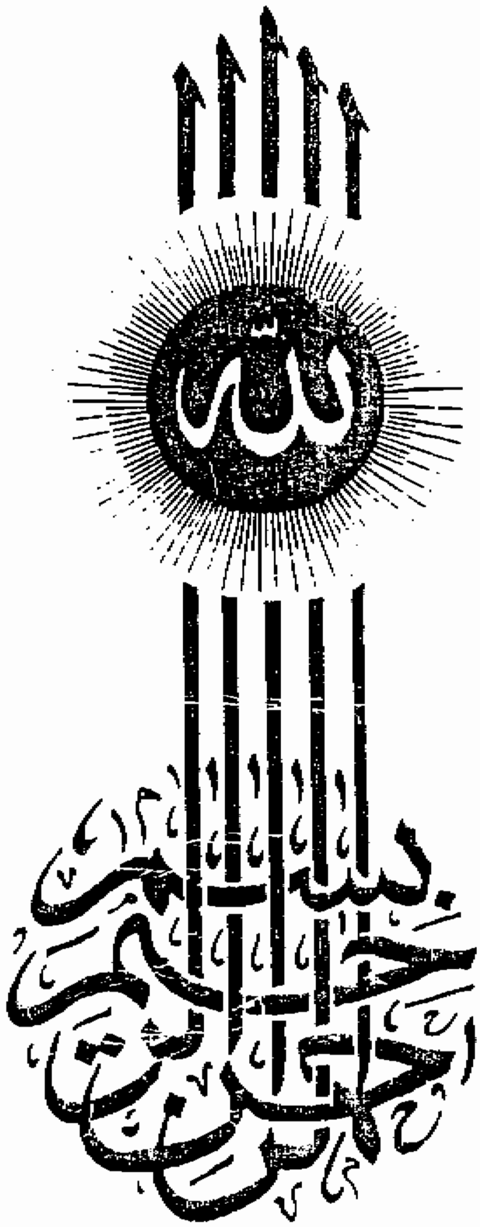
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بسم الله الرحمن الرحيم

Immobilization, Disuse and Hormonal effect on skeletal muscle.
ESSAY

Submitted in Partial Fulfilment of
the Master Degree in
Orthopaedic Surgery

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Contents

Example :

The term prime mover (**agonist**) is used to designate a muscle that is responsibe for producing a desired motion at a joint.

If flextion is the desired action, the flexor muscles are the prime movers and the muscles (extensors) that are directly opposite to the desired motion are called the antagonists. The desired motion may not be opposed by the antagonists, but these muscles have the potential to oppose the action.

Ordinarily when an agonist is called to perform a desired motion, the antagonist is inhibited (reciprocal inhibition). If, however, the agonist and the potential antagonist contract simultaneously, then co-contraction occurs. Co-contraction of muscles around a joint can help to provide stability for the joint and represents a form synergy that may be necessary in certain situations. Co-contraction of muscles with opposing functions can be undesirable when a desired motion is prevented by involuntary co-contraction such as occurs in disorders affecting the control of muscle function.

*Muscles that help the agonist to perform a desired action are called synergists.

Example :

If flexion of the wrist is the desired action , the flexor carpi radialis and the flexor carpi ulnaris would be referred to as the "agonists" or "prime movers" because these muscles produce flexion. The wrist extensors would be the potential antagonists. The synergists that might directly help the wrist flexors would be the finger flexors.

Synergists may assist the agonist directly by helping to perform the desired action , such as in the wrist flexion example, or the synergists may assist the agonist indirectly either by stabilizing a part or by preventing an undesired action.

