Coaching Applications

Training Zones Revisited

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Abstract

The purpose of this paper will be to describe a different interpretation of training zones that is based on training the three muscle fiber types. The physiological rationale for this theory was presented in an earlier paper (12). This paper goes into greater detail concerning how to administer training according to the theory.

Introduction

The notion of training zones is tied to the practice of blood lactate testing which became very popular in the decades from 1980 to 2000 and is still used today in many parts of the world.

The early physiological rationale behind training at the anaerobic threshold was that aerobic metabolism would be overloaded maximally at this speed with very little interference from anaerobic metabolism. Thus, by training at anaerobic threshold speed, athletes could overload the mechanisms of oxygen delivery and utilization in muscle fibers. It was also theorized that faster training speeds were not as effective for this purpose because the metabolites of anaerobic metabolism would interfere with and reduce the aerobic training effect.

A typical lactate/velocity curve can be used to locate the anaerobic threshold. There are three velocities and six training zones that are usually estimated from lactate/velocity curves. They are the aerobic threshold velocity, the anaerobic threshold velocity and VO_{2max} velocity. The training zones are (1) the recovery zone, (2) the aerobic training zone, (3) the training velocity at the anaerobic threshold, (4) the combined aerobic/anaerobic training zone, (5) the training velocity at VO_{2max}, and, (6) the anaerobic training zone.

In a previous paper (12), I suggested that a more definitive explanation of the physiological adaptations occurring in these zones involves the recruitment and training of the three major types of muscle fibers in humans, slow twitch (ST), fast twitch a (FTa), and fast twitch x (FTx) fibers. In this paper, I want to describe my hypothesis in greater detail while also suggesting guidelines for designing repeat sets that might be more accurate for targeting each training zone and, therefore, effective for improving the aerobic and anaerobic capacities of the various types of muscle fibers. This is because, in doing so, race performances may be improved to a greater extent.

A Different Interpretation of Training Zones

Before describing my interpretation of training zones, I would like to discuss how muscle fibers are recruited during work. The so-called "Ramp Effect of muscle fiber recruitment is illustrated in figure 1. FTa fibers are recruited into the effort as swimming speeds approach anaerobic threshold velocity with progressively more recruited to assist the ST fibers as speeds approach VO_{2max} velocity. It appears the FTx muscle fibers are not recruited in great numbers until swimming speeds exceed VO_{2max} velocity, or until a significant number of FTa fibers have become fatigued at some slower velocity. In which case, the FTx fibers would be recruited in an effort to maintain the swimmer's pace.

