

6th Lecture

Stretch Reflex and Golgi Tendon Reflex

Physiology Team- 430

This Lecture is done by :

Layan Akkielah

Organized by : Layan Akkielah

Stretch Reflex and Golgi Tendon Reflex

- The spinal cord is responsible for integration of many basic reflexes .
- The cord gray matter is the integrative area for the cord reflexes.

Keep in mind :

- Proper control of muscle functions requires :

1) Excitation of the muscle by spinal cord anterior motor neurons .

Anterior motor neurons are located in each segment of the anterior horn of the cord gray matter . They have two types :

- **Alpha motor neurons** :

They branch into type A alpha motor nerve fibers . Each alpha motor nerve fiber excites a motor unit (several muscle fibers) and innervates the extrafusal muscle fibers .

- **gamma motor neurons** :

They transmit impulses through smaller type A gamma smaller nerve fibers . They supply the intrafusal fibers (small special skeletal muscle fibers that are located in the middle of the muscle spindle and they help in controlling the muscle tone) .

2) Continuous feedback of sensory information of the muscles' functional status from each muscle to the spinal cord .

To provide this information the muscle and their tendons are supplied by **two special types of sensory receptors** :

**** Golgi tendon organs:**

Site : Located in the muscle tendons

Function : transmit information about **tendon's tension or the rate of change of tension** .

**** Muscle spindles:**

Site : Distributed throughout the belly of the muscle .

parallel to extrafusal fibers (which constitute the muscle bulk) & attached to it or to tendons.

Function : send information about **the muscle's length or the rate of change in the muscle's length**

muscle spindle act to maintain muscle length against rupture:-

-if muscle is stretched>> muscle spindle discharge>> reflex shortening of muscle by contraction to keep its length.

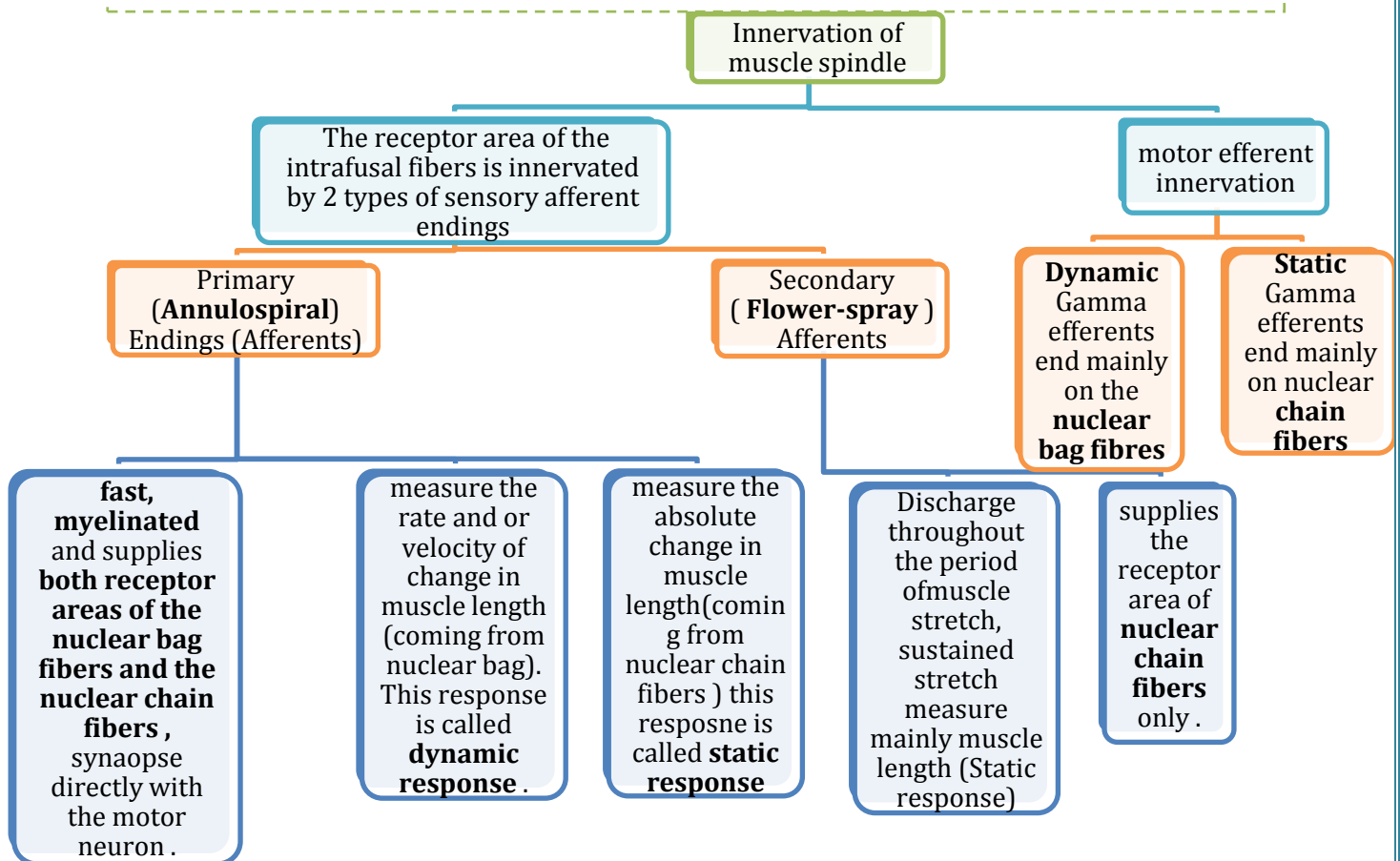
Structure : Each spindle consists of 3-12 Intrafusal muscle fibers that are pointed at their ends .