Example :

If the desired action is finger flexion, such as in clenching of the fist, the finger flexors, which cross both the wrist and the fingers, cannot function effectively (a tight fist cannot be achieved) if they flex the wrist and fingers simultaneously. Therefore, the wrist extensors are used synergistically to stabilize the wrist and to prevent the undesired motion of wrist flexion. By preventing wrist flexion, the synergists are able to maintain the finger flexors at an optimal length.

person A,s biceps might contain the following motor units:

75 percent FG fibers

15 percent FOG fibers

10 percent SO fibers

whereas person B,s biceps might have only

50 percent FG fibers

35 percent FOG fibers

15 percent SO fibers

The variations in fiber types among individuals are believed to be genetically determined. The vastus lateralis, rectus femoris, deltoid, and gastrocnemius muscles have been found to be similar among individuals in that they have been found to contain about 50 precent FG and 50 percent SO fibers.[2]

The soleus muscle, on the other hand, has been found to contain twice as many SO fibers as FG fibers.[9]

Muscles that have a relatively high proportion of SO fibers in relation to FG fibers , such as the soleus muscle, are able to carry on sustained activity because the SO fibers do not fatigue rapidly. These muscles are often called stability, postural, or tonic muscles because they help to maintain stability of the body.

The relatively small SO motor units of the soleus muscle, which have a small cell bodies, small-diameter axons, and a small number of muscle fibers per motor unit, are almost continually active during erect standing so as make the small adjustments in muscle tension that are required to maintain body balance and counteract the effects of gravity.

Muscles that have a high proportion of the FG fibers , such as the biceps brachii, are sometimes designated as mobility, nonpostural, or phasic muscles. These muscles are involved in producing a large ROM (Range Of Motion) of the bony components.[10]

The FG fibers respond more rapidly to stimulus but also fatigue more rapidly than SO fibers . Following intermittent bouts of high-intensity exercise, muscles with a high proportion of FG fibers , which involve a large intial response, show greater fatigue and recover more slowly than muscles with a high proportion of SO fibers.[11]

CHARACTERISTICS OF SKELETAL MUSCLE FIBERS

	Fast-twitch Glycolytic (FG)	Fast-twitch Oxidative Glycolytic (FOG)	Slow-twitch Oxidative (SO)
Diamter	Large	Intermediate	Small
Muscle color	White	Red	Red
Capillarity	Sparse	Densee ——	Dense
Myoglobin content	Low	Intermediate	High
Speed of contraction	Fast	Fast	Slow
Rate of fatigue	Fast	Intermediate	Slow
Motor unit size	Large	Intermediate to large	Small
Axon conduction velocity	Fast	Fast	Slow

Size, Arrangement, and Number

Muscle fiber length, fiber arrangement, and number muscle fibers per muscle vary throughout the body. These structural variations affect not only the overall shape and size of the muscles but also the function of the various muscles.

Each muscle fiber is capable of shortening to approximately one-half of its total length. Consequently, a long muscle fiber is capable of shortening over a greater distance than a short muscle fiber .

<u>For example:</u>

A muscle fiber that is 6 in,long is able to shorten 3 in, whereas a fiber that is 4 in,long is able to shorten only 2 in.

The significance of the preceding example is apparent if one considers that a hypothetical muscle with long fibers is able to move the bony lever to which it is attached through a greater distance than a muscle with short fibers. However, the relationship between the length of a muscle fiber and the distance it is able to move a bony lever is not always a direct relationship.

The arrangement of the muscle fibers affects the the length-shortening relationship and therefore must be taken into consideration.

Arrangement of fasciculi, like the length of the muscle fibers. Varies among muscles.

The fasciculi may be :

(1) parallel to the long axis of the muscle

(2) may spiral around the long axis

(3) or may be at an angle to the long axis

Muscles that have a parallel fiber arrangement (parallel to the long axis and to each other) are designated as strap or fusiform muscles. In strap muscles, such as the sternocleidomastiod, the fasciculi are long and extend throughout the length of the muscle.

However, in the rectus abdominis, which also is considered to be a strap muscle, the fasciculi are divided into short segments by fibrous intersections.