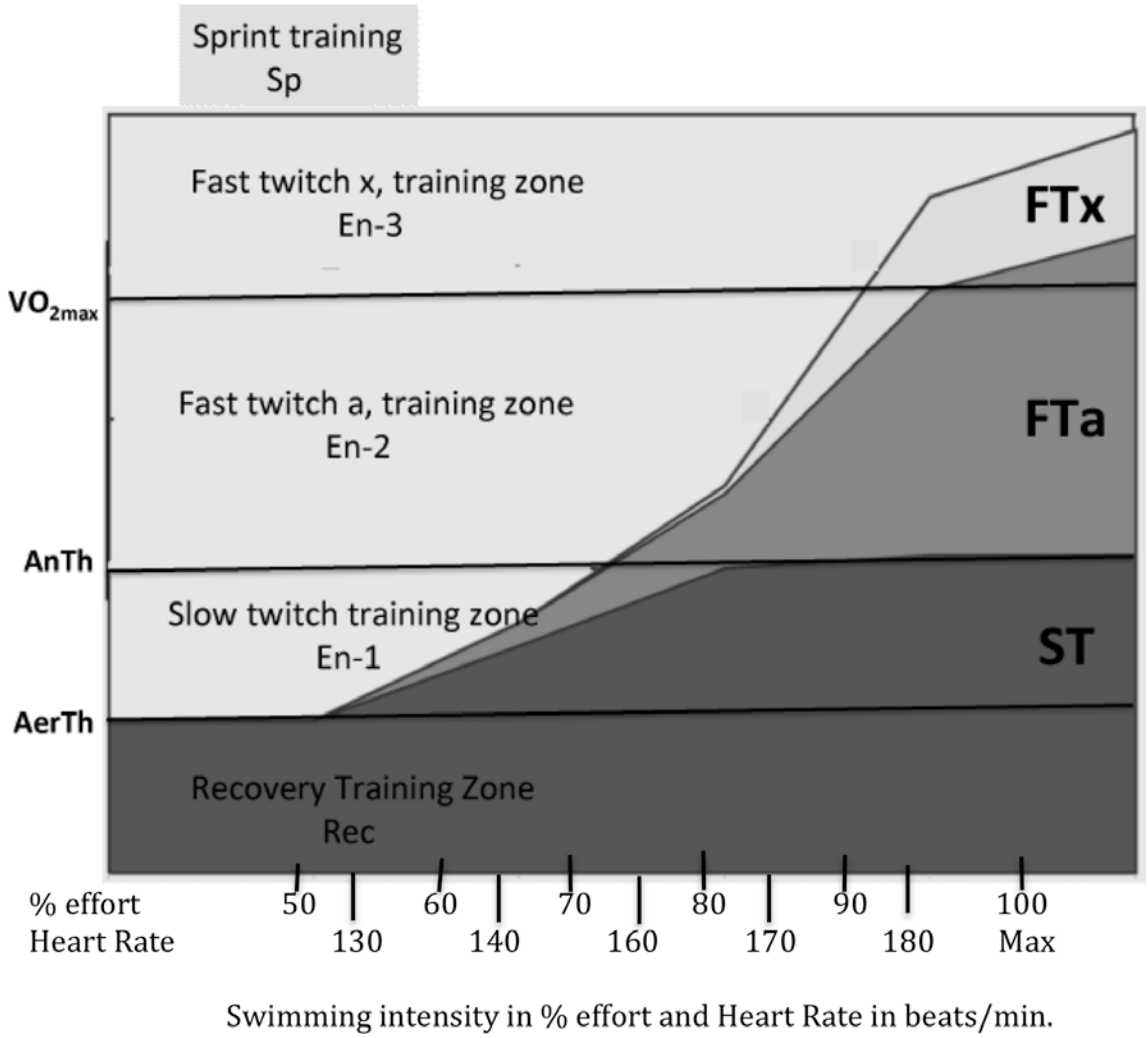

Figure 1. *The ramp effect of muscle fiber recruitment. Adapted from J.H. Wilmore and D.L. Costill (2004**). Physiology of Sport and Exercise**, p. 50. Champaign, IL: Human Kinetics. This figure is a graphic representation of the manner in which the three muscle fiber types, slow twitch (ST), fast twitch a (FTa), and fast twitch x (FTx) are recruited during different*

intensities of work. This figure also displays the location of three zones of endurance training relative to measures of aerobic threshold, anaerobic threshold and VO_{2max} velocities on the left vertical axis. Estimates of percent efforts and heart rates that correspond to training in each zone are listed on the horizontal axis. A fourth category of training, sprint training is located at the top of the chart.

My interpretation consists of three zones of endurance training and one category of sprint training. These are also depicted in figure 1. The endurance levels are listed as En-1, En-2 and En-3. The purpose of the En-1 level is to train the aerobic metabolic processes of slow twitch muscle fibers. It lies between the aerobic threshold and anaerobic threshold training velocities. The purpose of the En-2 level is to train the aerobic metabolic processes of fast twitch a muscle fibers. The En-2 zone lies between the anaerobic threshold and VO_{2max} velocities. The purpose of the En-3 level is to train the aerobic metabolic processes of fast twitch x fibers. That requires speeds in excess of VO_{max} velocity.

