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DEHYDRATION AND FLUID REPLACEMENT IN ENDURANCE SPORTS

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The idea that an athlete should drink during exercise, especially marathon running, is of recent origin. Thus American Joseph Forshaw, who finished fourth in the 1908 Olympic Marathon and tenth in the 1912 Olympic marathon, wrote: 'I know from actual experience that the full race can be covered in creditable time without so much as a single drop of water being taken or even sponging of the head'. Similarly, advice given to marathon runners of the early 1900s included the following caveats: 'Don't get into the habit of drinking and eating in a marathon race; some prominent runners do, but it is not beneficial.'

As recently as 1957, Englishman Jim Peters, who set the world marathon record on four occasions and who may have been the greatest marathoner of all time, expressed a similar belief: '[In the marathon race] there is no need to take any solid food at all and every effort should also be made to do without liquid, as the moment food or drink is taken, the body has to start dealing with its digestion, and in so doing some discomfort will almost invariably be felt.'

The landmark scientific study that reversed these beliefs was that of two Johannesburg physiologists, Cyril Wyndham and Nick Strydom in 1969.[1] They studied runners in a 32 km road race in Germiston and showed that the body temperatures of athletes who became dehydrated by more than 3% of their pre-race body weight were elevated to levels that the authors considered unacceptable. They concluded, incorrectly it now turns out, that the weight loss that develops during exercise is detrimental because it causes the body temperature to rise excessively and must predispose the athlete to heat stroke. In fact heat stroke occurs when athletes exercise too intensively in environmental conditions that are too hot. As a result, their rates of heat production are too high and the environmental conditions too hot to allow adequate dissipation of that heat load. Consequently, heat storage occurs and the body temperature rises.[2]

But even this should not be sufficient to cause heat stroke since an internal (brain) control causes the exercise intensity to fall and ultimately to stop when the body temperature exceeds about 40°C. As a result, when heat stroke does occur during exercise, there are usually other contributory factors, such as drug use (amphetamines or related stimulants like ephedra) or the presence of a genetic predisposition, including conditions such as malignant hyperthermia. Nevertheless, heat stroke is more likely to occur in short-distance running events in which very high rates of heat production are maintained for relatively short periods of time and in which significant dehydration is unlikely to occur.

As a result, increasing rates of fluid ingestion will not prevent the development of heat stroke under these conditions. Indeed there is no evidence that the prevention of dehydration plays any role in the prevention of heat stroke. Rather, all that is needed to prevent heat stroke is to avoid vigorous exercise in the heat, and never to ingest (banned) stimulants before or during exercise in the heat.

Nevertheless, the 1969 South African study was of great practical significance, for it drew attention to the potential dangers of the International Amateur Athletic Federation's Rule No. 165.5, which stipulated that marathon runners could drink no fluids before the 11 km mark of a 42 km marathon and thereafter could only drink every 5 km. This ruling was an improvement of the 1953 rule that stated that '... refreshments shall (only) be provided by the organisers after 15km. No refreshments may be carried or taken by a competitor other than that provided by the organisers.' These early rulings discouraged marathon runners from drinking during races and promoted the idea that drinking was unnecessary and a sign of weakness.

From the results of their original study, Wyndham and Strydom concluded that marathon runners should aim to drink 250 ml of fluid every 15 minutes during exercise to give a total of 1 litre per hour, a value that matched their sweat rates. It is now clear that no elite runner in the long history of the sport has ever achieved such high rates of fluid ingestion during competition. Only in intermittent activities in the heat have such high rates of fluid ingestion been reported.

On the other hand non-elite joggers and walkers are quite capable of drinking fluid at such high rates since they travel so slowly and have ample time to stop and drink as often as they desire during 'competition'. But since such high rates of fluid ingestion exceed the real fluid requirements of persons sweating little because they are exercising at such low intensities, these high rates of fluid ingestion will cause the development of water intoxication (hyponatraemia) if sustained for more than 3 - 4 hours with potentially fatal consequences.[3] Indeed runners in Wyndham and Strydom's study drank only about 100 ml per hour, which is probably similar to the current practices of world class runners in races of 5 - 42 km.[4,5]

In general, most studies show that the voluntary rates of fluid intake during exercise are usually between 250 and 1 000 ml per hour. Perhaps the best advice is that drinking according to the personal dictates of thirst (*ad libitum*) appears to be both safe and effective. *Ad libitum* rates of fluid intake typically range between 400 and 800 ml per hour in most forms of recreational and competitive exercise; less for slower, smaller athletes exercising in mild environmental conditions, more for superior athletes competing at higher intensities in warmer environments. To ensure they do not develop water intoxication, subjects exercising for prolonged periods in extreme cold may need to drink even less.

References available on request.