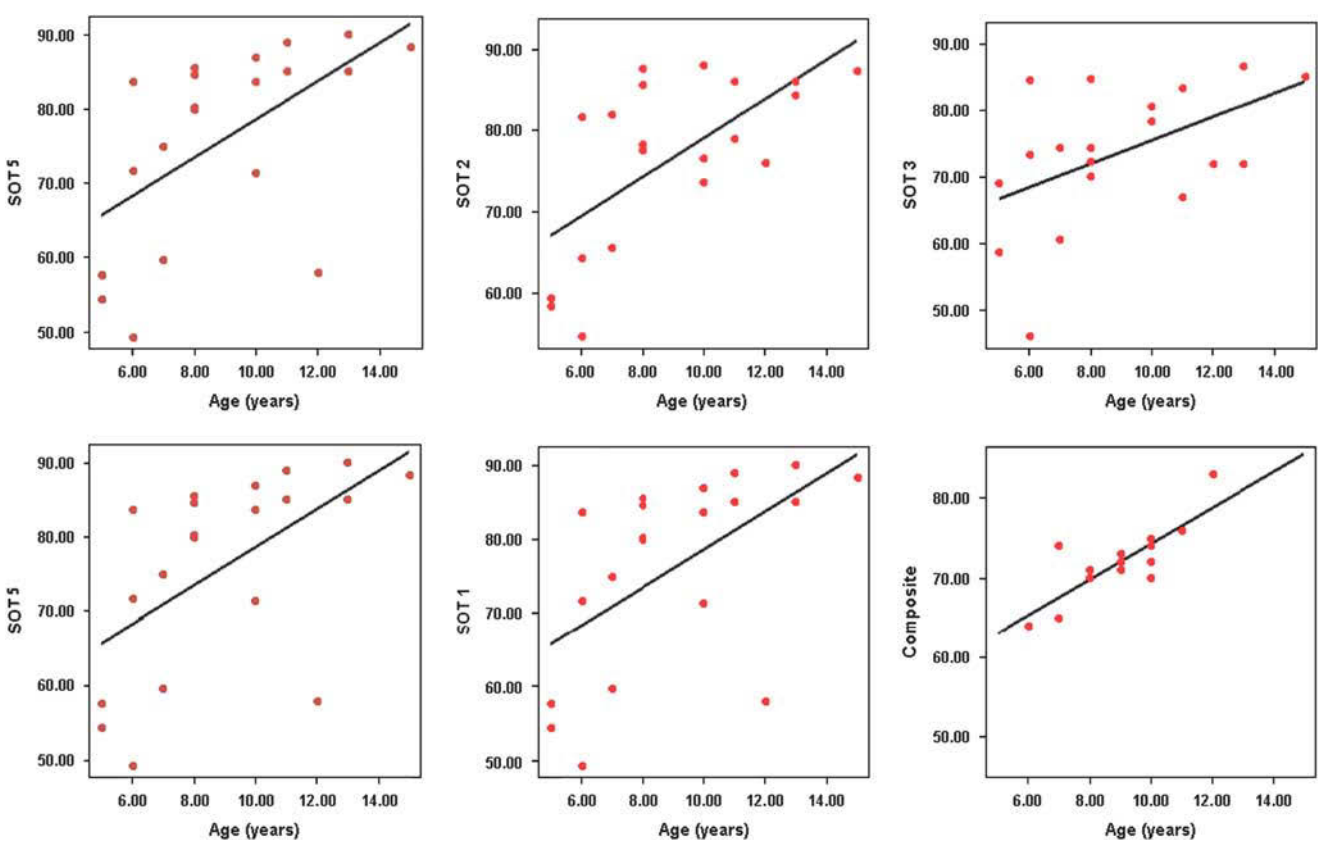
There was a statistically significant difference (*P*-value < 0.05) in the correlation between age and SOT results of the control group in all SOT conditions, except in SOT 4.
SOT, Sensory Organization Test.
**P*-value is significant if > 0.05.

