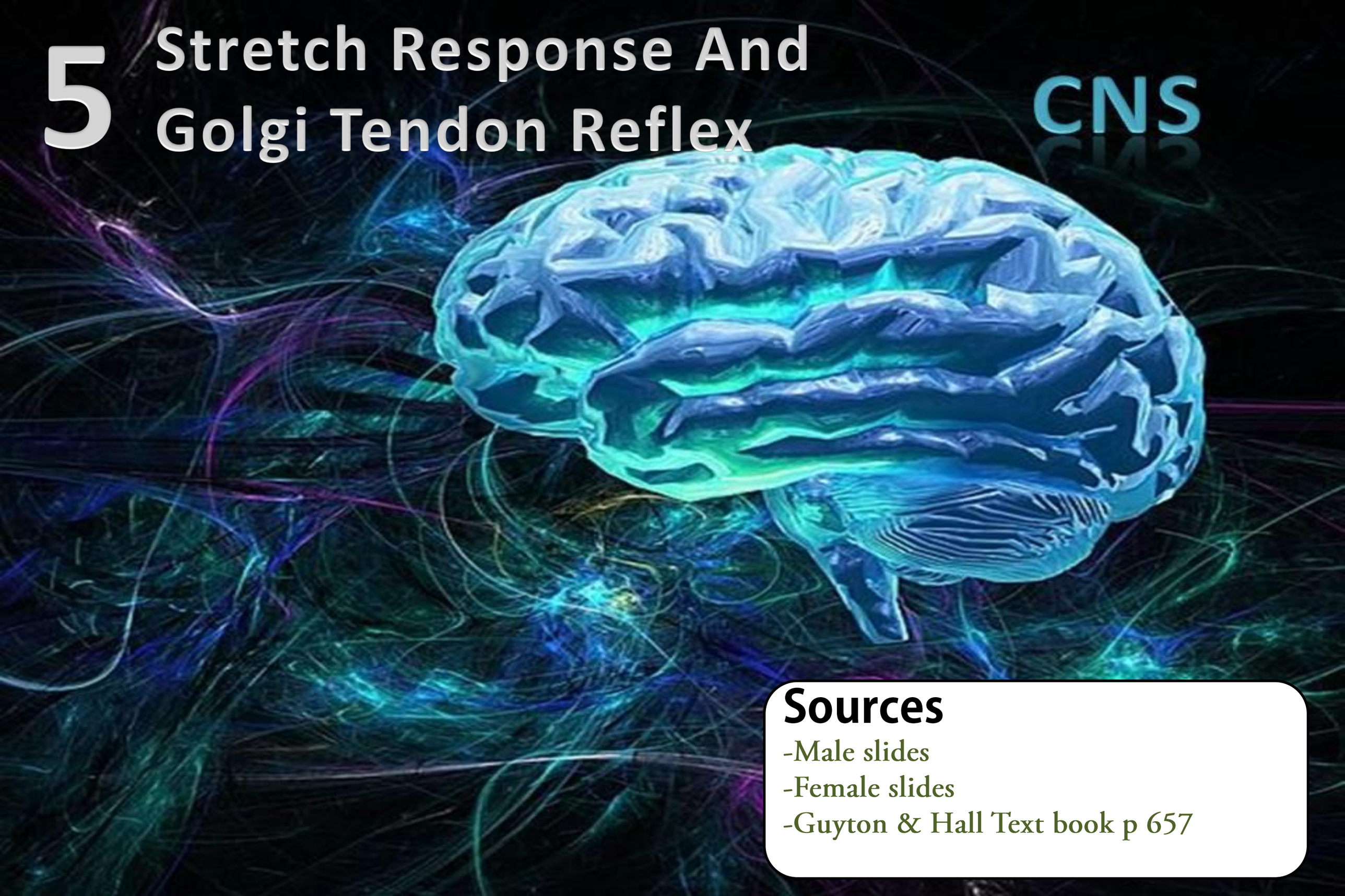
5 Stretch Response And Golgi Tendon Reflex



Sources

-Male slides
-Female slides
-Guyton & Hall Text book p 657

Objectives

be able to describe a stretch reflex .(1)
(2) Define muscle tone
(3) be able to explain what is muscle tone
(4) describe the structure , innervations and function of the muscle spindle .
(5) explain what is meant by static and dynamic stretch reflex .
(6) describe the spinal and supraspinal regulation of the stretch reflex .
(7) describe the inverse stretch reflex and its function

