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Biopac Student Lab® Lesson 20

SPINAL CORD REFLEXES

Introduction

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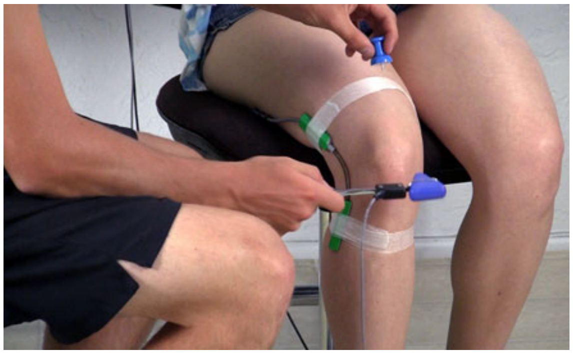
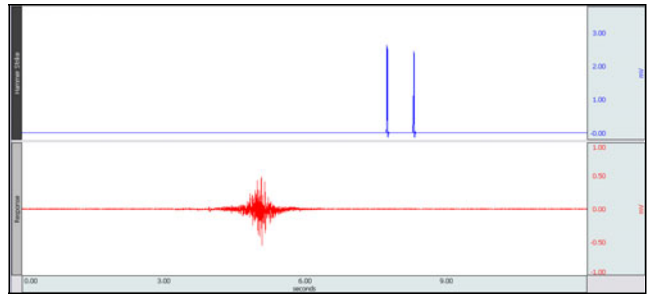




I. INTRODUCTION

Physiologically speaking, a reflex is an involuntary, or automatic, programmed motor response to a sensory stimulus. Literally, the word reflex is derived from a term meaning to reflect, or return back, with reference to the direction of travel of first the sensory impulses and then the motor impulses along the reflex pathway. Touching a hot object and jerking the hand away, or stepping on a tack and lifting the injured bare foot are examples of simple human reflexes. Reflexes in animals represent the earliest organization of neurons into a functional unit. Even in adult animals that lack a brain, such as a jellyfish, neurons have become specialized and organized to provide for simple, often life-preserving, reflex responses. In humans, reflex activities appear about five months before birth.

Reflexes allow the body to react automatically and involuntarily to a variety of internal and external stimuli so as to maintain homeostasis. Some reflexes are structurally and functionally simple, such as the extensor reflex illustrated in Fig. 20.1.

