



# 16<sup>th</sup> Lecture

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## Proprioception in Balance

**PHYSIOLOGY TEAM – 430**

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## Proprioception in Balance

- **Posture:**

- It is a relative position of the trunk, head and limb in space

The head is the heaviest part in our body

- Center of gravity must be in the center to keep posture undisturbed, To keep posture stable the center of gravity of body is needed to be maintained in position over its support base e.g. between the legs

- **Three systems will try to keep the body in position:**

1. Vestibular apparatus
2. Proprioceptors
3. Visual system

If any system is not working properly could cause imbalance

- **When a person is about to fall:**

- 1- 1<sup>st</sup> defense mechanism is achieved by the previous 3 systems.
- 2- 2<sup>nd</sup> defense mechanism is achieved by the cerebellum and the basal ganglia, they work to make is smooth (the response)

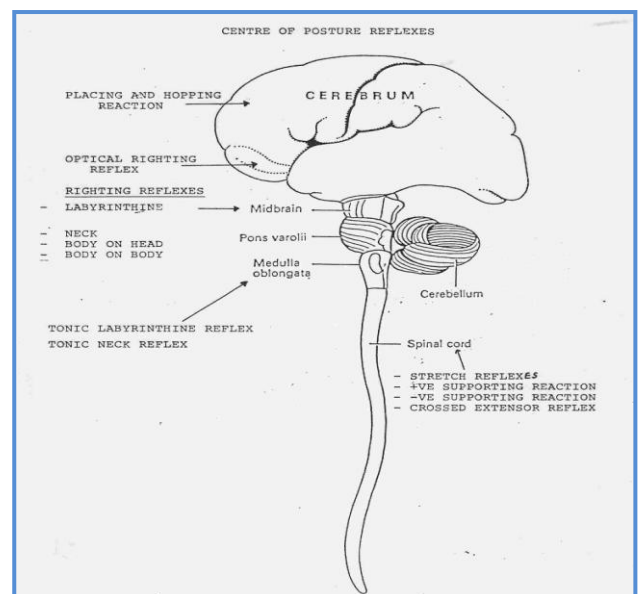
Primary requirement in balance is TONE, tone of antigravity muscles

- **Tone:**

- Is the resistance in muscles against movement
- Example: If an uncooked meat was put in a plate and it takes the shape of the plate. Then it has no tone
- Tone is maintained first at the spinal cord reflexes

- **Tone for correction of posture is generated through various levels:**

Medulla oblongata – Mid Brain – Cortex



- **Receptors:**

Are transducers that convert any external or internal stimulation into electrical signals (generate potential then action potential)

- **Proprioception:**

The awareness of body position especially when the eyes are closed (position of joints – position of body in space – position of each part of the body in relation to other parts)

- **Proprioceptors:**

Receptors of proprioception (carry information about body position)

- **Proprioceptor location:**

Proprioceptor	Site	Respond to:
<b>Golgi tendon organ</b>	Present in tendons of muscles	Changes in muscle tension
<b>Muscle spindle (stretch receptors)</b>	Present in muscles	Changes in muscle length
<b>Pacinian corpuscle</b>	A laminated capsule with pressure sensitive nerve endings in the center of the capsule	1- High velocity changes in joint position 2- Deep pressure

- **Types of proprioceptors:**

Pressure receptors	Body proprioceptors	Neck proprioceptors
as in sole of feet initiate positive supporting reaction ( magnet reflex)	Proprioceptors of anti-gravity muscles	Detect head position in relation to the trunk

- **Types of proprioception:**

- 1- **Conscious proprioception:**

Reach the level of cerebral cortex sensory area via dorsal column system (via gracil and cuneate tracts)

- 2- **Unconscious proprioception:**

Reach the level of cerebellum via spinocerebellar tracts

- **Lesion of dorsal column system (which carries conscious proprioception to the cerebral cortex):**

- **Happens in:**

- 1- Diabetic Polyneuropathy
- 2- Tabes Dorsalis

- **This lesion causes:**

- 1- Sensory ataxia (uncoordinated sensation)
- 2- Positive rombergism (a positive Romberg sign when the patient can't stand and keep balance when his eyes are closed)
- 3- Stamping gait (the patient raises his leg then drop suddenly to the ground due to loss of knowledge of the position of the lower limbs)

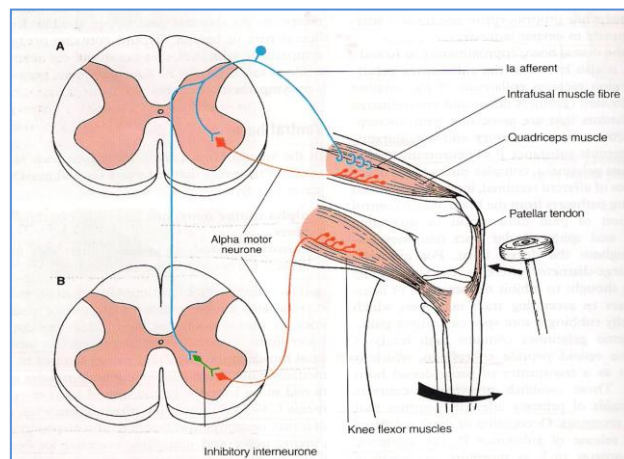
- **Postural reflexes that depend on proprioceptors:**

