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- ✓ **Physiology of balance**

- Balance is the ability to maintain the body's center of mass over its base of support.
- A properly functioning balance system allows humans to see clearly while moving, identify orientation with respect to gravity, determine direction and speed of movement, and make automatic postural adjustments to maintain posture and stability in various conditions and activities.
- Balance is achieved and maintained by a complex set of sensorimotor control systems that include sensory input from vision (sight), proprioception (touch), and the vestibular system (motion, equilibrium, spatial orientation); integration of that sensory input; and motor output to the eye and body muscles. Injury, disease, certain drugs, or the aging process can affect one or more of these components.
- Postural balance is controlled by intricate connections between the vestibular, visual and proprioception system. Among these, the vestibular system is one of the key factors in coordinating and maintaining balance.

- ❖ **Vestibular System Function**

The vestibular system is the sensory apparatus of the inner ear that helps the body maintain its postural equilibrium. The peripheral apparatus for the vestibular system consists of the semicircular canals, which sense head rotation; and the otoliths, which sense gravity and linear acceleration. The information furnished by the vestibular system is also essential for coordinating the position of the head and the movement of the eyes. There are two sets of end organs in the inner ear, or labyrinth: the semicircular canals, which respond to rotational movements (angular acceleration); and the utricle and saccule within the vestibule, which respond to changes in the position of the head with respect to gravity (linear acceleration). The information these organs deliver is proprioceptive in character, dealing with events within the body itself, rather than exteroceptive, dealing with events outside the body, as in the case of the responses of the cochlea to sound. Functionally these organs are closely related to the cerebellum and to the reflex centres of the spinal cord and brainstem that govern the movements of the eyes, neck, and limbs. The central vestibular pathways form a large network from the vestibular nuclei, ocular motor nuclei, integration centers in the pons and rostral midbrain, vestibulocerebellum, thalamus, to the multisensory vestibular cortex areas in the temporoparietal cortex. The most important structures for the central vestibular pathways are those mediating the vestibulo-ocular reflex (VOR), and the descending pathways into the spinal cord along the medial and lateral vestibulospinal tract which mediate postural control. The cortical structures involved in vestibular function are the parietoinsular vestibular cortex, the retroinsular cortex, the superior temporal gyrus and the inferior parietal lobule. Activation of the cortical network during vestibular stimulation is not symmetrical; dominance is stronger in the nondominant hemisphere, in the hemisphere ipsilateral to the stimulated ear and in the hemisphere ipsilateral to the slow phase of the vestibular caloric nystagmus. Disorder of the vestibular pathway, anyway along its various tracts, may result in balance and coordination impairments and lead to misperception of motion.

- **INPUT FROM THE EYES**

Sensory receptors in the retina are called rods and cones. Rods are believed to be tuned better for vision in low light situations (e.g. at night time). Cones help with color vision, and the finer details of our world. When light strikes the rods and cones, they send impulses to the brain that provide visual cues identifying how a person is oriented relative to other objects. For example, as a pedestrian takes a walk along a city street, the surrounding buildings appear vertically aligned, and each storefront passed first moves into and then beyond the range of peripheral vision.

- **INPUT FROM THE MUSCLES AND JOINTS**

Proprioceptive information from the skin, muscles, and joints involves sensory receptors that are sensitive to stretch or pressure in the surrounding tissues. For example, increased pressure is felt in the front part of the soles of the feet when a standing person leans forward. With any movement of the legs, arms, and other body parts, sensory receptors respond by sending impulses to the brain. Along with other information, these stretch and pressure cues help our brain determine where our body is in space.

The sensory impulses originating in the neck and ankles are especially important. Proprioceptive cues from the neck indicate the direction in which the head is turned. Cues from the ankles indicate the body’s movement or sway relative to both the standing surface (floor or ground) and the quality of that surface (for example, hard, soft, slippery, or uneven).

- **INTEGRATION OF SENSORY INPUT**

Balance information provided by the peripheral sensory organs—eyes, muscles and joints, and the two sides of the vestibular system—is sent to the brain stem. There, it is sorted out and integrated with learned information contributed by the cerebellum (the coordination center of the brain) and the cerebral cortex (the thinking and memory center). The cerebellum provides information about automatic movements that have been learned through repeated exposure to certain motions

- **MOTOR OUTPUT**

As sensory integration takes place, the brain stem transmits impulses to the muscles that control movements of the eyes, head and neck, trunk, and legs, thus allowing a person to both maintain balance and have clear vision while moving.