Each intrafusal fiber consists of :

- 1) **Central non-contractile area** .It has few or no actin or myosin filaments therefore it doesn't contract. It acts as the **receptor area**.
- 2) **Peripheral contractile parts** on either side of the central receptor area.

There are two types of intrafusal fibers:

- 1) **Nuclear bag fibers** : contain many nuclei in a dilated **central area** ("bag") . Typically there are **2 nuclear bag** fibers per spindle .
- 2) **Nuclear chain fibers** : thinner and shorter than nuclear bag fibers , and have **one line** of nuclei spread in a chain along the receptor area . bind to nuclear bag on each side There are **4 - 9 nuclear chain fibers** per spindle.



Sensory Afferent :

Remember that :

- Nuclear bag fibres are supplied by primary endings **only** responsible for the **dynamic response** (Like knee-jerk)
- Nuclear chain fibres are supplied by **both** primary and secondary endings responsible mainly for the **static response** (and to a much lesser extent , dynamic response).

The Dynamic Response occurs mainly when the muscle is suddenly stretched.

The Static Response occurs mainly with maintained muscle stretch .

Motor efferents :

Motor supply to the Muscle Spindle is by Gamma Efferents (Motoneurons)

Function :

- Gamma Efferents cause contraction of the peripheral ends of the intrafusal fiber leading to stretching & stimulation of the middle, receptor part of the intrafusal fiber
- This leads to action potentials in the spindle afferents (annulospiral & flower-spray) leading to stimulation of Alpha Motor neuron contraction of the extrafusal fibers.

-Effect of gamma efferent discharge:

A) Dynamic gamma efferent :

plate endings which end mainly on the nuclear bag fibers

, increase sensitivity of muscle spindle to rate of change of stretch as in **sudden stretch to the muscle**

B) Static gamma efferent :

trail endings which end mainly on the nuclear chain fibers, increase sensitivity of muscle spindle to **steady maintained stretch**

Stretch reflex

• What is **stretch reflex** ?

It is reflex contraction of muscle resulting from stimulation of the muscle spindle by stretch .

• Characteristics of stretch reflex:

** It is a **monosynaptic reflex** (because the only synapse in the reflex arc is the one between The afferent and efferent neuron) .

