

Muscle Terms:

Agonist (prime mover): the muscle that contracts to cause a movement

Antagonist: the muscle that yields to the agonist yet aids in regulating movement

Synergist: muscles that contract to stabilize intermediate joints in a system.

Contractions

Isotonic contractions

1. concentric isotonic contraction: the tension in the muscle is great enough to overcome the resistance and the muscle shortens to move an object.

2. eccentric isotonic contractions: the length of a muscle increases during a contraction.

Isometric contractions: the force generated is not enough to overcome the resistance and the muscle length does not change.

Production of ATP in muscle fibers

Three mechanisms

1. From creatine phosphate: when muscles are resting they have more than enough ATP. The excess ATP is used to make creatine phosphate, a high energy molecule found only in muscle fibers. Basically, the enzyme creatine kinase transfers one phosphate group from an ATP molecule to a creatine molecule, which results in the formation of creatine phosphate. Creatine is produced in the liver, kidneys, and pancreas and is then transferred to muscle tissue. When muscles are active and ADP levels begin to rise, creatine kinase transfers a phosphate from the creatine phosphate back to the ADP to produce ATP. Together the ATP reserves and the creatine phosphate provide enough energy for maximal contraction for about 15 seconds.

2. Anaerobic cellular respiration: a series of ATP producing reactions that DO NOT require oxygen. In this process glucose is catabolized to generate ATP. Glucose easily passes from the blood into muscle fibers via diffusion, but it is also produced by the breakdown of glycogen stored in skeletal muscle. Glycolysis (a series of 10 reactions) breaks down glucose into two pyruvic acid molecules. This requires the energy from two ATP molecules but produces 4 ATP molecules, for a net gain of two. If not enough oxygen is available most of the pyruvic acid is converted into lactic acid. Most of this (80%) diffuses out of the muscle tissue into the blood. The liver can then convert some of this lactic acid back into glucose. This serves two purposes; 1, it produces new glucose molecules and 2, it reduces the acidity of the blood. This method can provide enough energy for about 30 – 40 seconds of maximal muscle contraction.

3. **Aerobic cellular respiration:** a series of reactions that require oxygen to produce ATP in mitochondria. If sufficient levels of oxygen are present the pyruvic acid produced by glycolysis will enter the mitochondria where it can be completely oxidized. These oxidation reactions produce ATP, carbon dioxide, water, and HEAT. Although this system is slower than glycolysis it produces much more ATP. Glycolysis produces about 36 molecules of ATP. Aerobic respiration can produce more than 100 molecules of ATP from 1 fatty acid molecule. The nutrients used in aerobic respiration include: pyruvic acid, fatty acids from the breakdown of triglycerides in fat cells, and amino acids from the breakdown of proteins.

Muscle Fiber Types:

Red vs White fibers: essentially come down to the amount of myoglobin present in the muscle. The more myoglobin the darker the muscle fiber. Red fibers also have a greater blood supply and have more mitochondria.

We also classify fibers as SLOW or FAST depending on how fast the ATPase in the myosin heads hydrolyzes.

These functional and structural classifications give us three major muscle fiber types:

1. Slow oxidative fibers (SO): these fibers have the smallest diameter and are the least powerful type of muscle fiber. These fibers contain large amounts of myoglobin and have a rich capillary supply both of which give them a dark red color. These fibers have large amounts of mitochondria and, as their name implies, generate ATP primarily through oxidative mechanisms. The other portion of their name, “slow,” comes from the speed at which the myosin heads hydrolyze ATP. Slow hydrolysis results in a relatively slow speed of contraction. The twitch contraction of this type of fiber lasts roughly 100 – 200 msec. Due to their extensive myoglobin content and rich blood supply these fibers are relatively resistant to fatigue.

2. Fast oxidative-glycolytic fibers (FOG): in a manner of speaking are intermediate fibers. Their diameter is larger than that seen in SO fibers but is smaller than what we will see in fast glycolytic (FG) fibers. As their name implies they can use both oxidative processes and glycolytic processes to generate ATP. These fibers have a high myoglobin content and a rich blood supply, so they also appear rather dark. These fibers also have a high intracellular glycogen level which enables them to generate ATP through anaerobic glycolysis. These fibers are referred to as “fast” because the myosin head hydrolyzes ATP 3 – 5 times faster than is seen in SO fibers. FOG fibers reach peak tension faster than SO fibers but maintain this tension for a shorter period of time, approximately 100 msec.

3. Fast glycolytic fibers (FG): have the largest diameter of the muscle fiber types. This diameter is related to the amount of myofibrils within the muscle fiber. The larger amount of myofibrils gives these muscles the greatest power of the three fiber types. These fibers appear “white” because they have little myoglobin, few capillaries, and few mitochondria. They do however contain large amounts of glycogen and hence generate

large amounts of ATP via glycolysis. These fibers are best suited for quick, strong contractions, but they fatigue quickly.