Biomechanics of Muscular Movement

A muscle is composed of about 80 percent water and 20 percent protein (127). Muscle has three basic classifications whereby muscles of the body are classified into smooth, cardiac and skeletal muscle.

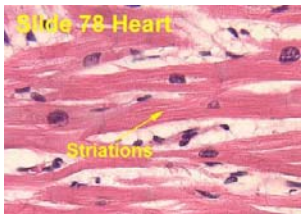
Smooth Muscle

Smooth muscle is generally considered involuntary muscle. It is non-striated and called smooth because of this characteristic. A single smooth muscle fiber is spindle shaped. Within the fiber is a single, oval, centrally located nucleus. Smooth muscle is found in the walls of all the hollow organs of the body (except the heart). Its contraction reduces the size of these structures. Thus it

- Regulates the flow of blood in the arteries
- Moves your food along through your gastrointestinal tract
- Expels urine from your urinary bladder
- Sends babies out into the world from the uterus
- Regulates the flow of air through the lungs

Cardiac Muscle

Also called **Heart muscle.** This type of muscle makes up the wall of the heart. Throughout life, it contracts some 70 times per minute pumping about 5 liters of blood each minute. Heart muscle is striated in appearance but is also considered involuntary muscle. The cells of cardiac tissue are roughly quadrangular and possess a single nucleus. The individual fibers are covered by a thin, poorly defined sarcolemma, and the internal myofibrils produce the characteristic striations. Cardiac fiber is most like skeletal muscle tissue, but has several microscopic differences. About 1 percent of cardiac muscle cells, like certain forms of smooth muscle, are autorhythmic, that is, they are capable of self excitation. Cells of cardiac muscle are designed like tiny electrical generators which send out signals telling the heart to contract.



Skeletal Muscle

Skeletal muscle, as its name implies, is the muscle attached to the skeleton. It is also called **striated muscle**. The contraction of skeletal muscle is under voluntary control. Skeletal muscle is what we talk about when we refer to our muscles in the gym. They have common names such as biceps, triceps, hamstrings and quadriceps. Skeletal muscle is unique in its design.

When muscles cause a limb to move through the joint's range of motion, they usually act and are further broken down in the following cooperating groups:

Agonist Muscles

In any given movement, the muscle mostly involved with that movement is the **agonist** or commonly referred to as *prime movers*. Agonist or prime movers may contract concentrically to lift a weight, or eccentrically to lower that weight.

For example, in a biceps flexion, the primary movers are the biceps brachii, brachialis and brachioradialis muscles since these muscles will control the lowering and lifting of the weight. Some exercises will involve only one prime mover, others more than one prime mover. A push up for instance will involve shoulder extension and elbow extension. Therefore the prime movers will be the triceps and the pectoralis major muscles.

Antagonistic Muscles
The muscle that lies directly opposite to the agonist or prime mover and is responsible for the opposing action of that movement is the antagonistic muscle. The triceps are the **antagonist muscle** to the biceps curl for instance, and the biceps would be the antagonist in a triceps extension.
They are responsible for returning a limb to its initial position.

The following is a list of commonly used agonist/antagonist muscle pairs:

- pectorals/latissimus dorsi (pecs and lats)
- anterior deltoids/posterior deltoids (front and back shoulder)
- trapezius/deltoids (traps and delts)
- abdominals/spinal erectors (abs and lower-back)
- left and right external obliques (sides)
- quadriceps/hamstrings (quads and hams)
- shins/calves
- biceps/triceps
- forearm flexors/extensors

Stabilizing Muscles
These muscles provide the necessary support to assist in holding the rest of the body in place while the movement occurs. **Stabilizers** are also sometimes called *fixators*. For smooth motion to occur in certain joints, other joints must be stabilized. For example, when performing a pushup, the spine must be held stable by the erector spinae in order to maintain form. In addition, the knee joint must be stabilized to keep the legs straight. Both show examples of the importance of stabilization. In addition to stabilizing, we also see guiding muscles. These are muscles which guide movements and maintain smoothness and stability in motion. Guiding and stabilizing muscles are usually considered together.

When analyzing motion, it is important to understand how these muscles work together. An excellent example is a sit up. Let's consider two individuals, both performing a sit up. Individual A has placed themselves on the ground and have bent their knees placing their heels close to their buttocks. Feet are placed on the floor. Individual A will maintain lower back contact with the floor and curl their spine so that the shoulders clear the floor by 6-8 inches. The curl is terminated when the rectus abdominis reaches full range.

Individual B has hooked their feet under a bar. They use this leverage to bring their body up to their knees. Their spine does not flex or extend, but rather motion is primarily from hip rotation.

Let's see how the muscles used will have affected the exerciser:

Table 5

Exercise	Correct sit-up	Incorrect sit-up
Prime Mover	Rectus abdominis	Hip Flexors
Antagonist	Erector Spinae	Gluteus maximus
Stabilizer	Internal/External Obliques	Rectus Abdominis

As you can see for this illustration, while both exercisers intended to do sit ups, only one performed them effectively. On that note, had both performed sit ups to lower body fat, neither would have achieved their objective.

Synergists
These muscles perform, or assist in performing, the same set of joint motion as the agonists. Synergists are sometimes referred to as *neutralizers* because they help cancel out, or neutralize, extra motion from the agonists to make sure that the force generated works within the desired plane of motion.

The Concept of Synergy
Synergy is not well understood in the industry because it is somewhat alien to the equipment manufacturers who sell their exercise equipment proclaiming that isolation is the only way to properly strengthen each muscle. This is a dangerous assumption since isolation does not occur in the real world. We do not for instance pick up a laundry basket with only one muscle in isolation. In fact, we use multiple muscles in multiple planes of movement, this is not isolation but synergy. Synergy then, is the cooperation of multiple muscle groups used in tandem to complete a movement. In addition, a muscle trained in isolation risks the development of imbalance which may actually contribute to injury later on, a great example is when a sprinter pulls a hamstring due to the imbalance of quadriceps to hamstring strength ratio. Also, when we use synergy of the muscles, we are expending a much, much greater amount of calories. This is important to the effects on body composition and also important when it comes to the amount of time a client can dedicate to training.

As an example, when you flex your knee, your hamstring contracts, and, to some extent, so does your gastrocnemius (calf) and gluteal muscles. Meanwhile, your quadriceps are inhibited (relaxed and lengthened somewhat) so as not to resist the flexion (Reciprocal Inhibition – flexibility section). In this example, the hamstring serves as the agonist, or prime mover; the quadricep serves as the antagonist; and the calf and glutes serve as the synergists. Agonists and antagonists are usually located on opposite sides of the affected joint (like your hamstrings and quadriceps, or your triceps and biceps), while synergists are usually located on the same side of the joint near the agonists. Larger muscles often call upon their smaller neighbors to function as synergists.