HYDRA+ & HYDRA 10
THE SCIENCE BEHIND

HYDRA+ & HYDRA 10

HYDRA+ & HYDRA 10

HYDRA+ & HYDRA 10
THE SCIENCE BEHIND

KEY POINTS

- Sweating occurs during most vigorous exercise bouts. The more intense the activity the greater the sweat rate, and this is exacerbated by a hot and humid external environmental condition.
- Sweating leads to dehydration. Body weight loss due to sweating can be significant – often more than 3-4kg after prolonged sporting events.
- Athletes are encouraged to start training or competitive in a hydrated state by drinking fluid in the 2-3 hours prior to the event.
- Fluids ingested during exercise for the purpose of hydration should be low in carbohydrate (around 2% or less) and contain some electrolytes (notably sodium and magnesium).
- Athletes should drink a volume equivalent to 150% body mass loss in order to rehydrate; preferably within the first 1-2 hours.
- A reasonable Na+ content for any ingested drink is essential. Concentrations in excess of 30mM are desirable.
- Hydra10 & Hydra+ are ideal hydration/rehydration products as they are low in carbohydrate but possess sodium at a high enough concentration and additional magnesium. They meet all the requirements as an ideal fluid for sport.
- Take either as a drink before training (suitable with or just after breakfast if morning training).
- Take during training if hydration is a factor e.g. during strenuous training in the heat or indoors.
- Take after training if significant sweat loss.
- Good product to take on a carb-loading day i.e. day before a match/competition.
- Take as a second half drink during matches.
- Useful for anyone to drink when there is a need to keep hydrated (even when not exercising).

INTRODUCTION

Fluid loss through sweating invariably leads to some degree of dehydration and this is a usual consequence of any type of exercise, whether short term or prolonged. The deleterious effects of dehydration on athletic (and even mental performance) have been well researched (Cheuvront & Kenefick, 2014). A recent meta-analysis (McCartney et al., 2017) has shown significant decreases in aerobic and high intensity exercise performance as well as muscular strength and endurance when participants started the activity in a dehydrated state. Experimental investigations have also demonstrated motor-skill impairments on sport-specific tests (e.g. cricket, basketball, golf, hockey, and surfing) following fluid loss. Some degree of dehydration is commonly observed not only amongst athletes but also manual workers (e.g. military personnel, fire fighters and manual labourers) who are engaged in heavy physical work.

The importance for euhydration (having the body fluids at their normal level) or even hyperhydration (having the body fluids in excess) prior to training or competition is therefore important.

It is also important to attempt to balance fluid intake with fluid loss, if possible, during exercise. However, it is often invariable that some or a substantial imbalance of body fluids takes place as a consequence of exercise, particularly in hot and humid environments. Body fluid losses in the region of 1-4 litres per hour (i.e. 1-4 kg of body weight since 1 litre of fluid weighs approximately 1 kg) after prolonged bouts of activity are common, as are sweat rates of 1-2 L/h (Shirreffs, 2010). Figure 1 highlights some selected sweat rates during training or competition in a range of sports, and clearly demonstrates the significant impact of exercise on fluid loss from the body. Consequently it would be sensible to recover from dehydration (i.e. to rehydrate) adequately before undertaking any further activity.

Hydra 10 is a scientifically formulated hydration product from NutritionX which should be used by athletes who wish to hydrate before training or competition, or to rehydrate during and after training/competition.

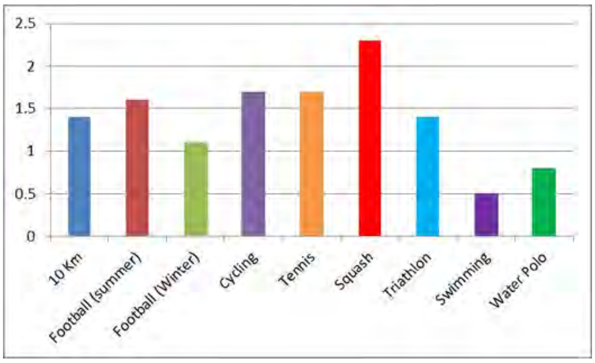

Figure 1: Sweat rates (Litres per hour) during various sports.

BODY FLUIDS

Approximately 60%, by weight, of a human body is made up of water of which 20% is extracellular fluid (i.e. outside cells) and 40%intracellular fluids (see Figure 2).

These body fluids are constantly changing due to ingestion of food and drink (input) and to losses via sweating, urine production and excretion, and insensible loss via breathing (see Figure 3).

