

Experiment AM-2: Skeletal Muscle, Summation and Tetanus

Background

About 40% of the total body mass of a human is skeletal muscle. Skeletal muscle is intimately associated with the skeletal system and, combined, these muscles and bones are responsible for supporting and moving the body. While skeletal muscle fibers have sarcomeres and the same banded appearance, different muscles can contract in different ways. For example, some are relatively weak and fatigue resistant, while others are strong but fatigue quickly. These features may be explained in terms of the biochemical properties of muscles. The muscle fibers found in most mammalian skeletal muscles are either fast or slow twitch-types. Each type has a different myosin isoform, with different rates of ATPase activity and cross-bridge binding. Within the group of fast-twitch fibers, there are fibers that use glycolysis and oxidative phosphorylation. There are also fast-twitch fibers that just use glycolysis; this group is less reliant upon oxygen and is much stronger than the fibers using phosphorylation. However, these stronger “glycolytic” fibers breakdown glucose very inefficiently; so, they fatigue more quickly, have diminished glucose levels, and accumulate lactic acid.

Most skeletal muscles are composed of some combination of the different twitch-type fibers. Interestingly, a motor neuron makes only one synapse on each of their target fibers, and the muscle fibers innervated by a motor neuron are all of the same type. Therefore, stimulation of a particular motor neuron will create a contraction of only one muscle fiber type; this property is used by the brain to recruit different muscle fibers into a contraction. A motor unit is composed of only one type of muscle fiber and recruitment allows the increase in individual motor units. Activity in descending tracts excites the spinal motor neurons; but, the size of the cell bodies and the activation thresholds of these neurons are different. Motor neurons that supply weak, slow, oxidative fibers have the lowest threshold; those innervating fast, intermediate-strength oxidative fibers have higher thresholds; and those that supply the fast, strong, glycolytic fibers have the highest thresholds. In this way increasing the amount of activity descending from the brain activates progressively more motor neurons, and more of the stronger muscle fibers, into the response.

This will be simulated in the following experiment by slowly increasing the voltage applied directly to the muscle to recruit more muscle fibers into the contraction. In addition, the amount of contraction is dependent upon stimulus frequency.