



THIRSTY WORK

HYDRATION AND EXERCISE



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Good hydration at any level of exercise participation is important in preventing unnecessary cardiovascular stress as well as many of the other side effects of dehydration such as nausea, vomiting, headaches and sluggishness. It is particularly important in hot and humid weather when sweat loss is much greater.

Most of us do not consume enough fluid on a daily basis and therefore spend much of our lives in a permanent state of dehydration, albeit a relatively minor one, and with little noticeable effect on our lives other than the odd headache or feeling of lethargy. However add physical activity to the equation and good hydration becomes essential to staying healthy and at elite levels, particularly in endurance related sport, it could mean the difference between winning and losing.

Methods of heat loss

Energy metabolism can easily increase 10-20 fold in active individuals and trained athletes respectively compared with metabolism at rest but only around 20-25% of the energy expended is actually used to perform physical work, the rest is lost as heat. This heat needs to be expelled from the body in order to keep core body

temperature within safe limits (less than 40 degrees centigrade). During rest, sweat does not usually contribute significantly to heat loss except in very hot climates, but during activity it is the most important method of thermoregulation.

Exercise, particularly in hot conditions, presents an interesting conflict to the cardiovascular system because while increasing the blood supply to superficial areas such as the skin is very effective for releasing heat it also means that blood, and therefore oxygen, is diverted away from the muscles. Exercise in hot weather is particularly challenging with regards to thermoregulation. Humidity also limits heat loss as the moisture in the air reduces vaporisation of sweat. The result of the combination between environment and core body temperature is referred to as thermal stress. The body is under increasing thermal stress with combinations of a high internal build up of heat (ie. during high exercise intensity), high humidity and/or a hot environment.

It is possible to become acclimatised to the heat in the same way as fitness improves with training. This can result in earlier onset and increased sweat production as well as a change in the electrolyte concentration of the sweat. This 'fitness' begins to take effect after just 1-2 sessions.



While good hydration is important in preventing heat related illness, it should be noted that hyperthermia (overheating) can occur without dehydration, when metabolic rate is very high (ie. during high exercise intensity).

Good hydration is particularly important in reducing core temperature and strain on the cardiovascular system as well as optimising exercise performance. It is thought that fluid ingestion reduces plasma adrenaline, which may reduce heart rate and maintain skin blood flow, but optimal dosage continues to be a subject of debate and will vary for every individual.

Golden goal

The golden goal in fluid ingestion is to try and match sweat loss. This may be a challenge in reality, particularly for people exercising at high intensities. Attempting to match sweat loss of over 1-1.5 litres per hour is likely to result in some gastrointestinal discomfort. A number of studies have revealed that 0.8 to 1 litre every hour is the most achievable ingestion rate.

The American College of Sports Medicine (ACSM) (3) suggests in its most recent position statement that 150-300 ml should be ingested for every 15 minutes of vigorous activity (ie. running). However this is a general guideline and does not take into account individual differences that can vary significantly.

The optimal fluid for hydration depends on a number of variables including:

- exercise intensity
- exercise duration
- ambient temperature
- existing hydration levels
- fitness
- individual characteristics (ie. body weight, size, sex).

One of the best methods of judging sweat loss is by weight measurement before and after exercise. A decrease of one kilogram in weight is approximately equivalent to one litre of fluid loss.

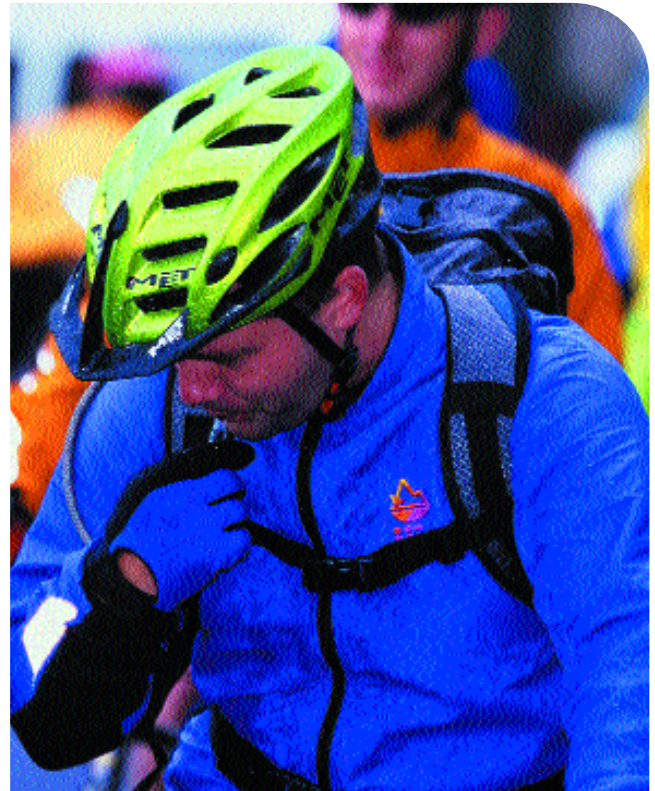
Effects of dehydration

A fluid loss representing just 2% of body weight can result in an impaired response to exercise. Blood volume decreases which not only results in a rise in core temperature but also in the effort the body, and more specifically the cardiovascular system, must sustain to meet the same physical challenge.

