Advanced Anatomy & Physiology

Unit 3 – Neuromuscular and endocrine systems

Lesson 3.3 – Receptors and reflexes
Step 1 – Aims

This lesson will enable you to:

- List the different types of proprioceptors
- Describe the process involved in the reflex arc
- Explain the stretch reflex and the inverse stretch reflex and their application to exercise

Step 2 – Introduction

In order for you to exercise safely and effectively, your nervous system needs to control the exact position of your body and the amount of stretch and force your muscles are subjected to. This requires careful monitoring and control of your body, and its relationship to the environment.

Step 3 – Proprioceptors

Throughout our body we have specialised structures known as proprioceptors or mechanoreceptors. These are sensory receptors located in muscles, tendons and joints. They convey information about body position, muscle length and tension, and the position and movement of our joints.

They do this by sensing distortion in tissues, which occurs through stretch, compression, tension and vibration.

There are several different types of proprioceptors, including muscle spindles, Golgi tendon organs and joint receptors.

**Muscle spindles** are specialised fibres that lie in the belly of a muscle. They monitor muscle length and are sensitive to stretch and the rate at which a muscle lengthens.

**Golgi tendon organs** are sensory receptors situated at the point where the muscle and the tendon meet. These are sensitive to changes in muscular tension and the rate of tension change.

**Joint receptors** are located in and around the joint capsule. They respond to pressure, acceleration and deceleration of the joint. These receptors act to signal extreme joint positions, and so play an important role in preventing injury.
Step 4 – Reflexes

Now that we have an understanding of proprioceptors, let’s have look at how they work with the nervous system to reduce your risk of injury and help you to exercise more effectively. To do this we need to have an understanding of reflexes.

A reflex is a fast involuntary pre-programmed sequence of actions that is initiated and controlled by the nervous system in response to certain stimuli. This may be a practised response, such as the emergency stop action when driving, or a pre-programmed one.

In relation to exercise, reflexes work to modify movement, maintain posture, prevent injury and alter body metabolism to accommodate the demands of exercise.

Step 5 – Reflexes

For example, if you touch something hot, thermoreceptors will initiate a response for you to move your hand. By the time you sense pain, the reflex action will have kicked in and you will have snatched your hand away from the hot surface without having to consciously think about it.

Step 6 – The reflex arc

The process by which a nerve impulse produces a reflex is known as the reflex arc. Let’s have a look at the example of moving your hand from a hot surface to see how it works.

1) First, a thermoreceptor responds to the stimulus of the hot surface by producing a nerve impulse
2) Then a sensory neuron conducts the impulse from the receptor to the integrating centre
3) An integrating centre located in the brain or spinal cord then relays the impulses from sensory to motor neurons
4) A motor neuron then conducts nerve impulses from the integrating centre to an effector, in this case, a muscle
5) Finally, the muscle responds to the motor nerve impulse to produce the desired action of snatching your hand away from the hot surface.

This whole process happens in milliseconds and without you having to think about it.

**Step 7 – The stretch reflex**

Now that you have an understanding of the nature and function of reflexes, let’s have a look at a couple of reflexes that you have probably experienced when exercising. We’ll begin with the stretch reflex.

The stretch reflex, which is also known as the myotatic reflex, is a pre-programmed response by the body to a stretch stimulus in a muscle. It is a protective measure for the muscles, to prevent overstretching.

Let’s see how it works.

When a muscle spindle is stretched, an impulse is immediately sent to the spinal cord and a response to contract the muscle is received to prevent further stretching, which could injure the muscle.

The more sudden the change in muscle length, the stronger the responding muscle contractions will be. Since the impulse only has to go to the spinal cord and back, not all the way to the brain, it is a very quick impulse. It generally occurs within 1–2 milliseconds.

One of the reasons for holding a stretch for a prolonged period is that as you hold the muscle in a stretched position, the muscle spindles become accustomed to the new length and reduces their signalling. Gradually, you can train your stretch receptors to allow greater lengthening of the muscles.
Step 8 – The inverse stretch reflex

When muscles contract they produce tension at the point where the muscle connects to the tendon. This is where the Golgi tendon organ is located. This monitors the change in tension, and the rate of change of the tension, and sends signals to the spinal cord to convey this information.

When this tension exceeds a certain threshold, it triggers the lengthening reaction known as the inverse stretch reflex. This inhibits the muscles from contracting and causes them to relax. This reflex is also known as the inverse myotatic reflex or autogenic inhibition. This basic function of the Golgi tendon organs helps to protect the muscles and tendons from injury.

Another reason for holding a stretch for a prolonged period of time is to allow this lengthening reaction to occur, which helps the stretched muscles to relax. It is easier to stretch a muscle when it is not trying to contract.

Step 9 – Activity

Is the statement true or false?

Muscle spindles are specialised fibres that are situated at the point where the muscle and the tendon meet. They monitor muscle length and are sensitive to stretch and the rate at which a muscle lengthens.

Step 10 – Activity

The process by which a nerve impulse produces a reflex is known as:

- Proprioception
- The reflex arc
- The stretch reflex
- The inverse stretch reflex

Feedback: Although the stretch reflex and the inverse stretch reflex are both types of reflex, the process by which a nerve impulse produces a reflex is known as the reflex arc.

Step 11 – Activity

Use the words from the list below to complete the statement.

- Change
- Exceeds
- Golgi
- Inverse
- Lengthening
- Organ
- Tension
- Threshold
The ............ tendon ............ monitors the change in ............ and the rate of ............ of the tension, and sends signals to the spinal cord to convey this information. When this tension ................ a certain ................ it triggers the ............. reaction known as the ................. stretch reflex.

**Step 12 – Summary**

Now that you have completed this lesson you should have a better understanding of the following:

Proprioceptors are sensory receptors located in muscles, tendons and joints. They convey information about body position, muscle length and tension and the position and movement of our joints.

There are several different types of proprioceptors, including muscle spindles, Golgi tendon organs, and joint receptors.

A reflex is a fast, involuntary, pre-programmed sequence of actions that is initiated and controlled by the nervous system in response to certain stimuli.

The stretch reflex is a pre-programmed response by the body to a stretch stimulus in a muscle. It is a protective measure for the muscles to prevent overstretching.

When tension in a muscle exceeds a certain threshold, it triggers the lengthening reaction known as the inverse stretch reflex. This inhibits the muscle from contracting and causes it to relax.