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ORIGINAL RESEARCH

# Development of postural control and maturation of sensory systems in children of different ages a cross-sectional study

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Postural balance;
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**Abstract**
*Objective:* To evaluate the stability, postural adjustments and contributions of sensory information for postural control in children.
*Methods:* 40 boys and 40 girls were equally divided into groups of 5, 7, 9 and 12 years (G5, G7, G9 and G12). All children were submitted to dynamic posturography using a modified sensory organization test, using four sensory conditions: combining stable or sway referencing platform with eyes opened, or closed. The area and displacements of the center of pressure were used to determine stability, while the adjustments were used to measure the speed of the center of pressure displacements. These measurements were compared between groups and test conditions.
*Results:* Stability tends to increase with age and to decrease with sensory manipulation with significant differences between G5 and G7 in different measures. G7 differed from G12 under the conditions of stable and sway platform with eyes open. G9 did not differ from G12. Similar behavior was observed for adjustments, especially in anterior–posterior directions.
*Conclusion:* Postural stability and adjustments were associated with age and were influenced by sensory manipulation. The ability to perform anterior–posterior adjustments was more evident and sensory maturation occurred firstly on the visual system, then proprioceptive system, and finally, the vestibular system, reaching functional maturity at nine years of age. Seven-year-olds seem to go through a period of differentiated singularity in postural control.


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## Introduction

The acquisition of postural control is multifactorial. Despite the fact that postural control has been investigated in two studies,[1,2] sensory mechanisms of postural control are still unclear in literature. Besides the interactions between sensory information and motor performance in children, postural control also depends on the maturation of the structures involved, as well as on their motor experiences. Furthermore, in order to maintain postural control, the central nervous system makes differential use of sensory information during various phases of motor development.[1,2]

By the age of seven years, the development of the structures responsible for motor control is complete,[3] and studies agree that seven-year-old children have generally achieved mature postural control[3–6] as evaluated by displacements of the center of pressure (COP). However, children at this age have not yet had enough motor experiences for their complete motor development and postural control[7] and require skill development for postural adjustments.

According to Roncesvalles et al.,[8] by the age of 10 years, children will have achieved postural stability similar to adults. However, postural control, as determined by the speed of COP displacements, is generally developed during puberty.[6] There have been reports that children between the ages of four and five years of age employing large and rapid postural adjustment strategies.[9] From 8 to 10 years of age, reductions in speed and increases in precision of adjustments are clearly seen, as there is better integration between the open and closed-loop control systems to maintain this control.[6,9,10] In addition, amongst biomechanical parameters, the COP speed displacements appear to best characterize postural control.[11] Thus, there is a need to standardize postural control variables for various ages, so that the results are more conclusive.

Another issue that must be clarified is the importance each type of sensory information has in postural control during child development. The predominance of one sensory system may be a strategy adopted by the nervous system to avoid information conflicts,[12] and may vary according to age, motor experiences, and system maturation. Up to the age of 11 years, visual information appears not to have the same importance for postural control as it does in adults, and vestibular information is integrated only after the age of 12 years.[13,14]

The aim was to compare postural control through postural stability and adjustments in children aged 5–12 years, and the contribution of sensory information to postural control within each age group.

## Methods

### Study type and participants

This was a cross-sectional study that recruited a non-probabilistic convenience sample of healthy school children (40 boys and 40 girls) with no neurological or musculoskeletal disorders from a large metropolitan area in Brazil.[15] Children were recruited at local elementary schools of different social levels. All children took part in physical education classes, and were deemed active. The subjects were equally divided into four groups according to age (G5, G7, G9, and G12). Each group consisted of 10 boys and 10 girls. The sample size calculation using a power of 0.8 estimated 10 children would be needed in each age group This study was approved by the Research Ethics Committee of Universidade Federal de São Paulo (UNIFESP), Santos, SP (protocol 128/11) Board of each institution, and consent was obtained from all parents.

### Measuring instruments

A double-force platform with transducers and amplifiers, connected to a computer, was used to perform the tests. The commands of the sway mechanism were provided by the Pro Balance Master software (8.1.0) (NeuroCom Inc., Oregon, USA). A modified sensory organization test was used for the computerized dynamic posturography – a non-invasive procedure to determine postural balance performance in different sensory conditions. This test assessed balance together with sensory visual conditions (i.e. open and closed eyes) and support surfaces (i.e. fixed and sway referencing platforms).

The sway referencing platform condition was obtained using the servo-driving mechanism, which promoted proportional rotations in the platform for anterior–posterior oscillations. Through this sway referencing platform, the Achilles tendon lengthening reflex was altered, the information to the surface of the platform was reduced, and a situation of sensory conflict was induced. The visual information was manipulated for the closed-eye condition. The condition of the closed-eye sway-referencing platform was considered to be the predominance of vestibular information for postural control.

### Procedures

The children were assessed barefoot, wearing comfortable clothes, and were supervised by an examiner because of the risk of falling. The assessment was performed at a laboratory in the Psychiatric Institute of the University of São Paulo, a well-lit and ventilated room with adequate heat and sound. The children were instructed to stand on the platform with their arms by the sides of their body. Their feet were positioned and corrected by the examiner, according to the standardization processes for the platform. When in position, three trials of 20 s were performed at a sampling frequency of 100 Hz for the four test conditions, in the following order: open-eye, fixed-platform (FIX/op); closed-eye, fixed-platform (FIX/cl); open-eye, sway-referencing-platform (SWR/op); and, closed-eye, sway-referencing-platform (SWR/cl).

### Data processing

The COP coordinates were calculated from the force platform. The *Y* and *X*-axes indicated the anterior–posterior and medial-lateral directions, respectively. For data processing, the first trial for each test condition was discarded to allow for familiarization. The COP parameters, as a function of time, were calculated for the other two trials, as follows:



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