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# PEDIATRIC OTONEUROLOGY (PART I): THE IMPORTANCE OF THE VESTIBULAR SYSTEM AND BODY BALANCE IN CHILD DEVELOPMENT

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# **PEDIATRIC OTONEUROLOGY (PART I): THE IMPORTANCE OF THE VESTIBULAR SYSTEM AND BODY BALANCE IN CHILD DEVELOPMENT**

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**These monthly bulletins aim to provide clear and accessible information in the field of health education. And it is with great pleasure that we begin a new series of newsletters focused on pediatric otoneurology.**

We invite you to read some previously published materials related to this topic, namely:

- **Benign Paroxysmal Vertigo in Childhood (Sanfins et al., 2023).**
- **Motion Sickness – Part I (Sleifer et al., 2023).**
- **Dizziness: a look at the impacts on child development (Cabral et al., 2023).**



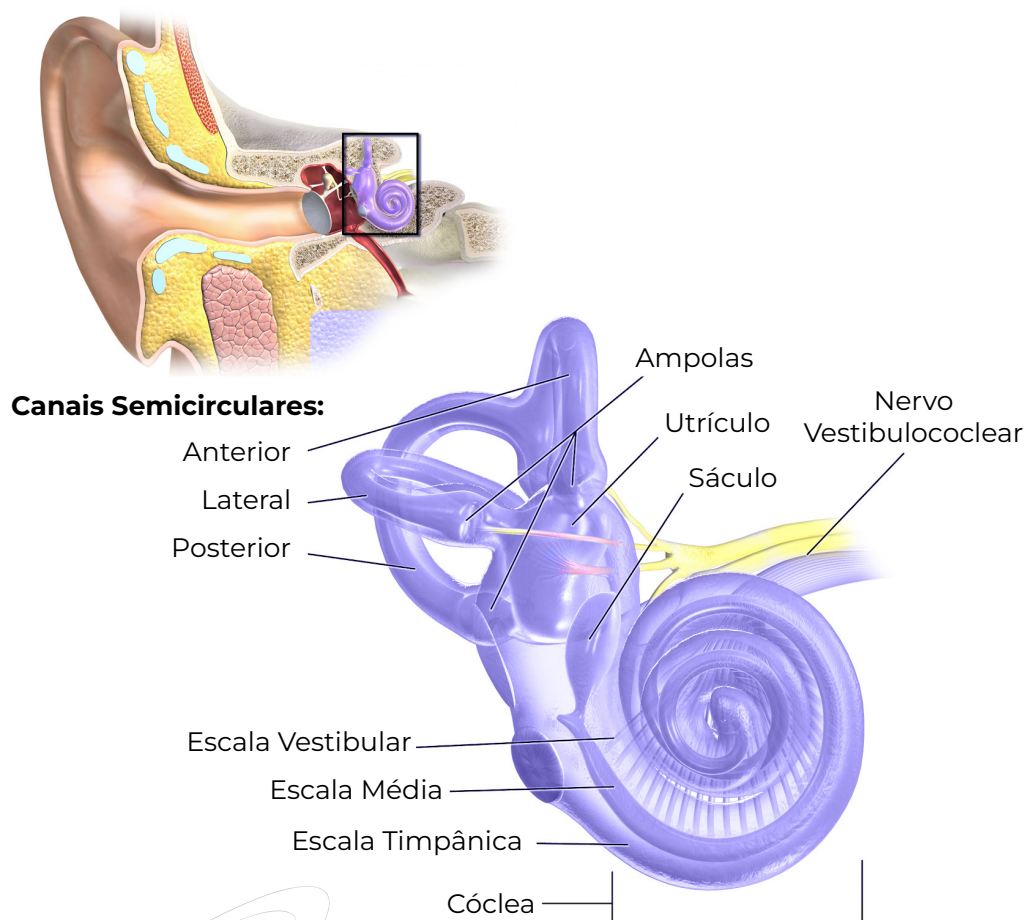
## BODY BALANCE

Body balance is a complex process, in which the visual, vestibular, and proprioceptive systems are responsible for capturing and transmitting specific information to the central nervous system and the somatosensory cortex. Here, there is an integration of responses that allows for neuromuscular control, maintenance of body balance, and appropriate motor responses.