In fusiform muscles, most but not all of the muscle fibers extend throughout the length of the muscle. Generally, muscle with a parallel fiber arrangement will produce a greater ROM of a bony lever at a joint than muscles with the same cross-sectional area but with a different fiber arrangement.

Muscles that have a fiber arrangement oblique to the muscle's long axis are called

* unipennate,
* bipennate,
* multipennate muscles because the fiber arrangement resembles that found in a feather, and the word 'pennate" is derived from the Latin word for feather.

The fibers that make up the fasciculi in pennate muscles are usually shorter and more numerous than the fibers in many of the strap muscles.

In unipennate muscles

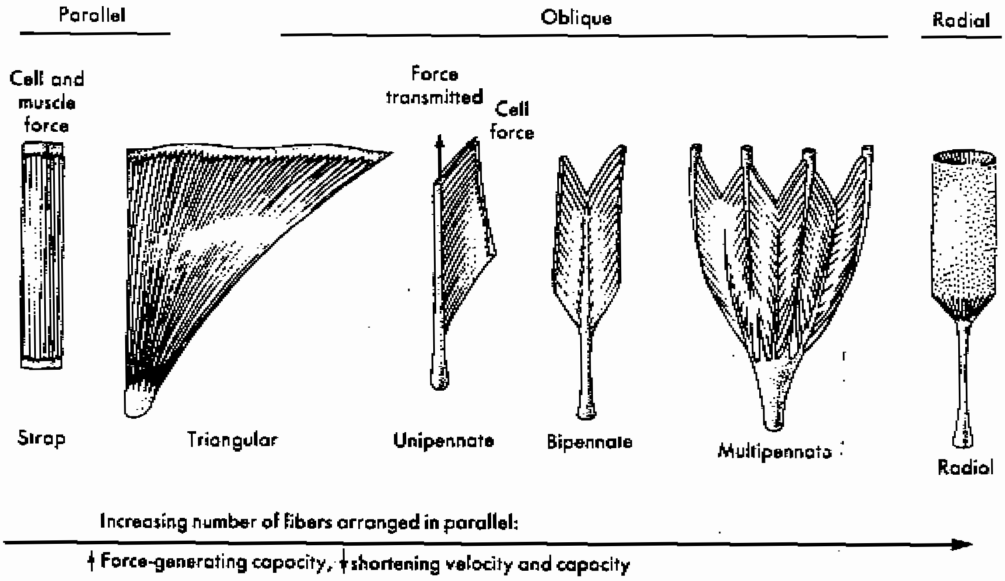
Such as the flexor pollicis longus, the obliquely set fasciculi fan out on only one side of a central muscle tendon.

In a bipennate muscle,

Such as the gastrocnemius, the fasciculi are obliquely set on both sides of a central tendon. In a multipennate muscle, such as the deltoid, the oblique fasciculi converge on several tendons.

The oblique set of the muscle fibers in a pennate muscle disrupts the direct relationship between the length of the muscle fiber and the distance that the total muscle can move a bony part. Only a portion of the force of the pennate muscles goes toward producing motion of the bony lever.

However, because pennate muscles usually have a large number of muscle fibers, they are able to transmit a large amount of force to the tendon to which they attach.



– Some arrangements of skeletal muscle fibers. The force generated by all of the individual cells is fully transmitted to the skeleton in only a few straplike muscles. The cells in most muscles are arranged at an angle to the axis of the muscle. This allows more fibers to be attached to a tendon and increases the total force-generating capacity. However, not all of the force generated by each cell is usefully transmitted to the tendon with an oblique geometry, and the overall shortening velocity and shortening capacity of the muscle are less than that of the individual cells. (Redrawn from Gray's anatomy, ed. 35 [British], Philadelphia, 1973, W.B. Saunders Co.)

Elements of Muscle Structure

The two types of materials that are found in skeletal muscle are
* muscle tissue (contractile)
* connective tissue (noncontractile).

