MAKING THE MOST OF MUSCLE

There's more to muscle than fast-twitch and slow-twitch

By Dario Fredrick

[Velo News, Vol. 33/No. 19, December 20, 2004]

Most cyclists will tell you they've heard of slow- and fast-twitch muscle fibers, and some may take the labels somewhat literally, thinking of a pure sprinter as fast-twitch and an ultra-endurance cyclist as slow-twitch. To some degree this is true, but it's also an oversimplification.

Understanding the differences among muscle-fiber types can give us some insight as to why two talented riders of similar body weight, like Jan Ullrich and Alessandro Petacchi, can have such different natural abilities, or explain how Lance Armstrong bloomed from a one-day classics rider to a six-time Tour de France champion. It can also show how adopting a higher pedaling cadence can improve performance for some cyclists. Cycling intensities are not only a function of proportions of aerobic and non-aerobic energy delivery, but of specific muscle-fiber-type recruitment.

MUSCLE FIBER TYPES

Within the slow- and fast-twitch categories, scientists have identified three main fiber types in human muscle: Type I, Type IIa and Type IIb. Type I is slow-twitch fiber, while fast-twitch fiber is subdivided into Type IIa and Type IIb (Table 1).

• Type I — Type I fibers are called slow-twitch because their Vmax (maximal shortening velocity or speed of contraction) is slower than fast-twitch fibers. Also referred to as "slow-oxidative" fibers, Type I fibers have a high aerobic capacity. Aerobic metabolism is a more efficient energy pathway than non-aerobic metabolism, providing much more energy per unit of fuel and allowing the use of multiple types of fuel (glucose, fats, lactate). As a result, Type I fibers are more efficient than Type IIa and IIb. Type I fibers do not produce forces as great nor as quickly as the fast-twitch types, but they are very fatigue-resistant.

• Type IIb — Fast-twitch muscle fibers have the highest Vmax and produce the greatest force, but also suffer the highest rate of fatigue. Type IIb fibers are called “fast-glycolytic” because they rely primarily on glycolysis (anaerobic metabolism) for fuel. They have a large anaerobic capacity but little potential for aerobic fueling. Their main fuel source is glycogen, and since glycolysis is a fast energy-delivery pathway, they can burn through glycogen stores quickly. Glycogen can not be replenished during exercise, and its depletion results in fatigue.

• Type IIa — The Type IIa fibers are the intermediate fast-twitch fibers. These “fast-oxidative glycolytic” fibers can be thought of as a cross between Type I and Type IIb fibers as they have the capacity for both aerobic and anaerobic metabolism. Type IIa fibers produce more force and have a higher Vmax than Type I, but less than Type IIb fibers. They have a low to moderate rate of fatigue depending on the energy pathway and fuels they rely upon. Perhaps most important to endurance cyclists, Type IIa fibers can be trained to improve their aerobic capacity and rely upon it more while increasing efficiency and reducing their rate of fatigue.

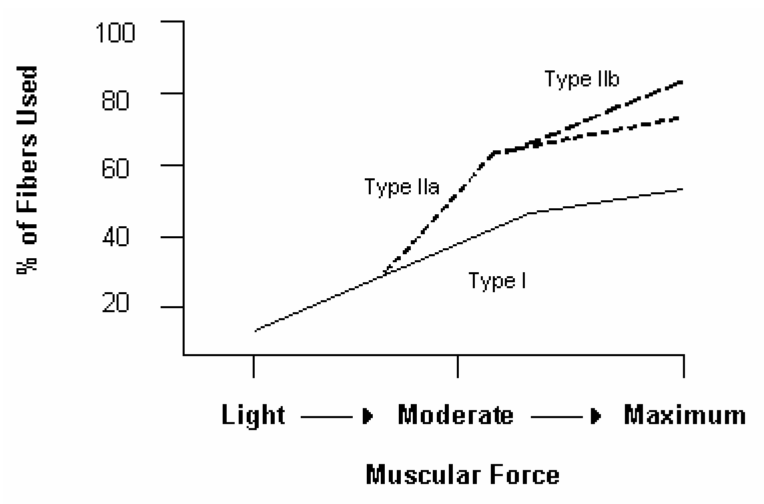
Table 1 - General characteristics of muscle fiber types

