Hydration, dehydration, overhydration and cramps.

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Runners, organizers, and volunteers will be spending much time and effort thinking about the Six Foot track Marathon. I've prepared this article to assist with race strategies regarding hydration and pacing- important factors to enjoy the track!

A little Exercise Physiology

During prolonged exercise, blood is diverted from relatively inactive organs to the active muscles. The increase in oxygen demand from muscles is offset by reduced blood supply to the skin and gut. However in warm conditions we need to lose excessive heat, the most efficient way is by sweating. Exercise is relatively inefficient and over 75% energy that is generated by muscle fuel use (oxidation) is liberated as heat. The heat from raised core temperature is transported to the skin where heat loss should occur.

The appropriate thermoregulatory response to exercise in usual Australian summer conditions is dilation of skin blood vessels and sweating. Although the body needs to release excessive heat, thermoregulatory responses are tempered by the need to deliver blood to active muscle by constriction of skin blood vessels.

Considering these conflicting demands, there has to be physiological compromise. From a runner's perspective this means that speed is sacrificed to maintain core temperature. Increased sweating without adequate fluid replacement will lead to dehydration; the consequences include impaired thermoregulation leading to heat-related problems, and impaired performance due to decreased circulating blood volume (among other things).

Most runners slow down when running in warm conditions but highly motivated individuals can ignore warning signs, with serious consequences.

Hydration and Dehydration

I expect that most Six Foot starters would have done previous marathons, and in training would have developed a fluid replacement strategy. Although there have been recommendations over the years, each runner will have specific fluid and energy requirements that varies according to weather conditions. In other words, a runner's fluid requirements during a marathon will not be the same as the next.

When watching elite marathon runners it seems that they hardly drink during their sub 2:10 (or sun 2:30) effort. It seems that runners can tolerate loss of 1-2% body weight during marathons (in temperatures up to ~22^{0}C) and this is assumed to be largely water loss (even this is debatable). Further fluid loss during exercise will lead to dehydration and associated problems.

Marathon runners have been urged to drink regularly during races, and are advised to consume 200-300mL every 10 – 20 minutes (Wendt et al, 2007). In my opinion liberal interpretation of this advice could lead to overhydration. Ingestion of solid food and carbohydrate drinks over 6% concentration usually slows down gastric emptying, leading to feelings of nausea and abdominal distention. Tim Noakes (University of Cape Town) observes that the advice to drink regularly during marathons coincides with the development of sports drinks.

The International Marathon Medical Directors Association recommends fluid ingestion of 400 – 800mL/ hr, with faster and heavier runners requiring more, and less in cooler conditions and for

slower runners. This is a more sensible recommendation although individuals should determine their individual fluid requirements rather than rely on prescriptions.

Overhydration

Runners heeded advice about fluid replacement and are generally aware of dangers associated with "dehydration". However the practice of drinking regularly during marathons has lead to newer problems. There is much talk among exercise physiologists about a phenomenon known as "exercise-induced hyponatremia" (EAH) which is a potentially fatal condition related to drinking too much fluid during endurance events.

Drinking water or sports drinks in excess to sweat loss can "dilute the blood", and is measured by low sodium concentrations (less than 135 mmol/L). Most sports drinks contain 18- 28 mmol/L sodium, and will not prevent EAH, although some sports drinks contain much higher sodium concentrations.

Early signs of EAH include headache, nausea, vomiting, feeling bloated and "puffy". More severe features include confusion, agitation, respiratory distress, and coma. Many of these signs are present in dehydrated individuals, so the diagnosis is vitally important as administering fluids will worsen problems in someone who is already fluid overloaded.

The second international exercise-induced hyponatremia consensus conference in New Zealand, 2007 noted risk factors that include:

- Excessive drinking behavior
- Weight gain during exercise
- Low body weight
- Females
- Slower, inexperienced runners
- Use of nonsteroidal anti-inflammatories (e.g. ibuprofen, diclofenac)

Event-related factors include:

- Availability of fluids
- > 4hr exercise duration
- Unusually hot or extreme cold

Medications such as some anti-depressants may contribute to EAH.

Six Foot Track Marathon Research

In 2006 Dr Steve Reid and I worked at the medical facility at Caves House at the end of the race. Eighteen runners (2.3%) presented for medical assistance. Seven were treated for multiple abrasions and three required suturing for lacerations. We measured the serum electrolytes of the nine competitors who required intravenous fluids after collapsing during and after the marathon. All competitors had raised urea and creatinine concentrations, supporting the diagnosis of dehydration. St Johns Ambulance personnel treated many more runners for minor complaints (not included in data).

None of the collapsed runners had EAH, which we thought was due to a number of factors:

- Relatively cool conditions – measured temperatures were 14.5 ^{0}C at 8am and 23^{0}C at 1pm.
- Aid stations were on average about 2.6km apart.
- Food and salt tablets were available at aid stations.
- Runners were relatively more experienced.

