جامعة الملك سعود
King Saud University

MED437

16th Lecture | The Physiology Team

Physiology of Postural Reflexes

Objectives :

- Able to define human posture
- Explain/define the concepts of " center of gravity " and " support base ".
- Explain what are postural reflexes and their overall function .
- Know the centers of integration of postural reflexes .
- Explain the structure and function of the vestibular apparatus (utricle, saccule & semicircular canals) in maintenance of balance.
- Describe decorticate rigidity and decerbrate rigidity and explain the mechanisms underlying them .

Done by :

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Colour index:
important
Numbers
Extra

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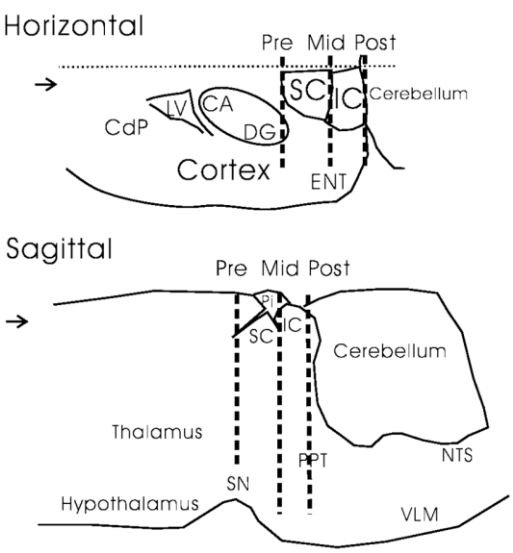
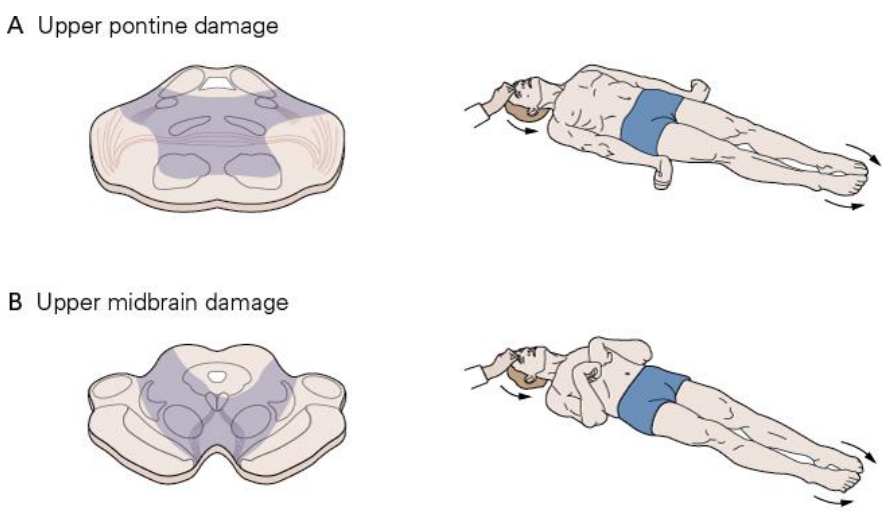
For better understanding

- **Decerebration** *is the elimination of cerebral brain function in an animal by removing the cerebrum, cutting across the brain stem, or severing certain arteries in the brain stem.*
- *Generally* **lower decerebration** *(the cut is made above the upper border of the pons),* **middle decerebration** *(cut is made through the red nucleus) and* **upper decerebration** *(cut is made so the cortical area is removed).*
- *As a result, the animal loses certain reflexes which are integrated in different parts of the brain.*
- *Furthermore, the reflexes which are functional will be hyperreactive (and therefore very accentuated) due to the removal of inhibiting higher brain centers (e.g. the facilitatory area of the reticular formation will not receive regulating input from cerebellum, basal ganglia and the cortex).*
- *Lower decerebration results in a "bulbospinal" animal: reflexes which are integrated within the spinal cord and medulla oblongata are functional, reflexes integrated in midbrain and cortex are absent.*
- *The most obvious accentuation is seen in the tonic labyrinthine reflexes, the otolithic organs mediate input about the gravitational force exerted on the body and the labyrinthine reflex acts on the extensor muscles in order to resist this gravitational force. In an animal where the cortical areas or the midbrain have been "cut off" from the neural axis, this reflex is hyperactive and the animal will maximally extend all four limbs. This phenomenon is known as* **decerebrate rigidity.** *In humans true decerebrate rigidty is rare since the damage to the brain centers it might be caused by usually are lethal. However* **decorticate rigidity** *can be caused by bleeding in the internal capsule which causes damage to upper motor neurons. The symptoms of decorticate rigidity are flexion in the upper limbs and extension in the lower limbs.*





