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Deficits in sensory organization for postural stability in children with Tourette syndrome

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KEYWORDS

Tourette syndrome
Sensory organization test
Balance control

ABSTRACT

Tourette syndrome (TS) is a childhood-onset developmental disorder characterized by involuntary motor and vocal tics. Previous studies have indicated that children with TS demonstrate postural control anomalies when standing. The aim of this study was to compare postural stability under normal and altered sensory conditions in children with TS and healthy control (HC) children. A convenience sample of twelve children with TS (9 boys and 3 girls; 9.4 ± 1.1 yr) and 12 HC age- and gender-matched children (9.2 ± 1.1 yr) participated in this study. The Sensory Organization Test (SOT) was used to assess postural stability under six altered sensory conditions (1. normal vision, fixed support; 2. eyes closed, fixed support; 3. vision sway-referenced, fixed support; 4. normal vision, support sway-referenced; 5. eyes closed, support surface sway-referenced; 6. both vision and support surface sway-referenced) using the SMART Balance Master® 8.2 (NeuroCom® International, Inc, Clackamas, OR, USA). The results showed significant differences between the two groups in conditions 5 and 6 (p=0.003 and 0.002, respectively). The mean composite equilibrium score in children with TS was significantly lower than that of HC children (p<0.000). The results suggested that children with TS had greater difficulty in maintaining postural stability, especially when vestibular information was challenged. The results of this study provide supporting evidence for possible deficits in impaired access to vestibular information and sensorimotor integration of postural control in children with TS.

1. Introduction

Tourette syndrome (TS) is a neurodevelopmental disorder characterized by involuntary motor and vocal tics and is often associated with various comorbidities such as attention deficit and hyperactivity disorder (ADHD) and obsessive-compulsive behavior [1-3]. The overall cross-cultural prevalence of TS is approximately 1% [4]. In Taiwan, it was reported in 0.56% of Taiwanese school-aged children [3]. Several researches have already addressed balance problems in children with TS [5-7]. Children with TS demonstrated greater and faster postural sway during static standing compared to healthy controls [5]. Furthermore, younger children with TS exacerbated the COP velocity of anomalies in standing when performing the mental counting task simultaneously [6]. Both of the above results were independent of tic severity, medication, and attention deficits, suggesting that children with TS demonstrated larger postural sway regardless of tic-related conditions including tic severity, medication, and ADHD [5,6]. Furthermore, postural control problems in younger children with TS were more obvious than in older children with TS under an attention-demanding dual task condition [6]. The results suggest that the acquisition of postural control might be delayed in children with TS: if the task required more cognitive attention, the younger children with TS tended to show obvious postural control anomalies, but older children with TS did not. Furthermore, Lemay et al. proposed that the postural control anomalies in children with TS might be due to either impaired access to sensory information or difficulties in sensorimotor integration. They considered it likely that postural control anomalies in children with TS may be due to difficulties in sensorimotor integration [5]. However, their hypotheses have not been examined yet. Consequently, it would be interesting to know the influence of different sensory information on postural control in children with TS.

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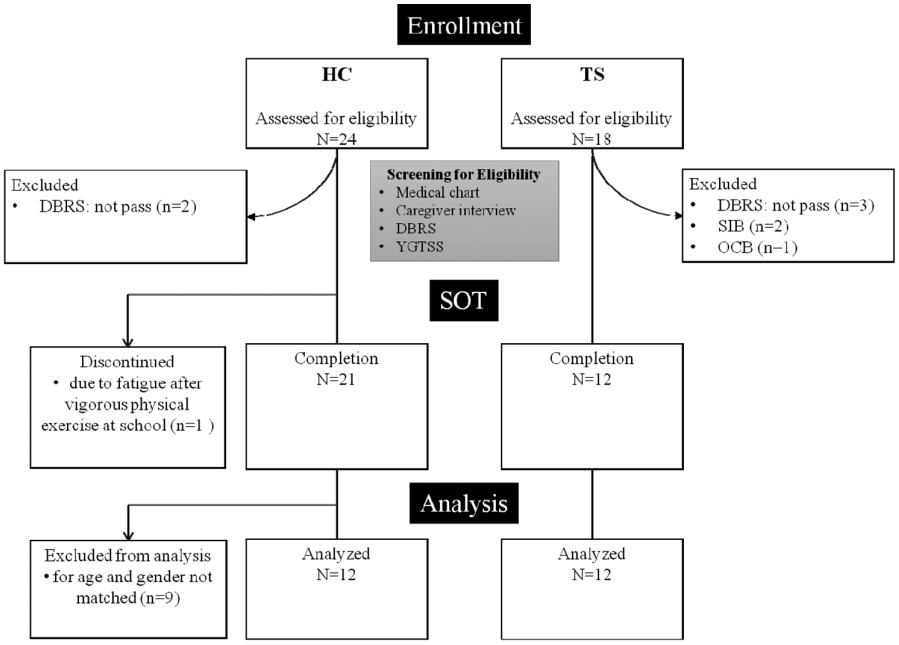