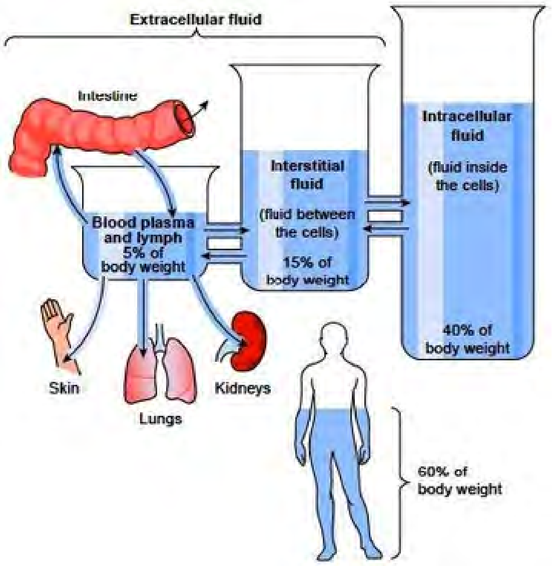

Figure 2: Schema illustrating the distribution of fluids in the human body.

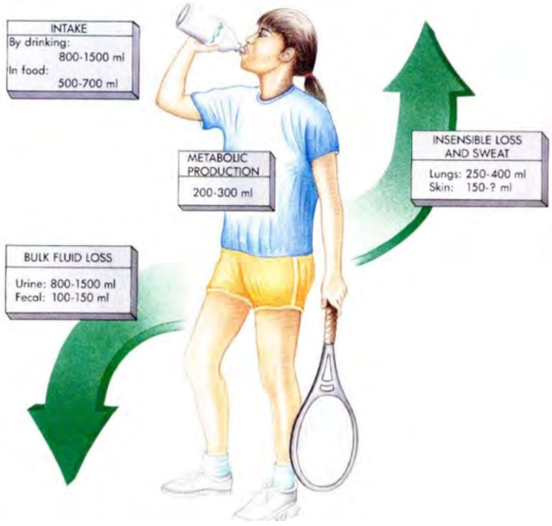

Figure 3: Illustration of body fluid gains and losses.

During exercise the body loses significant amounts of fluid through sweating, whereas urine production is drastically reduced (see Table 1). At rest however, most of the fluid loss occurs due to urine production and elimination.

HYDRA+ & HYDRA 10
THE SCIENCE BEHIND

Body fluids are not merely plain water, but have various components dissolved or carried. From a hydration and rehydration perspective, the important components are electrolytes dissolved in plasma (extracellular) or within the cell (intracellular). Table 2 highlights key electrolytes found in the extracellular and intracellular fluids. It is noticeable how much they vary – greater amounts of sodium and bicarbonate in the plasma whilst more potassium and magnesium inside cells.

The functions of these electrolytes and how much is required for athletes in training can be seen in Table 3. These electrolytes are lost in sweat during exercise and so should be replaced by drink or food when appropriate. Notable losses of sodium and magnesium are observed in the sweat of athletes – with some athletes exhibiting much higher levels of 'salty' sweat (sodium and magnesium) than others.

Source of loss	Rest		Exercise	
	ml/h	% total	ml/h	% total
Insensible loss				
Skin	15	15	15	1
Respiration	15	15	100	7
Sweating	4	5	1200	91
Urine	58	60	10	1
Faeces	4	5	-	0
TOTAL	96	100	1325	100

Table 1: Body fluid losses at rest and as a result of exercise.

Extracellular Fluid (Plasma)		Intracellular Fluid	
Sodium	142 mEq/L	Sodium	10 mEq/L
Potassium	5 mEq/L	Potassium	150 mEq/L
Chloride	103 mEq/L	Chloride	
Magnesium	2 mEq/L	Magnesium	40 mEq/L
Calcium	5 mEq/L	Calcium	
Bicarbonate	26 mEq/L	Bicarbonate	10 mEq/L

Table 2: Major electrolytes in body fluids.

Electrolyte	Main Role	Daily Intake for Performance
Sodium	Muscle contraction Nerve transmission	1,500 – 4,500 mg
Potassium	Nerve transmission	2,500 – 4,000 mg
Chloride	Muscle contraction	
Magnesium	Energy (ATP) production	400 – 800 mg
Calcium	Nerve transmission Muscle contraction	1,200 – 1,600 mg

Table 3: Major electrolytes in body fluids.

SWEAT RATES

The rate of sweating by an athlete varies dependent on the intensity of the exercise and also on environmental conditions. Figure 4 illustrates the range of sweat rates according to the severity of the exercise and to the climatic conditions i.e. greater sweating at higher or faster running and also in hot and humid conditions.