What is posture?

- Posture is the attitude taken by the body in any particular situation like standing posture, sitting posture, etc.. even during movement, there is continuously changing posture.
- The basis of posture is the ability to keep certain groups of muscles in sustained contraction for long periods. Variation in the degree of contraction and tone in different groups of muscle decides the posture of the individual.

Postural reflex

- These reflexes resist displacement of the body caused by gravity or acceleratory forces, and they have the following functions:

1. Maintenance of the upright posture of the body. → 2. Restoration of the body posture if disturbed. → 3. Providing a suitable postural background for performance of voluntary movements.

Postural reflexes

depends on the following receptors

vestibular apparatus receptors

- Maculae (utricle & saccule) & SCC "Semicircular canals" cristae.
- **Macula** for linear acceleration and orientation of head in space.
- **SCC Cristae** for angular acceleration.

visual (vision) & auditory (hearing) receptors

- Vision can compensate for loss of auditory, vestibular & proprioception (tabes dorsalis +ve rombergism).
- If a patient with sensory ataxia stands with eyes closed, he/she falls down.
- **+ve Rombergs sign** when the posture maintenance is fully vision dependent

Proprioceptors of muscles, tendons, ligaments & joints

Neck Proprioceptors

Detect head position in relation to trunk

Body Proprioceptors

Proprioceptors of anti-gravity muscles

Pressure receptors

As in sole of feet initiate positive supporting reaction (magnet reflex)

Stretch reflexes and postural reflexes can be modified by coordinated activity of:

Spinal cord | Medulla | Midbrain | Cerebral cortex | Cerebellum

Postural reflexes

Static reflexes
(at rest) (statotonic)
Maintain posture at rest

Spinal Reflexes

Medullary Reflexes

Righting Reflexes
Center: In the midbrain

N.B: spinal receptors can be studied in spinal animal with cut at neck between the S.C & brain stem so all S.C is intact.

Phasic reflexes
"center in Cerebral Cortex"
(with motion) (statokinetic reflex)
Maintain posture during motion

A- Hopping Reaction

- *when animal is pushed laterally hopping reflex occurs to keep limbs in position to support body.*
- *The receptors are in muscle spindles.*

B- Placing Reaction

When a blind folded animal suspended in air & moved towards a supporting surface, the feet will be placed firmly on the supporting surface
(receptors are touch receptors & proprioceptors in soles of feet)

Supporting, Placing and Hopping Postural Reflexes

Spinal Reflexes

"Center in Spinal Cord"

Studied in spinal animals; with cut between spinal cord and brain stem

Local Static Reflexes (in 1 limb)

i. Stretch Reflexes (*static):*
This is the most important local static reflex which controls the tone in those extensor muscles which keep the body upright (antigravity muscles).

ii. Positive supporting reaction *(magnet reflex):*

- *Receptors are proprioceptors of flexors (contraction of both flexors & extensors) (protective reflex).*
- *When you stand on one foot (contraction of both flexors & extensors AT THE SAME TIME, this is a against reciprocal innervation).*
- *It* **is the only reflex** *where there is contraction of both Agonist and Antagonist at the same time*

Segmental Static Reflexes (in 2 limbs)

Mediated by one segment of the spinal cord as:

i. Crossed extensor reflex.

ii. Negative supporting receptor:

- *It refers to disappearance of positive supporting reaction.*
- *It is initiated by stretch of the extensor muscles.*
- *Which release +ve supporting reaction (receptors are proprioceptors of extensors of the released limb).*

