

Motor Control - The Motor Cortex and Brainstem, Human Physiology Academy
2014-2015

Vestibular Pathways and Balance - Objects fall over if the centre of gravity is outside the base of the object; (the centre of gravity is the point through which the force of gravity acts). In the body, adjustments of the distribution of forces generated by muscles ("Muscle Tone") keep the line of gravity within the base. These include **Postural Responses** in which Upright Posture and Balance are maintained by automatic adjustments of muscle tone; such movements are involuntary (they are not willed) and determine one's posture. **Reflexes influencing balance.** The sensory input that influences these adjustments comes from several sources:

- The inner ear (utricle and saccule) senses the direction of gravity - the position of the head in space
- The inner ear (semi-circular canals) senses the direction of rotation or acceleration of the head, and provides some rapid dynamic responses
- Muscle, tendon and joint receptors sense joint the position of the limb
- The eyes sense the visual environment, e.g. The horizon, and the distance of objects

All of these influence the distribution of forces generated in the body musculature, by sending information to the brainstem and cerebellum through which precise adjustments of muscle tone within the body are performed.

The inner ear contains several sensory organs two of which provide information about the direction of the force of gravity. These are the Saccule and Utricle; these organs sense the direction of tilting of the head and produce some basic reflex (automatic) responses. This reflex response involves the descending pathways from the vestibular nuclei, and these projections to the spinal cord are responsible for adjusting the position and tone of the muscles of the limbs and the axial muscles so as to keep the centre of gravity within the base. If the tilt is sideways, the reflex produces some side-stepping in order to a wide base beneath the centre of gravity.

Vestibular Connections with the Cerebellum

The cerebellum is concerned with the control of movement, integrating signals from different parts of the nervous system and generating error signals that allow adjustments to be made to any muscles involved so as to achieve the desired objective of the movement.

The vestibular apparatus and the vestibular nuclei have a special relationship with the oldest part of the cerebellum, the flocculonodular lobe. This lobe modulates the vestibulo-ocular reflex system and is used to help stabilize the position of the eyes during rotation and tilting. Neurons in this part of the cerebellum extract from the vestibular input a signal about the speed of movement that allows the eyes to follow a moving object smoothly - this is known as a pursuit movement of the eyes. Visual inputs to the cerebellum can modify these pursuit movements.

Motor memory can be attributed to pathways being laid down in this lobe of the cerebellum during the early development of motor skills. The ability of a child to sit up, stand, balance and walk appear to be dependent on pathways laid down in this part of the cerebellum during development. These cerebellar circuits also allow the cerebellum to adapt to and compensate for damage to the inner ear.