# VESTIBULAR SYSTEM

The peripheral portion of the vestibular system consists of three semicircular canals and two otolithic organs (sacculle and utricle), providing complementary information about the rotational and translational movements of the head relative to gravity.





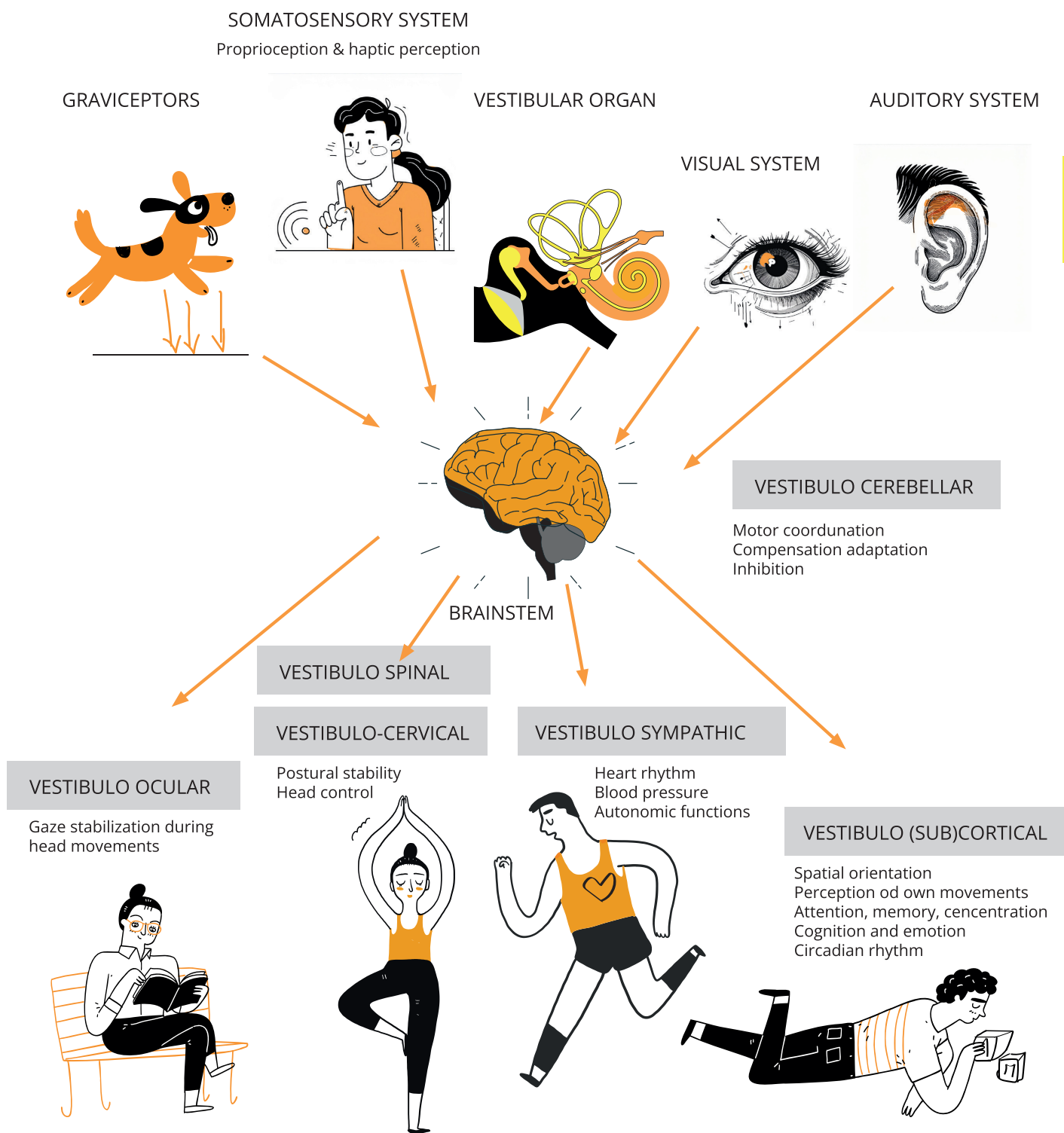


The peripheral portion of the vestibular system consists of three semicircular canals and two otolithic organs, the saccule and utricle. The vestibular system transforms linear and angular acceleration of the head into nerve signals, informing the brain about speed and position. Further, it helps control posture and stabilizes the eyes during head movements, all of which are done by the vestibulo-ocular, vestibulo-spinal, and vestibulo-cervical reflexes (Van Hecke et al., 2021).