Table 3 Pearson correlation coefficient (*r*) between age and Sensory Organization Test results of the control group

	SOT 1	SOT 2	SOT 3	SOT 4	SOT 5	SOT 6	Composite
Age							
r	0.472	0.085	0.473	0.558	0.84	0.56	0.808
P-value	0.076	0.763	0.045*	0.048*	0.058*	0.05*	0.001*

There was a statistically significant difference (*P*-value < 0.05) between age and SOT results of the control group in all SOT conditions, except in SOT 1, 2.
SOT, Sensory Organization Test.
*Significant.

Figure 1



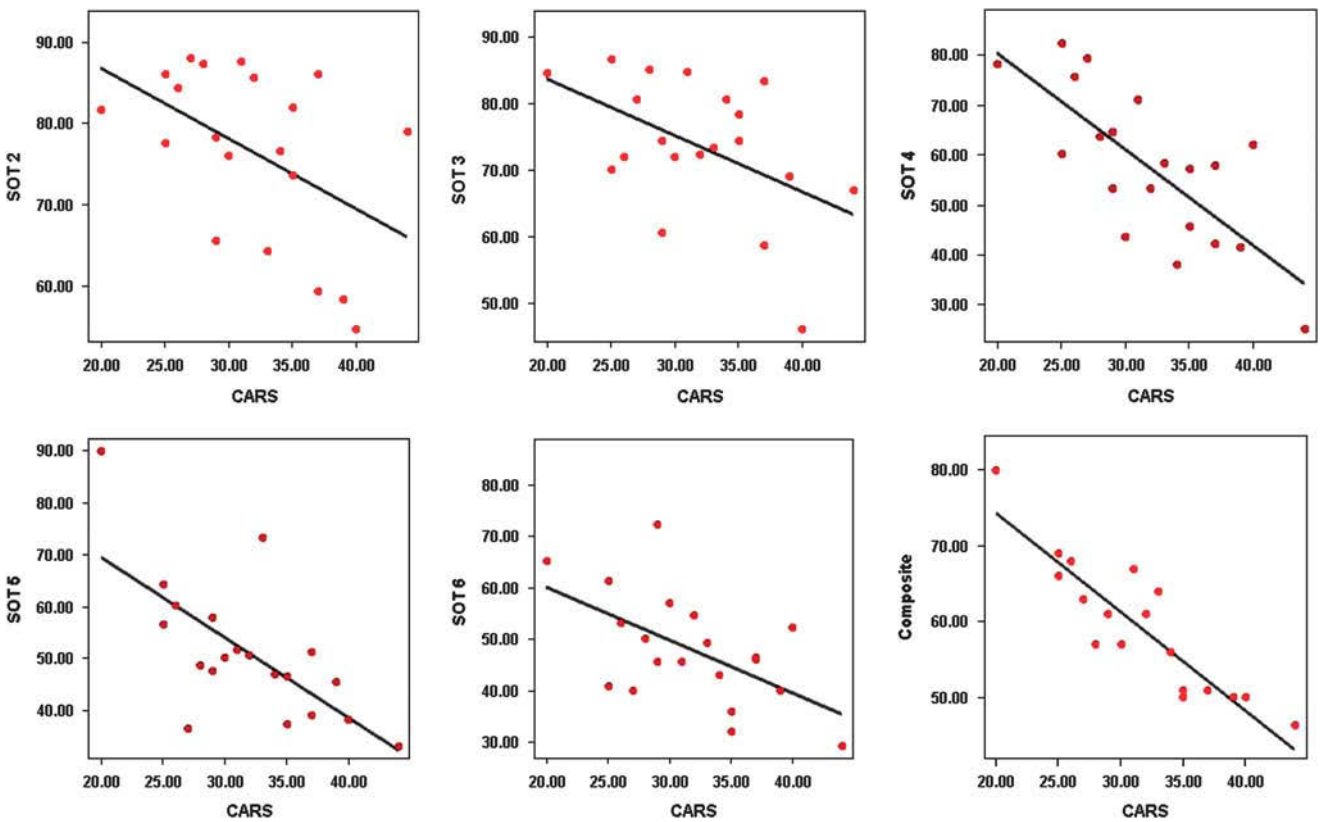
Correlation between age and Sensory Organization Test (SOT) results of the study group.

