In Search Of The Ideal Aerobics Routine

"[Six to 8 very hard 20 second intervals with 10 second rest periods] may be one of the best possible training protocols...."

.....Izumi Tabata, Ph.D., National Institute of Health & Nutrition, Tokyo, Japan

Why does this very short interval workout (it is also discussed in article #10, Forget The Fat-Burn Zone) work so well? Why does this protocol substantially improve both aerobic and anaerobic capacity? Why is that a surprise? Is there a lesson in this for bodybuilders and others interested in both strength and endurance?

Overload and Specificity

The answers to the first three questions lie mainly in the principles of overload and specificity. The overload principle says that training adaptations come about when the body is subjected to unaccustomed stress. Specificity says the adaptation depends on the nature of the overload imposed. In other words, specific exercise overload brings about specific training effects. For example, strength training induces specific strength (anaerobic) adaptations and endurance exercise elicits specific endurance (aerobic) adaptations - with essentially no interchange between the two types of training. As you'll see, these two principles explain both why the single protocol was not supposed to cause both aerobic and anaerobic improvements and, interestingly, why both types of adaptations did in fact occur.

As a follow-up to the study discussed in article #10, Forget The Fat-Burn Zone, Dr.Tabata and his colleagues conducted a second study "to evaluate the magnitude of the stress on the aerobic and the anaerobic energy release systems" of the high intensity protocol used in the previous study and, additionally, of a second interval protocol. (***Medicine and Science in Sports and Exercise (1997) 29, 390-395)*** The two protocols in the follow-up study differed in three ways**:** interval duration, intensity and rest between bouts.

As in the previous study, young male members of college varsity teams exercised on stationary bicycles. The two protocols were given the catchy names 1E1 and 1E2. Protocol 1E1 was the same as before**:** following a 10 minute warm-up, each subject did one set of 6-7 bouts of 20 seconds at approximately 170% of the subject's maximal oxygen uptake (VO2max), with 10 second rest periods, to exhaustion. The 1E2 group did 4-5 bouts of 30 seconds at 200% of VO2max, with 2 minute rest periods, to exhaustion. For each protocol, the criteria for exhaustion was that the subject was unable to maintain a pedaling speed of 85 rpm. Expired gas was collected continuously every 10 seconds to measure the oxygen uptake. As in the earlier study, accumulated oxygen deficit was used to measure anaerobic energy release.

The results were eye-opening. The 1E1 protocol taxed both aerobic and anaerobic capacity significantly more than the 1E2 protocol. The peak oxygen uptake during the last 10 seconds of 1E1 was "not statistically different from the subjects' VO2max." But the peak oxygen uptake at the end of 1E2 "was much less than the VO2max." Likewise for anaerobic output**:** For 1E1, accumulated oxygen deficit was essentially 100% of the subjects anaerobic capacity, but for 1E2 it was only 67%. In short, the 20 second intervals, with 10 seconds rest, overloaded both aerobic capacity and anaerobic capacity to the max, while the longer and harder interval protocol, with two minute rest periods, did not. In both respects, the stress produced by 1E2 fell well short of maximum.

This, of course, is why 1E1 improved both aerobic and anaerobic fitness. In the words of the researchers, "For most physical properties the more demanding the training is the greater the improvement of the property." If you overload aerobic capacity and anaerobic capacity maximally, you should get maximum improvement in both capacities.

Yes, this study is good news for the many athletes engaged in high-intensity sports which demand both aerobic and anaerobic fitness and those who strive for total fitness. But why did 1E1 work so much better than 1E2? (The explanation is a little long, so bear with me.)

First, it has long been known that intervals are an effective training method. With intervals, more total work can be accomplished at a given intensity than when exercising continuously. For example, few people can run a 4 minute mile, but many more can complete a mile in 4 minutes of actual running, if the distance is broken into segments or intervals separated by rest periods.

The Surprise

Exercise physiology textbooks tell us that work interval duration and intensity, and the length of the rest periods - the variables studied by Dr. Tabata - must be carefully adjusted to meet the specific requirements for different performances. As indicated above, adaptations are specific to the speed and duration of workout. Generally, short hard intervals with long rest periods are recommended to improve anaerobic capacity; and many sets and repetitions of longer less intense intervals with short rest periods are suggested to overload the aerobic system.