However, the role of the vestibular system goes beyond posture and balance; it is also involved in refining various cognitive, social, and emotional skills. In children, integration of the vestibular system with other sensory systems is important for the proper development of complex spatial behaviors and cognitive skills, otherwise there can be deleterious effects.



# THE VESTIBULAR SYSTEM AND ITS MOST IMPORTANT INPUT AND OUTPUT STRUCTURES



Sleifer et al, 2025

Fonte: Figure 1: Figure developed by the authors based on an image by Van Hecke et al, 2021

Vestibular disturbances can create discomfort and disrupt a child's interaction with the environment, potentially interfering with the acquisition and development of language and learning.

## VESTIBULAR SYSTEM AND AUDITORY SYSTEM: WHAT IS THE CORRELATION BETWEEN THEM?

The vestibular and auditory systems are located in the inner ear and both are closely interconnected phylogenetically and anatomically.

An auditory stimulus can trigger vestibular dysfunction, and both the auditory and vestibular systems are susceptible to harmful factors, such as ototoxic drugs, infectious agents, trauma, and insufficient blood supply to the inner ear, among others.

**Researchers report that one in three children with hearing loss (from severe to profound) exhibited vestibular deficits (Martens et al., 2023).**

Studies show that children with sensorineural hearing loss are more likely to have a vestibular impairment. Although the association between vestibular dysfunction and sensorineural hearing loss has long been established, the vestibular system has often tends to be overlooked during assessment of children with hearing loss.





Sometimes a young child (before walking age) who suffers meningitis will experience sudden complete vestibular loss, and in these cases research has shown that postural control is delayed even though there is no neurological impairment (Wiener-Vacher et al., 2013). Furthermore, it is suggested that the oscillopsia which results from a complete lack of vestibular information in these children leads to dynamic instability of the head and trunk, and this can contribute to secondary delays in learning.

Children with hearing loss are at risk of vestibular dysfunction, which can happen because of the anatomical proximity of hearing and balance. The cochlea and

the vestibule share similar membranous structures and sensory cells, and both are vascularized by a common blood supply.

A cohort study by Wiener-Vacher et al. (2024) aimed at identifying the prevalence of vestibular impairment according to the origin of hearing loss. It assessed the association between vestibular impairment and delay in postural development in children with profound hearing loss, and reported that vestibular impairment was prevalent. Furthermore, there was an association with postural motor development, and all developmental milestones were linked to the severity of vestibular impairment.

**Children with profound sensorineural hearing loss may benefit from a comprehensive vestibular assessment before cochlear implantation, which would support early and tailored treatment (Wiener-Vacher et al., 2024).**

Given the importance of the correlation between the vestibular and auditory systems, guidelines aimed at awareness and diagnosis were developed by Martens and collaborators (2023). The guidelines, called Vestibular Infant Screening – Flanders, recommends vestibular screening in infants, especially those with severe to profound hearing loss, syndromic hearing loss, or congenital viruses (cytomegalovirus, rubella, and others), as well as in cases where there are concerns regarding motor development.



# HOW TO IDENTIFY THE SIGNS AND SYMPTOMS OF VESTIBULAR DISORDERS IN CHILDREN?



**Children with vestibular disorders may exhibit signs and symptoms such as:**

- Headache
- Motion sickness
- Nability or difficulty in performing coordinated movements
- Inability for some physical exercises
- Frequent falls
- Motor development delay
- Difficulty in playing and interacting with friends or peers
- Indefinite malaise
- Dizziness
- Nausea
- Vomiting
- Visual change
- Sudden change in behavior
- Sleep disturbances
- More restless and distracted

In light of this, it is worth emphasizing the need to be alert to pediatric vestibular changes, as they can have other repercussions on child development.

In addition to the vestibular, visual, and proprioceptive systems, other parts of the central nervous system act on body balance, such as: the frontal lobes, which initiate and coordinate the planning of movements; the basal ganglia, which add control and fluidity to movements; and the posterior and superior parts of the temporal lobes, which provide awareness.

