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QUESTION

Discuss the physiology of balance

WHAT IS 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. In addition to the contribution of sensory information, there may also be psychological factors that impair our sense of balance.

SENSORY INPUT

Maintaining balance depends on information received by the brain from three peripheral sources: eyes, muscles and joints, and vestibular organs. All three of these information sources send signals to the brain in the form of nerve impulses from special nerve endings called sensory receptors.

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.

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. 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.

INPUT FROM THE VESTIBULAR SYSTEM

Sensory information about motion, equilibrium, and spatial orientation is provided by the vestibular apparatus, which in each ear includes the utricle, saccule, and three semicircular canals. The utricle and saccule detect gravity (information in a vertical orientation) and linear movement. The semicircular canals, which detect rotational movement, are located at right angles to each other and are filled with a fluid called endolymph.

The ear is a sensory organ that picks up sound waves, allowing us to hear. It is also essential to our sense of balance: the organ of balance (the vestibular system) is found inside the inner ear. It is made up of

three semicircular canals and two otolith organs, known as the utricle and the saccule. The semicircular canals and the otolith organs are filled with fluid.

THE VESTIBULAR SYSTEM

The vestibular apparatus, which is responsible for the sense of balance or sense of equilibrium, is located in the inner ear along with the cochlea. It consists of 3 semicircular ducts and 2 otolith organs, which together facilitate spatial orientation and registration of movements.

STRUCTURE OF THE VESTIBULAR APPARATUS

The vestibular system has two parts.

- **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).

Each has a different function.
It is made up of three semicircular canals and two otolith organs, known as the utricle and the saccule. The semicircular canals and the otolith organs are filled with fluid.

The structure of the vestibular apparatus is similar to that of the cochlea. The ducts of the vestibular apparatus are also filled with endolymph, and the sensory cells are also hair cells. However, unlike the hair cells of the cochlear, these develop cilia and several stereocilia that are connected via tip links. They are covered by a gelatinous mass. Inside the semicircular ducts, this mass, which contains mucopolysaccharide, is called the cupula. In addition, this mass contains small calcium carbonate crystals inside the otolith organ and is, therefore, called the otolithic membrane.

The vestibular system is the sensory apparatus of the inner ear that helps the body maintain its postural equilibrium. The information furnished by the vestibular system is also essential for coordinating the position of the head and the movement of the eyes. 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.

Although the vestibular organs and the cochlea are derived embryologically from the same formation, the otic vesicle, their association in the inner ear seems to be a matter more of convenience than of necessity. From both the developmental and the structural point of view, the kinship of the vestibular organs with the lateral line system of the fish is readily apparent. The lateral line system is made up of a series of small sense organs located in the skin of the head and along the sides of the body of fishes. Each organ contains a crista, sensory hair cells, and a cupula, as found in the ampullae of the semicircular ducts. The cristae respond to waterborne vibrations and to pressure changes.

The vestibular system (inner ear balance mechanism) works with the visual system (eyes and the muscles and parts of the brain that work together to let us 'see') to stop objects blurring when the head moves. It also helps us maintain awareness of positioning when, for example, walking, running or riding in a vehicle. In addition, sensors in the skin, joints and muscles provide information to the brain on movement, the position of parts of the body in relation to each other, and the position of the body in relation to the environment. Using this feedback, the brain sends messages to instruct muscles to move and make the adjustments to body position that will maintain balance and coordination.

FUNCTION

- The vestibular system functions to detect the position and movement of our head in space.
- This allows for the coordination of eye movements, posture, and equilibrium.
- The vestibular apparatus found in the inner ear helps to accomplish this task by sending afferent nerve signals from its individual components.
- The utricle and the saccule are responsible for sensing linear acceleration, gravitational forces, and tilting of the head.

Mechanism

The mechanism involved with the function of the peripheral vestibular system involves the acceleration of endolymph within the various structures of the vestibular apparatus. Head movement in various directions is responsible for this acceleration that results in the stimulation of the stereocilia of hair cells. When the head stops accelerating, hair cells return to their baseline position which allows them to respond to further changes in endolymph acceleration. Depending on the direction of acceleration, the inertial drag of the endolymph will push the stereocilia either towards or away from the fixed kinocilium.