Neuromuscular system

Welcome back to another unit in human anatomy, where we will be looking at the neuromuscular system. So, the learning objectives for this particular unit, we will try to define and understand what is the basic structure of the neuromuscular system. We will understand the basic functions of neuromuscular system, right? The role of what is called the motor unit. We will study all of these concepts. And then, finally, we look at the application of neuromuscular concepts, specifically neuromuscular control and recruitment as applicable in sports and movements, right. So, what is the neuromuscular system? Emphasis on the word system.

So, it is composed of multiple subsystems, some of which you have already studied. In particular, the skeletal muscle fibers and neural circuits, which is the neuro and the muscle part. So, the neural circuits consist of what is called, what are called motor neurons, which are the efferent neurons. So, which is to say, they bring the signal from the brain or from your spinal cord out to the muscle.

Then you have sensory neurons, or what are called afferent neurons. These take signals from the muscle, from your sensory organs, and back to the brain for processing. So, the signals will go from here to here through these sensory neurons. And the signals will come back after being processed, and the brain deciding to do something through the motor neurons. So, I will come back to sensory neurons in just a bit.

But there are also what are called the Golgi tendon organs. So, instead of going up to the muscle, these go up to the tendons. So, these are nerve fibers that innervate the tendons, and they sense the tension in the tendons when the tendon is loaded. So together, these form this sort of a system of efferent and afferent neurons. So, as you can probably understand, the afferent neurons or the sensory neurons, along with the Golgi tendon organs, are used by the neuromuscular system to sense particular characteristics of the points at which they are attached.

So sensory neurons, they form what are called muscle spindles, which are located deep within the muscle fibers. So, you will have, as you have seen in the previous module with the muscle fibers, you have these muscle fibers here, which are forming part of this larger muscle. And then you have these muscle spindles. So, these muscle spindles, they wrap around the muscle fibers, pass through these muscles, and then go up to the spinal cord or the rather, the central nervous system. So, we'll discuss the central nervous system as well.

And you'll learn more about it in the motor control units. So, the way sensory neurons work, these are afferent neurons, the muscle spindles specifically, they sense the state of stretch of the muscle and the amount of stretch in the muscle. And they send that information back to the central nervous system to the spinal cord. The action that is supposed to be taken motor neuron. And we'll discuss that next as well.

But before that, I've been using this term neuron a lot. So, let's just quickly look at that. So, the nervous system is made of nerves, which are cells called neurons. So, you have these cells, you have these cells which are called neurons, the outgoing messages from the brain. So, any decision that your brain takes, goes out.

It travels from the brain along the along certain pathways in your spinal cord and then to the respective organs. So, these neurons that make up these pathways are called the motor neurons. So, these neurons are responsible for the movement for conveying the decision that your brain made to move to grab a certain object in space, for example. Similarly, incoming messages, just like we were discussing earlier with the efferent neurons. Incoming messages are sent from the sensory organs, for example, your skin; when you have with the sense of touch or heat, and you have visual feedback, you have olfactory feedback from your nose, auditory feedback.

Every sensory organ basically sends back the signals along the sensory neurons. So, the next thing you need to understand is what is called the motor unit. A motor unit consists of a motor neuron or motor neurons and the muscle fibers they innovate. Here is a representative figure. So, this right here is a neuron.

It is a motor neuron, which means it is responsible for conveying the decisions made by the brain or the central nervous system to the muscle to perform the required action. In this process, there are muscle fibers, and you have multiple points from this neuron, where this where it attaches to the muscle fibers. Each muscle comprises of multiple motor units. So, this whole thing is one motor unit. And understanding motor units is critical because it will help you optimize muscle recruitment and training and behavioral patterns.

So, let’s look at the motor unit and neuromuscular junction. So, how does this neuron actually attach? So, I will draw a representative figure. So, you have your neurons endpoint coming in. You have your muscle fiber inside. And there is a small gap.

So, the chemicals that are released, and we will not go into the details of the actual process, but the chemicals that are released are transferred across this gap into the muscle fiber and into the muscle fiber. And those chemicals are responsible for triggering the contractile action. So you have your myelin. And this is a very simplified way of looking at it. And the chemicals coming in trigger that contractile response of the muscle.

So, as you are probably seeing in this particular figure, there are 1, 2, 3, 4, 5 points of innovation. So, different motor neurons, different neurons can have a different ratio of innovation. It's called innovation ratio. And it can range anywhere from three for parts like your eyelid muscles to approximately 100 for your limb muscles, muscles in the limb. So, which means that one neuron is responsible for controlling the contraction of multiple muscles.

