Muscle Stretch Reflex

Physiology > Musculoskeletal > Musculoskeletal

SUMMARY

Overview

Synonyms

• Monosynaptic reflex, myotactic reflex, deep tendon reflex, tendon jerk

Definition

• It is an automatic, monosynaptic reflex that involves a muscle and tendon, and produces a jerk.

Most commonly tested

• Biceps (C5, C6)

- Elbow flexion

• Triceps (C7,C8)

- Elbow extension

• Patella (L2 – L4)

- Knee extension

• Achilles (S1,S2)

- Foot plantarflexion

Key mediators

• Muscle spindles, which activate via muscle stretch.

• Spinal neurons, which receive sensory input and generate motor output.

• Muscle fibers, which contract.

• Interneurons, which modulate neuronal firing.

• Golgi tendon organs, which activate via muscle contraction to terminate the reflex.

ACTIVATION

When the patellar tendon is activated, the muscle spindle sends an excitatory volley along the Type 1a sensory afferent, which excites the extensor motor neuron. It activates the muscle extensors, which extend the knee.

INTERNEURONAL INHIBITION

Renshaw cells are interneurons that lie in the anterior horn of the gray matter of the spinal cord. When Renshaw cells are activated, they inhibit flexor motor neurons using the inhibitory neurotransmitter glycine.

TERMINATION

Golgi tendon organs are situated where the quadriceps tendon inserts into the patella. Type 1b fibers project from the Golgi tendon organs to the Renshaw interneurons. Inhibitory fibers project from the the Renshaw interneurons to the extensor motor neurons. The Type 1a and 1b fibers fire at the same rate, but the muscle spindle fibers have a much lower threshold to fire than Golgi tendon organs, thus, the muscle spindle fibers fire first, and then later the Golgi tendon organs fire, which terminates the muscle stretch reflex. Neurobiological influences, such as myosin ATPase and calcium re-accumulation into the endoplasmic reticulum aid in muscle contraction.

CLINICAL CORRELATION

In comatose patients, presence of the triple flexor reflex to plantar stimulations a sign of disinhibition, similar to the Babinski sign.

FULL-LENGTH TEXT

OVERVIEW

• Here, we will draw a muscle stretch reflex.

• Start a table.

Synonyms

• The muscle stretch reflex goes by many names, including: monosynaptic reflex, myotactic reflex, deep tendon reflex, tendon jerk.

Definition

• Taken together, denote that these names connote the essential elements of the muscle stretch reflex: it is an automatic, monosynaptic reflex that involves a muscle and tendon, and produces a jerk.

Key Mediators

Muscle spindles, which activate via muscle stretch.

- Spinal neurons, which receive sensory input and generate motor output.

- Muscle fibers, which contract.

- Interneurons, which modulate neuronal firing.

- Golgi tendon organs, which activate via muscle contraction to terminate the reflex.

KNEE EXTENSOR REFLEX (EXAMPLE)

We'll use activation of the knee extensor reflex as our example, here, so first let's set up its key anatomical components.

Anatomy

• First, draw an axial hemi-cord cross-section of the spinal cord.

• Outline the dorsal root (and dorsal root ganglion), which receives sensory fibers.

• Outline the ventral root, which carries motor fibers.

• Delineate the gray matter.

• Specify the anterior gray matter horn.

• Now, sketch a lower extremity flexed at the knee (in its resting state).

• Show a quadriceps (extensor) muscle group in the anterior thigh.

• Then, draw a hamstrings (flexor) muscle group in the posterior thigh, which flexes the knee.

• Next, draw the flexor neuron in the posterior anterior horn of the spinal cord and the extensor neuron in the anterior aspect of the anterior horn (we discuss this localization in more detail elsewhere).

• Then, draw A-alpha motor fibers from the motor neurons to their muscles.

Motor Fiber Innervation

• Let's pause to consider motor neuron to motor fiber innervation ratios.

- Write that in large muscle groups, such as the quadriceps, a single motor neuron commands as many as 1,000 extrafusal muscle fibers,

- whereas in a small muscle group, such as the extraocular muscles, a motor neuron commands as few as 10 extrafusal muscle fibers.

• Now, draw a muscle spindle within the quadriceps muscle.

