

## Excerpts From Vestibular System: What Is It? And Why Should We Care?

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### The Vestibular System in a Nutshell.

The vestibular system is an extremely complex system located in the inner ear, where semicircular canals, hair cells, and otolithic organs collectively offer information to the brain regarding the body's position in space. These structures are extremely sensitive to even the slightest changes in rotation and linear movement of the head, providing the feedback necessary for the brain to dictate adjustments that allow the body to maintain equilibrium, the "state of being able to maintain bodily balance." This information is transmitted to the brain via the vestibular nerve, which specializes in the "sense of balance and the transmission of space-orientation impulses."

### The Vestibular System, a Study in Diversity.

The vestibular system is one of the pivotal mechanisms in the human body. We generally recognize it as a system of balance. However, its roles in the realms of visual function, posture and muscular control are of the utmost importance to activities of daily life, and its impact on our physiology rivals that of the heart and lungs.

The interconnectedness of the vestibular to major systems in the body is profound. This complex system has been linked to the functioning of both the sympathetic and parasympathetic systems. It plays a role to varying degrees in vision, muscle coordination, motor development, respiration, learning, language, and, of course, balance. Numerous studies, to be discussed later, have demonstrated a strong link between vestibular therapy and improvements in the areas of visual, auditory, and motor function, and overall human development, including among children with disabilities. One study even suggests that the structural integrity of the developing spine is dependent upon the accurate interpretation and integration of vestibular information/input. A functioning vestibular system contributes to sensory integration and eye movements that are imperative for reading and learning. In fact, "Delayed vestibular maturation correlates significantly with sensory integration dysfunction, slow vision processing, and reading disability." Visual neurons require input from the vestibular system in order to properly process visual stimuli, while the vestibuloocular reflex that produces "rapid compensatory eye movements" to stabilize vision while the head is in motion are inextricably connected to vestibular information. Without these rapid adjustments, we would not be able to see clearly.

The auditory system is intricately linked to the vestibular system. In fact, the receptors for both are located in an area of the temporal bone called the "bony labyrinth," which encases the inner ear. Damage to either system negatively impacts the functionality of the other. One study found that two-thirds of hearing-impaired subjects had "significant vestibular deficits." The vestibular system is crucial to the processing of auditory information.

Vestibular abnormalities frequently lead to difficulties in both the processing and production of language. "The vestibular system influences motor control and planning that are necessary to use those fine muscles to produce intelligible speech." Multiple therapies for speech and movement have found strong correlations between the two.

The vestibular system influences the function of our muscles. The vestibulo-spinal tracts originate in the brain stem at the vestibular nuclei and extend into the spinal cord, where they mediate postural adjustments and head movements. Our ability to remain upright is dependent on the proper functioning of these tracts. The central nervous system uses information from the vestibular system to orient space perception, strongly related to proprioception. Without information from the vestibular system, our muscles would not be able to accurately compensate for changes to the body's place in space. Movement of any kind would cause us to fall.

Neuromotor development and maturation relies on accurate perception and integration of sensory information within the vestibular system. Improper function of either process can lead to delays in motor development. "The close relationship of the vestibular system with other regulators of sensorimotor functions is well documented." Gross motor milestones are only possible with the input of a properly operating system of balance. **One early study found that infants who participate in sessions of mild semicircular canal stimulation demonstrate significant improvements in gross motor skills compared to control groups. Motor delays can often be traced to a faulty vestibular system and/or its failure to appropriately interact with the major body senses; i.e., vision, sight, touch.** The vestibular system plays a role in most activities related to daily life. This small but complex system can mean the difference between wellness and illness, depression and peace, accurate or faulty interpretations of the world around us. Quality of life depends, in many ways, on the proper functioning of the vestibular system.

### Early Vestibular Development.

Vestibular development begins early in gestation, around the third week of life when the epithelium (sensory organ) is formed in the semicircular canals and otolithic organs. By

Week 6, the central vestibular nuclei are formed and begin to extend to the endorgans in the inner ear. Hair cells in the semicircular canal and otolithic organs have matured by Week 9. In just nine short weeks, the five receptors of the vestibular system (semicircular canals and otolithic organs) are fully differentiated, and by 14 weeks these receptors will have almost reached adult maturity, with full myelination of neuronal tracts occurring at about 20 weeks of life. Still, vestibular development is a long-term project with full maturation spanning childhood and early puberty.

