Fluid needs for training and competition in athletics.

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Abstract

The diverse nature of the athletic events together with the varied training programs and individuality of athletes taking part inevitably means that fluids needs are highly variable; between athletes, perhaps between training and competition, and with differing environmental conditions and degree of training and heat acclimatisation. There are limited data from athletics on all aspects of fluid balance, but wherever possible we have focussed on this information to draw conclusions. When appropriate, euhydration may best be ensured by consuming 6-8 ml kg\textsuperscript{-1} body mass of a sodium-containing fluid, or sodium-free fluid together with food ~2h before exercise. The individual sweat responses are so variable that athletes should assess their own individual sweat losses to determine if these are likely to be a cause for concern. The volume of drink that is consumed should never be so much that an athlete gains mass over an event, unless perhaps there is evidence that they started already hypohydrated. This may be a particular concern in the field events and multi-event when competition can be spread over a number of hours and when there are significant rest periods between activities.
Introduction

An in depth discussion of the rationale and requirements for water and electrolyte intake before, during and after exercise took place at the June 2003 International Olympic Committee Consensus Conference. The outcomes of the conference were published in the January 2004 issue of the Journal of Sports Sciences, with the papers by Coyle (2004) and Shirreffs, Armstrong and Cheuvront (2004) being particularly relevant. The information presented in these reviews will not be covered in depth again here as there is no good evidence to suggest that the physiology or nutritional requirements of track and field athletes, with regard to their water and electrolyte requirements, differ significantly from those of other athletes in general. The focus of this manuscript is new and updated material on these topics that has become available since the 2004 publication or other pertinent material not covered in-depth in the two noted documents.

This review focuses on the water and electrolyte needs of adults who train and compete in athletic events. Where available, data from track and field athletes are presented and recommendations based on this information are proposed. The recommendations may be used by athletes and coaches to optimise performance and health, and by governing organisations who set the rules and regulations of the sport or the timing of events to guide their decisions. Other relevant recent publications on this topic include the updated Position Stand of the American College of Sports Medicine (American College of Sports Medicine, 2007) and information on individualising fluid needs for athletes (Casa, 2007).

The 1995 IAAF Conference and the 2003 IOC Conference

The first IAAF Consensus Conference, held in 1995, (Journal of Sport Sciences, 1995) did not have a specific paper on hydration but the topic was covered with regard to both the young athlete (Bar-Or, 1995) and in general by Terrados and Maughan (1995). The 2003 IOC consensus conference concluded the following with regards to hydration in its consensus statement (Consensus Statement, 2004).

“Dehydration impairs performance in most events, and athletes should be well hydrated before exercise. Sufficient fluid should be consumed during exercise to limit dehydration to less than about 2% of body mass. … … … …. Sodium should be included when sweat losses are high, especially if exercise lasts more than about 2h. Athletes should not drink so much that they gain weight during exercise. During recovery from exercise, rehydration should include replacement of both water and salts lost in sweat.”

In addition, and specifically from the two recent specific international papers which covered the topic of hydration (Coyle, 2004; Shirreffs et al., 2004) the following conclusions were drawn:

- A reduction in body mass of 2% is tolerable in temperatures up to 22°C but impairs absolute power production and predisposes athletes to heat illness in ambient temperatures above 30°C (Coyle, 2004).
- Sodium should be included in fluids consumed during exercise if the exercise lasts more than 2h. It should also be included in fluids consumed by individuals in any event who lose more than 3-4g of sodium in their sweat (Coyle, 2004).
- Normally, before commencing exercise euhydration should be ensured. Urine osmolality, specific gravity and colour may be markers that can be used as a guide (Shirreffs et al., 2004).
- After exercise that has resulted in body mass loss due to sweat loss, water and sodium should be consumed in a quantity greater than
those in the losses to optimise recovery of water and electrolyte balance (Shirreffs et al., 2004).
The evidence on which these comments were based can be found within the papers.