The properties of these tissues and the way in which they are interrelated give muscles their unique characteristics. Muscle tissue, like other biologic tissue, is viscoelastic.[1] Muscle tissue also possesses the properties of contractility and irritability.

- Contractility refers to the muscle's ability to develop tension.
- Irritability refers to a muscle's ability to respond to chemical, electrical, or mechanical stimuli.[1]

Composition of a Muscle Fiber

A skeletal muscle is composed of many thousands of muscle fibers. The arrangement, number, size, and type of these many fibers may vary from muscle to muscle,[2] but each fiber is a single muscle cell that is enclosed in a cell membrane called the sarcolemma.

Muscle cells (muscle fibers) are grouped together in bundles called fasciculi and a single muscle contains many fasciculi. Like other cells in the body, the muscle fiber is composed of cytoplasm, which in a muscle is called sarcoplasm.

The sarcoplasm consists of structures called myofibrils, which are the contractile structures of a muscle fiber and nonmyofibrillar structures such as ribosomes, glycogen, and mitochondria, which are required for cell metabolism.

The myofibril is composed of tiny filaments called myofilaments. Some of the myofilaments are composed of the protien actin, while others are composed of the protien myosin. The binding together of these two myofilaments causes a muscle contraction.

The actin myofilaments are thin and are formed by two chin like strings of actin molecules wound around each other. Molecules of the globular protein troponin are found in notches between the two actin strings and the protein tropomyosin is attached to each troponin molecule.

The troponin and tropomyosin molecules control the binding of actin and myosin myofilaments.

The myosin myofilaments are thick and composed of large myosin molecules that are arranged to form long molecular filaments.

The myofilaments formed by the myosin molecules are not of equal diameter throughout their length but are wider in the middle portion. Each of the myosin filaments has globular enlargements called head groups.[3]

The head groups, which are able to swivel and are the binding sites for attachment to the actin, play a critical role in muscle contraction and relaxation. When the entire myofibril is viewed through a microscope, the alternation of thick (myosin) and thin (actin) myofilaments forms a distinctive striped pattern. Therefore, skeletal muscle is often called striated muscle.

