Introduction to Exercise Physiology & Sports Performance

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Lecture - 04
Functional Anatomy of Skeletal muscle

Good morning ladies and gentlemen and welcome back to lecture 4 of week 1 of this course on exercise physiology and sports training. I am Colonel Dr. Anup Krishnan, and I will be your instructor for this lecture. I will be talking to you about the functional anatomy of the skeletal muscle. I will be covering this lecture under the following heads.

Introduction, structure of the muscle, structure of the muscle fibre. We will talk about something called the sliding filament theory and we will have a conclusion. Exercise requires movement of the body. And this movement is accomplished through the action of skeletal muscles.

If there are no muscles, there is no movement. If there are no bones, there is no movement. If there is no musculoskeletal system, there is no movement. Exercise and sports physiology depends upon human movement. And this knowledge of human movement needs knowledge about the structure and function of the skeletal muscles.

Let us talk about the structure of the muscle. If you look at the muscle, the entire muscle, it is surrounded by a sheath of connective tissue called the epimysium. This sheath surrounds the muscle and it keeps it intact. Inside the muscle, if you see, there are small bundles of muscle fibre which are wrapped in a connective tissue sheath. Now these bundles are called fasciculi.

Each bundle is called a fasciculus, and bundles in plural are called fasciculi. And the connective tissue sheath surrounding each fascicle is called the perimysium. So, we will be going from the gross to the microscopic. So we are now at the level of the muscle. Muscle is surrounded by a sheath called the epimysium.

It is made up of several bundles of muscle fibers which are wrapped in a connective tissue sheath. These bundles are called fasciculi and the connective tissue sheath surrounding each fascicle is called the perimysium. If you cut through the perimysium and use a microscope, you will see an individual muscle fibre. Each muscle fibre is also a muscle cell. Unlike most cells in

the body, muscle cells are multinucleated.

Most cells in the body are single nuclei. But muscle cells are multinucleated. A sheath of connective tissue called the endomycin covers each muscle fibre. Muscle fibre is further broken down into a thick filament and a thin filament. We will discuss that more in detail.

So I hope you are with me so far. We have come down from the muscle to the muscle fiber. A single muscle cell is known as a muscle fiber. It has got a cell membrane and the same organelles, cell organelles that the other cell types have, but it is multinucleated. Muscle fibers range in diameter from 10 to 120 micrometer.

So they are nearly invisible to the naked eye. To see them or to study them properly, you will generally require a microscope. Individual muscle fiber is surrounded by a plasma membrane called the plasmalemma. The plasmalemma is part of a larger unit called the sarcolemma. The sarcolemma comprises the plasma lemma and a basement membrane.

At the end of each muscle fiber, the plasmalemma fuses with the tendon which inserts into the bone. I hope you are with me so far. We are discussing the cross section of an individual muscle fiber. Each individual muscle fiber is surrounded by a plasma membrane which is called the plasma lemma. The plasmalemma is part of a larger unit referred to as the sarcolemma, which comprises of the plasmalemma and the basement membrane.

And towards the end of the muscle fiber, the plasmalemma fuses with the tendon, which further inserts into the bone. The myofibril is the contractile element of the muscle. The sarcoplasm is a gelatin-like substance which fills the spaces within and between the myofibril. The sarcoplasm contains mainly dissolved proteins, minerals, glycogen, fats and the cell organelles. It also contains a large quantity of stored glycogen and myoglobin.

The sarcoplasm also has an extensive network of transverse tubules or T-tubules, which are extensions of the plasmalemma that pass laterally through the muscle fiber. These are the transverse tubules. These tubules are interconnected. They allow nerve impulses to be transmitted rapidly to individual myofibrils. These tubules also provide pathways from outside the fiber to its interior, enabling the substances to enter the cell and waste products to leave the fibers.

A longitudinal network of tubules called sarcoplasmic reticulum is also found within the muscle fiber. These membranous channels are run parallel to the myofibrils and they may loop around them. They serve as a storage site for calcium, which is very, very important for muscle contraction. Now let us talk from the myofibril, let us come down to the sarcomere. A sarcomere is the basic functional unit of a myofibril and the basic contractile unit of the muscle.

Basically, if you look at a myofibril, you will see these Z discs. The area between one Z disc to the other Z disc is one sarcomere. Now, each myofibril is comprised of numerous sarcomeres joined end-to-end at the Z-discs. Each sarcomere includes what is found between each pair of Z-disks in a sequence. An I-band, which is this band here.

An A-band, which is this dark zone here. An H zone in the middle of the A band, which is this zone here. An M line which is there in the middle of the H zone. The rest of the A band and the second I band. This is the structure of a sarcomere.

I hope I have been able to put it very simply and I hope you have been able to understand this because this is essential when we move forward from here. If you look at the sarcomere, you will also see two types of filaments. The filaments which are attached to the Z disc are the thin filaments or the actin filaments. The filaments which are in the center which are not attached to the Z disc are called the thick filaments or the myosin filaments. A sarcomere is composed of two different types of filaments, thick and thin filaments.

Myosin, the primary protein of the thick filament, is comprised of two protein strands, each folded into a globular head at one end. So this is how the myosin heads look like. The thin filament comprises of actin, tropomyosin, and troponin. And one end of each thin filament is attached to the Z disc. These are the thin filaments and they attach to the Z disc.

These are the thick filaments. They are not attached anyway. Now let us talk about something called the sliding filament theory. There is something called myosin cross bridges. When they are activated, they bind with actin. These are the actin fibers and these are the myosin fibers.

When the myosin cross bridges are activated, the myosin slides over the actin and continues to keep sliding. This causes what is called the sliding filament. It starts and keeps on sliding. Basically, the myosin filament keeps sliding over the actin filament. This tilting of the head of the myosin is called the power stroke.

And this pulls the thin filament towards the center and it shortens the sarcomere and generates force. Because the sarcomeres are joined end to end within a myofibril, And as the sarcoma is shortened, the myofibril will also shorten. And the muscle fibers within the fascicle will shorten. The end result of many such fibers shortening is an organized muscle contraction. So let us discuss what we have learned in this lesson so far.

A muscle comprises of several components. These are organized into bundles surrounded by connective tissue. Muscle fibers have several unique characteristics which we have seen and discussed. Muscle proteins are unique and contribute to its function. There is something called

the sliding filament theory of muscle contraction which we have discussed.

These are the references and I would strongly urge you to go through the references in the interest of better understanding of this syllabus and the lecture. I thank you for your time and patience, ladies and gentlemen. We will be glad to reply to any questions or queries which you may put through in the email. Thank you very much, ladies and gentlemen, and Jai Hind.