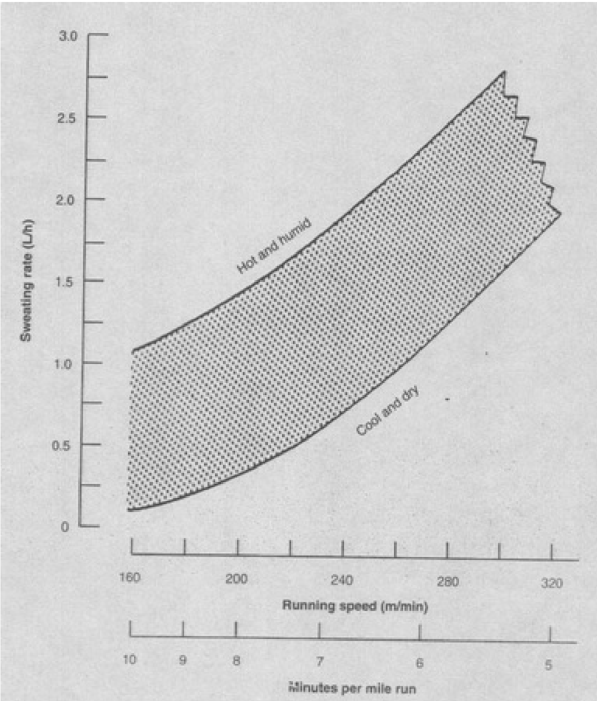

Figure 4: Schema of how exercise intensity and environmental conditions affect sweat rate.

In order to calculate decrease in body weight due to dehydration it is normally necessary to measure body weight before and then again after the activity (both preferably nude weight and after being towelled dry) and include weight due to any fluid intake over that period of time. An example of how this can be achieved and then used to calculate sweat rate is given below:

Pre-competition weight = 85kg
Post-competition weight = 84kg
Actual body weight loss due to fluids = 1 kg
However - Total fluid ingested during competition = 1 litre (or 1 kg equivalent)

Therefore – actual fluid loss = 1 kg (BWt)+1 kg (Fluid intake) = 2 kg or 2 litres

To estimate the sweat rate it is necessary to have a measure of the time period for the competition and so divide the total fluid loss by the time. So, if the competition lasted 90 minutes, the sweat rate would be 2 litres/90 min or 2,000mL/90 min = 22.22mL/min or 1333.2mL/h.

Figure 5 provides an example of the sweat rates of runners who completed a marathon in Aberdeen in fairly cool conditions. Note how the faster runners had the higher sweat rates.

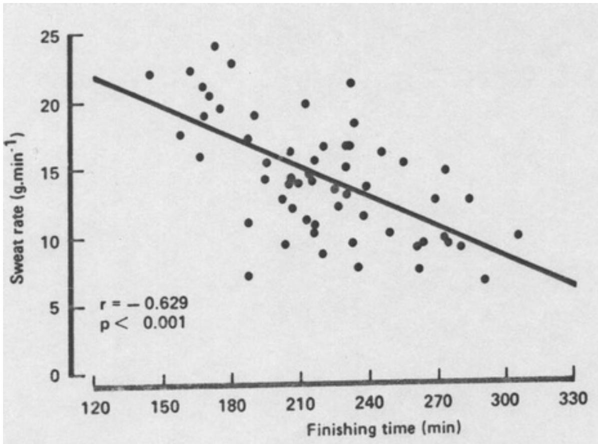

Figure 5: Relationship between sweat rate and finishing time in an Aberdeen marathon (after Maughan et al., 1985).

IS DEHYDRATION A PROBLEM?

Earlier (Figure 1) the fact that various sports result in sweat rates of greater than 1 litre per hour was highlighted. Such rates as playing football over 90 minutes for example would result in a total loss of around 2 kg of body weight from the 2 litres of sweat loss. For a 70kg person this represents nearly 3%loss of body weight. The schematic in Figure 6 illustrates that any loss of body weight of around and greater than 2% could prove detrimental to performance, and that values in excess of 5% represent heat exhaustion.

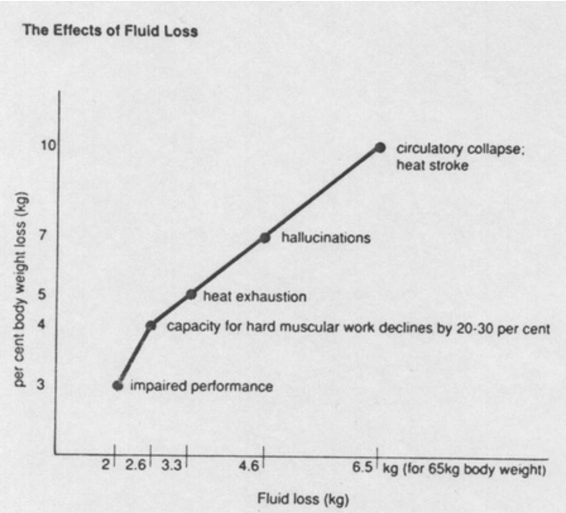

Figure 6: Schema of fluid loss, % body weight loss, and likely effects on performance.