Table 4 Pearson correlation coefficient (*r*) between the Child Autism Rating Scale and Sensory Organization Test results in the study group

	SOT 1	SOT 2	SOT 3	SOT 4	SOT 5	SOT 6	Composite
CARS							
r	0.392	−0.476	−0.487	−0.754	−0.682	−0.563	−0.912
P-value	0.103	0.029*	0.033*	0.001*	0.003*	0.009*	0.006*

There was a statistically significant difference (*P*-value < 0.05) in the correlation between CARS in the study group and SOT results in all SOT conditions, except in SOT 1.
CARS, Child Autism Rating Scale; SOT, Sensory Organization Test.
*Significant.

Figure 2



Correlation between the Child Autism Rating Scale and the results of different Sensory Organization Test (SOT) conditions in the study group.

The autistic children in the study group were found to have reduced postural stability, on performing SOT, when compared with the control group as shown in Table 1, especially for the conditions in which somatosensory input was disrupted, which is seen in some patients who are unable to use reliable visual or vestibular information to maintain balance. This is indicative of a problem with multimodality sensory integration. This is in agreement with Minshew *et al.* [6], who found that there was a significant difference between autistic participants and the control group as regards postural stability. This is also in agreement with Kimberly *et al.* [2], who found that there was significant systematic postural instability in children with ASD using functional tasks representative of two different categories of postural challenges. They hypothesized that children with ASD had increased postural sway during a quiet stance and a decreased COP shift mechanism that functions to separate the COP and center of mass during GI. It therefore appears that the sequelae of ASD include a retarded development or disruption of postural control abilities during a quiet stance and GI.

As regards the effect of age on postural stability, we found that there was a significant positive correlation between the age of the study group and the SOT results of the same group, Table 2 and (Fig. 1). This was also found in the control group as shown in Table 3. This is in agreement with Minshew *et al.* [6], who found that postural control did not begin to improve in the autistic participants until the age of 12 and never achieved adult levels, whereas in control participants, it improved steadily from 5 to 15 years and up to 20 years, where it reached a plateau at adult levels. This is also in agreement with Kimberly *et al.* [2], who found that the sway area for children with ASD appears to be greater than the sway area of normal children. When combining the findings of this cross-sectional investigation with our study that observed children with ASD, it appears that postural

sway decreases as age increases for normal children, but remains relatively unchanged for children with ASD.

Our findings of reduced postural stability with occlusion of vision and reduction in proprioceptive input as shown in Tables 1 and 4 are consistent with the study of Molloy *et al.* [10], of eight ASD children aged from 6 to 12 years. The autistic and mentally retarded nonautistic participants had significantly lower postural stability than the normal control children at the level of preschool children. The autistic participants, but not the nonautistic mentally retarded participants, showed paradoxically better stability when vision was occluded or somatosensory input was restricted. The postural instability in the autistic participants was comparable with that of the mentally retarded nonautistic participants; it was only their paradoxical response to somatosensory and visual stimuli that was distinguishing. The results showed that children with autism presented with increased stability on more difficult positions, stood with an unusual distribution of weight, and excessively mobilized in the more primary, somatosensory postural control systems when visual cues were fully available [11].

In the current study, as regards the degree of autism, depending on the value of CARS score, we found a significant negative correlation between the CARS score and SOT results in the study group as shown in Table 4 and (Fig. 2); there was an inversely proportional relationship between the CARS score and SOT results of the study group (r was negative). The findings of this study do not support localized cerebellar or vestibular dysfunction. However, Kohen-Raz *et al.* [11] proposed that in adults, this type of generalized postural dysfunction can be seen with Parkinson's disease, progressive supranuclear palsy, disequilibrium of aging, and Huntington disease. The similarity of the postural findings in autism in this study to those in these other disorders suggests the involvement of the basal ganglia, supplementary motor, and anterior cingulate regions to which it is reciprocally connected and to subcortical connections more generally.