<b>Stretch reflex and muscle tone</b>	required to maintain body tone which is essential to balance the body
<b>Golgi tendon reflex (inverse stretch reflex)</b>	- senses the pull on the tendon and controls the muscle tension to prevent muscle rupture - This type of reflex happens when there is severe reflex and causes relaxation of the
<b>Crossed extensor reflex</b>	
<b>Positive and negative supporting reaction (magnet reflex)</b>	Initiated by proprioceptors of flexors, cutaneous pressure receptors as in sole of feet
<b>Neck postural reflexes</b>	Neck proprioceptors detect head position in relation to trunk & initiate neck postural reflexes
<b>Righting reflexes</b>	by Body Proprioceptors proprioceptors of neck and anti-gravity muscles

## 1) Components of stretch reflex:

### 1- Dynamic stretch reflex (dynamic/phasic response):

- When there is a sudden rapid stretch of muscle, the nuclear bag fibers respond to the rate or velocity of the stretch and causes the primary endings of muscle spindles to discharge of synchronous strong impulses (strong impulses that go at the same time and same rate to the alpha motor neuron and to motor nerve that supplies the stretched muscle and causes it to synchronously contract its extrafusal fibers)
- This dynamic stretch reflex is the basis of jerk movements
- Tendon jerk: Contraction followed by relaxation of knee, biceps and triceps



### 2- Static stretch reflex (static response):

- Happens when there is a persistent stretch of the muscle. The nuclear chain fibers respond and discharge impulses with increased rate. The impulses are transmitted in the secondary sensory nerve then to alpha motor neuron and to the motor neuron that supplies the stretched muscle and causes it to asynchronously contract its extrafusal fibers
- This results in mild sustained contraction of muscle extrafusal fibers as long as it is stretched
- This static stretch reflex is the basis of muscle tone

### • Muscle tone (static stretch reflex):

- It is the stretch of skeletal muscle between its origin and insertion
- Present in antigravity muscle (extensors of lower limbs, back, neck, flexor of upper limbs, muscles of abdominal wall and elevator of mandible)

<b>Loss of muscle tone</b>	Lost by low gamma efferent discharge	✓ Hypotonic ✓ Flaccidity
<b>Increased muscle tone</b>	Increased by high gamma efferent discharge	✓ Hypertonic ✓ Spastic muscles



## 2) Golgi tendon reflex (inverse stretch reflex):

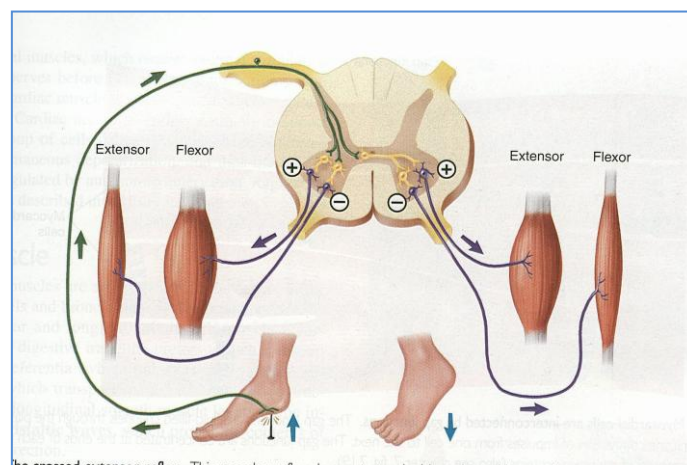
- It is the opposite response to stretch reflex
- Excessive tension in the muscles (caused by overstretch of tendon or muscle contraction) causes the tensed muscle to relax to protect the muscle from rupture
- Golgi tendon organs (3-25) are receptors in the tendons
- They are stimulated when the muscle fibers are tensed and send impulses through fast A $\alpha$  fibers to the spinal cord. Then:
  - 1- The inhibitory interneurons are stimulated and secrete glycine which inhibits alpha motor neuron and lead to muscle relaxation
  - 2- The excitatory interneurons are stimulated to antagonist muscle

Stretch reflex → moderate stretch

Golgi tendon reflex → strong excessive stretch that could damage the muscle

## 3) Crossed extensor reflex:

- Occurs with painful stimulus that stimulates one limb and causes:
  - 1- Flexion and withdrawal of that limb
  - 2- Extension of the opposite limb
- This reflex ensures that the opposite limb will be in position to bear the weight of the body when the injured limb is withdrawn from the stimulus



### **Reciprocal innervations occur in crossed extensor reflex:**

Flexors in the opposite limb are inhibited while extensors are excited pushing the body away from the injurious agent and supporting the body weight against gravity -hence it is an Antigravity Reflex

#### **4) Positive supportive reaction (magnet reflex):**

- Initiated by proprioceptors of flexors & cutaneous pressure receptors as in sole of feet
- No reciprocal inhibition both flexors & extensors are contracted

#### **5) Negative supporting reflex:**

- Releases positive supportive reaction
- receptors are proprioceptors of the extensors of the released limb

#### **6) Neck postural reflexes:**

- Neck proprioceptors detect head position in relation to trunk & initiate neck postural reflexes
- This type of reflex is stimulated by the change of head position

#### **7) Righting reflexes:**

- controlled by body proprioceptors of neck and anti-gravity muscles
- This type of reflex is to bring the body to normal position in space

#### **8) Phasic reflex:**

- maintain posture during movement