**Although vestibular disorders are found less frequently in childhood and adolescents than in adults and the elderly, epidemiological studies have shown that about 15% of school-aged children have experienced at least one episode of dizziness within a year.**

Li et al. (2016) report that 5.3% of children and adolescents in the United States present otoneurological complaints, with children over the age of seven being more able to better express the nature of their body balance difficulties. Otorhinolaryngological complaints in the pediatric population are generally under-researched. Some studies have highlighted the existence of these complaints among children, but the problem is the subjectivity of the complaints and, consequently, the difficulty in identifying and describing the symptoms by the child and their families (Sleifer; Borges 2023).

**Thus, it is understood that the prevalence of vestibulopathies in childhood is underestimated and underreported, making clinical diagnosis and interventions difficult.**

Healthcare professionals need to pay close attention to possible changes in body balance, as these changes can precipitate various negative consequences to the well-being and overall development of the child.



# WHAT ARE THE CONSEQUENCES OF VESTIBULAR DISORDERS IN CHILDHOOD?

Children with vertigo may be more susceptible to changes in cognitive function, developmental delays, learning difficulties, and attention deficit disorder.

Dizziness can have a major impact on school life, which is likely to have a significant impact on the child's quality of life. Vestibular dysfunctions impair cognitive abilities, such as:

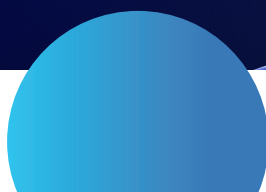
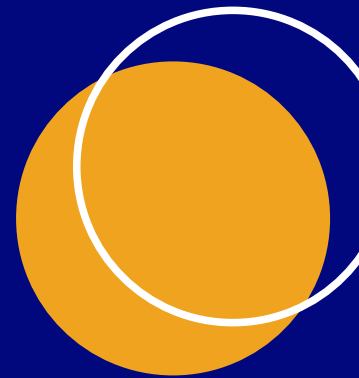
- **Attention, short-term memory,**
- **Executive functions,**
- **Concentration, and visuospatial ability.**

All these are prerequisites for learning.

Children with vestibular dysfunctions are more inattentive, restless, and distracted due to the need to seek better head and body adjustments for comfort and safety.

The indirect effects of vestibular deficits on cognition stem from the increased demand for cognitive and attentional processing resources at the expense of other ongoing activities. That is, lack of vestibular information requires the sometimes laborious substitution of visual, proprioceptive, and other signals to maintain balance, posture, and gaze. Moreover, such a lack impairs visuospatial processing, reduces attention, limits

concentration, and can hinder other activities, such as multitasking, sequential processing, and shifting of attention.





# IMPORTANCE OF KNOWING THE MILESTONES OF MOTOR AND POSTURAL DEVELOPMENT AND THEIR IMPACT ON CHILD DEVELOPMENT

It is important to know the milestones of motor and postural development in children in order to identify problems early on and minimize deleterious impacts on child development. The stages of motor development are gradual and happen in an organized manner. Each stage is a consequence of the preceding one and necessary for the acquisition of the next. Furthermore, until the age of eight, the child is dependent on visual and proprioceptive information to adequately maintain postural control, as the vestibular system and sensory integration are not yet fully mature.

The stimuli arising from sensitivity to muscle contraction, tendon stretching, and joint position inform the cortex of the positions of body parts in space. The vestibular system provides information about the position of the head in space, both statically and dynamically. These stimuli provide the sensation of bodily balance. Vestibular signals play an essential role in postural, static, and dynamic functions, as well as impacting spatial and non-spatial cognitive functions. There is still much to be learned about the impact of partial or complete vestibular loss at different ages in children and how it affects the development of postural and fine motor control, oculomotor control in cognitive activities (such as reading and writing), spatial orientation, and body representation (2018).



## FINAL CONSIDERATIONS

Considering the advances in otoneurology in terms of diagnostic and intervention methods, there is a strong need for good clinical guidance specifically directed at balance disorders and vestibular system dysfunctions affecting children.

The vestibular system and its integration with other sensory systems is important for the proper development of complex spatial behaviors and cognitive skills. Body balance is essential for motor learning, performing daily activities, appropriate social interaction, and full child development.

It is therefore important that information about pediatric otoneurology is widely disseminated so that parents, guardians, and educators can recognise any type of alteration, and professionals can make a precise and early diagnosis.

With this in mind, we are launching this series of newsletters and invite you to read our next contribution, which will delve deeper into new concepts in pediatric otoneurology.



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