	Slow-twitch fibers	Fast-twitch fibers	
Characteristic	Type I	Type IIa	Type IIb
Main energy pathway	Aerobic	Aerobic or Anaerobic	Anaerobic
Maximal force	Moderate	High	Highest
Efficiency	Highest	Moderate	Low
Fatigue resistance	High	Moderate	Low
Primary fuels used	Glucose, fats, lactate	Glucose, lactate, glycogen	Glycogen

FIBER RECRUITMENT

As force increases from light to maximum (see Figure 1) the recruitment of fiber types expands from Type I to include Type IIa, then Type IIb fibers. Aerobically fueled Type I fibers contribute significantly to all power outputs, even in an all-out sprint. Thus, there is a large aerobic component to all cycling workloads even beyond one's performance threshold. Furthermore, since Type IIa fibers can produce a high level of force, maximizing aerobic capacity can improve endurance not only for low to moderate workloads, but for high sustainable power outputs as well.

Figure 1 – Fiber recruitment by muscular force



OPTIMIZING TRAINING WITH FIBER TYPES

With a greater understanding of fiber types we can see the importance of maximizing aerobic capacity for endurance-cycling performance. Endurance training of approximately 70-85 percent of maximal steady state heart rate (MSS = 30-minute performance threshold) can improve the aerobic capacity of Type I fibers, while training at 85-93 percent of MSS can improve the aerobic capacity of Type IIa fibers. At 90-93 percent of MSS, not only do the Type IIa fibers increase their aerobic qualities, some Type IIb fibers convert to Type IIa. Also, if training intensity is always kept below 85 percent of MSS, Type IIa fibers can convert to Type I.

Thus, for competitive cyclists, it is important to train accelerations or sprints to maintain the peak anaerobic capacity of Type IIb fibers for quick, high power demands, and also to maintain the high aerobic capacity of Type IIa fibers for moderate to maximum sustainable power.

While a natural predominance of one muscle-fiber type over another may be genetically determined, training can affect the qualities of muscle-fiber types. For example, ace sprinter Petacchi is gifted with plenty of Type IIb fibers, and he probably avoids training at intensities that convert Type IIb fibers to Type IIa to maintain his maximal power. Both his genetic gifts and his training may explain why he can't climb or time trial with Ullrich despite their similar size (although Petacchi would likely beat him in a sprint).

Armstrong, on the other hand, has trained his aerobic capacity (Type I and Type IIa fibers specifically) to the highest degree, perhaps forgoing his ability to dominate single-day classics and sprint finishes in the same manner as he dominates climbing and time trial stages in the Tour.

CADENCE AND BIOMECHANICS

How hard and fast you pedal determines which muscle-fiber types are recruited. For example, if you ride a relatively low cadence for moderate to hard efforts (i.e., under 70 rpm climbing and under 90 rpm on flat terrain), increasing your cadence by 5-15 rpm may improve efficiency and endurance while reducing fatigue.

These improvements result from a greater contribution of aerobically fueled fibers (Type I and IIa) and less reliance on Type IIb fibers because force for a given power output is reduced. Since power is the product of angular force (torque) and cadence, increasing cadence while maintaining power would result in a reduced force requirement.

Armstrong is an extreme example of this. He has significantly increased his cadence from his pre-cancer days, reducing the force component for his sustainable power. However, there is a point at which cadence increases beyond the capacity to apply force efficiently throughout the pedal stroke.

Similarly, optimizing biomechanics can improve endurance and reduce the rate of fatigue. For a given pedal stroke, applying force more evenly around the whole of the pedal revolution can reduce peak force for each pedal stroke. Reducing peak force puts less dependence on the highest-force fibers. Relying less on Type IIb fibers whenever possible is favorable to cycling performance, particularly when critical times in a race require large power outputs, specifically Type IIb recruitment. If glycogen stores are prematurely depleted and Type IIb fibers are fatigued, one's peak and maximum sustainable power will be significantly limited.

SUMMING IT UP

While we may each have a genetic predisposition to either slow- or fast-twitch muscle fiber, we can train specifically to maximize a particular aspect of cycling performance. How hard you pedal, how fast you pedal and how you apply force around the pedal stroke all can affect performance by determining which fiber type gets recruited. Maximize your aerobic capacity and biomechanical efficiency and you will not only be flexing your muscles when pedaling, you'll be flexing the right type.

Dario Fredrick, M.A. is an exercise physiologist, founder and head coach for Whole Athlete™. He can be reached via www.wholeathlete.com.