With a loss of 2% in body weight, ability to exercise and maximal aerobic capacity drop by 10-20%. A 4% loss may result in nausea and vomiting; at 5%, aerobic capacity will have dropped by 30% and at 8% dizziness, weakness and confusion are possible.

The more dehydrated an individual becomes, the less able they are to sweat as the blood flow tends to favour the working muscles rather than heat dissipation through the skin. This causes the core temperature to rise. The end result can be heat stroke, circulatory collapse and even death.

According to researchers in the US, urine colour is as good an indicator of hydration as urine osmolality measurements. Very pale to pale yellow indicates being within 1% of optimal hydration.



Facts and figures

- For an average person, approximately one hour of exercise will result in a loss of at least one litre of fluid, more in hot conditions
- Evaporation of 1 litre of sweat consumes 580-600 kcals of heat
- A decrease of one kilogram in weight is approximately equivalent to one litre of fluid loss
- Pale yellow urine indicates being within 1% of optimal hydration
- There is unlikely to be a decrease in performance if at least 80% of sweat loss can be replaced during exercise

Fluid intake

For some time it was thought that water was the best fluid during exercise as research had shown that increasing amounts of carbohydrate slowed gastric emptying.

However more recent studies suggest that drinks containing up to 5-8% of carbohydrate can improve endurance performance with no ill effects. Drinks with carbohydrate content exceeding 12% resulted in gastric discomfort as well as reduced performance in high temperatures.

Recent research has shown that ingesting one litre per hour of a 6-8% carbohydrate/electrolyte drink not only maintained good hydration but also improved performance over and above maintaining good hydration through ingesting water.

In 1995, a study revealed that during one hour of cycling in the heat, a high intake of water (1.33 litres) improved performance by nearly 7% compared with a water intake of 200 ml. The addition of 79g of carbohydrate boosted performance by a further 6.3% (1). Carbohydrate alone also increases performance.



It's all in the timing

Good hydration relies on a slightly more scientific approach than just drinking in response to thirst. Thirst is a very unreliable indicator of dehydration as levels sufficient to impair performance can have occurred well before the desire to consume fluid kicks in. Performance is also likely to be compromised if an individual is dehydrated at the beginning of training or competition. Research was carried out on groups of runners running 1,500, 5,000 metres or 10,000 metres at normal hydration, and dehydration at 2% of their body weight. The dehydrated runners ran 6-7% slower in both the 5,000 and 10,000 events (2).

The ACSM (3) suggests drinking around 500ml about two hours before exercising. This allows time for the body to become hydrated but also for excretion of any excess water. Follow this by drinking an additional 125-250ml immediately before exercise. The greater the volume of water in the body, the faster it reaches the intestines and replaces lost fluid in the body. It is therefore advisable to drink as much as is comfortable before and in the early part of exercise and then top up with small amounts frequently during the period of activity. The amounts consumed before discomfort is experienced will vary significantly between individuals.

Pre-participation

It is difficult to 'hyperhydrate' by ingesting water or even sports drinks as the body just excretes any surplus fluid. However research carried out in both Australia and the US revealed that the consumption of glycerol along with fluid two hours before exercise led to an extra 600ml of fluid being retained and an improvement in performance of 2.4% (4). It is thought that glycerol causes a powerful osmotic effect at both intra and extra-cellular levels, but in some cases the athletes experienced gastric discomfort and headaches. Generally 500ml of water two hours before exercise followed by 125-250ml just before commencing the activity is sufficient. Drinks containing suitable levels of carbohydrate (6-8%) will help ensure good hydration and provide a fuel source if the exercise is likely to be sustained and existing resources may be depleted (see 'Fluid compositions').

During participation

The ACSM recommends drinking 150-300ml of preferably cool fluids every 15 minutes during exercise. The temperature of the fluid affects palatability and may aid fluid uptake and the reduction of core body temperature. Research has also shown that exercisers favour drinks containing sweetening agents above water (5), probably again due to improved taste. Symptoms of nausea and gastrointestinal discomfort in response to exercise are likely to indicate dehydration. As discussed previously, dehydration slows gastric emptying which may result in a number of gastrointestinal reactions such as nausea, vomiting and a feeling of being bloated. Again the moral of the story is to maintain good hydration early on before thirst sets in and also during the activity.

