THE SCIENCE OF MUSCLE TESTING

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Chiropractic student Rich Silver loves to enthuse about his "art" and presented us with some fine material. Rich is now located in Sunnyvale, California (south of San Francisco) - took his Instructor Training Workshop here in Pasadena in September 1978.

The purpose of this lecture series was to present an eclectic body of knowledge which both supports and aids in the understanding of some basic fundamentals underlying muscle testing and muscle balancing. The primary topics of this three part presentation included: 1) The Biomechanics of Muscle Testing, 2) The Ultrastructure of Skeletal Muscle Tissue, and 3) The Physiology of Lymphatic Congestion. The following discussion will highlight the major points conveyed by these lectures.

The Biomechanics of Muscle Testing

To consider the biomechanics of muscle testing, there are several important factors that influence the proper delivery and accurate interpretation of the test. To help determine how much force to apply for a particular muscle test, the first two factors which deserve thought are leverage and the force of gravity.

The leverage factor is determined by the distance between the spot where force is applied and the joint where movement begins. For example, the standard tests for pectoralis major clavicular, latissimus dorsi, and supraspinatus have a leverage factor from the receiver's wrist to shoulder. In contrast, when testing teres minor and subscapularis, there is only a leverage factor from the wrist to the elbow.

The gravity factor is the force with which the earth pulls all objects towards its surface and it equals approximately 15 lbs. per square inch, a significant force. Testing an individual lying supine and given just the consideration of leverage and gravity, the supraspinatus test has a big leverage factor and works with gravity whereas the subscapularis test has a small leverage factor and works against gravity. When working against gravity and with small leverage factors, more force may be required for accurate interpretation.

Some other factors to consider with respect to how much force to apply include the size of the muscle group being tested and the body position assumed by the tester. Tester body position, the leverage factor, and the use of gravity can all be manipulated by the skillful tester in a way that will accommodate the development of a consistent and repeatable test force. It is the development of a consistent and repeatable force which ultimately enables the tester to accurately interpret a muscle test and it is therefore encouraged that students of the art experiment and explore their skills using these principles as a helpful guide.

The process of muscle test interpretation includes some additional considerations. It is useful to know what muscles assist the group in question since the assisting muscles will be heavily recruited when the primary muscle of interest does not respond. When this occurs, extraneous movements are often produced in response to the test; for example, the bending of the elbow during a latissimus dorsi test due to the recruiting of biceps. Even though the primary movement of biceps is to flex at the elbow, it assists with holding the arm in against the body. Therefore, when latissimus dorsi does not respond to a test, the biceps gets recruited more heavily than would otherwise be indicated.

A skillful tester will pick up little extraneous movements like elbow flexion during a latissimus dorsi test and not be fooled by the pparent strength. Another classic example is the turning out of the foot during a gluteus medius test in an effort to use quadriceps. Proper positioning and observing extraneous movements are important tools for interpreting test results successfully.

In addition, the presence of multiple muscle weakness will influence the sensation of the response received by the tester. For instance, during a gluteus medius test, the fascia lata and part of the quadriceps assist in the action. The response to the test will therefore be perceived differently if all three muscles are weak as opposed to just gluteus medius.

A final note on successful test interpretation resides with the muscular integrity and overall health of the tester. Since the perception of force and tension appears to have its origin in tissues associated with the tester's muscles, the degree to which this individual maintains efficient body mechanics through balanced musculature will influence the ability to correctly interpret the sensation of delivering a muscle test. Thus, a tester with multiple weaknesses may receive a false impression of strength from a muscle test and it is therefore of paramount importance to aspire towards the highest standards of personal health in order to provide the most effective and beneficial service possible.

The Ultrastructure of Skeletal Muscle Tissue

When a muscle group does not respond appropriately to testing, there is commonly some lymphatic congestion involved. But before considering the physiology of lymphatic congestion and its effect on muscle tissue, it is first helpful to examine the properties of normal muscle function. The processes which enable muscle contraction to occur are ultimately dependent on lymphatic integrity. Therefore, the following discussion will serve as a basis for understanding why muscles go weak in the presence of lymphatic congestion.

Muscle tissue is characterized by its intricate and orderly structure. This structure has been the subject of much study and, if one were to take a fantastic voyage deep within the microscopic world of skeletal muscle, its physical properties would reveal many interesting characteristics. Referring to Figure A, a small section of whole muscle has been blown up to produce the illustrion in Figure B. This represents the first level of magnification to be considered, the cellular level. Muscle cells can be very long and often extend the entire length of the muscle. If the development of skeletal muscle is followed in the embryo,it is noticed that many immature cells fuse end-on-end to form what will become a mature muscle cell or muscle fiber. It is here that muscle receives nerve endings, at the level of the muscle fiber. When stimulated, the nerve endings will transmit a wave of excitation that essentially spreads throughout the entire substance of the fiber. Sometimes as many as 400 muscle fibers can receive nerve endings from a single neuron[2] resulting in gross simultaneous contraction. In muscles controlling fine movements, such as in the eye, the ratio of muscle fibers to neurons can be as small as 3 to 1.