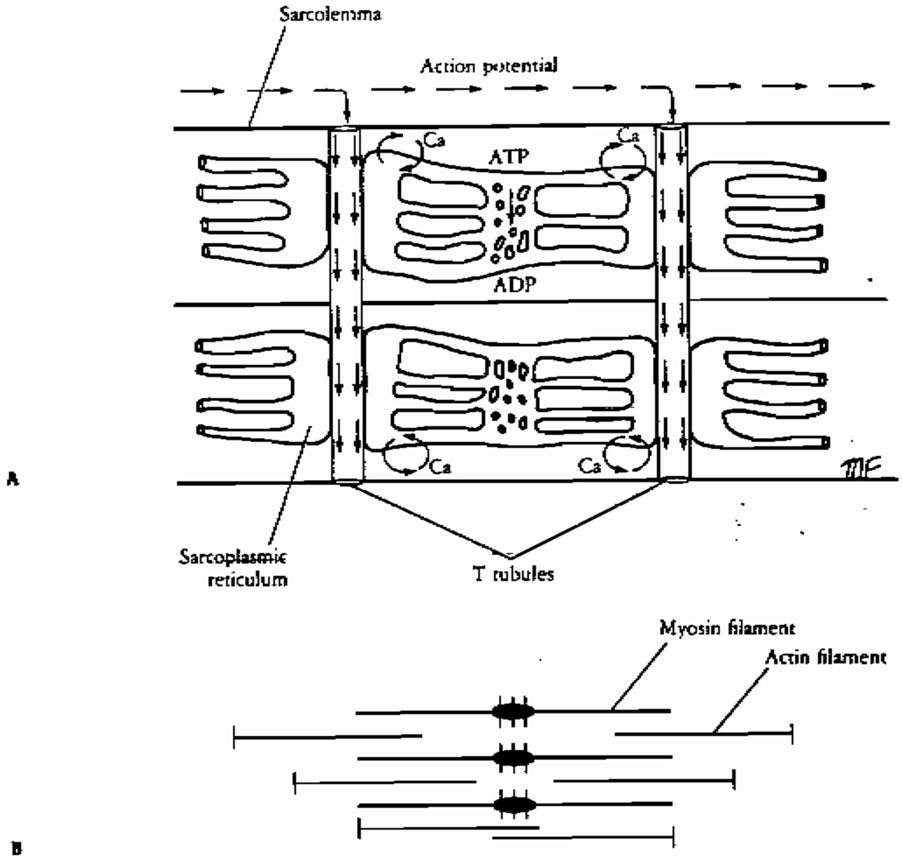
The Functional Unit

The stimulus that the muscle fiber receives that begins the contractile process is transmitted through a nerve called the alpha motor neuron. The cell body of the neuron is located in the anterior horn of the gray matter of the spinal cord. A long fiber called the axon extends from the cell body to the muscle, where it divides into either a few or as many as thousands of smaller branches. Each of the smaller branches terminates in a motor end plate that lies in close approximation to the sarcolemma of a single muscle fiber. All of the muscle fibers on which a branch of the axon terminates are part of one motor unit, along with the cell body and the axon.

The nerve impulse transmitted from the cell body along the axon to the motor end plate causes depolarization of each muscle fiber's sarcolemma and generates an action potential that spreads both along the external surface of the sarcolemma and into the interior of the fiber by way of narrow tubular invaginations called transverse tubules (T tubules). Two transverse tubules supply each sarcomere at the level of the junctions of the A and I bands.

The sarcoplasmic reticulum, which has a large calcium-storage capacity, is composed of anastomosing membranous channels that fill the space between the myofibrils and form large sacs (terminal cisternae) in areas where the membranous channels are close to the T tubules. The combination of two terminal cisternae with a T tubule in the middle is called a muscle triad.[1,4]

When the action potential sweeps down the T tubules, free calcium ions from the terminal cisternae are released into the myofibrils. However,



(A) Longitudinal section of skeletal muscle, showing the pathway taken by an action potential that causes the release of calcium ions from the sarcoplasmic reticulum; the calcium ions are taken up again by the calcium pump. (B) Sliding movements of the actin filaments as a myofibril contracts.

the exact mechanics by which the action potential in the T tubules causes the release of calcium from the sarcoplasmic recticulum is unknown. The release of the calcium ions initiates actin-myosin crossbridge activity and causes muscle tension. When the sarcolemma becomes electrically stable after depolarization, calcium ions rebind to the sarcoplasmic reticulum and the muscle fiber relaxes.[1,3] (Motor units go through a latency or refractory period just after firing and require time to recover before the cycle of depolarization and tension generation can be repeated. therefore, the frequency of firing of motor units is limited by the need for recovery time prior to reactivation).

The motor unit consists of the alpha motor neuron and all of the muscle fibers it innervates. The contraction of the entir muscle is the result of many motor units firing asynchronously and repeatedly. The magnitude of the contraction of the entire muscle may be altered by altering the number of motor units that are activated or the frequency at which they are activated. The number of motor units in a muscle as well as the structure of these units varies from muscle to muscle.