Fig. 1. Flow chart of children recruitment and data analysis. DBRS: Disruptive Behavior Rating Scale; OCD: Obsessive compulsive behaviors; SIB: Self-injurious behavior; YGTSS: Yale Global Tic Severity Scale.

Postural control can be considered as the integration of various body functions and structures, including but not limited to sensory functions, neuromusculoskeletal and movement-related functions, structures of the nervous system, structures related to movement, and mental functions. In order to optimize postural control performance, children need to receive and integrate various kinds of sensory and/or perception information, as well as automatically use effective or efficient postural adjustments to interact with the requirements of tasks and environment settings. For the sensory organizational processes, the kinds of information critically important to integrate include at least the visual, somatosensory, and vestibular systems. Subjects with TS have already been demonstrated to have suboptimal integration of visual inputs and organized motor output [8], and to perceive themselves to have heightened sensitivity to somatosensory and auditory stimuli [9]. Furthermore, tic generation has been linked to alterations of brain areas, such as prefrontal areas, the thalamus, the putamen striatum, and cortico-striato-thalamo-cortical loops [10]. All of the above brain areas, which showed abnormalities in subjects with TS, are also connected with the vestibulospinal tract, which is essential for supporting posture and maintaining balance. Despite the evidence that has suggested that the integrity of the visual, somatosensory, and vestibular systems of children with TS may need to be examined, their sensory organization of postural control has yet to be investigated.

Nashner has developed the Sensory Organization Test (SOT) protocol to quantify a subject's ability to make effective use of visual, vestibular, and proprioceptive inputs, as well as the subject's ability to suppress inaccurate sensory information while standing [11]. The SOT protocol has been integrated into several computerized dynamic posturographies. The reliability and validity of the SOT for various subjects, including children, was good [12-18]. Previous studies have indicated that children with ADHD (combined type) and developmental coordination disorder (DCD) had different sensory organization problems of postural control [17,18]. The aim of this study was to compare postural stability under normal and altered sensory conditions between children with TS and healthy control (HC) children.

2. Material and methods

2.1. Participants

This study was approved by the Institutional Review Board (IRB) for Human Studies at Chang Gang Memorial Hospital, Taiwan (98-3568B). Children in both groups were recruited using convenience sampling. Written informed consents to participate in the study were obtained from the parents of all children, as well as written assent forms from all children according to the rules of the IRB. Inclusion criteria for this study were that the children should be between 7 and 12 years old, attend regular classes at an elementary school, have normal or corrected-to-normal vision, and (for the TS group) not be diagnosed with any other conditions except TS. For inclusion in the TS group, children were required to have been diagnosed with TS by a pediatric neurologist according to the DSM-IV-TR [19] criteria. Children were excluded from this study based on parental reports and medical records if they met any of the following conditions: inability to follow verbal orders, known pervasive developmental disorders or ADHD, a history of head injury, any other neurological disorder, musculoskeletal disorders, tympanitis or other infections, uncorrected auditory deficits, history of surgery within six months of the start of the study, or any medication within one month of the start of this study. Children were also excluded through interviews with parent and child if they reported pain during daily activities or failed to pass the Disruptive Behavior Rating Scale (DBRS) [20]. In total, 12 children with TS and 12 age- and gender-matched HC children participated in this study (Figure 1). Descriptive characteristics of all children are presented in Table 1. There were no statistical significant differences between the two groups. In the TS group, tic severity was assessed using the Yale Global Tic Severity Scale (YGTSS) [21], and the range of tic severity was from mild to severe.

2.2. Instruments

The SMART Balance Master® 8.2 (NeuroCom International, Clackamas, Oregon, USA) was used in this study. Using the SMART Balance Master, the Sensory Organization Test protocol