The effects of dehydration on the body during exercise can be realized in an elevated heart rate, increased rating of perceived exertion (RPE), as well as reduced performance variables in prolonged efforts (particularly in the heat). Figure 7 highlights the effects of dehydration on heart rate during prolonged walking in the heat when supplied with water, saline drink, or given no fluid. Imbibing fluid clearly has a reduced heart rate response even during low levels of activity such as walking.

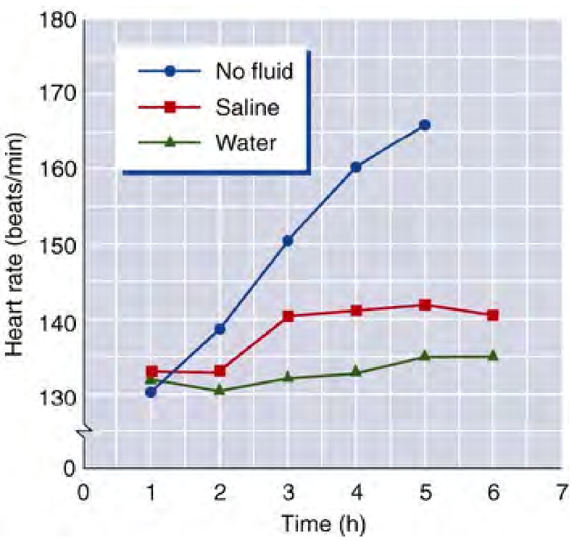

Figure 7: Schema illustrating the distribution of fluids in the human body.

In another study, participants were dehydrated by 2%body weight through sweating in a sauna prior to a 10km run. A noticeable deleterious effect is observed due to dehydration (Figure 8).

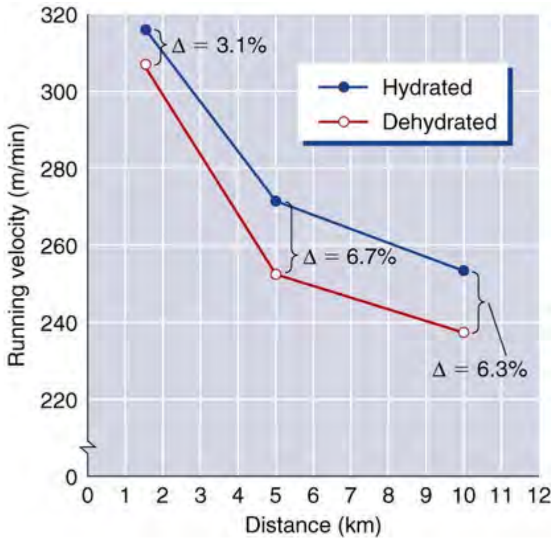

Figure 8: Effect of 2% body weight loss due to dehydration on subsequent 10km run performance.

The American College of Sports Medicine guidelines suggest that athletes should be encouraged to consume around 500ml (1/2 litre) of fluid in the 2-3 hours before engaging in prolonged activities. This can be easily achieved as part of a pre-match or pre-training strategy. The fluid can be plain water (or a carbohydrate-electrolyte drink) if taken with a meal. Hydra10 would be an ideal accompaniment to hydrate athletes before an activity either on its own (if a person does not wish to eat) or as part of the meal.

The effects of dehydration on the body during exercise can be realized in an elevated heart rate, increased rating of perceived exertion (RPE), as well as reduced performance variables in prolonged efforts (particularly in the heat). Figure 7 highlights the effects of dehydration on heart rate during prolonged walking in the heat when supplied with water, saline drink, or given no fluid. Imbibing fluid clearly has a reduced heart rate response even during low levels of activity such as walking.

HYDRATION DURING EXERCISE

Keeping hydrated during exercise is always a balance between sweat loss and fluid intake. In most warm or hot conditions it is NOT possible to match fluid intake with sweat loss since the latter is invariably greater i.e. it is highly unlikely that an athlete can ingest more than around 600 - 800ml of fluid per hour without gastric problems yet sweat rates in excess of 1 litre per hour are easily reached (in this situation the result is a deficit of 200 – 400 ml per hour).

The main reason for this imbalance is that of the rate of gastric emptying i.e. how quickly fluids can pass through the stomach into the small intestine where water and nutrients are absorbed into the blood. It should be remembered that blood flow to the gut is severely restricted during exercise as blood flows predominantly to the muscles – so a reduced blood flow in the gut means slower emptying. Figure 9 shows a number of factors which influence gastric emptying.