So now that we have a better understanding of what a motor unit is, what is a motor neuron, how it works with the muscle, let's look at an example action, a couple of reflex actions essentially. So, we'll see in this process how the individual components in this system act in unison to deliver a particular outcome. So, in the previous units, you have studied the muscular system; you understand that the muscles have elastic characteristic to them. So, let's take a look at one of the reflex actions that adds to that elastic action. So, within the muscle fibers, you have your muscle spindles, which are feeding back to the central nervous system.

These are there to detect the state of stretch as we previously discussed, right, and can also detect how fast the stretch is happening. So, let's say I am lifting something; it's stretching a particular muscle, right? Right now, the triceps are contracted, but here triceps will, but here triceps will relax and start stretching. If the muscle stretches beyond a certain range, then a certain signal can be triggered and sent to the central nervous system, which in turn will send, which in turn will send a signal to them through the motor neurons to a motor unit, right, which will cause the muscle to flex or contract, right? So beyond, so this is the stretch reflex. Beyond a certain range, it is protecting this action is protecting the muscle from from physical damage, right? In a similar sense, we have the Golgi tendon organs. Now, the Golgi tendon organs are there to protect the the innervation of the muscle onto the backbone or to protect it from detaching.

A scenario like that could arise when, say, you have lifted up too much load, right? And there is too much tension being detected in these Golgi tendon organs. This will cause a reflex by sending the signal back to CNS, which will, which will send a shutdown signal to the muscles, basically preventing, preventing you from trying to lift up the load further. If you have ever tried to squat with too much load, for example, right, when you go down, and you try to get back up, your tendons are under too much stress. And in that case, your muscles essentially are sent a shutdown signal to protect them from detaching from the bones. It's pretty fascinating mechanism, right? Inbuilt protection.

It's kind of like your, it's kind of like your household electrical circuit protection, right? So, you have appliances that are pulling in current. And if some appliances suddenly start pulling in too much current, maybe if it is short-circuited, then you know, the MCB in the house trips or one particular circuit trips. So, this mechanism is kind of similar to that where too much load is being applied. So, it trips the activity of the muscle and prevents you from doing that particular action, which would otherwise result in the destruction of this appliance vis-a-vis the tendon attachment to the bone. So, that brings us to the topic of neuromuscular recruitment, right? So, muscles are there in your body by themselves.

They do not work, right? They need some sort of activation. That activation comes from the nerves, which in combination forms the neuromuscular system, right? So, this means that there are strategies that the body employs to recruit muscles based on the desired outcome. So, there are two ways in which increase in muscle force can happen. You can either recruit larger motor units, right? Or you can increase the firing rate of the motor unit. Now, I'll take you back to this particular topic of muscle fiber types, which you've studied in the previous unit.

So, you have fast twitch fibers, right? Which excel in explosive movements. So very fast plyometric kind of movements, sprinting, weightlifting, Olympic weightlifting, I mean, where the snap clean and jerk requires really fast, really strong movements. Similarly, you have slow twitch fibers, which are more oriented towards endurance. So long-distance running, you know, cycling, you have the Tour de France, right? Those kinds of events. There, the slow twitch fibers are recruited, which is not to say that there is necessarily a very big distinction between these is just the way these motor units are built.

If I have an activity for which I require explosive movements, the muscle fibers need to be recruited instantly, which means the frequency at which a signal is sent to the fibers is very high, right? So that is what is meant by increasing the firing rate of muscle unit. So, you could increase the firing rate on a slow twitch fiber as well. It will just be slightly more effective for a fast twitch fiber. Similarly, if you are lifting more and more load, right, progressively larger muscles are required to be involved. So, if I'm trying to lift something up, right, I can lift it up with my biceps up to a certain point.

But if I have to really lift up something really heavy, then I have to recruit my glutes, my thigh muscles, quadriceps, hamstrings, right, hamstrings for the entire action. So, the neuromuscular system can really adapt based on training to identify which particular motor units to recruit. How to progressively recruit them correctly, right? And which of these strategies to apply. So, at the end of this, we have taken a look at what is a motor unit. It is comprised of muscle fibers and motor neurons, which form the fundamental one of the fundamental units in neuromuscular systems. And the recruitment of different motor units can happen in two broad ways either the size of motor unit recruitment can be improved, right, employ increasing size or so now at the end of this unit on neuromuscular systems, I hope you can define what are the components of a neuromuscular system.

What are motor units? What how neurons interact with muscles in a very basic manner. And you have some understanding of how neuromuscular recruitment happens. The next unit will cover nervous system. Good luck. Thank you.