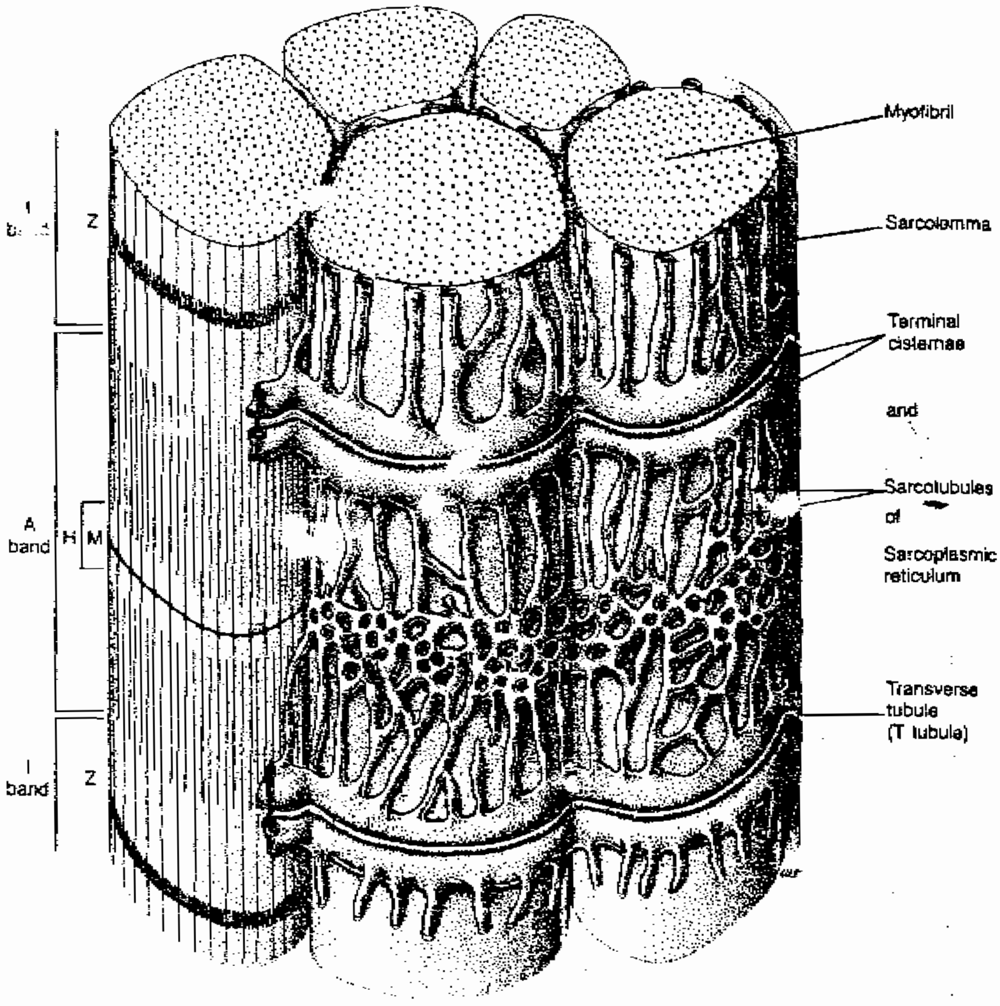
Motor units may vary according to the size of the neuron cell body, diameter of the axon, number of muscle fibers and type of muscle fibers. Each of these variations in structure affects the function of the motor unit. Some motor units have small cell bodies others have large cell bodies. Unit that have small cell bodies have small diameter axons. Nerve impulses take longer to travel through small diameter axons than they do through large-diameter axons. therefore, in the small diameter units, a stimulus will take longer to reach the muscle fibers than it will in a unit with a large-diameter axon.

The size of the motor unit is determined by the number of muscle fibers that it contain. number of fibers may vary from two to three to a few thousand.

Muscles that either control fine movement or that are used to make small adjustments have small-size motor units, and such motor units generally have small cell bodies and small-diameter axons.

Muscles that are used to produce large increments of force and large movements usually have large-size motor units, large cell bodies, and large-diameter axons.

The motor units of the small muscles that control eye motions may contain as few as six muscle fibers, while the gastrocnemius muscles have motor units that contain about 2000 muscle fibers.[3]



The sarcoplasmic reticulum and transverse tubules of a skeletal muscle fiber in relation to myofibril striations. The triple structure where terminal cisternae flank a transverse tubule is described as a triad.