 The debate over limitations in human performance has been waged for decades. In the endurance sports world, the commonly-held perception is that the cardiovascular system is the primary limiting factor. The belief expressed by many endurance sports coaches is that maximum VO₂ and lactate threshold are the primary culprits - and thus, we need to track and scrutinize the appropriate training parameters - namely, heart rate.

 But here are some thoughts to refute those claims - to take our focus away from the past and turn it towards the future.

  Improvement in maximum VO₂ has an upper limit unto itself - typically no more than about a 15% improvement over time. If your maximum VO₂ was the primary limiter, athletes would initially undergo a significant improvement, then plateau. Once you hit this plateau, you'd go no further. We know that this doesn't happen. A low maximum VO₂ doesn't prevent you from attaining high levels of performance - and a high maximum VO_{2}doesn't guarantee success. Athletic performance can continue to improve over years, not just months - and certainly by more so than 15% over time. There have to be other, more critical factors at play.

 Lactate threshold is the next belief to be refuted. The thought is that lactate "builds up" in muscles, thereby preventing them from contracting. Yes, lactate does accumulate - but the muscle knows how to use this lactate as a fuel for muscle contraction - or it can be trained to do so more effectively. Consistent with this belief is the assumption that a muscle cannot contract in an acidic environment - which we now know is a falsehood.
 On top of these issues is perhaps a more elemental one - and that is the use of heart rate as a measure of performance and workload. Though this may initially give an athlete a means to assist in the correlation of "effort" and "pace", heart rate on it's own is a tenuous measure. If you are dehydrated, it will be skewed. If you are training in the heat (or cold), it will be skewed. Your target training heart rate ranges are calculated around a moving target - namely, using your age-adjusted (calculated) maximum heart rate. So you have an arbitrary heart rate range - which will be affected significantly by environmental variables - that is calculated from an arbitrary maximum heart rate. From a mathematical point of view, it's not very accurate. From a functional perspective, it is not the best way to establish your level of work in any conditions. So if the cardiovascular system isn't the primary limiter of endurance sports performance, what is? Well, ladies and gentleman - it's all in your head. The central nervous system.

 Yes, that gray thing between your ears, the one thing that many coaches want you to focus with and many want you to shut off. The same entity that controls your thoughts, your emotions and ... your training?
  The central nervous system (CNS) is integral to muscle fiber recruitment. It's all about synaptogenesis - creating new synapses - and using them constructively. If I can send the right signal to the muscle, and it has some fuel on board, it will contract. If I can't, it won't. Unfortunately, the CNS doesn't have ready access to carbohydrate for fuel (as the muscle does with it's own locally-stored glycogen) so it has to attain it via the blood stream and liver. This is a rather limited resource and thus requires steady supplementing throughout a workout or event for optimal function. Fatigue is an issue of the CNS being unable to function properly - oftentimes due to not having the neural connections or simply not having the fuel to allow the neuron to fire.

 That being the case - how do I raise the upper limit of my performance if the CNS is the limiter?

 Power-based activities require the athlete to recruit a large number of muscle fibers, thereby requiring many active neural connections to do so. If I am a more efficient athlete biomechanically - ie. better running form - then I have programmed in

much better goal movement patterns. Simply stated, this is having better wiring!

 But, you ask, why do power activities when I am an endurance athlete? If I have a high power output, then I can (purposefully) turn back my power output (as in "slowing down my pace") and with an appropriate fuel source, go slower - longer. Given that your training has provided you with the appropriate mechanisms to gain and improve tissue integrity and "architecture" (another power-based aspect), then you are ready to go longer - without necessarily having "gone longer" as part of your training.
 If you need a measure of workload, then you can use power or velocity in conjunction with perceived effort. Strange as this may sound, perceived effort has been shown in the scientific literature to be a very accurate measure of workload - and is consistently used in exercise physiology and cardiac stress testing labs worldwide. Of course, in this discussion of the CNS we must also remember that "the brain controls everything". With that in mind (no pun intended), your ability to maintain attentional focus is critical in being able to maintain power output over time. Let's face it - how often do we tell ourselves "I can't" long before the body says "I won't"? How often does our self-talk get in the way of our performance - in an event - or in our everyday lives?

 In the grand scheme of human performance, the brain is the primary limiter. Fortunately, it's also the primary resource for success. For that, we can be thankful. &#65533;

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