Muscle Structure and Function

(From 'Lore of Running' 4th edition- Prof Tim Noakes, MBChB, MD, DSc, FACM, Hon FFSEM(UK)

The subject of muscle structure and muscle function will take more than one letter, as altitude training will also come under this heading. For those who wish to go further into the chemistry of muscle cross-bridge cycling etc., there are pages (Lore of Running 4th Edition) of very clear explanations and diagrams, following the muscle's response in sequence from its first impulse from the brain. In these letters, I shall only attempt to cover the sections in the book, which may be helpful to the coach's understanding of the muscle's functions and the implications for training.H.G.L

Types of muscle fibres

In line with the most modern classification of muscle fibre types, fibres are either defined as **Red, Type 1, slow-twitch, (ST), OR, White, Type 2, fast-twitch, (FT)** fibres. The understanding is that the Type 2 fibres (FT) contract so rapidly because they have a high myosin ATPase activity, whereas Type 1 fibres (ST) have a lower myosin ATPase activity. However, it now seems that the situation is not quite this simple; the myosin ATPase activity is not simply either fast or slow and there may be varying grades of fastness or slowness among the Type 1(ST) and Type 2 fibres(FT). Thus, the Type 1(ST) fibres of some athletes may have contraction speeds that approach those normally found in Type 2(FT) fibres.

In addition, the Type 2 fibres(FT) can be divided into at least five subtypes: 2a,2b,2c,2ab and 2ac. The Type 2a fibre(FT) is believed to be a Type 2 fibre that is also adapted for endurance exercise. The Type 2b(FT) fibre conforms to the classical (very fast and powerful) Type 2 (FT). The Type 2c fibre is of uncertain origin, and maybe an uncommitted primitive fibre, capable of developing into either a Type 2a or a Type 1 fibre. More recently the Type 2c fibre has been named the Type 2x fibre. *In vitro* studies show that Type 2x fibres produce about twice as much power (force at speed) as Type 2a fibres, which are about five times more powerful than Type 1 fibres.

Extracts (shortened - from correspondence with Prof Noakes)

The physiological principles from which I begin are:

- First, that muscles adapt exactly to the predominant stimulus to which they are exposed.
- And second, that technique is specific to the speed at which it is done. This is why skills must be practiced at the exact speeds at which they will be needed in competition.
- I do not believe that energy systems(aerobic and anaerobic) can be so easily compartmentalized. Physiologists are trying to design programmes according to physiological principles that we do not fully understand.
- You need to start thinking muscle recruitment and strength, not metabolism and power systems as the basis for training programmes. We are then likely to be closer to a real understanding of the real changes with training that determine performance changes. Indeed all so called anaerobic training may indeed be aerobic.
- My model is that the muscle has to be trained so that its power output is increased so that it can then access more of the energy systems that are inherently present in the muscle. Emphasis must be on increasing the power of the muscle and its fatigue resistance; the energy is always there. The point again is that in my view, the training adaptations that are most important are in the fibre types and the power that they can produce.
- You are actually adapting the recruitment patterns and the strength of the muscle fibres. Train the fibres that will actually be needed in the race at the contraction speeds and powers that they will need to perform in the race.
- The only real physiological principle that I think is beyond doubt is that high intensity training is necessary to swim short distances fast. Whenever the training is prolonged – perhaps more than 60 seconds, the recruitment pattern is altered and the training effect is on the development of fatigue resistance – ie., you can keep going at a high intensity with only a small fall in performance.
  So the key is to get the correct balance of both.

Specificity of Training

In studies lasting up to twelve weeks, enzyme concentrations, appear to show a gradual and progressive increase. At present it seems that the rate and magnitude of these changes is a function within limits of the total amount of muscle contractile activities. The rate can be increased either by performing more contractions in a given time period (increasing exercise intensity) or by maintaining the same frequency of contraction for a longer period (increasing exercise duration).

As will be discussed, it seems that the former method of increasing exercise intensity may produce more rapid and greater results than the latter, but at a greater risk of overtraining

The first practical point of this research is that there is a limit to the extent to which the mitochondrial enzyme can adapt and this limit is reached more quickly, with less total training time, by performing high-intensity exercise of short duration than by running at much lower intensities for very much longer.

What practical value can be derived from this knowledge? Firstly, mitochondrial adaptations to training only occur in the trained muscle and then in muscle fibres that are active during these specific exercises. This indicates that when training for a particular event or sport, an athlete must concentrate on utilizing the correct muscle groups, and, more specifically, the appropriate muscle fibres and the appropriate metabolic pathways in those fibres. This wisdom underlies an important principle of training, known as the 'specificity of training'

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