Medullary Reflexes

"center in Medulla oblongata"

	Neck Static Reflexes	Labyrinthine static reflex
Studied in	*a decerebrated animal cut above medulla + labyrinth destroyed.*	*decerebrated animal + elimination of neck proprioceptors (labyrinth intact).*
Stimulus	*changing head position that (+) neck proprioceptors.*	*gravity*
Receptors	*neck proprioceptors.*	*otolith organs (maculae).*
Responses	▸ **Ventroflexion of head**: *Flexion of forelimb (arms) + extension of hind limb (as in decortication).* ▸ **Dorsiflexion of head**: *Extension of forelimb (arms) + flexion of hind limb.* ▸ **Turning head to one side**: *Extension of limbs on that side + flexion of other side.*	▸ **ventroflexion of head** *(or prone position)* *4 limbs flexion* ▸ **dorsiflexion of head** *(or supine position)* *4 limbs extended(as in decerebration)*

Labyrinthine Static Reflex

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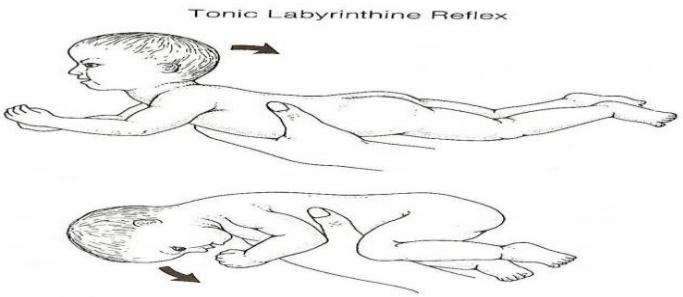


Righting reflexes

- *When upright posture is disturbed as is falling down*
- *Studied in a decerebrated animal → cut above midbrain "Upper decerebration"*

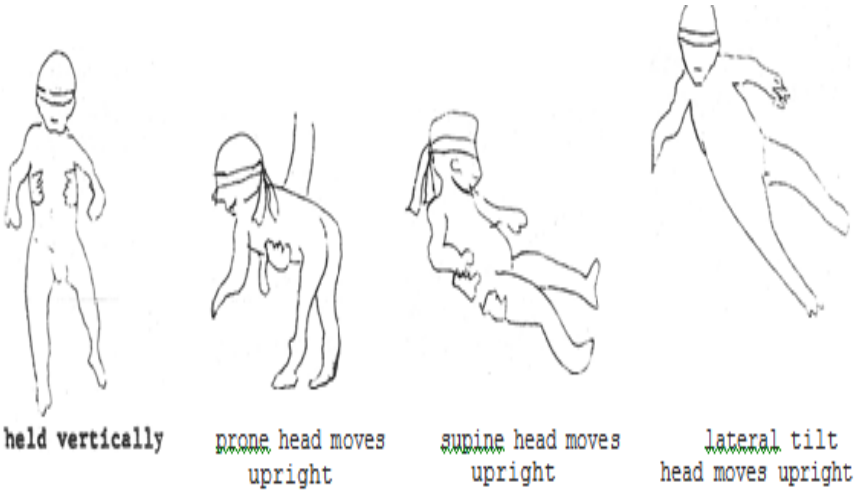
Reflex	Center	Stimulus	Receptors	Response
A. Visual Righting reflex	*Cerebral cortex*	*Visual stimulus*	*Eye receptors*	*Correct position of head & body*
B1. Labyrinthine righting reflex	*Midbrain*	*When the eyes are covered and the object is held in the air from pelvis. E.g: Tilting the head with covered eyes*	*Otoliths organs*	*Righting of head by stimulating neck muscles to correct the head level, when the head is not in proper site*
B2. Body on head righting reflex		*Pressure on side of body & head is free*	*Body pressure receptors*	*Reflex contraction of the head*
B3. Body on body righting reflex		*Pressure on side of body, while head is FIXED*	*Body pressure receptors*	*Reflex contraction of the body*
B4. Neck righting reflex		*"Correction of the head by B1 & B2 reflexes lead to twisting of the nick, this initiate reflex righting of the body".* **Stretch of neck muscles,** *if head is corrected and body is tilted*	*Proprioceptors of neck muscles*	*Righting of body and shoulders*