** **Deep reflex** (because its receptor “ muscle spindle” is inside the muscle) .

• Components :

Receptor	muscle spindle
Stimulus	sudden stretch
Center	anterior horn cell
Sensory afferent fibers	(a annulospiral+flowerspray)
Motor efferent fibers	(alpha fibers70%to extrafusal muscle fibers +gamma efferent 30% to muscle spindle intrafusal fibers).
Effector	muscle
Response	contraction of the muscle

- **How does it happen ?**

Elicitation of the reflex is by tapping on the muscle tendon , which leads to stretching of muscle → stimulation of the muscle receptor (muscle spindle)→ spindle afferents excite the alpha motor neuron → muscle contraction.

More detailed :

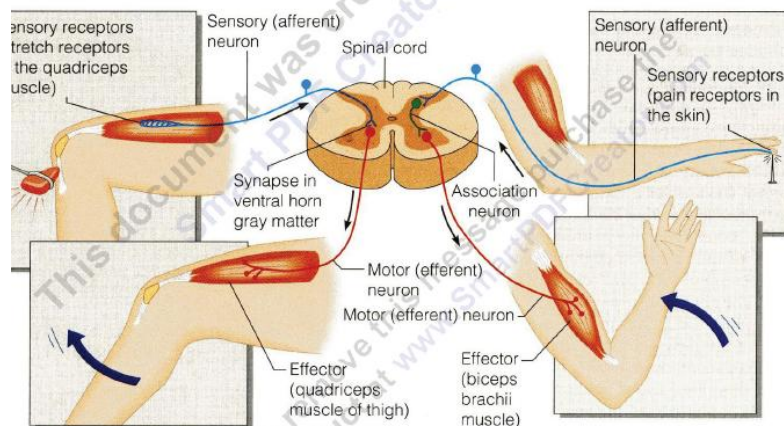
Stretching extrafusal muscle fibers will lead to Stretching of the intrafusal peripheral contractile fibers so it will stimulate the stretch receptor zone (central)in intrafusal fibers (muscle spindle) and this will cause stimulation of sensory afferent endings encircling receptor area.

-Afferent impulses →spinal cord will stimulate:

1- alpha motor neurons (70%) which send impulses to extrafusal ordinary muscle fibers which will lead to muscle contraction.

2- gamma motoneurons (30%) which send impulses to intrafusal peripheral contractile fibers causing contraction of the peripheral contractile parts of the intrafusal fibres & stretch central receptor zone.

The knee jerk and biceps jerk are two examples of the stretch reflex



- **Types of responses (stretch reflex) :**

1) Dynamic stretch reflex (phasic stretch reflex) :

Caused by a sudden rapid stretch of the muscle.

Sudden (phasic) rapid stretch of a muscle causes synchronous (at the same time) strong burst of excitatory discharges in Annulospiral Afferents to the Alpha Motoneuron This causes the latter to send strong Synchronous motor excitatory impulses to Extrafusal Fibers Causing sudden , jerky (brief) muscle contraction(jerky movement).

As the muscle shortens, the spindle becomes relaxed and ceases to discharge so no more stimulation of alpha motoneuron and no more excitatory impulses from alpha motoneuron to the extrafusal fibers → muscle relaxes

– This is the basis of Tendon Jerks (dynamic stretch reflexes), (contraction followed by relaxation) (knee, biceps, triceps).

When muscle contract, it shortens, muscle spindle relax>>> no discharge of primary endings, and muscle relax.

2) Static stretch reflex :

– Maintained (tonic) Nuclear chain stretch of muscle.

Impulses from muscle spindle travel through spindle afferents to alpha motor neuron, stimulating it to produce Asynchronous (not at the same time so it would last longer) motor excitatory impulses to Extrafusal Fibers Causing sustained (continuous) contraction of the muscle as long as it is stretched.

– The Static Stretch Reflex is the basis of **Muscle Tone**.

