Dehydration and performance

Even on cool days, dehydration can seriously damage your performance. Here's a guide to avoiding it:

Many athletes dehydrate during competitive events, especially long ones, even when it's not particularly hot. You can't rely on feeling thirsty as a reminder to replace fluid lost through sweating - one of nature's dirty tricks is that exercise suppresses thirst. Dehydration impairs both physical and mental performance in all types and levels of sport, yet it can be avoided (or at least minimised) by appropriate drinking strategies. Before we explain what those are, here's a bit of background physiology.

Exercise produces heat. Prevention of overheating occurs by transfer of heat to the skin by vasodilation of the cutaneous circulation, and by the cooling effect of evaporation of sweat. Exercise causes body fluid losses from moisture in exhaled air as well as from sweating. Although sweat rates are highest under conditions of high-intensity exercise in heat and high humidity, total fluid losses can be appreciable in very prolonged events, whatever the conditions. Unless fluid losses are replaced by drinks, sweating causes progressive depletion of circulating blood volume, leading to hypohydration (commonly called dehydration) and a thickening of blood. This places a strain on the cardiovascular system, with a rise in heart rate in order to maintain adequate blood flow to exercising muscles and vital organs. As blood volume depletes, blood flow to the skin is reduced. As a result, sweating decreases and heat dissipation from the skin is impaired, causing body core temperature to rise, potentially leading to heat stress, collapse and even death.

Even low levels of dehydration have physiological consequences. A loss of 2% bodyweight (just 1kg for a 50kg person) causes an increase in perceived effort and is claimed to reduce performance by 10-20% A fluid loss exceeding 3-5% bodyweight reduces aerobic exercise performance noticeably and impairs reaction time, judgement, concentration and decision making - vital elements in all sports, from pole-vaulting to football. A particular issue for boxers is that dehydration increases risk of brain injury.

The two main factors influencing early fatigue and impaired performance (both physical and mental) in all types of sports and exercise are depletion of body levels of carbohydrate (CHO) and/or fluid. Maintaining adequate CHO and fluid intake optimises training benefit by enabling athletes to train harder and for longer, and can make a difference between winning and losing. The opportunity and ability to eat and drink during training and competition depends on the sport; sports drinks may not be the only feasible option but most of them do provide a convenient supply of CHO and fluid simultaneously, are well tolerated if used appropriately, and can be adapted to suit individual needs in varying circumstances.

There are guidelines for fluid and CHO requirements of various activities, but deciding what, when and how much an individual athlete should consume is not always straightforward. In particular, sweat rates vary among individuals subjected to the same exercise conditions. Probably the most important feature of any sports drink is

PALATABILITY (in large volumes, not just a sip). The perfect drink has no value if it tastes awful, and what suits one person may not suit another.

Sweat losses

Most research has focused on high-intensity or prolonged exercise in the heat, for obvious reasons; dehydration is potentially fatal. Sweat rate rises with exercise intensity, and is increased by a hot or humid environment and heavy clothing (notably non-whicking, dark-coloured garments), both of which interfere with heat dissipation and sweat evaporation.

Prediction of fluid and sodium (Na) losses in sweat is complicated, since sweat rates and sweat Na concentrations vary widely among individuals exercising under the same conditions. For example, measures of sweat rates during one hour of exercise at 70% VO2max at an ambient temperature fo 23 deg. C have been quoted to vary between 426g and 1665g. A study of tennis players reported sweat rates of 0.7-1.4 litres per hour among women and 1.2-2.5 litres per hour among men in hot, humid conditions (32 deg. C with a relative humidity of 60%). Absolute sweat volume is relatively less for a small, lean athlete. Training status and degree of heat-acclimatisation influence composition of and volume of sweat by inducing earlier onset of sweating, a higher sweat rate and a more dilute sweat, conserving salt. Sweat Na concentration has been reported to vary between 40 and 140mmol/litre in volunteer runners, but little more than 20mmol/litre in heat-acclimatised tennis players.

