The structure of skeletal muscle biology essay

Skeletal Muscle is a form of fibrous tissue with the fibers arranged parallel to each other. A muscle fiber (cell) is surrounded by the endomysium. A group of these cells is wrapped by fascicles. Bundles of fascicles are covered by the perimysium and bundles of the perimysium are wrapped by the epimysium to form a muscle. The muscle fibers have contractile properties which enable them to move " bony levers in order to produce skeletal movement" 1. The functional unit of the muscle fiber is the sacomere which consists of most importantly, actin and myosin. The actin and myosin are arranged such that during contraction, they can slide over each other thus shortening the muscle2.

Muscles suffer from many diseases, one of which is polymyositis. This is an inflammatory myopathy that affects mainly the muscles of the thorax and those around the torso. It affects all age groups but has been noticed mainly in late childhood and early adulthood. The sypmtomps are nonspecific but results in general muscle weakness and the cause, though believed to be an invasion by the white blood cells, is not very clear10.

2. 0 The Structure of Skeletal Muscle.

In daily life, structures and arrangements of designs are dictated, to a large extent by the purpose and function for which the design is meant for. Knowing that skeletal muscle is made up mainly of fibrous tissues, the arrangement of these tissues and how they are bound together to maintain a particular shape in order to accomplish different purposes (mainly to generate force and produce movement) may to a large extent, define the structure of the muscle4.

At a macro level, the skeletal muscle is composed of bundles of individual muscle fibers, the supporting structure called the basal lamina, and the connective tissue sheaths as shown in figure 1. These connective tissues bind the cells together giving them strength and partly providing mechanical protection2. We can examine these connective tissues and their functions as follows:

2. 1 The basal lamina. This is an extracellular matrix that acts as a scaffold on which a cell sits. It has been realized that apart from providing structural support, the basal lamina can orient and constrain cell during the process of regeneartion3.

2. 2 The endomysium. This is a fine sheath of connective tissue that surrounds each individual muscle cell. The endomysium consist of loosely " interlacing fibers composed mainly of collagen" 4.

2. 3 The perimysium and fascilces. The individual muscle fibers wrapped by the endomysium, are grouped together in what is called fascicles. A layer of fibrous tissue called the perimysium wraps each fascicle4.

2. 4 The epimysium. This is the outside layer that finally wraps the whole muscle. It is composed of " dense irregular connective tissue" 4.

Figure 1

Source: http://www. web-books. com/eLibrary/Medicine/Physiology/Muscular/muscle_structure. jpg

3. 0 The muscle cell

Having described how individual muscle cells are organized into a muscle, it is imperative that we look at the structural composition of the cell itself. Just like many other cells in the body are specialized according to their functions, skeletal muscle cells are specialized to produce force and movement5. The skeletal muscle fiber is thus composed of mainly three structural elements:- the myofibrils, the sarcoplasmic reticulum and the mitochondria, each contributing a unique aspect of muscle function. The entire function of the muscle can be attributed to the shifts in proportions of these three structures6.

3. 1 The Myofibrills. These are cylindrical specialized sub-units within the muscle fiber. They consist of two types of contractile protein filaments-the thin filaments referred to as actin and the thick filaments referred to as myosin. The two most important parameters of the myofibrils are their diameter which determines its strength and the fiber length which determines it contraction velocity and distance over which the fiber can contract. The myofibril consist of two filaments-actin and myosin6, 2.

3. 1. 1 Actin (thin filament). Actin filaments are responsible for regulation of contraction. The actin filament is formed by a “ helical arranged of actin monomers which is an ambiguous protein” 2 (figure 2). Because of the helical nature, a long grove is formed along the filament and the protein troponin is located at intervals along the length of the actin filament. It is troponin which is responsible for turning on contraction2, 7.

Figure 2. The actin molecule. Source: http://www. ucl. ac. uk/~sjjgsca/Muscleslidingfilament1. gif

3. 1. 2 The Myosin (thick filament). Myosin filament is about 150nm long. It has a tail and two heads. The tail is formed by two helical shaped fibers that coil around each other. A collection of several of these helical tails together form a myosin filament (figure 3)4b.

Figure 3. The myosin molecule. Source: http://webanatomy. net/anatomy/myosin. jpg.

3. 2 The sarcoplasmic reticulum (SR). “ Groups of about 200 thick and thin filaments constitute a myofibril”. Each myofibril is thus enclosed in a membrane called the sarcoplasmic reticulum8. The SR membrane stores and releases calcium during muscle contraction and relaxation. The SR can therefore be thought of as the functional unit of the myofibril9.