Figure C represents the next level of magnification, the subcellular level. At this magnification, a mature muscle cell can be seen packed with cylindrical structures called myofibrils. It is the number of these myofibril structures which varies in accordance with muscular activity whereas the number of cells is genetically fixed and remains constant. Thus, mature muscle tissue never acquires more cells with exercise; the existing cells simply get larger due to an increased content of myofibrils.

A single myofibril demonstrates an organized pattern which is shown in Figure D. The pattern is produced by a special arrangement of filaments inside the myofibril. These filaments are the protein structures which constitute the contractile machinery of skeletal muscle. The degree of magnification has now reached a molecular level and is graphically represented by Figure E.

Notice that there are thick and thin filaments arranged in parallel with areas of overlap. Upon further magnification (Figure F), thick filaments are observed to send projections out to thin filaments in the areas of overlap. These projections or crossbridge structures are of great functional significance because they provide an attachment site for thin filaments and also have the capacity to swivel back and forth like oars of a row boat. In addition, the substance which provides the energy for contraction is housed in the crossbridge heads. This substance is calle ATP and will be of great significance in considering the effects of lymphatic congestion.

When contraction occurs, muscle length shortens. This accomplishment is accounted for by the following sequence of events: 1) In the presence of calcium and ATP, the crossbridge heads bind to the thin filaments. 2) An explosion of energy provided by the ATP[3] immediately follows, causing a stroke or rowing movement by the oar-like crossbridges, 3) With the energy of more ATP, the attachment between thick and thin filaments is broken and the oar-like arms return to their original position. 4) The process is repeated again and again in rapid succession; referring back to Figure E, the ultimate effect of this mechanism is the sliding of thin filaments towards the midline. Since the thin filaments are all anchored at the ends to a z-line, the z-lines are drawn closer together resulting in a shortening of the entire unit.

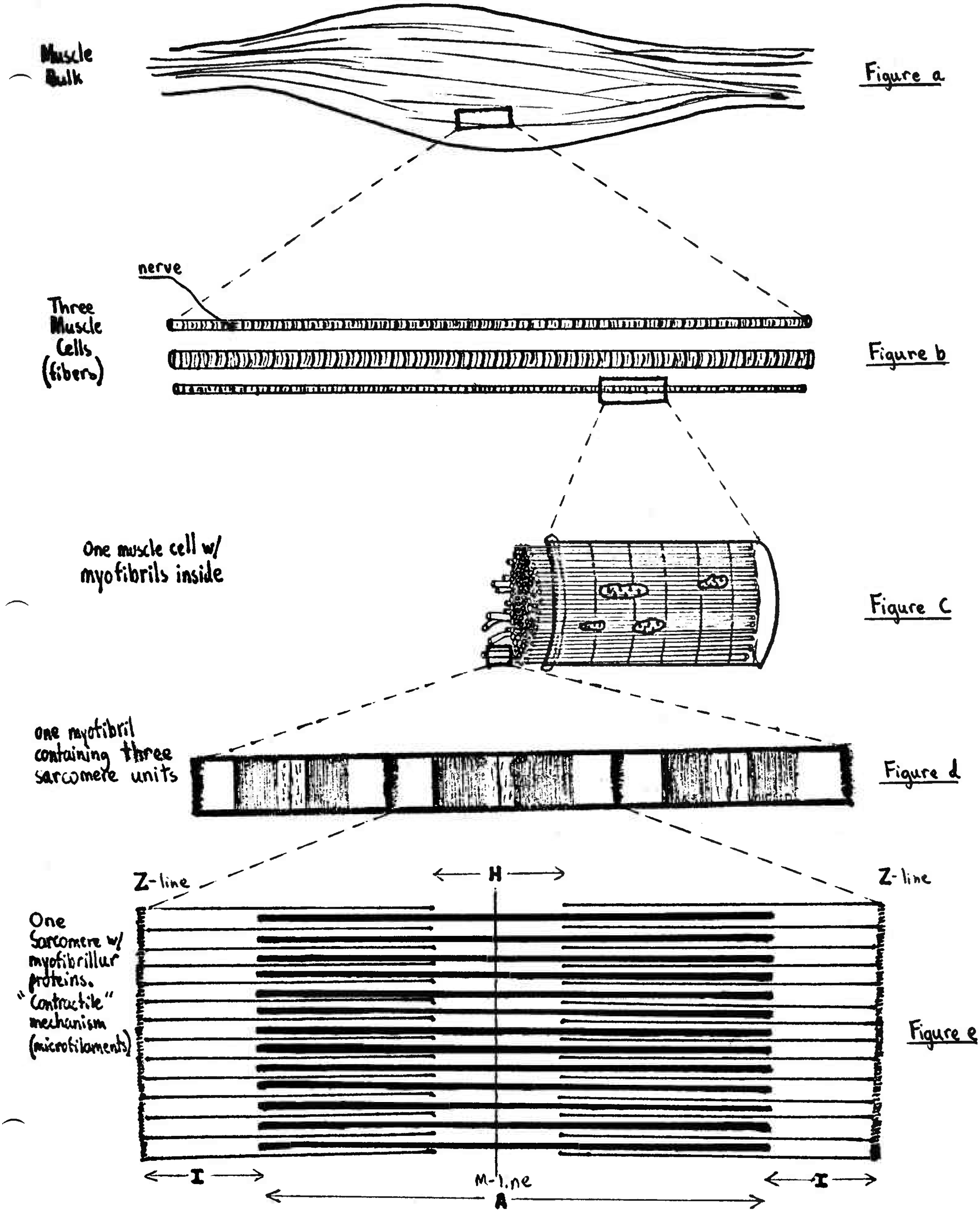
In summary, the ultrastructure of skeletal muscle tissue has provided present theory for how muscle contraction occurs. The structure is very well organized and the protein filaments comprise the contractile machinery while ATP provides the explosion power required for movement. ATP in the crossbridges is much like gun powder in the barrel of a gun. But the trigger can be pulled and nothing happens if the gun is not loaded first. Now we can speculate on what might cause the barrel to be empty during a muscle test.

