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Heat Stress, Plasma Volume, and the Benefits of Dehydration

Is heat training the new altitude?

By Alex Hutchinson [3] Friday, April 26, 2013, 12:00 am

I'm at the annual scientific meeting of the Canadian Academy of Sport & Exercise Medicine [4] right now -- lots of interesting talks and fun topics. My favorite from this morning was a talk in the Wilderness Medicine session called "14 Uses of a Foley Catheter," on improvising medical equipment in the backcountry. Did you know that, if you urgently need to rehydrate someone and they can't take in fluids orally, you can shove the tube of your hydration pack up their rectum and create an improvised Murphy drip [5] to get the fluids in through the back door? (I don't recommend trying this without appropriate training, and -- thanks to this new knowledge -- I also don't recommend buying hydration packs second-hand!)

Anyway, one of the best things about conferences like this is the chance to chat informally with people and find out what they're currently up to and working on. One of those conversations led me back to a topic that got some brief attention a few years ago: training in heat to produce big jumps in endurance performance. There was a University of Oregon study back in 2010 that had trained cyclists do 10 days of heat acclimation -- 100 minutes of exercise in the heat each day -- and saw a 5% jump in VO2max **measured in cool conditions** by the end of study. In other words, heat acclimation doesn't just make you better at dealing with heat; it makes you better, period. The researchers suggested that athletes could use this type of protocol just like they use altitude training camps, as a short-term intervention to improve performance. The study got quite a bit of attention, but I hadn't heard much about athletes and coaches actually adopting the idea.

It turns out there has been more research on this, and elite athletes are definitely using it. A New Zealand study published in 2012 in the *European Journal of Applied Physics* [6] used elite rowers, and put them through a shorter protocol: just five days, 90 minutes per day. The rowers were in a room at 40 C and 60% humidity, and they rowed at an intensity just sufficient to keep their core temperature at a "modest"

overheating level of 38.5 C. The training itself wasn't particularly hard: the goal was to overheat the rowers, not overwork them, and the 5-day acclimation period started two weeks before a major championship competition. The result: a 1.5% increase in 2,000m rowing performance.

There are a lot of different mechanisms that may be coming into play here, but I'm going to greatly simplify some of the practical takeaways as I understand them:

(1) The biggest benefit of heat acclimation may be plasma volume expansion. Just as altitude stimulates your body to produce more red blood cells, heat stress stimulates your body to produce more plasma. The result is a greater cardiac output, and higher VO2 at a given effort level. In the New Zealand study, resting plasma volume increased by 4.5%, even though the the athletes had very high plasma volume to start; in the Oregon study, plasma volume increased by 6.5%.

(2) One of the key signals that tells your body to adapt may be dehydration. So if you do the heat acclimation but are super-careful to stay hydrated, you miss out on the benefits. In the New Zealand study, the athletes were allowed 100 mL of water during the 90-minute bouts -- enough to stave of the **feeling** of being super-dehydrated, but not enough to stay hydrated. The benchmark some athletes are using: if you're not at least 2% dehydrated, you drank too much; 3% is good; 4% is too much. (Note: this is just for the heat acclimation sessions, not a universal rule for all training sessions!)

(3) This approach can be combined with altitude. Spend a couple of weeks up high to boost red blood cells, then a week in the heat to boost plasma volume, then maybe 7-10 days in normal conditions and you're ready to go.

The more general takeaway I draw from this is the importance of allowing your body to undergo training-induced stresses, rather than making heroic efforts to cushion your body from discomfort. That has been a theme of recent research in a variety of areas -- like nutrition (the adaptation benefits of doing some of your training with low or depleted energy stores), and recovery (the potential for things like ice-baths and antioxidants to suppress the signals that are supposed to tell your body to adapt and get stronger). This suggests to me that, in situations where safety and health aren't a concern (i.e. **not** ultra runs and **not** during heat waves!), leaving the water bottle at home may be a good call.

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