7.4.7

Skeletal Muscle Fiber Types

Classically, skeletal muscle fibers can be categorized according to their speed of contraction and their resistance to fatigue. These classifications are in the process of being revised, but the basic types include:

1. *Slow twitch oxidative (type I) muscle fibers,*
2. *Fast-twitch oxidative-glycolytic (Type IIA) muscle fibers, and*
3. *Fast-twitch glycolytic (Type IIX) fibers.*

Fast-twitch (type II) fibers develop tension two to three times faster than slow-twitch (type I) fibers. How fast a fiber can contract is related to how long it takes for completion of the cross-bridge cycle. This variability is due to different varieties of myosin molecules and how quickly they can hydrolyze ATP. Recall that it is the myosin head that splits ATP. Fast-twitch fibers have a more rapid ATPase (splitting of ATP into ADP + Pi) ability. Fast-twitch fibers also pump Ca^{2+} ions back into the sarcoplasmic reticulum very quickly, so these cells have much faster twitches than the slower variety. Thus, fast-twitch fibers can complete multiple contractions much more rapidly than slow-twitch fibers. For a complete list of how muscle fibers differ in their ability to resist fatigue see the table below:

	Slow Twitch Oxidative (Type I)	Fast-twitch Oxidative (Type IIA)	Fast-Twitch Glycolytic (Type IIX)
Myosin ATPase activity	Slow	fast	fast
Size (diameter)	Small	medium	large
Duration of contraction	Long	short	short
SERCA pump activity	Slow	fast	fast
Fatigue	Resistant	resistant	easily fatigued
Energy utilization	aerobic/oxidative	both	anaerobic/glycolytic
capillary density	High	medium	low
mitochondria	high numbers	medium numbers	low numbers

Color	red (contain myoglobin)	red (contain myoglobin)	white (no myoglobin)

In human skeletal muscles, the ratio of the various fiber types differs from muscle to muscle. For example, the gastrocnemius muscle of the calf contains about half slow and half fast type fibers, while the deeper calf muscle, the soleus, is predominantly slow twitch. On the other hand, the eye muscles are predominantly fast twitch. As a result, the gastrocnemius muscle is used in sprinting while the soleus muscle is important for standing. In addition, women seem to have a higher ratio of slow twitch to fast twitch compared to men. The "preferred" fiber type for sprinting athletes is the fast-twitch glycolytic, which is very fast, however, most humans have a very low percentage of these fibers, < 1%. Muscle biopsies of one world class sprinter revealed 72% fast twitch fibers and amazingly 20% were type IIX. The Holy Grail of muscle research is to determine how to change skeletal muscle fibers from one type to another. It appears that muscle fiber types are determined embryologically by the type of neuron that innervates the muscle fiber. The default muscle appears to be slow, type I fibers. If a muscle is innervated by a small neuron that muscle fiber will remain slow, whereas large myelinated fibers induce the fast isoforms. In addition, the frequency of firing rates of the neuron also alters the muscle fiber type. Research suggests that humans have subtypes of fibers, making up about <5% of the muscle, that are dually innervated and allow for switching between slow and fast to occur. Generally, it would appear that genetics determine the type of innervation that occurs and subsequent muscle fiber types and that training may be able to slightly alter the ratios due to the dually innervated muscles. However, since <5% have dual innervation, genetics is going to play a much greater role in your fiber types than your training.