Muscle tone

Muscle Tone is a static stretch reflex, stimulated by stretch of skeletal muscle (between origin and insertion), present in antigravity muscles (extensors of lower limb, back, neck, flexor of upper limb, muscle of abdominal wall and elevator of mandible)

*If lost by **low** gamma efferent discharge to muscle it will cause **hypotonic or flaccidity** muscle (weak and soft)

*If increased by **high** gamma efferent discharge to muscle it will cause **hypertonic or spastic** muscle (rigid and stiff)

• Muscle can contract by :

There are two mechanisms to stimulate the receptor :

1- Stimulation of alpha motor neurons by muscle stretch :

Stretching the muscle bulk (extrafusal fibers) stretches the receptor (muscle spindle)

AP discharges in the spindle afferents (annulospiral or flower-spray) to Alpha Motor neuron, stimulating it, APs discharges from Alpha Motor neurons to Extrafusal muscle fibers cause contraction of muscle bulk stimulation

2- Stimulation of gamma motor neurons :

By stimulating Gamma Efferents (to the same muscle) . Gamma efferent discharge cause contraction of peripheral ends of intrafusal fiber stretching the receptor zone, thereby stimulating it & afferent discharges in annulospiral or flower-spray fibers stimulate Alpha Motor neuron causing extrafusal muscle fiber contraction.

Best contraction is by stimulation of both alpha and gamma neurons

• **Reciprocal inhibition associated with stretch reflex as in knee jerk :**

Reflex contraction of an agonist muscle is accompanied by inhibition of the antagonist (contraction of biceps , relaxation of triceps / contraction of extensor of thigh , relaxation of flexor).

impulses from stretched muscle go to spinal cord to cause:

- 1-stimulation of the motor neurons of the stimulated muscle to contract (by glutamat)
- 2-send collaterals >>>> inhibitory interneuronssynapse on the AHCs of the antagonistic muscle & inhibit them (by GABA)

Summary of Factors Influencing/Modulating Gamma Efferent Activity (& hence the Stretch Reflex)

Enhances

A/ Supraspinal influences :

(1) Cortical (motor area 4) :
(voluntary , conscious + limbic → fear/apprehension , and anxiety , pain)

(2) Brainstem mechanisms :

- (i) Vestibular nucleus
- (ii) Pontine Reticular Formation

(3) Neocerebellum

B/ Largely spinal mechanisms :

related to noxious (painful) stimuli .

C/ jendrassik- maneuver

Inhibits

A/Supraspinal :

(1) Cortical (motor area 6)
(voluntary , conscious , mostly) .

(2) Extrapyramidal & Brainstem mechanisms :

- (i) Basal ganglia ,
- (ii) Red Nucleus .
- (iii) Medullary Reticular formation .

(3) Paleocerebellum)

B/ Largely spinal mechanisms :

1. Excessive muscle stretch
(stimulation of Golgi tendon organ) .
2. Muscle contraction

The cerebellum:

- Cerebellar cortex exerts an inhibitory influence on the stretch reflex.
- Deep cerebellar nuclei (DCN) are excitatory via lateral vestibular nuclei.
- However , cerebellar lesions in humans are characterized by hypotonia, due to deep cerebellar nuclei involvement .

If the examiner/ physician is applying the instrument (hammer) on the patient's knee to test his reflex while the patient is observing the instrument (hammer) the reflex wont be achieved (no involuntary , rapid movement to the receptor stimulus).Therefore , a technique was invented " Jendrassik Maneuver " by jendrassik person which can distract the patient by stressing on both of his hands and teeth .

The Golgi tendon reflex inverse stretch reflex

- Characteristics : deep polysynaptic reflex
- Receptor : golgi tendon organs (3-25) in tendons
- Stimuli : excessive tension .
- When muscle is excessively stretched ,it contracts strongly and pulls on the tendon, excessive tension is conveyed/transferred to the tendon ,this stimulates Golgi Organ in the tendon →it sends afferent impulses via the fast A α fibers →excitation of inhibitory interneuron in spinal cord (secretes glycine – inhibitory neurotransmitter) → inhibition of alpha motor neuron → muscle relaxation.
- This reflex protects muscle from rupture by excessive stretch & tension .