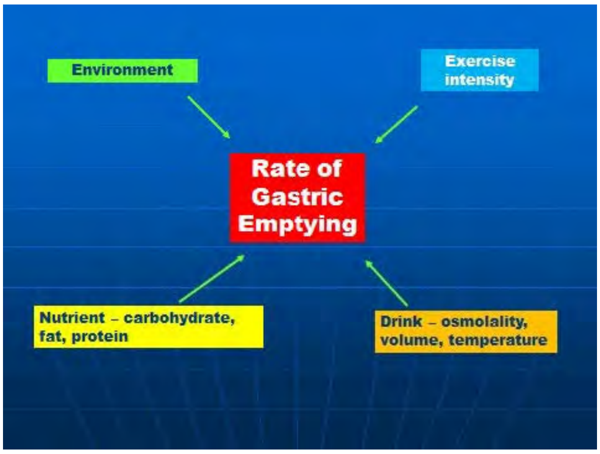

Figure 9: Factors influencing gastric emptying.

The key points to be concerned with respect to gastric emptying are:

a) Exercise intensity - there is no discernible effect until intensities greater than 70% VO2 max or around 80% of max heart rate are reached and then there is a significant reduction (see Figure 10),

b) Concentrated forms of carbohydrate in a drink – the more concentrated the carbohydrate in a drink the slower the rate of emptying (see Figure 11). That is why many sports drinks are between 6-8%carbohydrate if a mixture of energy and fluid delivery are required. On the other hand if hydration is of key importance then a concentration of around 2-3% carbohydrate is more suitable. Hydra10 has a concentration of 2% carbohydrate since it's major influence is fluid delivery and hydration.

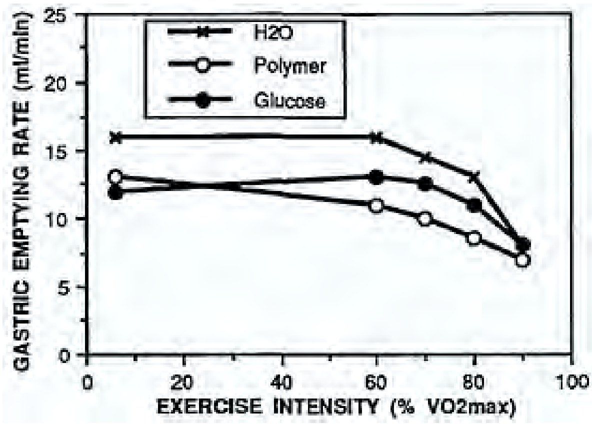

Figure 10: Effect of exercise intensity on gastric emptying.

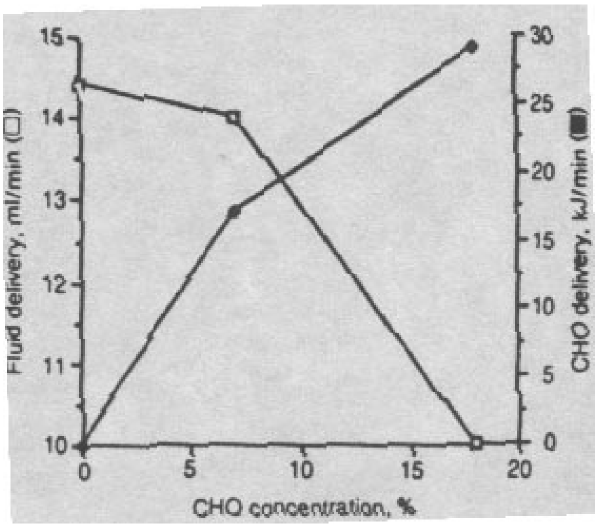

Figure 11: Effect of carbohydrate concentration on fluid delivery (left axis) and carbohydrate delivery (right axis).

In order for a sports drink to be suitable for hydration, it should be isotonic or hypotonic to body fluids. Since body fluids have an osmotic pressure of around 290mOsm/L, isotonic drinks should have the same value and if hypotonic then a value much lower. Hypotonic drinks are more suitable for hydration whereas isotonic drinks provide less fluid but more carbohydrate for energy. Table 4 illustrates the content of some drinks in relation to carbohydrate and sodium content as well as their osmolality (equivalent to tonicity).

Product	Carbohydrate (%)	Sodium (mg/L)	Osmolality (mOsm/L)
Lucozade Sport	6.5	510 (22mM)	290
Gatorade	6	510 (20mM)	340
Powerade	8	280 (12mM)	400
SIS Go electrolyte	7	460 (20mM)	300
Dioralyte	3	700 (36mM)	90
Hydra10	2	720 (40mM)	177
Hydra+	0.5	348(30mM)	133
Coca Cola	11	56 (2mM)	600
Fresh Orange juice	10	11 (0.5mM)	650

Table 4: Content of various drinks.

