Rowing Physiology for the Not-Too-Scientific, Part I

by Kris Korzeniowski, USRowing National Technical Director

This year’s Advanced Coaches Series’ lectures at the USRowing Annual Convention, scheduled for December 1-3 in Towson, Md., will focus on physiology for the coaches. This article was written by Kris Korzeniowski. Although it is a few years old, it is still a good primer on the basics of physiology. We will post part two of the article in a couple weeks.

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I remember when I first listened to professors explaining physiology. It seemed to me that they were speaking a completely different language. That was discouraging, not only because a basic understanding of physiology is so important, but also because I believe simpler explanations are possible. So, simpler explanations are the goal of the upcoming articles about the physiological concepts behind the formulation of training programs for rowing. I realize that many issues have been simplified here. I would not suggest this article as appropriate educational reading for anyone with a degree in medicine or physiology.

First, we need to understand the aerobic process and how it works in the sport of rowing. Imagine a rowing race. Approximately 80% of the energy required for a 2,000 meter race will come from the aerobic process – the process which uses oxygen to produce energy. Only 20% will come from the anaerobic process, which produces energy without oxygen. So, the aerobic process is the one we are most interested in, and the one in which we can make the most improvement with proper training. If we can develop our aerobic potential, then we can worry about the anaerobic.

In a rowing race, we have two “engines” at our disposal. The aerobic process is the big engine – the diesel. It’s very efficient and economical, but it takes time to start. So, in order to be competitive in a race and start quite fast, we have to switch to a different engine – a smaller, high evolution engine which is not too economical, and can operate for only a short period of time. Why? Because it produces a by-product – lactic acid. Accumulation of lactic acid in the muscles creates stiffness, decreases the ability to perform, and limits the possibility of using the big engine later on.

The race begins. We have to start quickly, so we start the smaller engine – the anaerobic engine – and let it run for about two minutes, while the bigger engine is warming up. After two minutes, the big engine – the
aerobic engine – is taking over, and we begin to cruise on diesel. Coming to the end of the race, we want to speed up for that last push, so we switch to the small engine again – just for a short period of time.

Now let’s be a little more scientific. The chart (A) represents the energy expended during a six-minute race. The curve represents total oxygen use (consumption) – the area below the curve indicates total aerobic work; the area above, total anaerobic work. It takes from 90 seconds to two minutes to get the aerobic processes to full efficiency. That is why the curve is climbing upwards. At that point the athlete can cruise on this aerobic maximum, or VO2 max. After about five minutes, that level is decreasing a little, which is why after five minutes into the race, or at approximately the 500 meter mark, rowing becomes so difficult. If I have very good aerobic capacities – that is, if my aerobic processes can be activated (warmed up) very quickly, then I can reach this maximum after only 90 seconds and decrease the amount of time I spend and decrease the amount of time I spend utilizing my anaerobic engine. That means I will also accumulate less lactic acid. Better athletes get to VO2 max much quicker, so the anaerobic area of the chart is reduced and they accumulate less lactic acid.

Our goal, then, is to increase our aerobic efficiency. There are two components of the aerobic process. Transportation or the ability to get oxygen to the muscle cells to produce energy, and utilization, or the ability to use oxygen in the process which creates energy in the muscle cells. It is very difficult to balance these two systems, especially in training. And there is also considerable controversy among physiologists about which part is more important to the athlete. Both, however, are extremely important to rowers.

The transportation system is really rather simple. We know that the air which we are breathing contains between 20-21% oxygen. Oxygen in the lungs goes to red blood cells (hemoglobin), which is transferred through the veins, to the muscles. The most important component in the entire transportation system is the heart. And, because the heart is a muscle, it can be developed and trained. All of our transportation training methods have the goal of increasing the volume of blood the heart is able to pump with each beat. If you are a well-trained athlete, your heart will be able to pump more blood, bringing more oxygen to the muscles with the same maximum heart rate.

If we want to strengthen the heart, we have to design special workouts. The stimulation has to be quite strong or we won’t notice any progress. In
order to develop increased efficiency, stimulations must be very close to maximum – 90-05% of maximum – so that we can push our aerobic limit higher and higher. Translating this to heart rate, it is approximately the maximum heart rate to maximum minus 10 beats. The rule of thumb is figuring maximum heart rate is 220 minus your age. I don’t recommend that people get too involved in stopping to check their heart rates every few minutes. Most people know when they’re close to their maximum output.