See the next slide for illustrative pictures & Video

Righting/Equilibrium Reflexes

Righting Reflexes
"jump to the second half of video"

labyrinthine righting reflexes



Body on head + Body on body righting reflexes

Neck righting reflexes

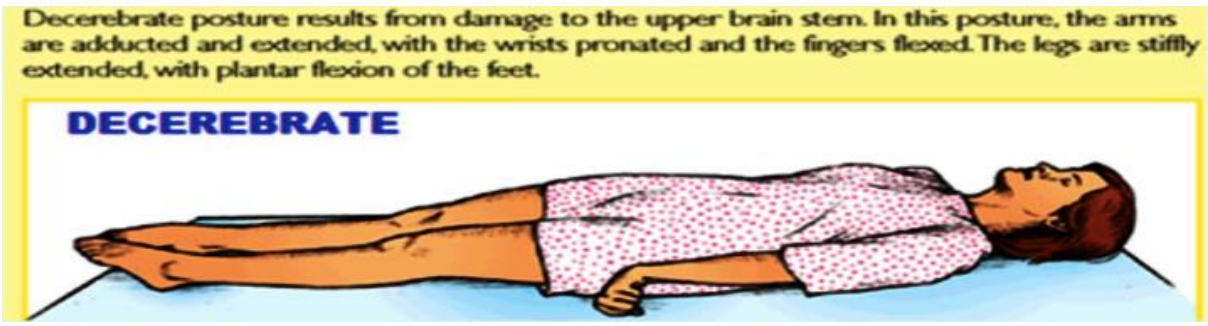
Decerebrate Rigidity

- **Site of lesion:** *between the superior and inferior colliculi of the midbrain, lesion below Red Nucleus (e.g. mid-collicular lesion).*
- *block normal inhibitory signals from brain & red nucleus in midbrain to tonically active pontile R.F & Vestibular nucleus causing:*

Extensive extensor posture of all extremities → Rigidity of all 4 limbs.

- *All limbs extended, arms extended by the sides & rotated internally (outward).*
- *Hallmark → elbows extended.*
- *Head may be arched to the back, it is due to:*

Increased general excitability of the motor neuron pool; especially Gamma efferent discharge (due to facilitatory effects of the un inhibited Vestibulospinal Tract) "Hyperactivity of gamma discharges"



- **In a decerebrated animal:**
  - *damage to level below red nucleus.*
- **Features of decerebrate rigidity:**

1. *Hyperextension of all four limbs.*
2. *Dorsiflexion (hyperextension) of tail and head.*
3. *Extreme hyperextension of the spine (opisthotonus) produces concave configuration of the back.*
4. *The animal can be made to stand on four limbs but is easily toppled by slight push..*