3. 3 The mitochondria. Found within the cell cytoplasm, the mitochondria are responsible for generation of most of the cell’s energy by the production of adenosine triphosphate (ATP). There are several mitochondria distributed along the length of a myofibril4.

4. 0 The mechanism of muscle contraction

Muscle contraction can largely be attributed to the structure of actin and myosin, their arrangement within the SR and the interaction between them in order to produce force (Figure 4). This type of arrangement allows the thin actin filaments to slide in and out by the action pull of the myosin heads8b.

Figure 4. Actin and myosin arrangement: Source: http://www. exrx. net/Images/ActinMyosin. gif

Muscles are composed of a number of actin and myosin filaments arranged in series in a basic unit called the sacomere. The sacomere consists of a thick filament in the meddle and two thin filaments, one overlapping on each side. The heads of the thick filament attach to the thin filament at the overlap and these heads allow movement in only one direction. When activated, each thick filament head " rachets" repeatedly along the actin, pulling the two actins closer together.

Since the actin are attached to the Z line (The distance between two Z lines form the sacomere), ends of the sacomere (Z lines) are pulled in and the sacomere shortens. The sacomeres are arranged in series so that when the muscle fiber contracts, all the sacomeres contract simultaneously transmitting the force to the end of the muscle. The whole process of contraction described above occurs when the muscle is " electrically" stimulated2b.

5. 0 Muscle stimulation.

" Skeletal muscle cells are stimulated by the motor neurons of the somatic nervous system". The reception of the motor stimulus (action potential) opens the calcium channels allowing calcium which is stored in the SR to be released. The release of calcium causes the release of acetylcholine-Ach (neurotransmitter). The calcium binds to the troponin on the actin filament. Troponin then regulates the tropomyosin which obstructs binding sites for myosin. This allows the tropomyosin to move, unblocking the bonding site.

Myosin then binds to the unblocked site on the actin and applies a pull. This will pull the Z bands towards each other thus shortening the sacomere, causing muscle contraction2b.

However, as calcium is released, the “ ATP-dependent calcium pump is activated” and it continuously pumps calcium back to the SR to be stored again. This leads to a drop in calcium level within the cytoplasm. When the calcium level is too low, the calcium binding action to troponin is terminated, releasing tropomyosin which again blocks the binding site. This stops the interaction between actin and myosin thus relaxing the muscle2b.

6. 0 Muscle Diseases

There are a number of muscular diseases and disorders ranging from acquired, familial to congenital. Limiting ourselves to one of the acquired disorders of the muscles, let’s look at polymyositis.

6. 1 Polymyositis (PM).

PM is a type of muscle inflammatory myopathy. Just like the name suggests, this disease causes inflammation of the muscle fiber. Although the causes of the disease are not well understood, it is believed that PM begins when white blood cells, spontaneously invade muscles. This can result in severe muscle weakness. Polymyositis is a persistent disease characterized by periods of increased and reduced or no symptoms. PM affects mainly the muscles of the thorax and is more common in women than men. It is said to affect all age groups although is it commonly noted in early childhood or 20s10.

Key pathologic and diagnostic features of the disease.

Endomysial inflammation. This is the inflammation of the outer connective tissue that surrounds the muscle fiber. This is done by the white blood cells that leave the blood and enter the tissue, somehow confirming the earlier assertion that the PM begins when white blood cells invade muscles.

Invasion of myofibers by autoaggressive lymphocytes. This is when the T lymphocytes begin to attack the intact myofibers. Unlike in muscle dystrophy where inflammation is associated with degenerating myofibers, the invasion of T lymphocytes causes inflammation of health myofibers in PM. This causes inflammation of healthy myofibers.

Other diagnostic features that may not be exactly specific to PM include “ myofiber necrosis, myophagocytosis, myofiber atrophy and fibrosis”, a feature of chronic PM10, 11.

7. 0 Conclusion

Human movement is only possible because of the action of muscle contraction. Voluntary contraction of muscle is made possible by the somatic nervous system which sends out an action potential activating the contraction process. The process is accomplished by the sliding of myosin and actin over each other.

Many diseases and disorders affect muscles, prominent among them is muscular polymyosis which causes inflammation of the muscles mainly around the torso. It’s believed to be caused by the unwanted action of the white blood cells and the symptoms include muscle weakness.