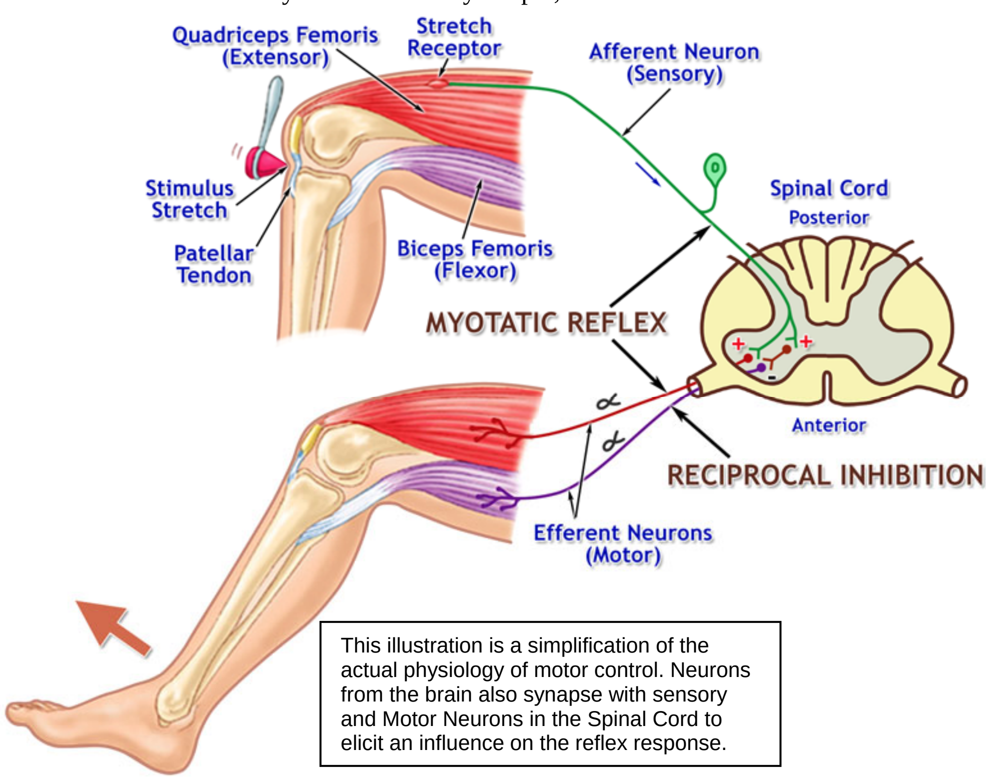


Fig. 20.1 Extensor Reflex

Other reflexes, such as those involved with controlling swallowing, sweating, respiration, or blood pressure, are more complex. Whether simple or complex, all human reflexes have common features. Physiologically, a reflex begins with the application of a stimulus to a receptor and ends with a response by an effector. Anatomically, a reflex pathway consists of the following components:

- Receptor: a specialized structure at the beginning of a sensory neuron that receives the stimulus. In Fig. 20.1, the receptors are specialized to detect muscle stretch when stimulated.

- Afferent neuron: the sensory neuron that relays sensory information from the receptor into the brain or spinal cord. Afferent neurons terminate within the central nervous system and synapse with association neurons and/or motor (efferent) neurons.
- CNS (Central Nervous System) Center: a center in the brain or spinal cord where information is relayed across one or more synapses from the sensory neuron to the motor neuron. In multisynaptic reflexes, interneurons or association neurons receive the information from sensory neurons and relay the information to motor neurons. In monosynaptic reflexes, sensory neurons directly synapse with motor neurons. The greater the number of neurons, and hence synapses, that are part of the reflex pathway, the longer the latent period (the interval between the stimulus delivery and the reflex response).
- Efferent neuron: the motor neuron that transmits information out of the brain or spinal cord to an effector.
- Effector: smooth muscle cell, cardiac muscle cell, pacemaker system cell, secretory cell (in glands,) or skeletal muscle cell that provides the reflex response.

Skeletal muscle reflexes are often named after the effector response. An extensor reflex involves contraction of an extensor skeletal muscle, such as when the leg is reflexively extended at the knee by stretching the extensor; a flexor reflex involves contraction of a flexor muscle, such as when the forearm is flexed at the elbow in a withdrawal response, and so forth.

If all of the components of a reflex pathway are located on one side (right or left) of the body, the reflex is called an ipsilateral reflex (ipsi=same, lateral=side). If the sensory input occurs on one side of the body and the motor output and effector response occur on the other side of the body, the reflex is called a contralateral reflex (contra=opposite). Two different reflexes may share the same sensory input. For example, stepping on a tack causes ipsilateral flexion at the knee (lifting the foot) and contralateral extension at the knee (standing on the other leg).

Skeletal muscle reflex pathways are usually not composed exclusively of excitatory neurons. Some association neurons are inhibitory. Sensory and motor neurons involved in the control of skeletal muscle are organized so that when one muscle or muscle group is voluntarily or reflexively activated to cause movement at a joint, the opposing muscles are inhibited. For example, when the patellar tendon is tapped with a percussion hammer, stretch receptors within the quadriceps femoris, an extensor of the leg, elicit reflex contraction of the extensor (the knee-jerk reflex). When the leg is extended, the opposing flexors are stretched. Therefore, contraction of the opposing flexors of the leg must simultaneously be inhibited so as to allow for extension of the leg without the flexors reflexively responding to their own stretch. Conversely, activation of flexors at a moveable joint is accompanied by simultaneous inhibition of opposing extensors. This pattern of skeletal muscle control at a movable joint is called reciprocal inhibition (Fig. 20.1).