The purposes I have ascribed to training in the En-2 and En-3 zones may have surprised you because swimming in excess of the anaerobic threshold velocity is thought to involve, primarily anaerobic metabolism. In fact, however, the major effect of training on fast twitch muscle fibers in the En-2 and En-3 zones is an improvement of their aerobic metabolic functions. The reason that athletes must train in excess of anaerobic threshold velocity to improve the aerobic metabolic processes of fast twitch muscle fibers is because those speeds are required to recruit FT fibers.

As you would suspect, an additional advantage of training in the En-2 and En-3 zones is that the anaerobic metabolic processes, i.e., the lactate removal mechanisms and buffering capacities, of FTa and FTx fibers can also be trained. It is possible that training at these levels will also improve those same functions in slow twitch muscle fibers to the extent that they are amenable to such training. Nevertheless, improving the aerobic metabolism of fast twitch fibers is the most important outcome of training in the En-2 and En-3 zones.

Sprint training is placed above the graph because it is a category of training rather than a zone. It has nothing to do with swimming above or below certain thresholds or at certain blood lactate concentrations. With regard to muscle fiber recruitment, nearly all of an athlete's muscle fibers types will be recruited in the working muscles when they are swimming at the near-maximal speeds required of sprint training. However, training in this category has little to do with training aerobic or anaerobic endurance. Nor is it concerned with improving buffering capacity and lactate removal rates. It's purpose is to increase maximum stroking power and the rates of energy release from the ATP-CP and anaerobic metabolic systems.

Some suggestions for designing repeat sets in each training zone

The Slow Twitch Training zone, En-1. As described previously, the En-1 training zone lies between the aerobic threshold velocity, the minimum velocity where training effects can be produced, and the anaerobic threshold velocity, the maximum velocity where the rates of appearance and disappearance of blood lactate are nearly in balance. The purpose of training in this zone is to improve the aerobic capacity of the slow twitch muscle fibers with little interference from anaerobic metabolism.

There are two broad categories of repeat sets that I believe should be swim in this zone. I call them *primary* and *secondary* repeats for want of better terminology. The purpose of a primary set of repeats is to maximally overload all or most of the slow twitch muscle fibers in working muscles so their rates of aerobic metabolism can be improved as much as it is possible to improve them. A set of this type should generally be a minimum of 20 minutes, for sprinters, to 40 minutes for distance swimmers to provide time for the desired training stimulus to take place. (Time rather than distance was used to define the desired training stimulus so the definition could be applied to any age group and ability level).. Several shorter sets completed in one training session with very little recovery time between them could also be used for this purpose so long as the sum total training time for all the sets is at least 20 to 40 minutes or longer within a single training session.

The send-off times should be set so short that athletes cannot swim faster than anaerobic threshold velocity and still complete the set. Let me repeat this last point. It is very important that the send-off times are so short that athletes cannot exceed anaerobic threshold velocity throughout most of the set. As mentioned before, this should ensure that all or nearly all of the slow twitch fibers in working muscles are recruited with, at the same time, only minimal involvement of fast twitch fibers.

It is not necessary to know a particular athlete's exact aerobic and anaerobic training velocities to swim at the proper intensity. Rough estimates of those velocities should be sufficient for this purpose. For this reason, perceived efforts and heart rates can be used to monitor the proper training intensity for these sets. Regarding perceived effort, the swimmers should feel they are swimming between 70% and 90% of maximum effort throughout the majority of the set. Where heart rates are concerned, they should be 150 to 170 b/min (15 to 17 beats for 6 secs.) for the majority of the set. They may be slightly less early in the set and, because of heart rate "creep", may approach maximum near the end of the set. However, as stated, heart rates of 150 to 170 b/min should be maintained for the majority of the repeat set.