The contents of various drinks in Table 4 demonstrates that those such as Coca Cola may well present athletes with high carbohydrate levels but are not beneficial for hydration due to being hypertonic (more likely to dehydrate further!), and also the lack of sodium prevents fluid being kept in the body. The carbohydrate-electrolyte sports/energy drinks (e.g Lucozade, Gatorade, Powerade) are also relatively high in carbohydrate (around 6%) and so useful during a sporting event if trading off between energy and fluid, whilst products such as Dioralyte and Hydra10 and Hydra+ are clearly most beneficial from a hydration perspective due to being hypotonic and also high in sodium.

c) A large volume of drink in the stomach increases the rate of gastric emptying (see Figure 12) since it affects stretch receptors in the stomach to 'hurry along' the movement of material to the intestine. This is something athletes may have to train their stomachs to undertake since a relatively full stomach may feel rather uncomfortable, and indeed could cause gut ache.

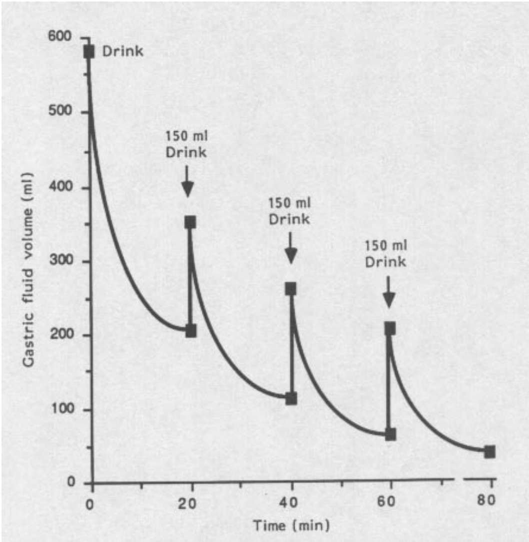

Figure 12: Effect of drink volume on rate of gastric emptying whilst cycling (note how the graph shows a rapid initial emptying then a slowing at a time point after the drinks have been ingested).

REHYDRATION AFTER EXERCISE

The amount of fluid needed to be retained in the body is likely to be that which has been lost as a consequence of the exercise bout. In other words, if 2L of fluid is lost then in recovery 2L of fluid should be retained. In order to achieve such a status it is important (a) to review how fluid balance is regulated, and (b) the time period for such rehydration as well as the volume of fluid required to be imbibed. Later subsections examine other potential intervening factors.

The key features of relevance for rehydration relate to the control of excretion of fluids by the effect of the hypothalamus and pituitary on the kidney. As a result of exercise-induced dehydration, the hypothalamus in the brain detects changes in osmotic pressure (the osmotic pressure is higher due to a reduced volume of fluid in the blood) and also the sodium (Na+) concentration of blood (elevated due to haemoconcentration), and so causes the posterior pituitary to release ADH (antidiuretic hormone). The net effect of the action of ADH is for water to be retained by the kidney.

Subsequently, when water is ingested in recovery after exercise the reverse happens at some time point –this is because the ingested water dilutes the blood Na+ and also reduces the osmotic pressure. A potential problem arises if too much water is taken in – this results in too much urine production and so the body fails to rehydrate properly. How can the body rehydrate if water ingestion has a knock on effect of causing more urine production? Clearly there is a need to address (a) how much water should be ingested to enable adequate rehydration to occur, and (b) whether plain water (as opposed to water containing electrolytes) is what is required?

In order to explore the effect of fluid consumption after dehydrating exercise on rehydration, most research studies use a procedure wherein participants are first dehydrated by exercise in a hot climate in order to dehydrate by ~2% body weight loss and then to drink fluid equivalent to the body weight loss and follow the course of rehydration over a period of time such as 6h. The time course for most research investigations on rehydration use a period from 1-6 hours; typically 4-6 hours, since it is expected (may be reasonably) that athletes should be capable of complete rehydration over a 24-h period.

Maughan et al. (1994) employed a well-established method to investigate the volume of fluid required for rehydration. Participants were dehydrated by exercise and heat to ~2% body weight loss and then required to drink (over a period of an hour) a volume equivalent to 50%, 100%, 150%, and 200% of the body mass loss. The drinks contained a small amount of glucose and an amount of Na+ equivalent to dilute sweat (i.e. 23mM). Figure 13 illustrates the findings of the study. It is clear that ingestion of 50% and 100% of the weight loss in fluid failed to rehydrate over any period of time, whereas those of 150% and 200% caused hyperhydration (dilute blood in effect) in the first hour and then euhydration thereafter. In order to understand why these results happen, it is important to reflect once again on the regulation of water balance and the interplay between plasma Na+, osmotic pressure of blood, the hypothalamic-pituitary axis, ADH, and the kidney.