Neurons that synapse with skeletal muscle fibers and cause contraction are called alpha motor neurons. Alpha motor neurons are always excitatory; therefore, inhibition of skeletal muscle contraction occurs as a result of inhibiting the alpha motor neurons by way of inhibitory association neurons (Fig. 20.1,) and not by directly inhibiting the skeletal muscle fibers.

The sensory, or afferent, nerve fibers and the motor, or efferent, nerve fibers of the reflex pathway may be located in cranial nerves and the CNS center in the brainstem, or they may be located in spinal nerves and the CNS center in the spinal cord. Brainstem reflexes include accommodation of the lens to allow for near and far vision, and the familiar pupillary response (constriction) to light shown into the eye. Spinal cord reflexes include urination and defecation reflexes as well as the aforementioned flexor and extensor reflexes.

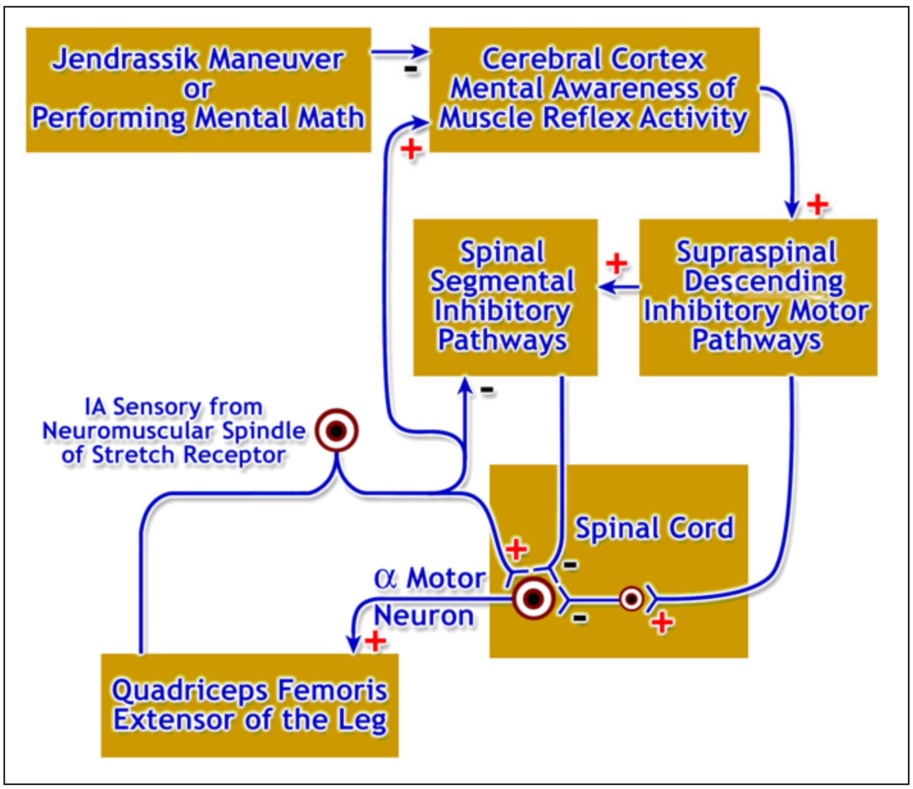
Impulses conducted along brainstem and spinal cord reflex pathways are also relayed to higher centers in the brain. This relaying of impulses permits coordination of reflex activities and informs the cerebral cortex so that interpretation of the stimulus type, intensity, and location can occur. Although the brain receives sensory information from an activated reflex pathway, input from the brain is not necessary to enable a reflex response. However, spinal cord reflexes, while not dependent on input from the brain for activation, may nevertheless be modified by the brain. Examples include brain inhibition of the spinal urination and defecation reflexes until an appropriate time and place allows the inhibition to cease.

Physicians and other clinicians test for the functional integrity of reflex pathways to obtain objective evidence regarding the function of muscles, peripheral nerves (motor and sensory,) and the central nervous system. Conclusions drawn from testing reflexes are not the sole consideration in diagnosis but rather are considered in conjunction with other symptoms and signs of pathophysiology. This lesson examines properties of some simple neuromuscular reflexes commonly tested in physical diagnosis.