How long? Remember that it takes from 90 to 120 seconds to activate the aerobic processes – to “warm up” the big engine. If we use two-minute pieces, then we will be using all of our time for warm up. If we use three minutes, the first two are wasted warming up and then only one minute is used to push the heart. That’s why the classic time is five minutes. As long as the heart rate is kept within the maximum range, we can use anywhere from four to 12 minutes, but five is one of the most efficient. It was for this purpose that we also use pyramid types of pieces as well, where intensity can build gradually and we can avoid an extremely intense first two minutes.

After those five minutes, I need to rest. Active rest – paddling, for example – but rest. This interval is very important if we hope to reach the goal of improving the heart’s efficiency. Let’s use the imaginary race again to illustrate. If we want to be efficient, we have to do our piece quite hard – at 90-95% of maximum. This will create some lactic acid accumulation – more during the first two minutes; less later on. Based on the results of experiments, we know that it takes about five minutes for lactic acid to travel from the muscles to the blood. And we also know that active rest gets rid of lactic acid faster than simply stopping, which is why you never see crews head straight for the dock following any hard race. They always go for long paddles instead. If you don’t allow the muscles to empty of lactic acid – if you rest is shorter than four to five minutes – there will be more lactic accumulated with each piece. Then when you being your next piece, your athletes will be starting with diminished capacities. You might find out how gutsy your athletes are, or how well they can tolerate lactic accumulation, but you won’t be working on VO2 max, because high lactic accumulation will prevent athletes from reaching this level. So, five minutes of hard work needs at least five minutes of active rest. Otherwise, the training effect is going to be very different from what was designed.

Sometimes, due to deficiencies in technique, some people may not be able to push themselves close enough to their maximum heart rate while rowing, either in a boat or on an ergometer. That’s why the majority of sports now utilize running hills as a part of their training programs. Cross
country skiing, cycling, running – everyone is doing five minute hills. Every year with our National Team we have one month of running. Running, as a more natural motion, guarantees that you will be able to push yourself to the necessary level, and push your heart, regardless of your individual rowing technique.

Another type of workout for the transportation system is the short interval. This is a little trickier to understand. Although the biggest accumulation of lactic acid occurs from zero to two minutes, the majority of that accumulation occurs between 45 seconds and two minutes. Before 45 seconds the levels are not so high. So, if we are able to row pieces that are less than 45 seconds, give ourselves a rest and get rid of lactic acid, then we will never reach the point of higher concentration.

One of the workouts in the National Team Training Program provides an example of this short interval idea. Again, running can be utilized instead of rowing – running stadiums will have very similar effects. An advantage of this workout is that it provides you with an opportunity to row relatively high stroke rates, even early in the season, without “killing yourself” – without producing lactic acid. It’s simple – 20 minutes of 20 strokes “on” (at quite a high rate – maybe 30 or 32 strokes per minute), and five strokes easy; and then again, 20 strokes on, five off, etc. Twenty strokes are approximately 45 seconds, so I am bringing my heart rate up quite close to maximum, and then I a resting. Because I am not crossing that 45-second barrier, I am not allowing my body to accumulate lactic acid, and the rest is so short that my heart rate doesn’t fall too much between the working phases. It is like beginning to fill a cup, and then emptying it. This is a hard workout, especially at the beginning but in 20 minutes you can accomplish 400 strokes without high concentrations of lactic acid. Compare that with two minutes on, two minutes off, four or five times. That will also equal 400 strokes, but will fill people with lactic acid and exhaust them.

In summary, to increase our aerobic capacity, we must increase the amount of oxygen we’re able to get to the muscles. To do that, we need to train the heart by stimulating it to 90-95% of its maximum. Two workouts especially designed to develop the transportation system are long intervals of four to 12 minutes at high intensity, followed by five to eight minutes of active rest, and short intervals of 20-45 seconds, followed by a brief active rest period (e.g. 20 strokes on, 5 off).

Once an effective transportation system gets the oxygen to the muscles, it is the job of the muscle cells to use the oxygen as efficiently as possible. That process is called utilization, another important training component
we’ll discuss in the July. August issue.

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