Whatever the environmental conditions, sweat losses are probably greater than many athletes appreciate. The highest reported sweat rate is 3.7 litres/hour for Alberto Salazar during the 1984 Olympic marathon. Sweat rates of 2 to 3 litres/hour can be expected during short periods of hard exercise in the heat, and an excess of 1.5-2 litres/hour during endurance events. Even in cooler conditions losses are appreciable. During a football game on a cool day (10 deg. C), players can lose up to two litres of sweat, and runners are estimated to lose around 1.2 litres/hour at 6 minute/mile pace on a cool, dry day (double this amount on a hot, humid day). Additionally, fluid is lost via moisture in exhaled air.

Except in extreme circumstances, blood Na levels are maintained during exercise. Sweat is mainly composed of water, and Na losses in sweat represent a small fraction of total body content and are readily replaced afterwards by normal food. Rare cases of hyponatraemia (blood Na depletion) have been observed, usually in events lasting eight hours or more, such as the Hawaii Ironman. This potentially life-threatening state results from 'water intoxication' - the consumption of large volumes of water or drinks containing little or no Na, or insufficient Na to match the losses in sweat which, in hot conditions over many hours, add up.

CHO-electrolyte drinks and performance

Since 1984, when the American College of Sports Medicine stated that water was the optimal drink for endurance exercise, many studies have shown performance-enhancing benefits of adding electrolytes (the only useful one being sodium, to speed fluid absorption) and CHO (to provide fuel).

Drinking plain water causes bloating, suppresses thirst (and thus further drinking) and stimulates urine output (therefore is inefficiently retained) - a poor choice where high fluid intake is required. Sports drinks generally contain 10-25 mmol/litre sodium, as salt - well below the optimal concentration for stimulating fluid absorption, but the ideal concentration would taste like sea-water, and palatability is vital. Optimum CHO concentration depends on the physiological demands of the sport, environmental conditions and the athlete's tolerance. In endurance sports, CHO depletion is a factor in early fatigue, but if sweat rates are high and dehydration is rapid, then fluid replacement takes priority over CHO. Powdered sports-drink formulas are practical since they can be diluted to suit the climate and the individual. Isotonic CHO-electrolyte drinks generally contain 4-8% CHO, are rapidly absorbed (as quickly as or quicker than water) and provide fuel. The benefits of CHO drinks in delaying fatigue are well documented; endurance cyclists and marathon runners achieve significantly faster times if they drink CHO-electrolyte drink in place of water and, in strength training, more reps of a given weight can be performed when CHO is consumed. This is not surprising, since the higher the exercise intensity, the more rapid the rate of CHO utilisation and the sooner that glycogen stores are depleted. The results of a recent study, well-designed to mimic the physiological demands of multi-sprint sports such as football, tennis and hockey, suggest that CHO supplementation benefits both physical and mental performance tasks. In other words, CHO not only delays fatigue but also helps maintain mental alertness and judgement.

How much CHO

Given these finding, it seems logical to advise that CHO-electrolyte drinks are taken during endurance events and team sports alike, when food is neither practical nor manageable. But what about CHO concentration? E.F. Coyle (see references) advises, for a 68 kg man, the provision of between 30 and 60g CHO/hour in the form of between 625 and 1250 ml/hour of a 4-8% CHO-electrolyte drink during endurance exercise. (Quantities should obviously be adjusted for different body weights.) In reality, however, some athletes find a 4-8% CHO drink 'heavy' and choose a weaker solution for easier tolerance, although tolerance of CHO drinks during exercise does improve with practice. In ultra events in the heat, where large volumes (usually 1-1.4 litres/hour) are recommended, boredom and flavour-fatigue can be a problem, in which case, a choice of drinks and the option of CHO-containing foods (if tolerated) can help.

In most sports situations, drinks in excess of 10% CHO concentration are inadvisable. However, during prolonged (more than 60-90 minutes) high-intensity exercise in very cold conditions, with low sweat rates, glycogen depletion is more a factor than dehydration, and a drink with up to 15% may be more beneficial, if tolerated.

