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Coaching Applications

Part I: Training Fast Twitch Muscle Fibers: Why and How

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Abstract

With the finding that short, intense sprints can improve aerobic capacity (Tabata, et al., 1996), there has been a huge increase in the number of experts who advocate this kind of training over traditional endurance training. Several successful swim coaches are among those recommending more high-intensity training while an equal or even greater number are warning of the pitfalls of training in this manner. A theory is presented in this paper that high-intensity training is essential for improving aerobic endurance. An argument is also presented for a balanced approach to training that includes adequate quantities of moderate-, and low-intensity swimming.

Introduction

In 1996 Dr. Izumi Tabata and associates published the results of a study that challenged traditional assumptions about endurance training. These researchers reported that training with a series of short sprints at very fast speeds was just as effective for improving VO_{2max} as traditional endurance training at moderate speeds. High-intensity training, as it was termed, also produced an additional benefit. The group that trained with sprints improved their anaerobic capacity by 28% while the traditional endurance-training group did not improve on this measure. Dr. Tabata's results were no "fluke". They have been replicated in several additional studies.

The major purpose of this paper will be to describe a theory that explains why high-intensity training can improve aerobic capacity. Additional purposes will be to outline some types of repeat sets that are effective for training fast twitch muscle fibers and to describe some questions that need to be answered about their training.

Recruiting fast and slow twitch muscle fibers

The reason why high intensity training increases aerobic capacity is probably related to the way that fast and slow twitch muscle fibers are recruited during work. At low levels of effort it is primarily the slow twitch muscle fibers that do the work. When the effort increases, fast twitch muscle fibers will be recruited to assist (not replace) their ST counterparts.

Since training that approaches and surpasses VO_{2max} speeds is probably necessary to recruit fast twitch fibers into the effort, it is no wonder that improvements of VO_{2max} have been reported where athletes trained with very short, intense efforts. When the pool of muscle fibers capable of taking up additional oxygen has been increased, the result should be an improvement of VO_{2max}.

Evidence for High Intensity Training

High intensity training also produces endurance benefits that are not achieved during low- and moderate-intensity training. In most studies, subjects who performed high-intensity training also improved buffering capacity and lactate removal rates, while those engaging in moderate intensity training did not (Edge, Bishop and Goodman, 2006: Pilegaard, Jeul, and Wibrand 1993).

High-intensity repeats of 30 seconds and longer have repeatedly been shown to improve both aerobic and anaerobic endurance. Similar results have also been reported for longer repeat distances of one to two minutes On the other hand, repeats that are shorter than 30 seconds do not usually produce improvements in aerobic and anaerobic endurance because they are so short that anaerobic and, particularly, aerobic metabolism are stressed minimally. If your purpose is to improve muscle power through a faster rate of energy release, the efforts should be 5 to 10 seconds in length (121/2 to 25 m repeats) and the rest periods between repeats should be 1 to 3 minutes. On the other hand, if your purpose is to use high-intensity training for improving aerobic and anaerobic endurance, efforts should be 30 seconds to several minutes in length with rest periods that allow the athletes to swim at near-maximum speeds.

Why traditional endurance training is still important

What has just been reported should not be taken to mean that traditional endurance training is a waste of time. There is a possibility that the aerobic capacity of slow twitch muscle fibers can be improved to a greater extent by swimming slower than by training at faster speeds. There are some indications in the literature that this may, in fact, be the case.

In studies with rats, (Dudley, Abraham and Terjung (1982) and Harms and Hickson (1983) the aerobic capacity of slow twitch muscle fibers was improved more by low and moderate intensity training than with high intensity training. If these results can be extended to humans, and I believe there is a good possibility they can, one important outcome would be that slow twitch muscle fibers will improve their aerobic capacity most when they are trained at speeds where aerobic rather than anaerobic metabolism is stressed.

In another study, again with rats as subjects, the group that trained with high intensity training increased VO_{2max} but did not increase mitochondria in the slow twitch muscle fibers. On the other hand, the group that trained at a moderate intensity increased mitochondrial density in their slow twitch muscle fibers.

It is possible that a large amount of sub-threshold (slower than lactate threshold) swimming will increase mitochondrial density in the slow twitch muscle fibers to a greater extent than it can be increased with high intensity training and that too much super-threshold (faster than lactate threshold) swimming may reduce this training effect. At the same time, it appears likely that swimming at very fast speeds is essential for increasing the aerobic capacity, including increasing the mitochondrial density of fast twitch muscle fibers.

Of course, high intensity training will also increase the anaerobic capacity of fast twitch muscle fibers, a training effect can not be produced to any great extent by sub-threshold training. Consequently, training of only one type, long and moderate, or short and fast will not maximize a swimmer's aerobic capacity.

These data suggest that fast twitch fibers are trained best by using fast, intense repeats with adequate recovery time between each. By the same token, it seems reasonable to suppose that the aerobic capacity of slow twitch fibers will be trained best with longer, moderate effort swims with shorter rest periods between them.

Some risks of too much high intensity training

It should also be noted that there is a possibility that sprint athletes may lose speed and power when they train the aerobic capacity of fast twitch muscle fibers (Noakes, 2001). In this respect, there have been indications that plyometric training may increase contractile velocity in single muscle fibers (Malisoux *et al.,* 2007). Therefore, it is probably wise to include this type of training in the programs of sprinters and middle distance swimmers. There have also been some interesting findings on the role of taper. In some studies, a period of hard training followed by a period of reduced training (taper) increased power beyond pre-training levels (Anderson, et al. 2005; Anderson and Aagard, 2000.

Conclusion

With this paper I have presented a theory that a certain amount of high-intensity training is necessary to maximize aerobic and anaerobic endurance because it improves these attributes in fast twitch muscle fibers. At the same time, I have cautioned that a significant amount of lower intensity training is needed because it may improve the aerobic capacity of slow twitch muscle fibers more effectively.