New Terms

Synchronous = existing or occurring at the same time.
Static = contraction of the muscle without movement, like back muscle during standing to hold the body from falling
Dynamic = Contraction of the muscle with movement
Muscle tone= the resistance of the muscle without contraction

Sources

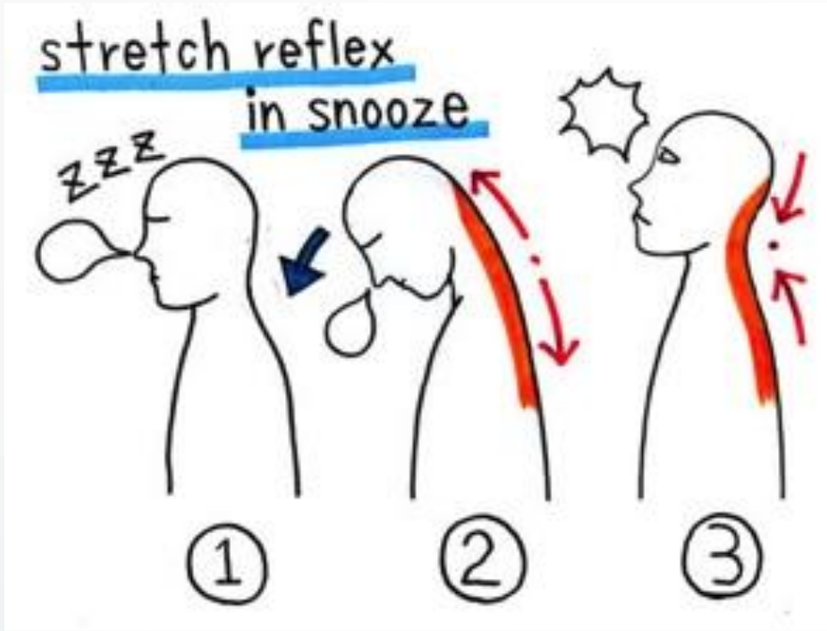
-Male slides
-Female slides
-Guyton & Hall Text book p657

Stretch reflex:

Whenever a muscle is stretched suddenly, excitation of the muscle spindle causes reflex contraction of the large muscle fiber (See the pictures).

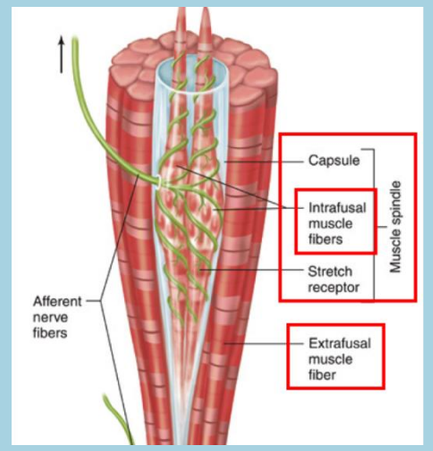
It is <u>deep and monosynaptic</u> reflex.

Stretch response is produced by <u>co-activation</u> of alpha & gamma motor neurons. But it is <u>maintained</u> mainly by the tonic (continuous) discharge of Gamma Efferent neurons.



Muscle spindle: It is a sensory receptors which are distributed throughout the muscle and it sends information to nervous system about **muscle length** or **rate of change in muscle length**.

- Each spindle is built around 3-12 intrafusal muscle fibers.
- Muscle spindles are parallel to extrafusal muscle fibers and they are attached to them or to the tendon.