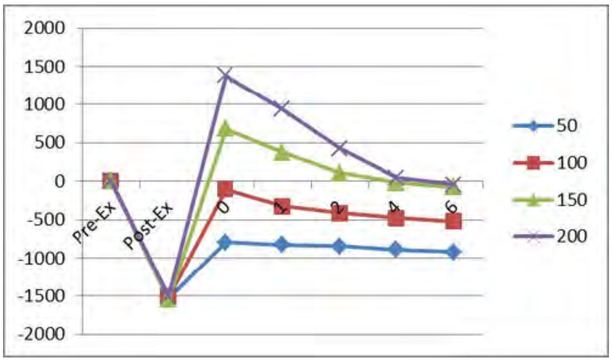

Figure 13: Net fluid balance for trials ingesting 50%, 100%, 150%, and 200% of body weight loss of fluid over a 6h period following ~2% dehydration (after Maughan et al., 1994).

In a slightly more recent publication Kovacs et al. (2002) reported on the impact of high v low rates of fluid ingestion on post-exercise rehydration.

Participants were dehydrated by ~3% body weight and then ingested a volume of a CHO-electrolyte drink representing 120% of weight loss either as 60%, 40%, and 20% in the first 1, 2, and 3 h (representing a faster intake in the early part of recovery) or as 24% over 5h (representing a slower rate of intake). The former represented the 'high rate' whilst the latter the 'low rate'. Figure 14 highlights the net fluid balance over the 5h period of recovery. It is evident that in the first 4 hours of recovery a 'high' rate of fluid ingestion is desirable. This may be particularly relevant in situations where athletes have double training sessions with short recovery period or in multiple competitions within a day such as rugby 7-a-side or soccer 5-a-side. It is also worthy of note that drinking a volume of fluid of 120%body weight loss just about leads to euhydration in the first 2 h and thereafter (unless additional fluid is ingested) there is a possibility of hypohydration. It may be useful to consider what would have occurred if the volume of fluids were 150% of body mass lost!

So we can conclude that if there is a need to rehydrate over a 4-6 hour time course, the volume of fluid required is greater than that lost during the prior exercise bout i.e. > 100% (preferably 150% of the weight lost). Furthermore, it is advisable to ingest the fluid over a short and fairly rapid time period within the first hour or so after completion of exercise if a further bout of exercise is to take place in a short period of time.

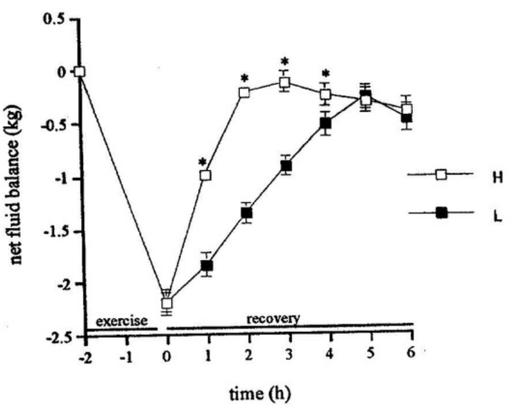

Figure 14: Net fluid balance (kg) between 'high' (H) and 'low' (L) fluid ingestion rates (Kovacs et al., 2002).

IMPORTANCE OF ELECTROLYTES

If large volumes of plain water are ingested following exercise, the plasma Na+ concentration and plasma osmolality fall rapidly (Nose et al., 1988). This has the effect of reducing thirst, limiting further fluid intake, and stimulating urine output, all of which may delay the rehydration process. The results from Nose et al.(1988) indicated that when plain water was consumed, the restoration of plasma volume following exercise-induced dehydration was ~ 3 times slower compared to consumption of a drink containing significant levels of sodium (77mM Na+). They proposed that this delay in rehydration, due to ingestion of plain water, was associated with a reduction in release of ADH, thus allowing a greater urine output. The results also indicated that plain water was less effective in restoring hydration status because not only did plain water reduce the stimulus to drink but the water clearance was also increased, mainly due to the loss of electrolytes during dehydration. Therefore, it has been suggested that rehydration after exercise can only be complete and rapid if the sodium lost in sweat during exercise is replaced as well as the water.

Maughan & Leiper (1995) examined the efficacy of rehydration drinks varying only in Na+ content. Over a 30-min period beginning 30 min after the end of exercise, participants ingested one of the four test drinks in a volume equivalent to 150% of their body weight loss). Composition of the drinks was constant except for the Na+ content, which were 2, 26, 52 and 100mM (see Figure 15). By the end of the 6-h recovery period, participants were still dehydrated for the two lower dose sodium drinks (2mM Na+ by ~ -700 ml, and 26mM Na+ by ~ -350 ml), whereas they were euhydrated for the two higher dose sodium drinks (52 mM Na+ by ~ -2ml and 100mM Na+ by ~ +100ml). Clearly there is a requirement for Na+ in any rehydration drink following exercise. In fact, it would appear that the higher the Na+ concentration, the better (at least from a rehydration point of view).

