Physiology

STRETCH REFLEX

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Stretch Reflex

- **Type:** **monosynaptic** (sensory neuron synapse with motor neuron) and **deep**
- **Stimulus:** Stretching of the muscles
- **Response:** Contraction of the muscles
- **Aim of the response:** to prevent tearing of the muscles by activating the extrafusal muscle fibers
- **Receptor:** **Muscle spindle** (located deep in the muscles): which consists of 3-12 intrafusal fibers.
- **Functions of the muscle spindles:**

  1-keep CNS informed about the muscle length and the rate of velocity of change in the muscle length and provide information about position (proprioception)

  2- send either: positive signals to indicate the stretching of the muscles, or negative signals to indicate that the muscle is unstretched

  3- maintain muscle length against rupture
- **Effector:** skeletal muscles
- **Afferent:**

  1/ annulo-spiral (primary ending), supplies *the nuclear bag fiber*(mainly) and the nuclear chain fibers

  Responsible for the **rapid and dynamic response** (velocity of change in the muscle length)

  Example: **tendon jerk**

  Very high velocity a 70 to 120 m/s

  2/ flower spray (secondary ending), supplies the *nuclear chain fibers* **only**

  Responsible for the **sustained and static response**

  Example: **muscle tone**

-The brain receives inputs about the state of the skeletal muscles enabling it to coordinate the muscular movements and allow conscious awareness by sensory neurons *by sending collaterals to the brain*.

- **Efferent:**

  1/ alpha motor fibers, supplies extrafusal muscle fibers (70%)

  2/ gamma motor fibers, supplies intrafusal muscle fibers *the peripheral contractile parts* (30%)

  - gamma motor fiber has 2 types:

  1- dynamic gamma (plate ending), supplies nuclear bag (enhances the dynamic response)

2- static gamma (trail ending), supplies nuclear chain (enhances the static response)

-In general, the gamma motor fibers **increase the sensitivity** of the muscle spindles by contraction of the peripheral part of the intrafusal fiber

❖ the intrafusal fiber:

- **the intrafusal fiber consists of 2 parts:**

  1- central (receptor) 2- peripheral contractile area

- **Types of intrafusal fibers:**

  1- nuclear bag fibers (responsible for the dynamic response)

  2- nuclear chain fibers which bind to nuclear bag on each side (responsible for the static response)

  -Nuclear chain is more abundant than the nuclear bag fibers

❖ How does the stretch reflex happen?

-Stretching of the muscle leads to stretching of the extrafusal fibers → stretching of the peripheral contractile parts of the intrafusal which leads to stretching of the receptor → stimulation of the afferent → impulses go to the spinal cord and stimulate: alpha motor neuron (contraction of the extrafusal fibers) and gamma motor neurons (contraction of the peripheral contractile parts intrafusal muscles which lead to contraction of the receptor and increased excitation of the afferents)

❖ Types of stretch reflex:

1/ Dynamic (phasic response)

Sudden stretching of the muscle leads to stimulation of the nuclear bag discharges strong synchronous impulses which go to spinal cord by annulospiral → stimulation of alpha motor neurons which causes contraction of extrafusal muscle fibers synchronously * why synchronously? Because we need to stimulate a large number of motor units so a powerful contraction can take place* and stimulation of d-gamma efferent causes contraction of peripheral parts of nuclear bag fibers → contraction of nuclear bag to increase its sensitivity

-Example: tendon jerk

2/ Static response

maintained stretching of the muscle leads to stimulation of the nuclear chain → nuclear chain discharges impulses which go to spinal cord by flower spray → stimulation of alpha motor neurons which causes contraction of extrafusal muscle fibers asynchronously * why asynchronously? Because we need to stimulate motor units gradually so a maintained contraction can take place for a long time* and stimulation of s-gamma efferent causes contraction of peripheral parts of nuclear chain fibers → contraction of nuclear chain to increase its sensitivity

- Example: muscle tone

Both dynamic and static response have damping function. How?

Signals from the spinal cord are transmitted in unsmooth form stretch reflex make the signals relatively smooth by lowering the frequency.