★

- **Reflexes that are lost/absent:**

1. *Optical (visual) righting Reflexes.*

★

- **Reflexes that are retained / still present**

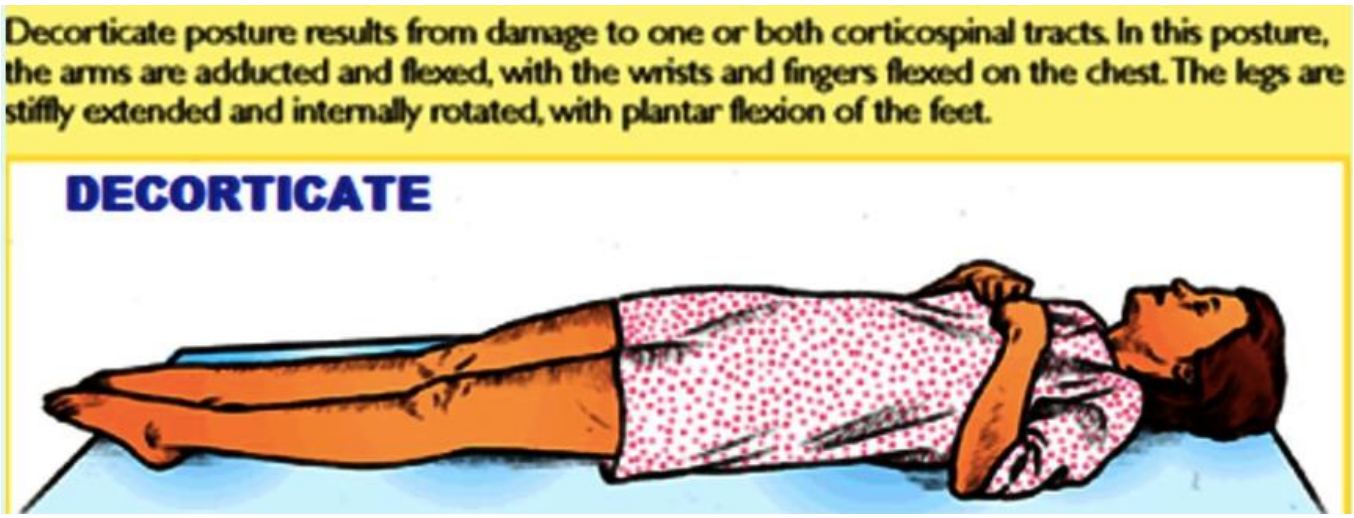
i.e. reflexes the do not depend primarily on cerebrum:

Maintained tonic static postural reflexes that support animal against gravity (medullary tonic neck & labyrinthine R).

1. *Tonic Labyrinthine reflexes.*
2. *Tonic Neck Reflexes.*
3. *Other Righting Reflexes.*

Decorticate Rigidity

- *In humans, where true decerebrate rigidity is rare, since the damage to the brain centers involved in it are lethal.*
- *Decorticate rigidity more common in human than decerebate rigidity, due to: Lesion in cerebral cortex, but brain stem is intact. However decorticate rigidity can be caused by bleeding in the internal capsule which causes UMNL (damage to upper motor neurons). As seen in hemiplegic patients after hemorrhage of internal capsule.*
- **Symptoms & Signs:**
- *Flexion in the upper limbs. Because* **the Red nucleus is intact** → *send inhibitory signals*
- *extension in the lower limbs. Why wouldn't we have flexion in the Lower limbs as in the upper limbs?* **Because the excitatory influence in the LM is more than the inhibitory**

