POSTURAL CONTROL
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1. Stabilization of upright posture
2. Postural support of voluntary movements
3. Stabilization of head and limb orientation in relation to the body and to the gravity vector
4. Role of different parts of CNS in the postural control
5. Development of postural control
Stabilization of the upright posture

Postural control system is keeping the projection of the centre of mass within the limits of the supporting area.

Postural stability in the frontal plane and in the sagittal plane is maintained by two different systems.
Operation of the sagittal plane system

Correcting motor responses

Postural control system can stabilize different positions
Sensory inputs for postural control system

Role of different sensory inputs for stabilization of the upright posture

- Normal subjects
- Vestibular loss
- Sensory conditions 1, 2, 3, 4, 5, 6

Diagram showing the sensory inputs to the brain, including vestibular organ, eye, spinal cord, and pressure receptors.
A corrective motor response organized in the distal to proximal sequence

Postural muscle synergy 1

Forward sway

Platform movement

Para
Add
Ham
Quad
Gast
Tib

0 100 200 ms

Final position
Initial position

Neck
Hip
Ankle
Platform

Postural muscle synergy 2

Backward sway

Platform movement

Para
Add
Ham
Quad
Gast
Tib
If the projection of the CM occurs outside the supporting area, the only way to prevent falling down is to perform a step.
2. Postural support of voluntary movements
Postural support of voluntary movements

Aim of anticipatory adjustment - to counteract the destabilizing consequences of a voluntary movement

Subject pulls on handle

Subject lifts the leg

Postural adjustment - shift of CM

Gastr.

Motor task

Biceps

Tone

Biceps

Gastr.
Basic principles of postural control

Feedback control

Sensory inputs

- Vestibular
- Visual
- Somatosensory

Processing & integration

Info. on body orientation

Desirable body orientation

Corrective command

Body orientation

Anticipatory adjustments

Destabilizing effect of voluntary movement

Feed-forward control

Motor cortex

Command for voluntary movement

Arm (leg) position
Role of experience and expectation

A rapid postural response in the gastrocnemius muscle occurs progressively earlier with repeated trials

The large contraction of gastrocnemius evoked by unexpectedly tilted platform is attenuated after a few trials
Postural control can be adapted to suit specific behaviors

Anticipatory adjustment adapts to the behavioral context

Anticipatory gastrocnemius action counters biceps

Biceps action pulls body forward
Handle fixed

Chest support

Biceps pulls body forward
Handle fixed

No gastrocnemius necessary

Gastrocnemius

Biceps

0 500 msec

Tone

0 500

Tone
3. Stabilization of head and limb orientation in relation to the body and to the gravity vector
Vestibular and neck reflexes stabilize the head position

**Neck-neck (cervicocollic) reflexes**
- stabilize the head position in relation to trunk

**Vestibular-neck (vestibulocollic) reflexes**
- stabilize the head position in relation to the gravity vector

- **Head**
- **Neck**
- **Trunk**

**Diagram Details**

- **IN** and **MN**:
  - IN: Input neuron
  - MN: Motor neuron

- **Vestib**:
  - Vestibular system

- **Gravity**

- **Muscles**
  - R-muscle and L-muscle:
    - Left: 0, Right
    - Tilt in relation to gravity
Goals of the two systems:

The same
- Vestibulocollic reflexes
- Cervicocollic reflexes

Different
- Vestibulocollic reflexes
- Cervicocollic reflexes
Vestibulospinal and cervicospinal reflexes have opposing actions on limbs

Right side down

Vestibular reflexes (head alone)

Left side down

Neck reflexes (axis rotation)

Neck reflex alone + Vestibular reflex alone = Combined reflexes
4. Role of different parts of CNS in the postural control
Integrity of brainstem centres is necessary for postural control

1. Spinal animal is not able to maintain the body weight.
2. Animal decerebrated between the superior and inferior colliculi (level 2) maintains the body weight but is not able to generate postural adjustments.
3. Animal decerebrated rostrally to superior colliculi (level 1) exhibits righting reflexes.
Postural centres of the brainstem

Integrity of brainstem centres is necessary for postural control

Level of decerebration

Sagittal plane

Stimulation of DTF and VTF affects posture

DTF stim

Gastr.

DTF

VTF
Motor cortex

RS

Command for anticipatory postural adjustment

Command for voluntary movement

Spinal cord

Intact cat

Upright posture

Left forelimb is lifted

RS is inactivated

CM
Adaptive postural control requires an intact cerebellum

A rapid postural response in the gastrocnemius muscle occurs progressively earlier with repeated trials in intact subject

Atrophy of the anterior cerebellar lobe prevents appropriate scaling of correcting postural response

Backward movement of platform

[Graph showing EMG, integrated EMG, and body sway responses over trials with 100 ms scale and platform amplitude (cm) on the x-axis and normalized gastrocnemius EMG (%) on the y-axis.]
5. Development of postural control
Motor development of the infant and young child
Conclusions

1. Posture is an actively stabilized definite orientation of the body and its segments in space and in relation to each other.

2. Postural control systems minimize deflections of the body from desirable orientation. Postural control systems are able to stabilize different postures.

3. Multimodal sensory inputs – somatosensory, visual, vestibular are used for postural control.

4. To maintain a desirable posture, a family of adjustments is needed. Postural adjustments are necessary also for all motor tasks and need to be integrated with voluntary movements.

5. Postural adjustments are achieved by means of two major mechanisms:
   (i) The compensatory or feedback mechanisms are activated by sensory events following loss of desirable posture. (Compensatory postural adjustments).
   (ii) The anticipatory or feed-forward mechanisms predict disturbances and produce preprogrammed responses that maintain stability. (Anticipatory postural adjustments).

6. Some of the compensatory postural adjustments are innate, while others have to be acquired by motor learning. Anticipatory postural adjustments must be learned, and then they operate automatically.

7. Postural control is adaptive. The shape of postural adjustment depends on behavioral context.

8. All levels of CNS are involved in postural control. Integrity of brainstem centers is necessary for generation of compensatory postural adjustments. Integrity of highest levels of the CNS including the motor areas of the cerebral cortex is necessary for anticipatory postural adjustments. Adaptive postural control requires an intact cerebellum.