Types of Intrafusal fibers

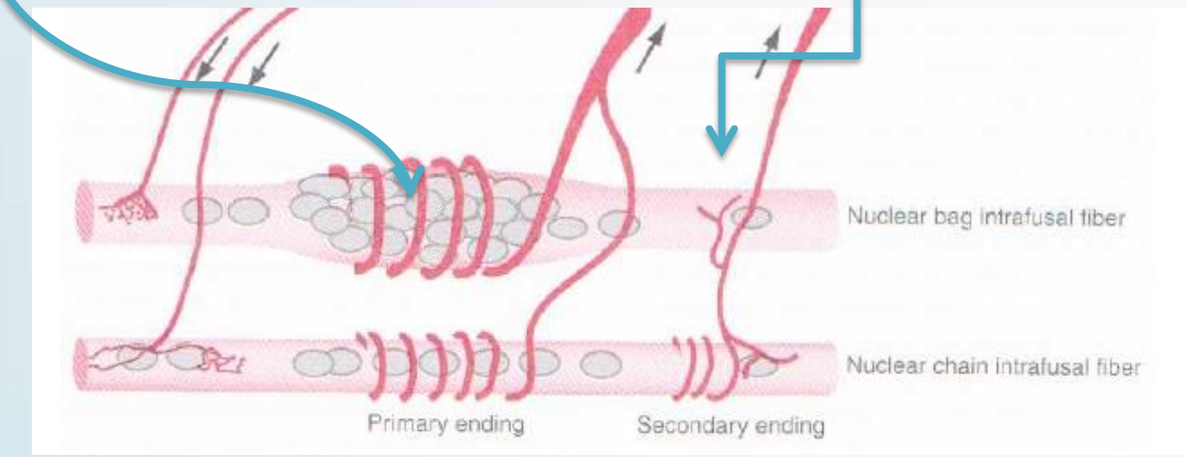
1) Nuclear bag fibers: contain many nuclei in a dilated central area (" bag ") . **Typically there are 2 nuclear bag fibers per spindle** .

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 . **There are 4 – 9 nuclear chain fibers per spindle**

Each intrafusal fiber consists of:

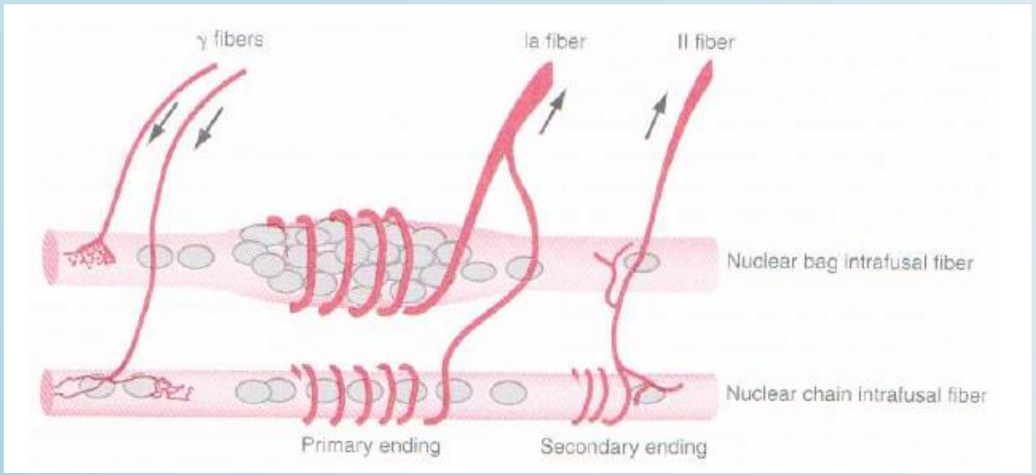
(1) Central non-contractile area (receptor area).

(2) Peripheral contractile area.



Sensory innervation of the muscle spindle: Two types of sensory innervation are found in central receptor area of the spindle primary and secondary:

	Primary	Secondary
Types of fiber that innervates	Two types of Intrafusal muscle (Nuclear bag **mainly** and chain)	Nuclear chain only
Measure	Muscle length and rate **(Dynamic response)**	Muscle length only **(Static response)**
Sends afferent response in	Static and dynamic response	Only static response
Type of conducing fibers	**Annulospiral afferent (fiber Ia)** (rapid fiber)	**Flawer-spray afferent (fiber II)**
Note	discharge most rapidly if the muscle is **suddenly stretched** and **less rapidly (or not)** during **sustained stretch**	Discharge throughout the period of muscle stretch, **(sustained stretch)**



Remember that:

Nuclear bag fibers are supplied by primary endings only. So, it's responsible for the dynamic response (e.g. in case of knee-jerk)

Nuclear chain fibers are supplied by both primary and secondary endings. So, it's responsible mainly for the static response (and to a much lesser extent , dynamic response) .

Steps of motor innervation of muscle spindle:

(Remember that **intrafusal muscle is supplied by gamma** and **Extrafusal is supplied by alpha**)

Muscle spindle is supplied by gamma motorneuron.