In other words, the interval protocols traditionally prescribed to engage the aerobic system are usually quite different from those suggested for anaerobic training. This is simply an application of the specificity principle, with little or no interchange predicted between the two types of training.

That, of course, is why it was a surprise when Dr. Tabata's earlier study found that the 1E1 protocol (20 second bouts with 10 seconds rest) "may be optimal with respect to improving both the aerobic and anaerobic energy release systems." As readers of my earlier article will remember, Dr. Tabata told Dick Winett in a personal communication "that the rate of increase in VO2max [14% in only 6 weeks] is one of the highest ever reported in exercise science." Recall also that anaerobic capacity increased by a whopping 28%.

The Key Factor

Like Goldilocks' porridge, it seems that Dr. Tabata has come upon an interval protocol that is "just right." As shown in the follow-up study, 1E1 overloads both aerobic and anaerobic capacity maximally - with the predictable result that both systems benefit optimally. As the original research report stated: "1E1 may be one of the best possible training protocols...."

But why? Why did the 1E1 protocol stress both aerobic and anaerobic capacity maximally, when the more intense (200% Vo2max vs. 170%) and longer (30 seconds vs. 20-s) bouts of the 1E2 protocol did not? The researchers believe the key factor was the difference in the rest periods.

The relatively long 2 minute rest periods in 1E2 allowed oxygen uptake to fall considerably and, therefore, when the next exercise bout started there was a delay before the oxygen uptake increased and began again to approach maximum. On the other hand, the short 10 second rest periods in 1E1 allowed only slight recovery, and therefore oxygen uptake increased in each succeeding bout, reaching maximum capacity in the fiinal seconds of the last bout. The same was true for anaerobic energy release. The long rest periods in 1E2 stopped the buildup of lactate and allowed the resynthesis of phosphocreatine (see creatine article on this website) to occur. Again, the short rest periods in 1E1 caused the oxygen deficit to continue building from rep to rep, reaching maximum anaerobic capacity at the end of the exercise.

Dr. Tabata's 1E1 protocol may not be perfect, but he and his colleagues seem to have found a sweet spot where aerobic and anaerobic capacity peak simultaneously.

The Lesson

It seems to me that the lesson in this for bodybuilders and other fitness enthusiasts is that more aerobic training is not necessarily better. Many athletes and coaches believe that gains in aerobic endurance are proportional to the volume of training. In fact, noted exercise physiologists Jack H. Wilmore and David L. Costill, in their text ***Physiology of Sport and Exercise*** (Human Kinetics, 1994), state flatly**:** "Because volume is the key to successful aerobic training, [athletes] must perform a large number of [intervals]." (They do caution that there's an upper limit.)

Importantly, the two studies by Dr. Tabata's group strongly suggest that volume is not necessarily the key.

Recall that the moderate-intensity group in the first study trained 5 days per week at 70% of VO2max, 60 minutes each session, and increased aerobic capacity only 10% and anaerobic capacity not at all. And in the second study, the 1E2 group exercised both harder and longer**;** they did more total work than the 1E1 group. Clearly, these studies indicate that gains are not necessarily dependent on volume or total work performed.

If the goal is improved aerobic and anaerobic capacity, the Tabata research suggests that intensity, carefully applied to produce maximum overload - not volume - is the key to success.

At A Price

Progress by this method, of course, comes at a price. Tabata's 1E1 protocol is physically and psychologically taxing. It requires considerable motivation. Dr. Tabata, in a personal communication, warned Dick Winett**:** "This protocol [was] invented to stress the cardiovascular systems of top Japanese [speed] skaters who got medals in the Olympic games. Therefore, the protocol is very tough. The subjects lay down on the floor after the training." Tabata wondered how many people would "feel eager to do this type of exercise."

Still, for those who are fit and healthy (if you have questions about your health by all means check with your doctor) and up to the challenge, Tabata offered this encouragement**:** "From the theoretical point of view, the higher the oxygen uptake obtained in a specific training protocol, the higher the improvement of VO2max."

Good luck.