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Special Issue:
"Manipulation of sensory information on postural control performance of children, young and older adults"

Editorial: Manipulation of Sensory Information on Postural Control Performance of Children, Young and Older Adults

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ABBREVIATIONS

DCD	Developmental coordination disorder
PD	Parkinson's disease
PPA	Physiological Profile Assessment
TD	Typical development
tDCS	Transcranial direct current stimulation
VFD	Visual Field Dependence

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ABSTRACT
Effective postural control is essential for daily activities, sports, and fall prevention. It relies on the integration of sensory information from the visual, vestibular, and somatosensory systems, which continuously adapt throughout life. Research in this area explores how altering sensory information impacts balance across different age groups and conditions. This special issue features studies on children, athletes, older adults, and individuals with neurological or developmental disorders, highlighting the complex relationship between sensory input and postural control. Two studies explore the developmental role of sensory systems in balance and investigate visual dependency and fall risk in older adults. Additionally, two studies examine how sensory manipulation affects postural control, particularly in older adults and individuals with balance deficits, such as Parkinson's disease. One infographic illustrates how hemophilia affects postural and gait performance. Finally, three studies discuss interventions such as physical exercise, neurostimulation (e.g., tDCS), and trunk resistance load, all aimed at improving postural control. By manipulating sensory information, we can gain a deeper understanding of how postural control functions and develop effective strategies to enhance balance, particularly for individuals with specific health conditions or age-related challenges.

KEYWORDS: Development | Postural sway | Sensory integration | Balance disorders

INTRODUCTION

Postural control is a fundamental aspect of human movement, integral to activities of daily living, sports performance, and fall prevention [1,2]. Throughout the lifespan, the ability to maintain balance and stability is constantly challenged and refined by sensory information from the visual, vestibular, and somatosensory systems [3,4,5,6,7]. However, these sensory systems do not operate in isolation. Effective postural control integrates information from all three body systems [8]. The interactions between these systems, their adaptability, and their ability to compensate are particularly evident when sensory information is altered, whether through experimental protocols, interventions, or changes in the natural environment [9,10,11,12,13].

This special issue of the Brazilian Journal of Motor Behavior brings together a diverse collection of research exploring how the manipulation of sensory information affects postural control across different age groups and contexts. The articles provide insights into specific populations, including children, athletes, individuals with neurological or developmental conditions, and older adults, highlighting the intricate relationships between sensory input and balance mechanisms. In addition, these articles present different approaches that employ innovative analysis techniques.

Schmuckler [14] provides a developmental perspective on how different sensory systems contribute to balance across the lifespan. This study addresses the importance of a "multi-component" approach to postural control development, which considers the interaction of various sensory and anthropometric factors, focusing on the relative weight of each of these factors. The research was based on an aggregated dataset from four studies, including participants aged 3 to 11 years and young adults. The analysis used multiple regression to predict postural sway based on two sensory systems (visual, tactile, and proprioceptive) and anthropometric variables, such as height. Two types of coding were examined: one capturing the presence or absence of sensory stimuli, and another quantifying the degree of stability provided by these stimuli. The findings highlight the predictive value of these factors for postural

stability, particularly emphasizing the role of proprioceptive information during key developmental stages. Furthermore, the analysis underscores the effectiveness of a stability-focused coding scheme in achieving consistent prediction accuracy.

Pliner, Hezel, and Lord [15] examine the relationship between visual dependency, sensorimotor integration, and fall risk, providing practical strategies to prevent falls among older adults aged 75 and older. This study evaluates the visual perception of verticality to classify Visual Field Dependence (VFD). Additionally, it uses a scoring method known as the Composite Physiological Profile Assessment (PPA), which incorporates measures of visual contrast sensitivity, lower-limb proprioception, knee extension strength, reaction time, and sway on a compliant surface (using foam), combined with an overall fall risk score. The study suggests a potential connection between lower limb strength, balance, and Visual Field Dependence (VFD), emphasizing its importance in preventing falls, especially in visually complex environments.

Beyond the influence of sensory manipulations, task complexity also plays a role, highlighting the interplay between sensory and task demands concerning the upper limbs. Magalhães et al.[16] investigated the postural control performance of older adults. At the same time, they performed grasping movements at varying levels of task difficulty, manipulating the somatosensory information using a compliant surface (using foam). The findings indicate that postural control is affected by age. Additionally, this study reveals that task difficulty and surface stability play crucial roles in regulating postural control across age groups, emphasizing the complex interaction between these factors and their direct influence on postural performance.