Many endurance athletes incur a deficit of fluid and CHO during competition. Sandwiches and tumblers of squash would help to replenish body stores, but post-event loss of appetite is common. CHO-electrolyte drinks may be easier to manage, are rapidly absorbed, well retained and relatively easy to drink in quantity since their sodium content drives thirst. For these reasons, CHO-electrolyte drinks can be particularly valuable in multi-stage events such as, for example, the Tour de France, major tennis tournaments and two-day mountain marathons, where not only are CHO and fluid requirements high but there is limited time to refuel and rehydrate before the next day. In these situations,

even athletes with huge appetites may have difficulty replenishing glycogen stores with food alone in the time available, and CHO-electrolyte drinks can be a useful top-up.

Why do athletes become dehydrated?

Dehydration is progressive depletion of body fluids caused when fluid losses, for whatever reason, exceed fluid intake. This leads to hypohydration (or dehydration). Athletes may arrive at the start of their event already hypohydrated - for example, after a long, hot journey to the event, or inadequate rehydration in between successive events, or 'making weight' strategies in, for instance, boxing, light-weight rowing and horseracing. Possible reasons for insufficient fluid intake during an event include:

1. poor understanding of fluid requirements. Because sweat rates vary so widely and are probably greater than most athletes appreciate, a worthwhile plan is to record fluid intake during training or events (also noting the weather conditions) and weighing, without clothes, before and after, to assess how well fluid intake matches losses.
2. limited opportunity to drink, or availability of drinks. Orienteers and fell runners common carry little or no drink, relying instead on streams. For events lasting an hour or more, if the availability of streams cannot be guaranteed, consumption of 500 ml of an electrolyte, or CHO-electrolyte, drink 10 minutes before the start will benefit performance in later stages.
3. poor drinking strategies. As I've said, exercise suppresses thirst, and the event itself can distract the athlete from drinking. Subsequent hypohydration impairs gastric emptying and can cause gastric upset, nausea or vomiting, which in turn limit further ability to drink.
4. poor tolerance of drinks during competition. The nausea that many athletes blame on sports drinks could be caused by dehydration itself, or too concentrated a drink. Dehydration can be mistaken for carbohydrate depletion. Drinks that contain more than 10% CHO impair gastric emptying (and therefore rate of fluid provision) and stimulate the secretion of body fluids into the intestine to dilute the drink before it can be absorbed, temporarily worsening dehydration.

   High CHO drinks can themselves cause nausea, more so in a dehydrated athlete. Carbonated drinks are likely to cause bloating or discomfort, and fructose (fruit sugar) in high concentrations can cause gastric upset and/or diarrhoea. Although fructose is included in some sports drinks, it is inefficient as a sole source of CHO because it is absorbed slowly and requires conversion to glucose by the liver before it is available for energy.

5. inability to match excessive sweat rates. Exercise intensities exceeding 70% VO2max will progressively suppress gastric emptying. The highest reported rate of gastric emptying is 2400ml/hour, in resting subjects. During exercise gastric emptying rarely exceeds 1-1.2 litres/hour, unless a large volume is maintained in the stomach. Runners in particular experience discomfort with high volumes in the stomach, and in race situations it is unlikely that athletes could drink more than two litres/hour, even if they could tolerate it. Some degree of dehydration is therefore inevitable when rates of fluid loss exceed sustainable drinking capacity.

In practice, competing endurance runners and canoeists generally drink about 500 ml/hour, and dehydrate at a rate of 500-1000 ml/hour. Even triathletes, who as a group are relatively knowledgeable about nutrition and hydration, have been shown to lose an average of 1.7% and 3.7% of bodyweight for a 3-hour and a 12-hour event respectively. Whereas cyclists are known to tolerate 1.2 litres/hour of a 6% CHO-electrolyte drink, runners are more likely to experience discomfort, and may believe that time lost through slowing down to drink may not be recovered. The volume that most athletes choose to drink during exercise replaces less than 50% of their losses. With this in mind, effective post-event hydration is vital in between consecutive heats or events spanning several days.

Source: Carolyn Wright www.pponline.co.uk

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