The Science of Muscle Growth and Repair

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Part 1 - Anatomy and Physiology of Muscles & Growth Factors

Introduction

The goal of the next articles is to acquaint our readers with the science of muscle growth and repair. This will be done in two parts.

- The first article will familiarize you with the anatomy and physiology of muscles and how they grow as well as the effects that various hormones and growth factors have on muscle growth.
- The next article will delve into the nutritional aspects of muscle growth. Certain amino acids play more of a part in muscle growth and repair than others and you will learn which they are. We will also describe additional nutritional entities that have the ability to make a difference in how you build muscle or recuperate from an injury. Milk proteins such as casein and whey are two of the outstanding protein sources of these substances that enhance the process of growth and repair of muscle.

Anatomy and Physiology of Muscles

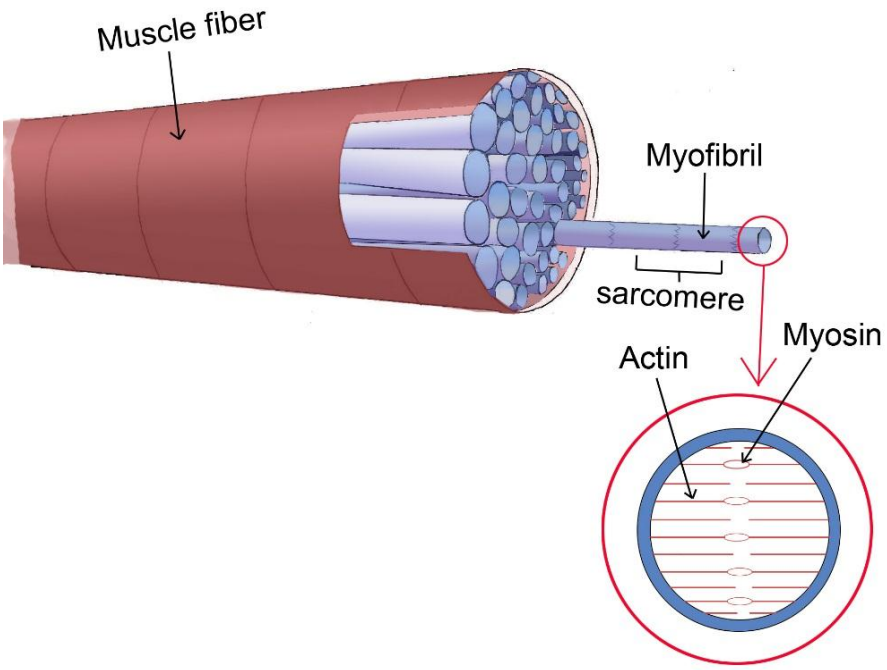
Muscle growth is absolutely related to resistive exercise such as lifting weights. Public and private gyms are more popular than ever. The reason is that significant numbers of the population have realized the physical and emotional benefits of regular exercise in addition to muscle growth.

The Centers for Disease Control and Prevention recommends that all adults get at least 30 minutes of moderate exercise five days a week. Although pumping iron is critical for muscle growth, studies have shown that even a consistent commitment to walking is associated with a decreased risk of mortality and decreased lifetime medical expenditures (1).

In addition to building skeletal muscle, the benefits of regular exercise include improved cardiovascular health, an improved cholesterol profile, decreased chance of developing diabetes, weight control, decreased incidence of some cancers, and a better mental outlook on life which translates into an improved ability to deal with adversity.

The human body has three types of muscle tissue-skeletal, cardiac, and smooth. They differ from one another in their microscopic anatomy, location, and control by the nervous and endocrine (hormonal) systems. Cardiac muscle tissue forms most of the heart. Smooth muscle tissue is located for the most part in the abdomen around and in most of the organs. This article will deal with skeletal muscle which is quite different in that it can be made to relax and contract voluntarily and is therefore under our control (2). It is known as voluntary as opposed to involuntary muscle.

Skeletal muscle is so named because it is attached primarily to bones and therefore contraction of various muscle groups enables us to move about voluntarily. Muscle cells are composed of tubular units called *myofibrils*. Myofibrils are composed of repeating sections called *sarcomeres*, which appear under the microscope as dark and light bands. Sarcomeres are composed of long, fibrous proteins that slide past each other when the muscles contract and relax.



The two important protein substances that compose muscle tissue are *myosin* which forms the thicker filaments, and actin *which* forms the thin filaments. A good supply of amino acids via the protein we consume is required to form both actin and myosin.

Contractility is the ability of the muscle to shorten and contract and thus cause movement in response to nerve impulses. **Amyotrophic lateral sclerosis (ALS),** also called Lou Gehrig's disease or classical motor neuron disease, is just one of many diseases that disrupts nerve signals to the voluntary muscles and renders them unable to contract at will.

How Does Lifting Heavy Weight Result In Muscle Growth

When weight lifters engage in intense exercises using heavy weight they actually cause microscopic damage to the muscle fibers themselves. They “tear” the fibers. This initially results in some necrosis of the damaged muscle fibers and initiation of an inflammatory response in the area. Inflammation causes an increased blood supply to the damaged area which brings with it a host of substances that play an integral role in repair and actually growth.

In an attempt to repair or replace the damaged fibers the body responds by activating “satellite cells”. These are cells on the outside of the injured muscle fiber. Each satellite cell has one nucleus and has the ability to replicate by dividing. These cells, which are similar to stem cells, subsequently mature into normal muscle cells. They then fuse to each other and to the existing muscle fibers to form new muscle strands called myofibrils (3). The muscles thus increase in size as more fibers are created.

It is this activation of the satellite cells that mature into muscle fibers that makes muscles grow in size. We have probably all wondered how it is that we lift weights and go to the gym as much as the next guy but somehow the next guy seems to build more muscle. An interesting study was

done which revealed that the reason some people build muscle more easily than others with the same amount of exercise is their inherent ability to activate the satellite cells and thus create new muscle fibers (4, 5).

Each satellite cell has a nucleus and it is with the addition of these additional nuclei that the two main contractile protein elements called actin and myosin are formed. These proteins form the "contractile myofilaments", which enable the muscle to contract and cause motion of our body parts at will. It is by this process that the normal loss of muscle mass with aging, known as sarcopaenia, can be reversed to a significant degree with resistive exercises in addition to a diet with higher protein content (6).

What Are the Effects of Hormones and Growth Factors?

Hormones and hormone-like compounds that have the ability to activate the satellite cells and produce muscle are called *growth factors*. Below is a description of some of the more significant ones.

Hepatocyte growth factor (HGF)	• Causes satellite cells to move toward the sight of muscle injury (5).
Fibroblast growth factor (FGF)	• Helps form new blood vessels in the newly formed muscle tissue (5).
Insulin-like growth factor (IGF)	• Primarily determines the amount of muscle mass growth (3, 5). • It facilitates glucose uptake and also activates satellite cells.
Insulin	• Enables glucose to enter the satellite cells by crossing the cell membrane. • Here it is used for fuel for those cells to do their job and produce muscle (5).
Growth hormone	• Stimulates the uptake and incorporation of amino acids into protein in skeletal muscle. • In addition it plays a role in metabolism of fat to serve as an energy source for the production of skeletal muscle (5).
Testosterone	• Stimulates amino acid uptake. • Increases muscle mass by increasing protein synthesis (7).

Conclusion

These are the basic factors for muscle growth and repair. Be patient, stay active, work hard, but don't overdo it and hurt yourself. In the next segment we will describe how consuming the appropriate nutrients can also be a significant factor in achieving your goal, whether it be building more muscle, recovering from an injury, or simply enjoying life more by being fit.

References

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