The Physiology of Lymphatic Congestion

How does lymphatic congestion cause a weak muscle test? The lymphatic system is a circulatory system. It comprises an extensive elaboration of vessels and regional lymph nodes. While the vascular system delivers nutrients with arterial blood and removes metabolic waste products with venous blood, the lymphatic vessels primarily drain the tissues of excess fluid and filter foreign bodies out of general circulation by way of the nodes. In this way, the lymphatics maintain a balance in cellular plumbing; they prevent the build up of excess fluids.

If the lymphatic system becomes locally congested, the excess fluid that accumulates in that area causes pressure to back up. The result is a reduction in ability to deliver blood to the insulted area. The degree to which local blood supply is reduced depends on the magnitude of the problem. Total lymphatic obstruction can occur and is almost always the result of long-standing chronic conditions. For example, in the presence of cancer, local lymphatics are overwhelmed regularly by metabolic waste products. The result is complete lymphatic obstruction followed by a process of fibrosis[4] and permanent blockage. Only repeated insults result in permanent blockage. When local lymphatics shut down in this manner, metabolic wastes find there way to other distant lymphatics and even the blood itself. This is how cancer is able to spread from one area of the body to another; it involves a progressive and systematic shut down in tissue plumbing, beginning with the lymphatics.

Extrafusal Muscle: SKELETAL MUSCLE



Myofibrillar Proteins
Contractile Mechanism :