The myotatic, or muscle stretch reflex, is an ipsilateral monosynaptic reflex. Myotatic reflexes can be tested at several locations in the body where a skeletal muscle can easily be stretched by tapping an attached tendon, such as at the knee (knee-jerk,) the elbow (biceps-jerk,) or at the ankle (ankle-jerk). A tendon is not easily stretched, so when it is tapped with a percussion hammer it quickly transmits stretching forces to the more easily stretched muscle.

The patellar reflex, more commonly known as the knee-jerk reflex, is elicited by tapping the patellar tendon below the knee with a reflex hammer, as shown in Fig. 20.1. In this lesson, a percussion hammer equipped with a transducer will be used to tap the tendon. The transducer allows the strength of the tap strike to be recorded the moment the tendon is struck. Contraction of the extensor is recorded using EMG (electromyography) electrodes or a goniometer (a transducer-equipped device used to determine angular displacement of the joint). The greater the force of the strike, the stronger will be the reflex response of the extensor, and the greater the angular displacement of the leg.

Descending neural pathways from the brain to various levels of the spinal cord may act to inhibit or depress spinal reflex neurons, as in the aforementioned urination reflex, or they may normally act to prevent exaggerated responses to sensory inputs. When normal inhibitory influences are decreased, spinal reflexes may become exaggerated, as in the Jendrassik maneuver. To perform the Jendrassik maneuver, the subject interlocks his/her fingers at chest level and then concentrates on pulling the hands apart with as much force as possible without breaking the interlock. The patellar tendon is tapped at the same moment the subject attempts to pull apart the interlocked fingers. The Jendrassik maneuver will heighten (exaggerate) the patellar reflex by countering some of the normal descending inhibitory brainstem inputs to reflex pathway interneurons, thereby facilitating synaptic transmission (Fig. 20.2). The amplitude of the reflex response is increased because a larger number of motor units have been activated due to the release of normal descending inhibitory influences. The Jendrassik maneuver, as well as the performance of mental math as the myotatic reflex is elicited, diverts attention from the reflex. Conscious attention to the reflex being elicited normally dampens the reflex response by way of the aforementioned pathways. In some cases cerebral influence may actually be sufficient to prevent the reflex. When the attention is diverted, the reflex response is facilitated and the response often heightened. The heightened response easily can be seen using electromyography. Clinically, exaggerated spinal cord reflexes manifest some brainstem lesions. In a way, the Jendrassik maneuver mimics the effect of these lesions.



The IA sensory fibers from the neuromuscular spindle stretch receptors and the alpha motorneurons supplying fibers of the same muscle form the neuronal basis of the myotatic reflex arcs (shown lower left). The sensory neuron also is part of an ascending sensory pathway that makes the cerebral cortex aware of reflex arc activity. The sensory neuron also can inhibit spinal segmental neurons that may presynaptically inhibit its input to the alpha motor neurons. This action tends to facilitate transmission between the sensory and motor neuron of the reflex arc.

The supraspinal descending inhibitory motor pathways modulate reflex arc sensitivity, normally preventing hyperreflexia, or exaggerated reflexes. The level of activity in these pathways is in part due to excitatory input from the conscious cerebral cortex. They originate in motor control centers in the brainstem and diencephalon, and act through spinal inhibitory neurons to suppress alpha motor neuron output, either by directly inhibiting the alpha motor neuron or by increasing activity in spinal segmental pathways that presynaptically inhibit the sensory neuron.

Fig. 20.2 Facilitation of the Myotatic Reflex

The ankle-jerk, or Achilles' tendon reflex, is another commonly tested myotatic reflex. The Achilles' tendon attaches the gastrocnemius muscle (calf muscle) of the posterior leg to the calcaneous bone (heel bone). Contraction of the gastrocnemius plantar flexes the foot, as in standing tip-toed.

In this lesson, students will record and compare the Subject's contractile force vs. stimulus strength, the influence of the Jendrassik maneuver, voluntary vs. involuntary (reflex) effector responses, and the Achilles' tendon reflex and patellar tendon reflex latent periods.