• Show a type 1a sensory nerve fiber project from it to the extensor motor neuron.

Knee extensor reflex

Now, let's walk through the knee extensor reflex.

• Tap the patellar tendon with a reflex hammer.

- Show that this excites the muscle spindle, which sends an excitatory volley directly to the extensor motor neuron.

- Show that the neuron excites the nerve, which stimulates the muscle extensor.

- Show that extensor muscle contraction produces knee extension.

Inhibition of the Antagonist

• Now that we've established the basic mechanics of the knee extensor reflex, consider what would happen the hamstrings were to fire at the same time (meaning, if the extensor and flexors shortened simultaneously)?

• Activate the top and bottom of your thigh, now, fell that it only stiffens.

• So we have to shut off the flexor muscle to get the knee to extend.

• Add a Renshaw cell (an interneuron) to the anterior horn of the gray matter of the spinal cord in close association with the motor neurons.

- Note that there is widespread intertextual variation regarding where Renshaw cells exist within the spinal cord gray matter.

• Show that the sensory afferent sends a branch to the Renshaw cell, which inhibits the flexor motor neuron, blocking flexor muscle contraction during the reflex.

• Indicate that the Renshaw cell acts via the inhibitory neurotransmitter glycine.

COMPLICATED SPINAL REFLEXES

• Interneurons are the lynchpins to more complicated spinal reflexes, as well, such reflex the triple flexor reflex, which is a component of the flexion-crossed extension reflex.

• Show that a painful stimulus to the bottom of one foot (such as stepping on glass) causes the affected extremity to flex at the joints, specifically:

- Ankle flexion (aka foot dorsiflexion)

- Knee flexion.

- Hip flexion.

• Show that the opposite extremity undergoes extension to provide body weight support, it undergoes:

- Ankle extension (aka foot plantar flexion).

- Knee extension.

- Hip extension.

• As a clinical correlation, in comatose patients, presence of the triple flexor reflex to plantar stimulation is a sign of disinhibition, similar to the Babinski sign.

COMMONLY TESTED REFLEXES

Let's now pause to review the most commonly clinically tested muscle stretch reflexes:

• Biceps, which involves the C5, C6 nerve roots.

• The triceps: C7, C8.

• The patella (drawn here): L2 to L4 nerve roots.

• The Achilles: S1, S2

TERMINATION OF THE REFLEX

So, now, how do we terminate the reflex?

• Draw another axial hemi-cord cross-section.

• Include the dorsal root.

• And ventral root.

• Again, delineate the gray matter and specify the anterior gray matter horn.

• Now, sketch a lower extremity that is extended at the knee (in its active state).

• Show the extensor muscle group (we can leave out the flexor group, here).

• Next, draw the corresponding motor neuron and nerve fiber.

• Close by, include the Renshaw cell.

• Show a type 1a sensory nerve fiber project from the muscle spindle to the motor neuron, which innervates the extensor muscle.

• Now, draw a Golgi tendon organ (an encapsulated afferent nerve ending) where the quadriceps tendon inserts into the patella.

• For the termination of the muscle reflex:

- Show that extensor muscle contraction activates the Golgi tendon organ, which sends a volley of afferent signal along a type Ib sensory nerve fiber to the Renshaw interneuron.

- Show that the Renshaw cell inhibits the (extensor) motor neuron.

- Show that this blocks excitation of the extensor muscle, so the knee relaxes.

Why does the Golgi tendon organ not terminate the reflex before it ever happens?

• Write that the location of the muscle spindle (being connected in parallel to the main muscle fibers) makes it sensitive to passive muscle stretch (tap of the reflex hammer).

• Whereas, the location of the Golgi tendon organ at the musculo-tendinous junction (being connected in series to the muscle) makes it sensitive to active muscle contraction (knee extension).

• So although the type Ia and Ib fibers fire at the same rate, the Golgi tendon organ fires later than the extensor muscle spindle, which explains why the muscle jerks before the reflex is terminated.

• Bear in mind that there are also a number of neurobiological influences on the relaxation of muscle contraction, which include:

- Myosin ATPase.

- Calcium re-accumulation into the endoplasmic reticulum.

• In fact, symptomatic hypothyroidism causes a delay in the relaxation phase of the muscle stretch reflex (aka Woltman's sign).