In the long run, exertion regulation wins the day for marathon runners

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Long-distance running is widely seen as one of the great physical challenges a human can undertake and as the 2008 Summer Olympics commence in Beijing on August 8, many eager sports fans will await with baited breath the last event of the Games – the men's marathon, held on August 24. For these armchair fans, how marathon runners can complete the gruelling, 42.195 km event – physically and mentally – may seem like a great mystery.

Now, reporting in the open-access journal *PLoS ONE*, Jonathan Esteve-Lanao and Alejandro Lucia at the European University of Madrid and colleagues at the VU University-Amsterdam and the University of Wisconsin-La Crosse describe their investigation of the physiological methods employed by well-trained runners in order to regulate the great physical strain and effort that are needed in order to complete and perform well in marathons and other endurance challenges.

In order to measure the exercise intensity undergone by male runners of various abilities, Esteve-Lanao and colleagues evaluated the heart rate response of 211 middle- and long-distance runners during running competitions ranging in length from five to 100 km. These runners were not elite performers but all were serious competitors and some had enjoyed success in regional competitions.

The researchers found that throughout the course of the races, the runners' heart rate increased in a very controlled way, which appeared to be scaled to the distance of the race. When the heart rate response was scaled to the proportional distance completed, the results across races of different lengths were virtually identical. These findings support the notion that athletes actively manage the increasing strain on their body, in anticipation of reaching the finish line, constantly reassessing their levels of fatigue. Peripheral muscle fatigue, for example, would be highly regulated, with the working muscles giving continuous sensory feedback to the central nervous system to ensure that muscle fatigue is confined within a threshold, above which potentially dangerous consequences – especially muscle damage – could occur.

A surprising finding in this study was that the elite runners didn't run proportionally harder than the less-accomplished athletes and the heart rate response was very similar in all the participants despite the wide variations in competition ability and running performance. This suggests that Paula Radcliffe and other elite marathon runners do so well because of their great, underlying physiological capacity rather than because they put in more effort into their competitions.

Esteve-Lanao and colleagues also investigated instances of discontinuity in a runner's performance, most notably that of "hitting the wall." This happens when the athlete's glycogen stores have run so low that the body must burn stored fat for energy, which does not burn so easily, leading to dramatic fatigue and, potentially, life-threatening collapses, such as Dorando Pietri's collapse, 100 years ago, at the London Olympics in 1908. These examples support the idea that physiological catastrophes can and do occur frequently during strenuous endurance competitions because the athletes are either unwilling or unable to slow down their heart rate, despite dangerously high levels of strain.

The scientists conclude that athletes actively control their relative physiological strain during competition proportionally to the length of the race. According to the runner, Sir Roger Bannister, "The man who can drive himself further once the effort gets painful is the man who will win," but athletes who are not able to regulate their heart rate over the course of a long-distance race may burn out too soon and end up crashing out of the competition.

Citation: Esteve-Lanao J, Lucia A, deKoning JJ,

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