Manipulating sensory information also helps to deepen the understanding of postural control in populations with balance disorders. One study in this special issue addresses the changes observed in postural control in individuals with Parkinson Disease (PD) and hemophilia. Santos et al.[17] focus on the effects of different visual conditions on postural control mechanisms in individuals with PD and healthy controls. This study combined the manipulation of visual conditions, including additional visual feedback, with data analysis techniques from the force platform, focusing on the rambling and trembling components. This innovative and refined method enhances the understanding of postural control mechanisms by separating the migration of a moving reference point in relation to the body's equilibrium (rambling), which is associated with central processes of postural control, from the center of pressure migration around the reference point (trembling), which is associated with the peripheral mechanisms. In addition, an engaging infographic by Tchonga, Bernardes, and Rinaldi [18] illustrates the effects of hemophilia on postural control, drawing attention to the fact that this population also experiences balance and gait disorders. This visual representation highlights the challenges individuals with hemophilia face in maintaining stability and raises awareness about how these disorders impact daily functioning. By showing the relationship between impaired postural control and the physical limitations associated with hemophilia, Tchonga and colleagues [18] contribute to a broader understanding of how balance disorders affect individuals with this condition—an often-overlooked aspect of their health.

Building on the concept of improving postural control, Lemos et al.[19] reinforce the idea that physical exercise may be an important preventive strategy to reduce the occurrence of falls, as it reduces postural sway. Physically active and inactive older women were assessed using the Sensory Organization Test. This study highlights the importance of considering both the aging process and individual characteristics, particularly a person's level of physical activity.

Finally, in addition to physical exercise, innovative approaches like neurostimulation and advanced training methods are gaining attention for their potential to influence postural control. For this special issue, Moura et al. [20] propose a protocol of a double-blind, placebo-controlled, crossover clinical trial to examine the immediate effects of transcranial direct current stimulation (tDCS) in the primary motor cortex and the cerebellum on postural control in children with Developmental coordination disorder (DCD) and with typical development (TD). Postural balance will be assessed by posturography with and without visual and somatosensory system manipulation immediately before and after each tDCS session. The authors outline innovative methods to explore the potential of neuromodulation in postural control in children with DCD and TD. This approach may provide valuable insights into the roles of the cerebellum and the motor cortex in postural control which can support intervention programs for children with DCD.

Likewise, Cantusio et al. [21] are exploring training methods for their potential to improve postural control in dynamic settings. The authors investigate the effectiveness of multiplanar trunk resistance in enhancing dynamic postural control during single-leg jumps in female college athletes who performed poorly in a single-leg squat test. These methods focus on strengthening the muscles and neural mechanisms involved in maintaining balance across various planes of movement, presenting promising strategies for improving postural stability in both clinical and athletic populations.

FUTURE DIRECTIONS AND IMPLICATIONS

The studies presented in this special issue underscore the complexity of postural control and several factors that contribute to maintaining balance across the lifespan. As we move forward, it is clear that further exploration of how sensory integration and task demands influence postural control will be essential for designing effective interventions for diverse populations, from children to older adults. The findings highlight the need for continued investigation into the interactions between sensory systems, as well as how these interactions are influenced by age, health conditions, and environmental factors.

A promising direction for future research is the continued exploration of neurostimulation techniques, such as tDCS, to improve postural control, particularly in populations with developmental or neurological disorders. Furthermore, physical activity, particularly exercises that enhance sensory integration, remains an effective strategy for improving postural control. In parallel, the investigation of

training methods, such as multiplanar resistance training, offers promising prospects for examining dynamic postural control.

Researchers could also focus on exploring the application of innovative methods in protocol design, data processing, and data analysis to other populations with balance disorders, expanding our understanding of how specific impairments influence postural control. Additionally, investigating interventions and protocols that use sensory manipulation may provide valuable insights into rehabilitation strategies for individuals with conditions such as PD, hemophilia, and beyond. These findings may have significant implications for developing personalized therapeutic approaches aimed at improving balance and reducing the risk of falls in these populations.

Lastly, interdisciplinary collaborations that merge knowledge from biomechanics, neuroscience, and rehabilitation science are likely to produce the most effective strategies for assessing postural control performance. By considering how sensory systems, neurostimulation, physical activity, and task complexity interact, researchers and clinicians can develop more tailored interventions for individuals with balance deficits. This approach aims to enhance quality of life and reduce the risk of falls throughout the lifespan.

We extend our gratitude to the authors, reviewers, and members of the editorial board who contributed to this special issue. Their collective contributions have helped advance scientific understanding and offer valuable insights that may have important implications for health, performance, and well-being throughout the lifespan. We hope this special issue inspires further inquiry and innovation in this area of study.

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