❖ Muscle tone

a sustained stretching of the skeletal muscles between insertion and the origin (present in the anti-gravity muscles)

Low gamma-s discharge → hypotonic muscles (flaccidity)

High gamma-s discharge → hypertonic muscle (spastic)

- **Muscle contraction can be by:**

  1-stimulation of alpha motor neurons by muscle stretching (stretch reflex)
  2-stimulation of gamma motor neurons (by impulses coming from the brain)
  3-coactivation of both alpha and gamma (signals from motor cortex to alpha mostly will be transmitted to gamma)

  - **Purpose of the coactivation:**

    1-maintain the sensitivity of the muscle spindles
    2- maintain the damping function of the muscle spindles

- **Stretch reflex main component:** **reciprocal inhibition**

  Stretched muscle send signals to spinal cordà stimulate the stretched muscle to contract by glutamate
  And inhibit the antagonistic muscle to contract by GABA through the inhibitory interneurons

  - **Aim:** (to make the stretch reflex stronger and to prevent conflict between the opposing muscles)

- **regulation of the stretch reflex**

  is done by supraspinal centers (mainly motor center in the brainstem and the cerebral cortex)
  regulation of the stretch reflex is done mainly by affecting the gamma motor neurons
  lesions of these centers à affect the stretch reflex

  - **Factors stimulating the stretch reflex:**

    1-supraspinal: primary motor area, vestibular nuclear, pontine reticular formation*bulboreticular*, neocerebellum
    2- anxiety
    3- noxious painful stimuli
    4- jendrassik-maneuver

  - **Factors inhibiting the stretch reflex:**

    1-supraspinal: suppressor areas 4 and 6, Medullary reticular formation, Basal ganglia, Red nucleus, Paleocerebellum
    2- golgi tendon reflex

The inverse stretch reflex

golgi tendon or lengthening reaction

- **Type:** **Polysynaptic (disynaptic) and deep**
- **Stimulus:** increased tension (overstretching)
- **Response:** **relaxation** of the agonistic muscle and contraction of the antagonistic muscle
- **Receptors:** golgi tendon organs which present in the tendon (3-25 in number)

Each golgi tendon organ is attached to 10-15 muscle fibers, the organ is stimulated when this bundle of fibers is over stretched

- **Afferent:** **Ib** nerve fibers (large and rapidly conducting fibers)
- **Aim:** protect the muscle from rupture and the tendon from avulsion and tear

- **How does it happen?**

-stimulation of golgi tendon organ → impulses via Ib go to spinal cord → inhibitory interneuron to agonistic muscles (secrete glycine) → inhibit alpha motor neuron → relaxation of the muscles At the same time, it also stimulates excitatory interneuron to antagonistic muscles → contraction (reciprocal innervation).

Check your understanding!

1- type Ia is :		2- Muscle spindle is :	
A	Afferent fibers	A	Sensory neuron
B	motoneurons	B	Motor neuron
C	Efferent fibers	C	Effector
D	B&C	D	Sensory receptor
3- The number of synapses in the stretch reflex are:		**4- motor neuron of stretch reflex**	
A	One (monosynaptic)	A	Alpha
B	Two (disynaptic)	B	Type ll
C	Three (trisynaptic)	C	Gamma
D	B&C	D	a&c
5- the spindles can send to the spinal cord in		**6- muscle spindles detect**	
A	Positive signals	A	Length
B	Negative signals	B	tension
C	No signal	C	Nothing
D	a&b	D	a&b
7- Static γ motoneurons synapse on		**8- Golgi tendon organ activates group**	
A	nuclear bag fibers	A	Ib afferent nerves
B	nuclear chain fibers	B	II Afferent nerves
C	golgi tendon organ	C	Ia afferent nerves
D	B&C	D	A&B

9- Which of the following is NOT a factor INHIBIT the stretch :		10- The response of golgi tendon reflex is	
A	ANXIETY	A	MUSCLE CONTRACTION
B	BASAL GANGLIA	B	NO RESPONSE
C	EXCESSIVE STRETCH REFLEX OF MUSCLE	C	MUSCLE RELAXATION
D	MEDULLARY RF	D	A&C
11- Regarding the role of muscle spindles and Golgi tendon organs.		**12-When a person steps on a tack with their left foot, flexor muscles on the right leg and extensor muscles on the left leg will be stimulated to contract.**	
A	Muscle spindles measure the tension of skeletal muscle.	A	True
B	Golgi tendon organs measure the length of skeletal muscles.	B	False
C	Muscle spindles receive both afferent and efferent nerve fibres.		
D	Muscle spindles are only of importance in the regulation of posture.		

Answers :

1- A	2- D	3- A	4- D	5- D	6- A	7- B	8- A	9- A	10-C	11-C	12-B