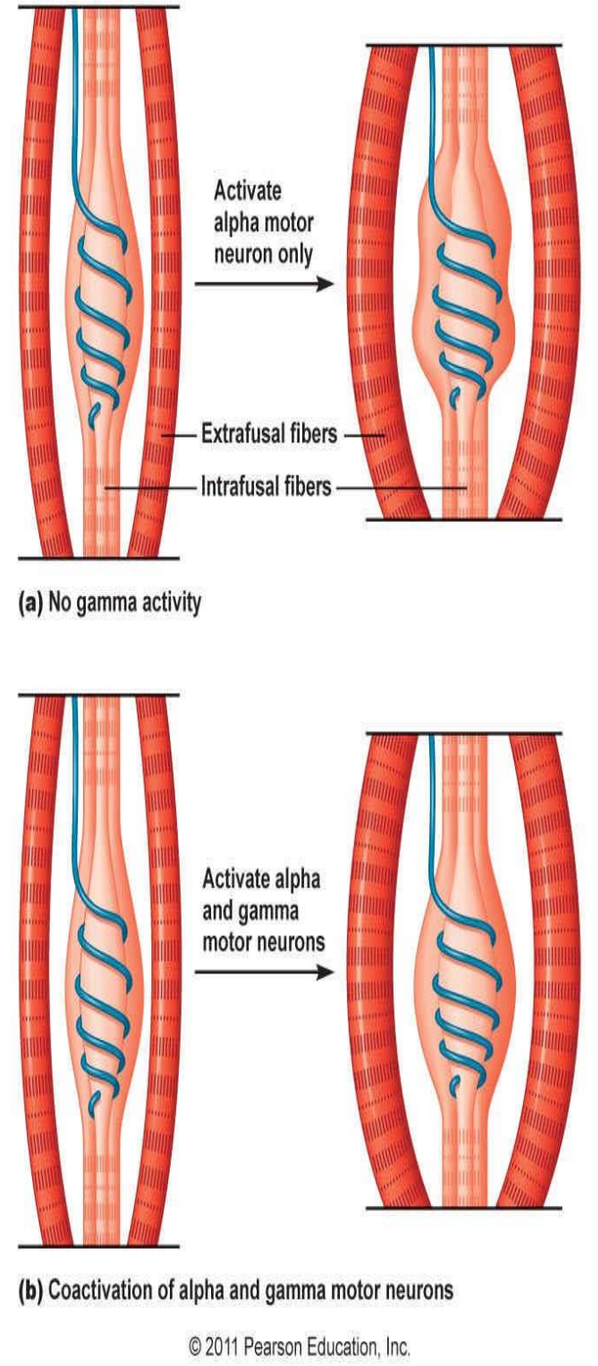
Gamma efferent causes a contraction in the peripheral end of the intrafusal fiber

Contraction will lead to stretching and stimulation of of the central part.

This leads to action potentials in the spindle afferents (Annulospiral & flower-spray)

leading to stimulation of Alpha Motoneuron

contraction of the extrafusal fibers



(remember a central part for sensation and it's non-contractile).

Types of gamma efferent

- Static innervates nuclear chain or **Trail endings**
- Dynamic innervates nuclear bag or **Plate endings**

There are two mechanisms to stimulate spindle muscles:

1) Stretching the whole muscle: Stretching the muscle bulk (extrafusal fibers) also stretches the receptor (muscle spindle , because the muscle spindle intrafusal fibers lie in parallel to the extrafusal fibers of the muscle bulk).
So, Stretching the muscle > stretch the receptor > action potential discharges in the spindle afferent (annulospiral or flower-spray) > monosynapes on alpha receptor > monosynaps action potential discharges from alpha to the muscle > contraction.

2) stimulating of gamma efferent without stretching the muscle: Gamma efferent discharge > causes contraction of peripheral ends of intrafusal fiber > stretching the receptor , thereby stimulating it > afferent discharges in annulospiral or flower-spray fibers > stimulation of Alpha Motoneuron > extrafusal muscle fiber (whole muscle) contraction .

Static stretch response

Maintained (tonic) stretch of muscle (like muscle back while standing) > Impulses from muscle spindle travel through spindle afferents to alpha motor neuron , stimulating it to produce > **Asynchronous** 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

Dynamic stretch response

Sudden (phasic) rapid stretch of a muscle > causes **synchronous** 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 lax (relaxed) > and ceases to discharge > no more stimulation of alpha motoneuron > no more excitatory impulses from alpha motoneuron to the extrafusal fibers > muscle relaxes
This is the basis of Tendon Jerks (dynamic stretch reflexes) .