Development of the vestibular system is crucial to both motor and cognitive functioning throughout the lifespan. There is much that we can do to enhance this development from the earliest of ages.

The vestibular system plays a major role in the functioning of our senses, informs important mechanisms of balance and coordination, and has far-reaching effects on activities of cognition, learning, and daily living. It is no surprise, then, that quality of life is negatively impacted as vestibular function declines.

#### Early Intervention.

Childhood is a time of crucial development of the vestibular system, a time when we can facilitate positive changes that provide for the overall health and well-being of our kids throughout their lifetimes. Children experience the same vestibular disorders and symptoms as adults but have the added complication of important developmental deficits with vestibular dysfunction. These unfortunate kids experience delays in communicative, social, cognitive, and neuromotor markers. Early intervention can help to alleviate, even eliminate, deficits in the vestibular system. In fact, there is some evidence that vestibular stimulation can be implemented in utero.

So important is this early development that entire therapies have been devised to target the pediatric population. Such techniques include those activities that provide for maximum development of the vestibular system. Significantly, these therapies have been shown to have profound implications for at-risk populations. These forms of vestibular stimulation use repetitive, scheduled vestibular-stimulating activities as a means to overcome developmental anomalies or delays, override pathology and rehabilitate trauma.

Vestibular stimulation has been utilized successfully as a form of therapeutic intervention with special-needs children and pre-mature infants. Developmentally disabled children have shown improvements in these areas following vestibular therapy:

- Improvements in spontaneous verbal language use (the ability to use recognizable language)

- Increases in visual and auditory alertness
- Marked improvements in ability to complete a cognitive-perceptual task
- Significant gains in gross motor skill and reflex integration
- Improvements in motor coordination and performance  
Increased alertness and curiosity
- Enhanced verbalization.

Repeated studies have demonstrated the “importance of the vestibular system and its relationship to the CNS (central nervous system) structures in developing motor skills, integrating postural reflexes, establishing and coordinating eye movements and visual attention skills, developing exploratory behavior, and regulating arousal level.” Other studies have pointed toward the role that vestibular function plays in allowing an individual to perceive a sense of self, a separating of him or herself from the larger world. These therapies have been shown to successfully assist children with special needs in these areas.

Similar gains are being reported among premature infants who are experiencing various developmental delays. Infants who are exposed to vestibular stimulation show significant advances in gross motor, visual, and auditory responses over their non-therapy counterparts. They moved better, track and fixate on objects more effectively, and responded more efficiently to stimuli. Improved eye-hand coordination and hand-to-mouth coordination is reported. Greater weight gain and decreased distress behavior have been observed, while scores for levels of mental functioning are significantly higher among the treated group. The prescriptions incorporated into such therapies will sound familiar. They are simply those movements that act upon the developing vestibular system, because the most efficient way to develop the vestibular system is to use it. Things that children do naturally—rocking, swinging, spinning, rolling, cart wheeling, getting upside down, moving from side to side—challenge the vestibular system and thereby force its development (though apparatus that rock and swing the children are most often used in therapies.) Healthy kids do these things because their bodies instinctively know it is what they need. There is a reason young children are in constant motion. “The child enjoys stimulating his vestibular apparatus and challenging his equilibrium and skills against the Earth’s gravity pull from the first time it lifts his head.” How many times have you seen a toddler stick its head on the ground and backside in the air? The vestibular system requires movement to develop, and that movement, if properly administered, can produce amazing results.

**CrossFit Kids and Vestibular Development.**

CrossFit Kids has a unique opportunity to address vestibular development through proper programming. That is why you will see constantly varied use of vestibular-challenging activities in the daily WODs, buy-ins and cash-outs. We are always looking for the most efficient and FUN ways to bring vestibular development to CrossFit Kids. We incorporate vast amounts of gymnastics movements, including swinging, rolling over, handstands (and handstand push-ups), cartwheels, push-ups, toes-to-bars, knees-to-elbows, wheelbarrows, and bar and ring work, to name a few. Agility work is used to challenge the vestibular system. A few examples include hurdling, jumping, dot drills, agility ladders, lateral hops and runs. Olympic lifts are an extremely effective way to develop the vestibular system, because the changes in direction required to complete the movement engage it in a unique and effective way.

This is something we get excited about at CrossFit Kids. Exercise isn't just about heart rates and blood pressure. By getting our kids moving in this way, we are improving their odds for appropriate development and future success in multiple areas of daily functioning. What an amazing opportunity and responsibility!

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