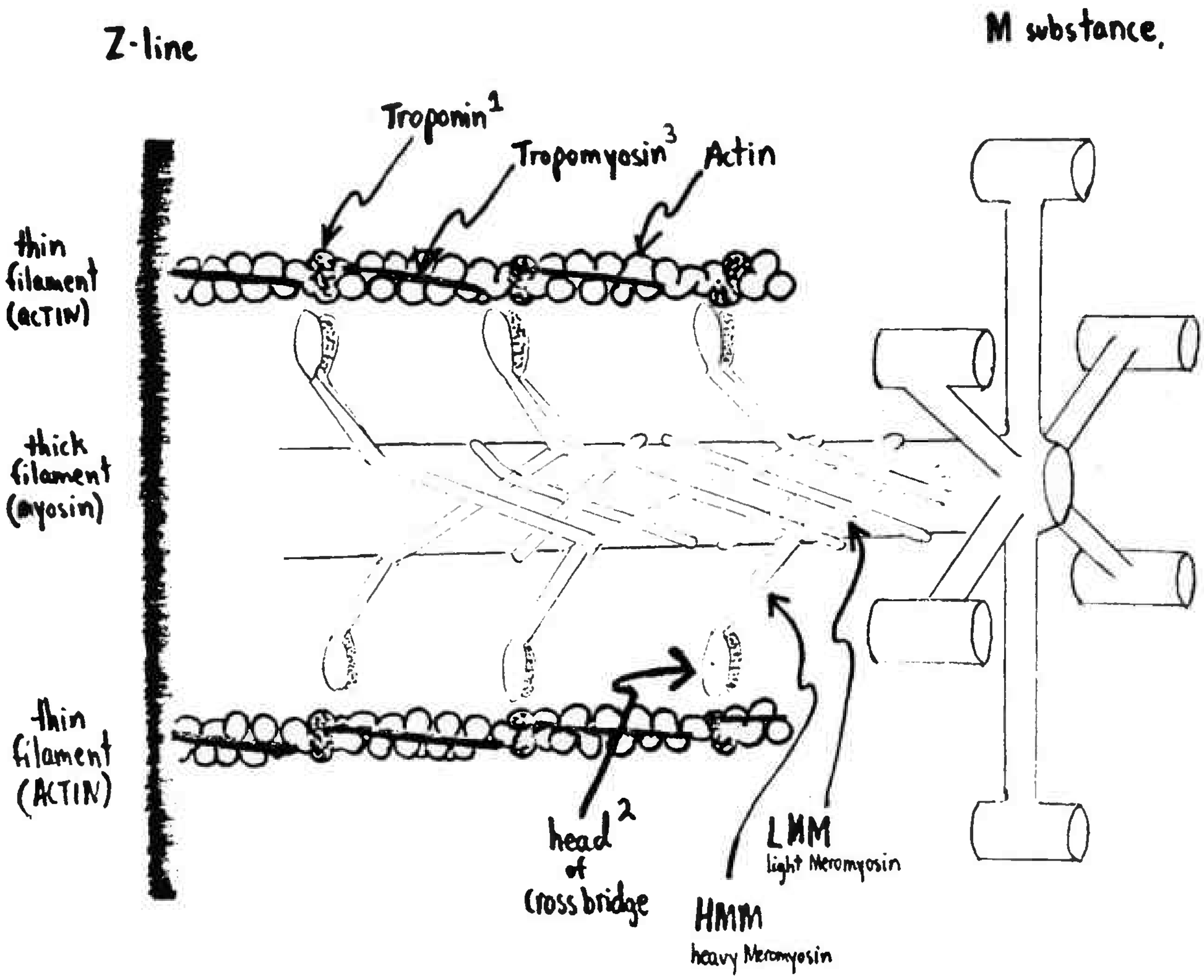


Figure f

[1] site for Calcium
[2] site for ATP
[3] blocks crossbridge interaction

Part of Cross Section of Myofibril showing organized arrangement of thick & thin filaments:

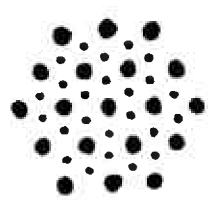


Figure g

Taken from Astrand & Rodahl, *Textbook of Work Physiology*
Taken from Edington & Edgerton, *The Biology of Physical Activity*

This represents an extreme example with lymphatic shut down. But a question which has direct implications for the student of muscle testing is: What is the effect of a relatively mild local lymphatic congestion? Recall that in order for muscle to contract, ATP must be present to provide the energy. The importance of ATP in life processes cannot be overemphasized. Anything that involves movement in the body requires ATP; for instance, the contractions of the digestive tract, the process of cell division, and even the whipping movements of the tail-like flagella attached to sperm cells. Sperm has a concentration of ATP at the attachment site of the flagella that propels it towards the egg. Movement and ATP go hand in hand.

In short, ATP production occurs in all cells throughout the body to meet local energy demands. ATP is the end-product of carbohydrate and fat metabolism; i.e., it is why we eat. It is the energy that we ultimately derive from our food.

In addition, the cellular manufacturing of ATP from carbohydrates and fats is almost completely dependent on oxygen. For all intents and purposes, without the availability of oxygen to the tissues, ATP production is functionally gone. The purpose of respiration is to provide the oxygen necessary to generate ATP production in all tissues and it is the blood that must deliver this oxygen. Oxygen that enters the lungs is absorbed into the blood and distributed to all the cells in the body where it can drive ATP production.

In retrospect, it is worthwhile to recognize just how much ATP skeletal muscle utilizes. Considering the number of muscle cells in a given muscle group, the number of myofibrils per cell, filaments per myofibril, and crossbridges per filament, there are literally millions upon millions of crossbridge heads to load with ATP for a complete and integrated contraction to occur. With local lymphatic congestion, the ultimate effect is a reduced oxygen delivering capacity with reduced ATP production and incomplete crossbridge loading. This explains how a muscle group can receive the signal to contract but in the presence of local lymphatic congestion, cannot generate normal forces of contraction.

In conclusion, it is hoped that from the information presented in this series, your horizons will expand both intellectually and through your capacity to provide services for improving the human condition.

FOOTNOTES

[1] supine: lying on back

[2] neuron: nerve cell

[3] ATP: Adenosine Triphosphate, a molecule with a very unstable high-energy chemical bond. Breaking of the bond with subsequent release of energy provides the impetus for movement. The bond breaks from mechanical stress when crossbridge links are formed.

[4] fibrosis: development of scar tissue due to infiltration with fibrous connective tissue.

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