Different types of sports offer varying opportunities for fluid replacement. For example, footballers only get the chance to ingest fluid at half time or during a prolonged injury break whereas it is much easier for tennis players to take regular opportunities to ingest fluid at breaks between games. Individuals, particularly those participating at high levels of competition need to experiment with fluid intake plans to find the one that suits them best.

Advice summary

Pre-exercise

Aim to consume 500 ml two hours before beginning exercise and an additional 125-250ml just prior to exercise – sports drinks speed rehydration and are good when resources are low

During exercise

On average one litre of fluid should be ingested for every 1,000 kilocalories used or one hour spent exercising (more in the heat or under intense activity levels) – approximately 250ml every 15 minutes

Post exercise

Aim to replace 1.5 times (150%) the fluid lost during exercise. On the basis that one litre of fluid is equivalent to one kilogram in bodyweight it is necessary to consume 1.5 litres of fluid post exercise for every kilogram lost. A small amount of sodium is beneficial to increase the urge to drink and promote fluid retention

Post-exercise

The general aim is to consume 1.5 litres of fluid for every kilogram of body weight lost during the exercise. The ACSM recommends the consumption of 500ml immediately after exercise and then to ingest the remaining amount as soon as possible without causing gastrointestinal discomfort. Another general guideline is one litre for every 1,000 kilocalories burnt. In hot and humid weather these amounts should be increased.

Fluid compositions

Exercise lasting for one hour or less

Optimal compositions will differ between individuals however for most exercise lasting up to an hour, when the carbohydrate needs of the body can be supported by existing stores, water is sufficient and economical for hydration purposes.

Exercise exceeding one hour

During strenuous activity lasting more than an hour or in a situation where the exerciser may have already depleted resources of either carbohydrate or fluid (ie. there has not been sufficient recovery time between exercise bouts such as during tournaments), resource replacement will be better provided by fluid containing carbohydrates. This carbohydrate helps maintain blood sugar levels and improves rates of carbohydrate oxidation when muscle glycogen levels are low (6). The ACSM recommends a carbohydrate intake of between 30-60 grams per hour. As discussed earlier it was traditionally thought that carbohydrate intake prior to exercise compromised gastric emptying.

However it is now recognised that during exercise fluid delivery is not compromised with carbohydrate intakes of between 4-8% (3) hence the explosion in sports drinks marketing. This carbohydrate delivery can be achieved by drinking 600-1200 ml/h (150-300ml every 15 minutes) of solutions containing 4-8% carbohydrate. Sports drinks are significantly better than water in any circumstances where rapid fluid replacement is a priority and/or when muscle glycogen is being used quickly.

The ACSM states that the type of carbohydrate can be either sugars (glucose or sucrose) or starch (eg. maltodextrins – sometimes referred to as glucose polymers).



Situations in which 'sports' drinks may be beneficial during exercise include:

- Exercise lasting for one hour or more
- High intensity exercise
- In warm and humid temperature conditions
- Where existing resources may be depleted.

Post-exercise

For athletes such as tennis players who may compete more than once a day (particularly for periods of more than an hour), sports drinks are a better way of speeding rehydration compared with water. Water reduces the osmolality of the blood and dilutes sodium concentration in the blood, thereby reducing the sensation of thirst, and increases urine output (7). The result may be to stop drinking even though hydration levels have not been recovered. As most sports drinks contain some sodium this is less likely to happen until hydration is complete.

Salt tablets are definitely not recommended as these provide an over-concentrated supply of sodium that delays rehydration as more water is required to dilute the sodium.

Research has shown there is little difference in the effects of carbonated and non carbonated drinks with regards to hydration (8), although carbonated drinks may cause gastrointestinal discomfort in some individuals.

The new breed of energy drinks

Sports drinks and traditionally named energy drinks should not be confused with the newer breed of energy drinks such as Red Bull and Red Devil. Sports drinks typically contain around 6% of carbohydrate, a small amount of sodium, sweeteners to enhance flavour and no caffeine.

The new breed of energy drinks typically contain stimulants such as caffeine and often also higher levels of carbohydrate (Coca-Cola contains around 10-11%) which slows absorption rates.

While caffeine has been shown to improve performance in both endurance and sprint based activities (and is consequently a regulated substance by the International Olympic Committee) it also increases the excretion of water from the body and may also cause anxiety and increased heart rate.

