Motor control and learning

Hello and welcome to module 3, Function Anatomy. Today, we are going to be looking at motor Control and Learning. So, some of the learning outcomes for these modules, we will have a quick brief recap into the nervous system, the significance of it in movement. There will be a quick introduction to motor control and motor learning. So, we will be looking at what is motor control, what are the key areas within the brain that allow for movement control and learning, the fundamental concepts that drive movement, and we will also be looking at the key areas that are responsible for motor learning. So, quick recap on the nervous system.

We studied a nervous system in module 2. So, it is fundamentally responsible for our ability to move, control our muscles, and respond to the environment. So, control our muscles and respond to the environment. It is the major controlling regulatory and communicating system in the body for various functions, specifically including movement.

So, the primary function of the nervous system as we know is to transmit the signals, process the information, and coordinate response to the stimuli including those related to the movement. The nervous system is divided into central nervous system, which consists of the brain, the spinal cord, and the peripheral nervous system, which consists of the nerves and the ganglia outside the central nervous system. So, these intricate network of neurons and sensory receptors in the system, they allow for the coordination and execution of movements. So, these various receptors coordinate and execute the movement. So, understanding its function and mechanisms is quite essential for us to optimize movement-enhancing performance.

So, let us look at what is motor control. So, motor control is an integrated product of the skeletal, muscular, and the nervous system that helps or assist in the coordination and the regulation of the mechanisms essential for movement. So, it influences the movement performance and precise skill execution. So, what are the key areas for movement in the brain? So, the primary motor cortex which is located in the frontal lobe. So, as you can see in the diagram here, so as you can see in the diagram here, this is where the primary motor cortex is located in the frontal lobe.

So, it is the command center for voluntary muscle movements. So, what does it do? It initiates and controls actions based on motor commands that are generated by the brain. How are they generated, and the process of it? We will be looking at it in the next few slides. So, the cerebellum, on the other hand, which is in the posterior part, so it is in the posterior part, it acts as a precision regulator. So, what is its main function? Its main function for movement is to fine-tune the movements and maintains balance during various motor activities.

It also ensures that the movement is well coordinated. So, the cerebellum is a precise regulator, maintains balance, and also ensures that the movement is well coordinated. Another area in the brain that is quite essential for movement execution is the basal ganglia. So, the basal ganglia is situated deep within the brain. So, in this figure here, that is your basal ganglia.

So, what does it do? It coordinates complex motor functions, including maintaining posture, balance, and executing learned sequences. So, posture, balance, and executing learned sequences. It also plays a very critical role in the planning and execution of movements. So, it also plays a very critical role in the planning and execution of movements. For example, gait control.

So, gait, we will be looking at what gait is in the next coming modules, but you need to remember that basal ganglia plays a critical role in maintaining the gait or the. So, let us look at what drives movement. So, sensory input, information processing and motor output are the fundamental concepts that drive optimal movement performance. So, these three concepts we will be looking at in each in detail in the next few slides are the fundamental concepts that drive movement performance. So, they help explain how individuals perceive, process, and respond to various movements and the external stimuli.

It further relies on proprioception for the final adjustment and refinement of complex movements. So, in order to synchronize, to refine, and to adjust complex movements, it relies on proprioceptive receptors. So, let us look at them in detail. So, sensory input. So, sensory input, it is the information received by the sensory receptors.

For example, in our muscles or in our body when we interact with the environment. So this involves a detection of various sensory stimuli such as visual, auditory, sorry, tactile, proprioceptive, which is the body position, vestibular, which means balance and spatial or space, spatial or space orientation information. So, it involves detecting these various stimulus and once the nervous system receives the stimulus from the different proprioceptors, it provides information about the body's position and movement. So, sensory input recruits receptors to continuously gather data about the position, motion, and forces that are acting on the body. So, whenever we are performing a movement, the data that is collected based on body position, motion, and forces acting on the body, the sensory input is in play.

So, let us look at an example. So, for example, during running, the sensory input from the feet informs you about the terrain. So, it informs us about the terrain, texture, and the slope. So, accordingly, the body adjusts to the gait or the running technique. Another example would be baseball.

So, the ability to accurately track a moving ball relies heavily on visual and proprioceptive input. So, let us look at information processing as a concept. So, information processing involves the brain's analysis and interpretation of sensory input to make decisions and generate motor responses. So, it plays a fundamental role in how we interact with our environment and execute the motor actions. It includes cognitive processes such as perception, attention, memory, and decision-making.

So, this sensory information is then transmitted to the central nervous system, just consisting of the brain and the spinal cord, wherein it undergoes complex processing. So, it is the central mechanism through which our bodies generate coordinated movements. So, once the sensory input

is received, it generates coordinated movements in adaptable or changing environments. And how does it do that? By integrating the input and planning the motor actions. So, let us take an example of basketball.