Muscle tone:

It is the resistance of muscle to stretch

What is the stimulus of muscle tone?

Stretch of skeletal muscle between origin and insertion

Where are muscle tone can be found?

Present in antigravity muscle (extensors of LL, back, neck, flexor of UL, muscle of abdominal wall and elevator of mandible

What are the abnormalities that may happen in muscle tone?

Low gamma efferent discharge to muscle > **hypotonic or flacidity**

High gamma efferent discharge to muscle > **hypertonic or spastic muscle**

Summary factors influencing gamma efferent activity	
Enhances	inhibits
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 (4) Jendrassik-maneuver	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 : related to noxious (painful) stimuli .	B/ Largely spinal mechanisms : 1. Excessive muscle stretch (stimulation of Golgi tendon organ). 2. Muscle contraction

- 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 .

The Golgi Tendon Reflex: (This reflex protects muscle from rupture by excessive stretch & 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 Aα fibers

↓

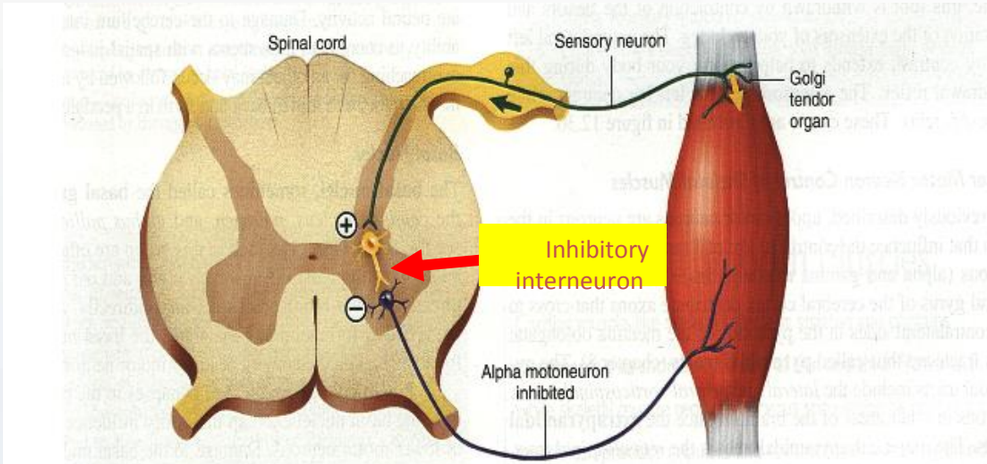
excitation of inhibitory interneuron (secrete glycine) in spinal cord

↓

inhibition of alpha motor neuron

↓

muscle relaxation



The action of the Golgi tendon organ. An increase in muscle tension stimulates the activity of sensory nerve endings in the Golgi organ. This sensory input stimulates an interneuron, which in turn inhibits the activity of a motor neuron innervating that muscle.

Summary

#What happen to the muscle when it's suddenly stretched and when it's excessively stretched ?

1-Suddenly stretched, contraction of muscle due to stimulation of the Muscle Spindle (intrafusal fibers/Gamma afferent).

2-Excessively stretched, muscle relaxation due to stimulation of the Golgi Tendon Organ.

#What are the types of intrafusal fibers and the function of every one ?

1-Nuclear bag fibers, measure the rate of change in muscle length (Dynamic/synchronous response).

2-Nuclear Chain fibers, measure the change in muscle length (Static/Asynchronous response).

#What are the sensory (Afferent) innervation of the Muscle Spindle?

1-Primary Endings (Annulospiral), innervates nuclear bag and nuclear chain fibers.

2-Secondary Endings (Flower-spray), innervates only the nuclear chain fibers

#What are the mechanisms to stimulate gamma afferent receptors?

1-Stretching the whole muscle.

2-Stimulating Gamma Efferents

Done by :
Ahmed Al-Hussien
Faisal S. AlGhamdi

Revised by :
Mojahed Otayf
Faisal S. AlGhamdi
Ahlam sallam

@PhysiologyTeam

Pht433@gmail.com

CNS Block