- Only one of the collapsed runners used anti-inflammatory medications in 24hrs before the race.

Cramps

Amongst athletes there is much talk and speculation regarding the treatment of cramps during sporting activity. The availability of sports supplements that claim to improve performance and reduce cramps presents a sometimes confusing decision for especially novice Six Foot Track runners.

The definition of cramping has been suggested as "the spasmodic painful involuntary contraction of a muscle during or immediately after exercise"

The earliest publication of information linking salt depletion and cramps was in 1933 when miners and steamship workers were noted to suffer from muscle cramps. There have been many more recent studies that have *not* found a relationship between serum electrolyte imbalances (sodium, magnesium, potassium, calcium). Similarly no direct relationship between dehydration and cramping has been found. Despite this there are many anecdotes that support the use of certain supplements to prevent cramps.

A survey of 1300 marathon runners identified factors that increase the likelihood of exercise associated muscle cramping (EAMC):

- Older age
- Higher body mass index
- Longer history of running
- Shorter and irregular stretching habits
- Family history of cramps
- Longer running duration
- Muscle fatigue
- Hill running

It is thought that abnormal neuromuscular control and muscle fatigue contributes to EAMC.

General advice for preparing and enjoying the Six Foot Track Marathon

- Train for the terrain: Include hilly runs, and walk up and down steep hills weekly.

- Train in the heat (about 100 minutes of running >25^{0}C) every few days if possible to heat acclimate. The number of runners who collapse is proportional to the maximal temperature of the day! It takes about 2 weeks to train the body to exercise more efficiently in the heat. Adaptations include:
    - Increased resting plasma volume
    - Lowered temperature threshold for sweating
    - Sweat is more dilute
    - Decreased core temperature during exercise
    - Running becomes more efficient- lower heart rate for submaximal exercise
    - Improved exercise tolerance

- Stretch regularly (especially hamstring, quads, and calf muscles)

- Try new things like shoes, orthotics, drinking and feeding plans during training. I do not advise trying something new on race day!

- Drink according to thirst, not according to a general schedule. Expect to lose up to 2% body weight as a result of the marathon (1.4kg in 70kg).

- Carbo load. During your tapering, aim to eat 10-12g/kg/day carbohydrate for the last two days before the marathon. I recommend foods with low fibre in the day before the marathon.

- Avoid non-steroidal anti-inflammatory medication for 24hrs before the race.

- When you stop (especially at the finish) keep walking for about 5 minutes or lay down with your feet up. Stopping and standing still or sitting can lead to blood pooling in your legs, lowering blood pressure in the head, causing fainting or collapse.

- Aim to run the first 15km (to Cox's River) conservatively. After the Coxs River you will be faced with the climb up Mini Mini Saddle. The descent to Alum River adds 190m climb to the Pluviometer. Although the total vertical ascent from Coxs River to the Pluviometer is 910m, there is a further 225m vertical ascent from the Pluviometer to the Caves Road crossing.

  What the figures tell us is that there's lots of uphill and downhill. The quads (thigh muscles) and knees will take lots of punishment in the downhill sections, particularly at the end of the race. So incorporate downhill running as part of your training! Eccentric muscle contractions (e.g. quads running downhill) are painful because of short-term muscle damage and inflammation (not lactic acid). This usually recovers after a few days, and depends on one's level of training and amount of downhill running. For this reason it is not advisable to do consecutive days of serious hill training.

- Happy Training!

References

1. Burke L. Nutrition strategies for the marathon. *Sports Med.* 2007; 35 (4-5), 344-347.
2. Hew-Butler T et al. Second International Exercise-Induced Hyponatremia Development Conference, New Zealand, 2007. *Clin J Sports Med.* 18 (2), March 2008.
3. Coyle EF. Physiological Regulation of Marathon Performance. *Sports Med.* 2007; 35 (4-5), 306-311.
4. Hawley JA, Spargo FJ. Metabolic Adaptations to Marathon Training and Racing. *Sports Med.* 2007; 35 (4-5), 328-331.
5. Kenefick RW, Sawka MN. Heat Exhaustion and Dehydration as causes of Marathon Collapse. *Sports Med.* 2007; 35 (4-5), 378-381.
6. Kenefick et al. Thermoregulatory Function during the Marathon. *Sports Med.* 2007; 35 (4-5), 312-315.
7. Noakes TD. Hydration in the Marathon. *Sports Med.* 2007; 35 (4-5), 463-466.
8. Noakes TD. Lore of Running. 2003. ISBN: 0873229592.
9. Reid SA, King MJ. Serum Biochemistry and Morbidity among Runners presenting for Medical Care after an Australian Mountain Ultramarathon. *Clin J Sports Med.* 2007; 17, 307-310.
10. Schwellnus MP. Cramping in the Marathon. *Sports Med.* 2007; 35 (4-5), 364-367.
11. Wendt D et al. Thermoregulation during Exercise in the Heat: Strategies for Maintaining Health and Performance. 2007, 37 (8); 669-682.