For example, a basket, it assists the athlete or the basketball player to assess the position of teammates, opponents and anticipate their movements, so that the athlete can then decide where to pass or where to shoot from. Another example would be of a gymnast. So, for a gymnast to mentally plan a complex routine, the information processing helps it coordinate movements based on visual and proprioceptive input. The third stage, sorry, the third process, when it comes to execution of movements, is the motor or generating a motor output. So, the motor output refers to the responses and actions generated by the central nervous system based on the process sensory information.

So, we have got the sensory information. The information is now processed, and now we are beginning to execute the motor skill. So, it involves the execution of the motor commands to produce physical movements, adjustments, or reactions. So, the higher-order areas in the brain, such as the motor cortex and the cerebellum, are involved in planning and executing these precise motor commands based on the processed information. So, your motor cortex, which is here, so we looked at primary motor cortex and the cerebellum which is here.

So, these two play a key role. So, the culmination of the sensory input and the information that is processed, as we looked at in the previous slides, is responsible for the execution of purposeful movements and or responses. So an example of that would be boxing. So, in boxing, for example, it helps the boxer to translate the perception of the opponent's movement into a counter-attack or defensive maneuver. So, it helps the boxer to take a decision based on where the opponent is at, whether to go in for a defense shot or to go in for an offensive shot.

So, what are motor skills? Now that we looked at the various processes, now that we looked at the different processes of how the brain takes in the sensory input, processes the information and delivers an output, let us look at what are the motor skills. So, motor skills are the learned abilities that involve coordinated movements using muscles and nervous system. So, there are two types of motor skills. There are fine motor skills and gross motor skills.

Let us look at them. Let us look at them in detail. So gross motor skills, these involve large muscle groups and are responsible for activities like walking, running, jumping, and throwing. So, they involve large muscle groups. So, these skills are fundamental for basic mobility and physical activity. Whereas fine motor skills, on the other hand, they are involved in precise intricate movements and hence, the smaller muscle groups are responsible for fine motor skills.

They are essential for tasks like writing, typing, intricate hand-eye coordination. So, now that we have looked at motor control, what controls it, and how we process the information, let us look at motor learning. So, what is motor learning? Motor learning is a process of acquiring a skill by which the learner once acquires it through practice and assimilating it, refines and then makes the

movement automatic or then makes automatic the desired movement. So, what does it involve? It involves the improvement of basic motor skills through practice, which are associated with long-lasting neuronal changes. So, once you have learned this skill and you practice it again and again, there are changes in the long-lasting neurons.

So, our ability to acquire these motor skills or refine new motor skills is quite essential for our physical and cognitive development. Let us look at the stages of motor learning. Learning can be broadly categorized into three stages. We have cognitive, associative, and autonomous. Let us look at these three in detail.

So, the cognitive stage, during this stage, which is the initial stage, the individuals understand the basics of a skill. So, they hence, they break it down into smaller components. They analyze the movement and create some kind of a mental model or a plan for the skill to be executed. So, because it is the initial stage of the skill, it is quite important in this phase, in the new learning phase, to receive instructions. So, for example, if you are training a beginner in coaching, it is quite important for them to give repeated instructions as they are planning or mental mapping as to how the skill needs to be performed.

So, it continuously integrates feedbacks provided. The athlete continuously integrates the feedbacks provided. So, during this phase, as it is the initial phase of learning, they might be considerable errors and high variability in performance. So, the duration of this phase, which is the learning phase or trying to understand the skill phase, it also depends on the athlete and also the complexity of the task at hand. So, a high attentional demand of the coaches required.

The next stage of learning is the associative stage. So, the second phase consists of consolidation of the motor performance. So, by now, the athlete would have had some kind of mental mapping and feedback from the coaches to develop some skill set into the new skill or the new movement that is introduced. So, the athlete now is more confident and, with practice becomes more and more accurate and refined, less error-prone. The last stage of learning is the autonomous stage.

So, in this stage, the skill is already learned and almost becomes automatic, sorry, and almost becomes automatic, requiring minimal conscious attention. So, what are the key areas for movement that go through these different stages of learning? So, motor learning is a very complex phenomenon with many components like the, where in the anatomical structures are involved depending on the particular movement. Depending on the movement, there are a few areas that play a major role. So, skill learning has many facets and likely engages large portions of the brain. Mainly, the cortical structures, including the motor cortex, including the motor cortex are quite important in skill learning.

The cerebellum, on the other hand, takes main part in adaptation learning. So, once you have learned the primary skills, it takes part in adaptation learning. So, to wrap it up, the nervous system is fundamentally responsible for our ability to move, control our muscles, and respond to our environment. Motor control is an integrated product of the three different systems which are your

skeletal, muscular, and nervous and they assist in coordinating and regulating mechanisms essential for movement. In movement, you have different fundamental concepts of sensory input, information processing, and motor output that drive optimal movement performance.

Motor skills are learned abilities that involve coordinated movements using muscles and the nervous system. And the process of acquiring a skill by which the learner, through practice and assimilation, refines and makes automatic desired movement is motor learning. So, in this module, we learned about the nervous system, motor control, and motor learning, wherein we learned how skills are, how the learning happens, how we learn movement.