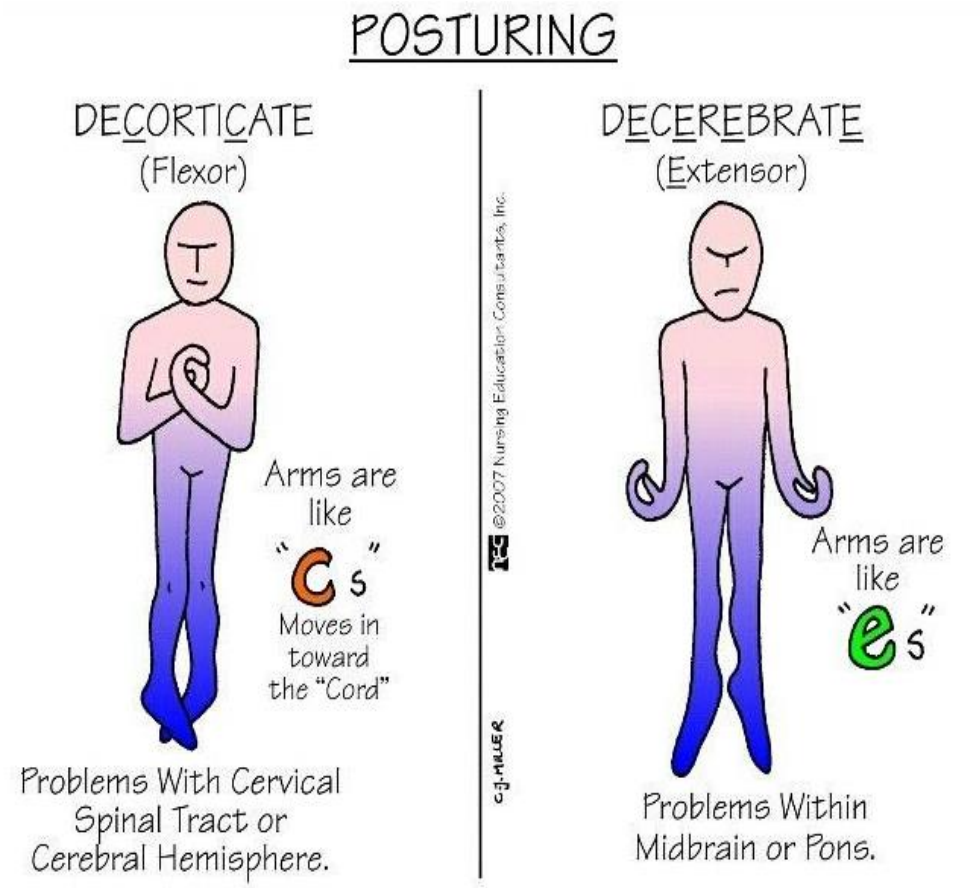


In a decorticate animal:

- *Decorticate animal is one in whom the whole cerebral cortex is removed but the basal ganglia and brain stem are left intact.*
- *Characteristic features: moderate rigidity is present*
- *Cortex inhibit medullary reticulospinal tract. Therefore, removal of cortex results in facilitation of γ motor neuron discharge.*

- **Reflexes that are lost/absent:** ★
  1. *Placing reaction, hopping reaction*
  2. *Visual righting reflex*
- **Reflexes that are retained /still present** ★
  i.e. Reflexes the do not depend primarily on cerebral cortex:
  1. *Tonic labyrinthine reflexes*
  2. *Tonic neck reflexes*
  3. *Other righting midbrain reflexes*

Decerebrate rigidity & decorticate rigidity



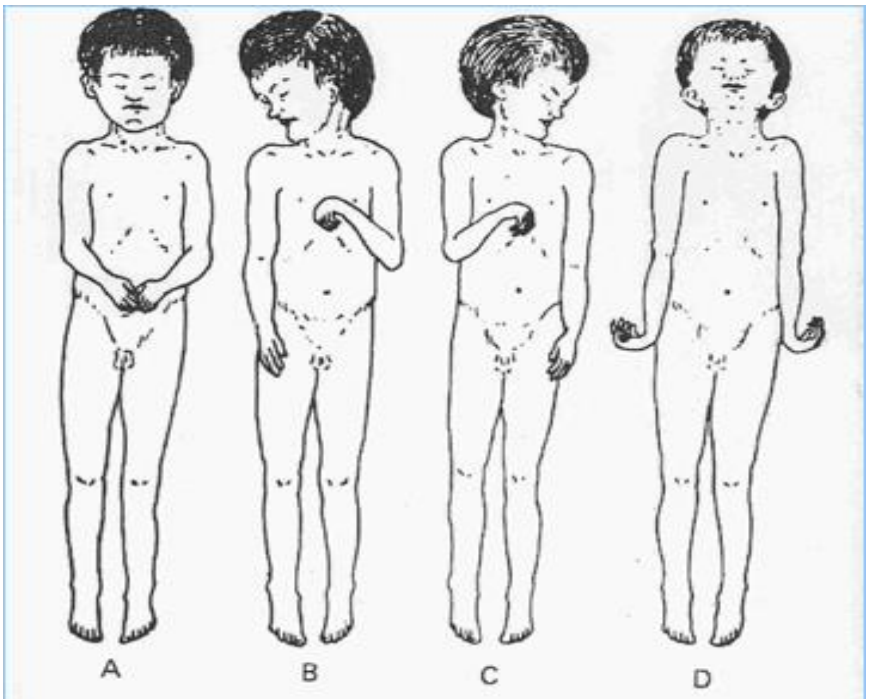


Figure 12–7. Human decorticate rigidity ***(A–C)*** and true decerebrate rigidity ***(D).*** In ***A*** the patient is lying supine with the head unturned. In ***B*** and ***C,*** the tonic neck reflex patterns produced by turning of the head to the right or left are shown. (Reproduced, with permission, from Fulton JF [editor]: *Textbook of Physiology,* 17th ed. Saunders, 1955.)