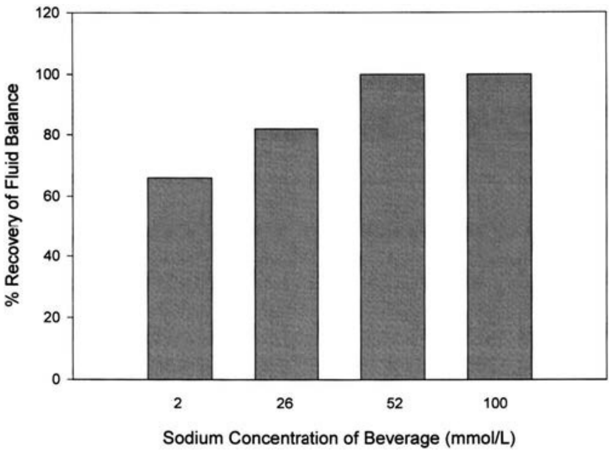

Figure 15: Effect of sodium concentration on recovery of fluid balance after dehydration (after Maughan et al., 1995).

Sodium is not the only electrolyte in body fluids nor in sweat. Potassium, calcium, and magnesium are also important electrolytes in body fluids and are also lost in sweat. Should they be important constituents of a rehydration drink? From the point of view of replenishing these stores it would be pertinent to include potassium and magnesium in a post-exercise recovery product. Having said that, the importance of potassium, calcium, and magnesium, for rehydration per se, does not appear to be of great significance. This is purely because sodium is the electrolyte actually monitored by the brain in determining whether ADH is secreted or not rather than potassium, calcium or magnesium, and so from a body fluid retention (and rehydration) perspective, sodium is the only relevant electrolyte required.

However since significant amounts of magnesium are lost in sweat, and that magnesium is important for muscle function and has been associated with alleviating muscle cramp, there is (in our view) a need to have magnesium in Hydra10 & Hydra+. From our own observations, Hydra10 has been reported to offset muscle cramps in susceptible athletes (i.e. crampers). These include rugby union forwards (notably line-out jumpers) and elite football players. Hydra+ is an offshoot of Hydra10 for athletes who feel a tablet form added to water is easier to use.

It can be concluded that Na+ is an important electrolyte for rehydration since it helps regulate body fluid loss via the brain and kidney. It appears that the higher the Na+ concentration in the ingested fluid, the better the prospects for rehydration. However, a high Na+ content in a recovery drink may be less palatable and so dissuade an athlete from drinking sufficient volume. A trade-off between Na+ content and palatability has led to the development of a wide range of 'sports' drinks (in effect carbohydrate-electrolyte drinks). Hydra10 & Hydra+ have been formulated to possess high sodium concentration to meet the requirements for sound rehydration after exercise.

REFERENCES

ACSM Position Stand: Exercise and Fluid Replacement (2007). Medicine and Science in Sport and Exercise. 377-390.

Cheuvront, S.N. and Kenefick RW (2014) Dehydration: physiology, assessment, and performance effects Comprehensive Physiology 4: 257-85.

Ismail I, Singh R, Sirisinghe RG: (2007) Rehydration with sodium-enriched coconut water after exercise-induced dehydration. Southeast Asian Journal of Tropical Medicine & Public Health, 38:769-85.

Kovacs, EMR., Schmahl, RM., Senden, JMG., Brouns, F. (2002). Effect of high and low rates of fluid intake on post-exercise rehydration. International Journal of Sports Nutrition & Exercise Metabolism 12: 14-23.

McCartney, D., Desbrow, B. & Irwin, C (2017) The Effect of Fluid Intake Following Dehydration on Subsequent Athletic and Cognitive Performance: a Systematic Review and Meta-analysis. Sports Med Open. 3: 13.

Maughan, RJ & Leiper, JB (1995). Sodium intake and post-exercise rehydration in man. European Journal of Applied Physiology. (1995) 71: 311-319.

Maughan, RJ. Taylor, AJ., Shirreffs, SM., Leiper, JB. (1994) Post-exercise rehydration in man: effects of volume consumed. Journal of Physiology. 475: 29-30P.

Nose, H., G. W. Mack, X. Shi, and E. R. Nadel (1988) Role of osmolality and plasma volume during rehydration in humans. Journal of Applied Physiology. 65:325-331.

Shirreffs, SM (2010) Hydration: Special issues for playing football in warm and hot environments Scandinavian Journal of Medicine and Science in Sports 20 (Suppl. 3): 90–94.

Shirreffs, SM. Taylor, AJ. Leiper, JB. Maughan, RJ (1996) Post-exercise rehydration in man: effects of volume consumed and drink sodium content. European Journal of Applied Physiology.

Verde, T., Shephard, R. J. Corey, P., and Moore, R. (1982). Sweat composition in exercise and in heat. Journal of Applied Physiology 53:1540-1545.