Other drinks

Fruit juices and other soft drinks such as squash tend to contain higher carbohydrate percentages that not only slow gastric activity but also require water for dilution before being absorbed by the body. The end result may actually contribute to dehydration.

Low calorie drinks do not contain sugar (only artificial sweeteners) and have low sodium concentrations and therefore have a similar effect to water.

TIP

An easy way to calculate the percentage of contents in a drink is to divide the amount in grams in one serving (in this case 4g) by the amount of fluid in millilitres in one serving (100ml) and multiply by 100 to give a percentage ie.
 $4g/100ml \times 100 = 4\%$

References

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Exercise and fluid replacement

Good hydration at any level of exercise participation is important in preventing unnecessary cardiovascular stress as well as many of the other side effects of dehydration such as nausea, vomiting, headaches and sluggishness. It is particularly important in hot and humid weather when sweat loss is much greater.

Guidance

- The overall aim during exercise is to consume fluids at a rate sufficient to replace all the water lost through sweating
- If conditions are hot and/or humid and/or you are already dehydrated, increase fluid uptake
- These are only general guidelines and do not take account of individual characteristics and physiology – drink as much as is comfortable, it is difficult to ‘hyperhydrate’ as excess fluid is excreted
- It is recommended that to improve the palatability and desire to consume the fluid during exercise, it is preferable for the drink to be cool (15-22 degrees C).

The sports drink composition

Research has shown that ingestion of certain concentrations of carbohydrate and sodium can aid rehydration. However these are relatively precise if they are to achieve their goals of rehydration.

The optimal sports drink should contain:

- 40-80 grammes of carbohydrate per litre or (4-8g/100ml) (sucrose, glucose, glucose polymers or starch) – amounts exceeding this concentration will slow digestion (which may lead to stomach discomfort, nausea and vomiting) and requires additional water in order to dilute the carbohydrate concentration to the level for absorption – this may actually increase the risk of dehydration and reduce performance. Coca-Cola and Pepsi contain carbohydrates at a concentration of 10-11%, and ready diluted bottles of Ribena contain concentrations of 14%
- a small amount of sodium – this promotes fluid retention and prevents the premature ‘switch off’ of the thirst mechanism

- NO caffeine – newer, trendy energy drinks such as Red Bull and Red Devil contain caffeine which acts as a stimulant giving a sudden boost to energy levels – however while caffeine has been shown to improve athletic performance it is also a diuretic promoting excretion of fluid (thereby hastening dehydration)
- not be carbonated (fizzy) – this can cause stomach discomfort and result in you feeling bloated.

Top tips

- Pale to very pale yellow urine indicates being within 1% of optimal hydration
- There is unlikely to be a decrease in performance if at least 80% of sweat loss can be replaced during exercise
- To calculate the percentage of contents in a drink divide the amount in grams in one serving (in this case 4g) by the amount of fluid in millilitres in one serving (100ml) and multiply by 100 to give a percentage ie. $4g/100ml \times 100 = 4\%$.

Exercise situation	Pre exercise	During exercise	Post exercise
≤ 1hr – low to moderate intensity	Drink around 500ml of water 2 hrs before exercise and another 125-250ml just prior to beginning	Drink small amounts of water frequently – a few sips every 15 minutes should be sufficient. The aim is to match intake of fluid with the amount of fluid lost during the activity. The key is to start drinking early and frequently. Drink as much as possible.	The general aim is to replace 150% of the fluid lost. A good indicator for low to moderate exercise is to aim to consume one litre for every 1,000 kcal burnt. Water is perfectly adequate.
> 1hr – moderate intensity	As above – although a sports drink may be beneficial in place of water – particularly if you may already be dehydrated or have failed to eat sufficiently during the day	Guidelines recommend 125-250ml every 15 minutes. The more intense or prolonged the activity, the more important this becomes. Water is sufficient but a sports drink may help sustain performance and replace lost fluid more quickly	Following the principle of replacing 150% of the fluid lost this equates to 1.5 litres for every kilogram of body weight lost during exercise. Water is adequate as long as enough is consumed.
> 1hr high intensity and for multiple exercise sessions per day particularly where a high level of performance is required ie. back to back tennis matches	As above – substituting water for a sports drink to provide sufficient fuel and fluid to optimise performance	For intense exercise it is recommended the consumption of 30-60g of carbohydrates an hour. This can be achieved by drinking 600-1200ml per hour (150-250ml every 15 mins) of a solution containing 4-8% carbohydrates (ie. suitable sports drinks)	As above it is important to try and replace 150% of the fluid lost. It is advisable to rehydrate using a fluid containing a small amount of sodium per litre. This encourages you to keep drinking when water may have ‘switched off’ your desire to drink (thirst) prematurely