Summary

Table 12–2. Principal postural reflexes.

Reflex	Stimulus	Response	Receptor	Integrated In
Stretch reflexes	Stretch	Contraction of muscle	Muscle spindles	Spinal cord, medulla
Positive supporting (magnet) reaction	Contact with sole or palm	Foot extended to support body	Proprioceptors in distal flexors	Spinal cord
Negative supporting reaction	Stretch	Release of positive supporting reaction	Proprioceptors in extensors	Spinal cord
Tonic labyrinthine reflexes	Gravity	Contraction of limb extensor muscles	Otolithic organs	Medulla
Tonic neck reflexes	Head turned: (1) To side (2) Up (3) Down	Change in pattern of extensor contraction (1) Extension of limbs on side to which head is turned (2) Hind legs flex (3) Forelegs flex	Neck proprioceptors	Medulla
Labyrinthine righting reflexes	Gravity	Head kept level	Otolithic organs	Midbrain
Neck righting reflexes	Stretch of neck muscles	Righting of thorax and shoulders, then pelvis	Muscle spindles	Midbrain
Body on head righting reflexes	Pressure on side of body	Righting of head	Exteroceptors	Midbrain
Body on body righting reflexes	Pressure on side of body	Righting of body even when head held sideways	Exteroceptors	Midbrain
Optical righting reflexes	Visual cues	Righting of head	Eyes	Cerebral cortex
Placing reactions	Various visual, exteroceptive, and proprioceptive cues	Foot placed on supporting surface in position to support body	Various	Cerebral cortex
Hopping reactions	Lateral displacement while standing	Hops, maintaining limbs in position to support body	Muscle spindles	Cerebral cortex

MCQ

1. Posture depends on:
   A. . Gravity
   B. . Vision
   C. . Muscle tone
   D. . Hearing
2. For efficient well-coordinated posture we need:
   A. . Vestibular apparatus.
   B. . Basal ganglia.
   C. . Cerebellum.
   D. . All of above.
3. Which of the following spinal reflexes is mediated by one segment of the spinal cord ?
   A. . Stretch reflexes
   B. . Segmental static reflex
   C. . Local static reflex
   D. . Negative supporting reflex
4. Which of the folowing is a stimulus of neck static reflex ?
   A. . Changing in position of head
   B. . Gravity
   C. . Raising limbs
   D. . Standing up
5. Study of Labyrinthine static reflex should be in a ?
   A. . Decerebrated animal with a cut above medulla oblongata
   B. . Live animal with spinal cord extraction
   C. . Decerebrated animal with elimination of neck proprioreceptors
   D. . Decerebrated animal with total spinal cord extraction

Answers:
1.C
2.D
3.B
4.A
5.C

SAQ

6. What are the structure needed to maintain coordination of Stretch reflexes & postural reflexes?
1. Spinal cord
2. Medulla
3. Midbrain
4. Cerebral cortex
5. Cerebellum

7. In labyrinthine static reflex there is an elimination of which type of proprioceptor , what it's function?
Neck proprioceptor, it's function to detect head position in relation to the body.

8. Explain the phenomena of decerebrate rigidity?
Unopposed activity of the pontine reticular nucleus which lead to increase activity motor neuron that facilitate stretch reflex.

9. What is the reason for the extension of all limbs in decerebrate rigidity?
It is because the inhibitory signals from the brain and red nucleus are blocked, that will result in excitation of
Medial Reticulospinal & Vestibulospinal tracts.

10. Which type of ridigity is possible to be seen on the hemiplegic side in humans after hemorrhages or thromboses in the internal capsule?
Decorticate Rigidity.

11. What are the clinical features of decorticate posture rigidity?
-the hands are clenched into fists
-the legs extended
-feet turned inward.