Two and three thousand swims for time make excellent primary En-1 sets for most teenage swimmers and those in their 20's and 30's. In the cases of younger and older swimmers, distances should be set so that they spend 20 to 40 minutes swimming continuously. As indicated earlier, repeat sets should also require at

least 20 to 40 minutes to complete for these swimmers. Repeat distances should be in excess of 200m (2 mins. and longer). My own experience as a coach has caused me to believe that repeat distances of 50 and 100m introduce too much rest into a set and, therefore, may not be as effective for isolating and developing the aerobic capacity of slow twitch muscle fibers.

The purpose of secondary En-1 sets is to improve, or at least maintain, the aerobic capacity of slow twitch muscle fibers. As such, they should be swum at a velocity that is faster than that at the aerobic threshold, and somewhat less than anaerobic threshold velocity. In other words, they should be swum in the middle of the En-1 range.

Secondary En-1 sets should also be done on send-off times that provide only 10 to 30 secs. rest. They should be swum on days when athletes are recovering from more intense training or during those parts of En-2 and En-3 sets that are designed for recovery. This is because fast twitch fibers can be resting and recovering while slow twitch fibers are working and receiving a training stimulus in the En-1 zone. Consequently, it should not be necessary to swim slower than aerobic threshold velocities to rest the fast twitch fibers.

Secondary repeat sets can be any total distance although 10 to 20 mins of continuous or short rest swimming at a time may be required to produce an adequate training effect. The send- off times should be set for short rest. These sets will not require a maximum effort of swimmers to be effective. Therefore, athletes can, once again, use perceived effort and heart rates for monitoring purposes if they do not know their individual aerobic and anaerobic threshold velocities. Perceived efforts should be in the range of 70 to 80% of maximum effort. Working heart rates of 130 to 160 b/min (13 to 15 beats for 6 secs.) indicate the proper intensity for the majority of the set. These repeats can be combinations of pulling, kicking and swimming, and, strokes can be mixed within them. Secondary En-1 swimming is also an excellent way to do stroke drills. Because they are swum at sub-maximal effort, athletes can concentrate on their strokes while still receiving the benefit of improving the aerobic capacity of their slow twitch muscle fibers.

The Fast Twitch a training zone, En-2. As is obvious from the name, training in this zone is primarily for the purpose of improving the rate of aerobic metabolism in FTa muscle fibers. Slow twitch muscle fibers will also be recruited and, therefore, should gain some important training adaptations. Training velocities should be between those at the anaerobic threshold and $VO_{2max.}$ Consequently, the rate of metabolite accumulation will increase markedly when training in this zone. This cannot be avoided because faster speeds are required to recruit fast twitch fibers, compared to their slow twitch counterparts. At the same time, however, their rate of aerobic metabolism will also increase stimulating training adaptations that will improve their aerobic metabolic capacity.

Sets designed to be swum in the En-2 zone will necessarily have to be shorter than those designed for the En-1 zone because the rapid rate of metabolite accumulation in fast twitch muscle fibers that accompanies their increased rate of anaerobic metabolism will cause them to fatigue more quickly than slow twitch fibers. They usually become exhausted within 10 to 20 minutes of intense swimming. Therefore, where skilled senior swimmers are concerned, repeat sets should probably not exceed 2000 meters. The repeat sets for younger, older, and less skilled swimmers will need to be scaled down accordingly to stay within the 10 to 20 minutes time frame.

Rest periods between repeats should not exceed work time and most probably should be shorter than the work time. For repeats in excess of 100 m the rest period should probably be less than one-half the work time. Rest periods should never be so short that athletes cannot swim in the En-2 zone, however.

Monitoring training in this zone is fairly easy. Perceived efforts should be between 70 and 90% of maximum. Heart rates should start at 150 to 160 b/min and reach maximum in the last half of the set. The goal should be to complete the set with the fastest possible average time without a noticeable fall-off in times from beginning to end. Quite often, athletes who are swimming repeats that are one-half their race distance or less will usually be repeating at race speed except when the repeat distances are 600 m and longer.