In agreement with our results, Vilensky and Damasio [12] found differences in gait in children with autism compared with normal children, including reduced stride lengths and increased stance times. More recently, Green *et al.* [13] assessed the motor skills of autistic children between the ages of 6 and 11 years using the Movement Assessment Battery for Children. The Movement Assessment Battery for Children [14] is designed to assess motor skills, including manual dexterity, ball skills, and balance, in children 4–12 years of age. They found that all of the children in their study with autism scored below the 15th percentile on the test, and nine of the children scored below the 5th percentile, indicative of a definite motor problem. In agreement with our study, O'Neill and Jones [15] stated that although children with autism typically move and appear to function well within their environment on a gross motor level, yet, the quality of their movement is typically very poor. O'Neill and Jones [15] suggested that the senses of vision, hearing, and touch inform us about our surroundings and our own position relative to them. The proprioceptive and the vestibular systems communicate with the motor systems about the length and tension of muscles, the angles of the joints, and the position of the body in space. Sensory and motor information is then integrated in order for coordinated movement to occur.

Conclusion and recommendations

There was a significant impairment in posture control in autistic children when compared with healthy children, even under the most basic conditions. This postural control development was significantly directly proportional to the age of these autistic children. However, it never reached normal values of healthy children. Moreover, the degree of autism as detected by the CARS score was significantly inversely proportional to the postural control of these autistic children. It is recommended to assess the postural control in autistic children, using Computerized Dynamic Posturography, as an investigation of the motor and sensory systems for better understanding of the widespread abnormalities in neural connectivity underlying autism. The degree of autism and its effect on the postural control need to be studied on a wide scale, and the effect of psychiatric rehabilitation therapy should also be considered in such a study.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Caronna EB, Milunsky JM, Tager Flusberg H. Autism spectrum disorders: clinical and research frontiers. Arch Dis Child 2008; 93:518–523.

2 Fournier KA, Kimberg CI, Radonovich KJ, Tillman MD, Chow JW, Lewis MH, *et al*. Decreased static and dynamic postural control in children with autism spectrum disorders. Gait Posture 2010; 32:6–9.

3 NIDCD. National Institute on Deafness and other Communication Disorders. Autism and communication. 2008; Available at: *http://www.nidcd.nih.gov/health/voice/autism.asp* [Accessed on 2008].

4 Hill EL. Executive dysfunction in autism. Trends Cogn Sci 2004; 8:26–32.

5 Klin A, Jones W, Schultz R, Volkmar F, Cohen D. Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. Arch Gen Psychiatry 2002; 59:809–816.

6 Minshew NJ, Goldstein G, Siegel DJ. Neuropsychologic functioning in autism: profile of a complex information processing disorder . J Int Neuropsychol Soc 1997; 3:303–316.

7 Ghaziuddin M, Butler E. Clumsiness in autism and Asperger syndrome: a further report. J Intellect Disabil Res 1998; 42 (Pt 1):43–48.

8 Just MA, Cherkassky VL, Keller TA, Minshew NJ. Cortical activation and synchronization during sentence comprehension in high-functioning autism: evidence of underconnectivity. Brain 2004; 127 (Pt 8):1811–1821.

9 Gepner B, Mestre D, Masson G, de Schonen S. Postural effects of motion vision in young autistic children. Neuroreport 1995; 6:1211–1214.

10 Molloy CA, Dietrich KN, Bhattacharya A. Postural stability in children with autism spectrum disorder. J Autism Dev Disord 2003; 33:643–652.

11 Kohen Raz R, Volkmar FR, Cohen DJ. Postural control in children with autism. J Autism Dev Disord 1992; 22:419–432.

12 Vilensky JA, Damasio AR, Maurer RG. Gait disturbances in patients with autistic behavior: a preliminary study. Arch Neurol 1981; 38:646–649.

13 Green D, Baird G, Barnett AL, Henderson L, Huber J, Henderson SE. The severity and nature of motor impairment in Asperger's syndrome: a comparison with specific developmental disorder of motor function. J Child Psychol Psychiatry 2002; 43:655–668.

14 Henderson S, Sugden D. *Movement assessment battery for children*. London: The Psychologica Corporation; 1992.

15 O'Neill M, Jones RS. Sensory-perceptual abnormalities in autism: a case for more research? J Autism Dev Disord 1997; 27:283–293.