The Fast Twitch x training zone, En-3. Training in this zone is for the purpose of recruiting and training FTx muscle fibers. The training effects they receive will be identical to those discussed for FTa fibers in the previous section.

I recommend repeat distances of 25 and 50m for training in this zone. There is no doubt, however, that fast repeats of 75m and 100m would also cause these fibers to be recruited. It would probably be a good idea to try various repeat distances and evaluate the effects for your self.

As a rule of thumb, the repeat distance should be short enough to be performed at speeds where FTx fibers would be recruited and the rest periods should be sufficient to permit a reasonable number of repeats to be performed at those speeds. Repeat speeds in the En-3 zone should be at or near race speeds for 50 and 100 swimmers and faster than race pace for swimmers in longer events.

Careful monitoring is probably not required when training in this zone. Training speeds should be very fast so FTx fibers will be recruited. Therefore it goes without saying that athletes should be swimming close to maximum effort and that heart rates will approach maximum during the duration of the set

Sprint Training, SP. The purpose for training in this zone is to improve maximum sprint speed. The common types of repeat sets that are used for improving speed

should be swum when training in this zone. These include sprints of 10 to 50m. Long rest periods should be taken between repeats to allow sufficient recovery toward the rested state so that metabolite accumulation does not interfere with the speed of the repeats. Recommend rest periods are 15 to 30 secs for 10m repeats, 30 secs. to 2 minutes for 25m repeats and 2 to 5 minutes for 50m repeats. Remember that you are trying to improve rested speed, not fatigued speed. Improvements of fatigued speed can be accomplished by training in the En-2 and En-3 zones.

The ideal number of repeats is not known but should probably be kept small. 10 to 15, 10m sprints, 6 to 10, 25m sprints, and 3 to 6, 50m sprints. The best rule of thumb is to stop when athletes are no longer able to repeat at speeds that are faster than those in the En-3 zone. Both sprint-resisted and sprint-assisted training should be included within this framework.

Mixed zone repeats. Swimming in 2 or more training zones within one set can also be an effective and motivating way to train. This can take at least two forms, descending sets and fartlek-like sets.

Descending sets begin in the En-1 zone and can finish in the En-3 zone. For example, a set of 8 x 200m swims could be completed in the following manner. Swim 4 X 200 in the En-1 zone on a short send-off time, 3 x 200m in the En-2 zone on a slightly longer send-off, and after a short rest period, 1 x 200m as fast as possible. Another example, of a descending set is the traditional down the ladder design where swimmers decrease the repeat distance and increase the speed throughout the set. For example, 3 x 300 followed by, 5 x 100, both on short-send offs. This could be followed by 4 x 50 on 1 minute.

The fartlek-like repeat sets are done in a slightly different manner. For example, an athlete might swim 3 x 300 on short rest in the En-1 zone, followed by 6 x 25 on 1 minute in the En-3 zone. This set could be repeated 3 to 4 times with no break between rounds. Another example, would be to swim 800 m in the En-1 zone, followed by 8 x 100m on short rest in the En-2 zone, presumably at race speed or faster, followed by 12 x 25 m on 1 minute in the En-3 zone. So long as you are aware of the zones being targeted and why, the possibilities for designing mixed zone sets are only limited by the creativity and knowledge of the coach designing them.

General Suggestions for Structuring a Training Week

Not having coached swimmers for several years, I do not feel qualified to provide anything but general guidelines concerning how training should be distributed in the four zones over a week or a season. As a general rule, I would suggest scheduling two major sets in each of the three endurance training zones each week. Where, the En-1 zone is concerned, the two sets should be of the primary type. The remainder of the week's mileage should be made up of secondary En-1 training and sprint training with occasional, short, forays into the En-2 and En-3 zones. These

can be structured as short, novel sets that are not exhausting. They can also be done at the tail end of secondary En-1 sets.

With experience, coaches should become competent at making adjustments in their weekly and season planning for different events and strokes and for the different physiological and psychological make-up of individual athletes.