Hydration for Sprints
The duration of the sprint events (60m flat and hurdles, 100m flat and hurdles, 110m hurdles, 200m flat and 400m flat and hurdles) is clearly such that no hydration intervention is going to be made during the event itself; by the time gastric emptying and intestinal absorption of any drink takes place, the event would have long finished (Vist and Maughan, 1994).

Sweat losses in sprinting
Maximum sweat rates reported in the published literature are typically in the order of 2 to 3 litres per hour. Whilst there is no published data on sweat rates during single sprints it would not be unreasonable to predict that many athletes would have rates in the upper part of this range during or immediately after their sprint because of the intensity of the exercise. However, the duration of the exercise is such that even with highest of sweat rates, the actual volume that would be lost during the event itself would still be relatively small. Therefore, the main concerns for hydration in sprint competition would be to ensure that any pre-race activities and warm-up procedures do not result in the athlete starting their competition in an undesirable hydration status; this obviously raises the question as to what an undesirable hydration status is and we have attempted to address this below. Consideration must also be given to situations where a number of events or rounds are timetabled for the same day. In this situation the cumulative losses from a cycle of race preparation, race, recovery, race preparation, race and recovery may quickly add up to a substantial sweat loss.

There appear to be no published data on the sweat losses that may occur during a typical training session of sprint athletes. However, Watson et al. (2005) monitored sweat volume losses in simulated sprint sessions. In these sessions the subjects, who were experienced but not elite sprinters, warmed up for 15min then ran either a 50 and 200m sprint separated by 40min or undertook vertical jumps and a 400m sprint. Each of these sessions was undertaken twice. The body mass reductions averaged 0.8 and 1.3kg in the 50m/200m sessions over a 2h period and averaged 0.5kg and 1.1kg in 45min in the 400m and vertical jump session. These reductions are equivalent to approximately 1 to 1.5 % of the athletes’ body mass.

Therefore, whilst sweat rates may be high with the high intensity work of sprinting, the short duration of that work will limit the extent of sweat loss that will occur. The greatest sweat losses are likely to occur in long duration training sessions, particularly in a warm environment or when warm clothing is worn and in also competitions where a number of rounds may be scheduled for the same day so that the cumulative sweat loss quickly amounts. In these situations the athlete must be diligent regarding fluid replacement to ensure significant deficits in hydration status do not occur.

Effects of hydration status on sprinting performance
The influence of hydration status on sprint performance has been investigated in many studies using a number of different exercise modes. Although the majority of these have involved sprint cycling, in this manuscript we have restricted our discussion largely to studies of running sprints. It is possible that hypohydration may influence exercise performance differently depending upon whether the sprinting being investigated is running, where body mass must be supported and moved, or whether it is cycle ergometer sprinting when this is not the case; if body mass is reduced it changes the
work required for the running. That is, the decreased body mass which is typically used to define the magnitude of hypohydration may compensate for any reduced muscular strength and/or power that it causes. However, whilst this will complicate the pure scientific interpretation of the findings of studies investigating sprint performance it is the situation that occurs in real athletic situations.

Watson et al., (2005) investigated the effects of hypohydration on both 50 and 200m sprint performance in experienced but non-elite sprinters. Body mass was reduced by 1.7 ± 0.4 kg (equivalent to 2.2± 0.5%, mean ± SD) by the administration of the diuretic furosemide. The study found no significant change in performance and reported a non-significant reduction in completion time by 0.01 ± 0.01 s in the 50m event and by 0.26 ± 0.22 s in the 200m event. Fogelholm, Koskinen, Laasko, Rankinen and Ruokonen, (1993) used a combination of fluid and energy restriction over a period of 59h followed by a 5h ad libitum eating and drinking phase and an overnight fast to overall reduce body mass by 2.0 ± 0.4 kg (equivalent to 2.7 ± 5%) then investigated the effects on 3x30m sprints. The subjects in this study were wrestlers and judokas, accustomed to this rapid body mass reduction, and the results indicated this had no significant effect on the 30m sprint performance averaging 4.16 ± 0.05 s after the body mass loss in comparison to 4.14 ± 0.05 s on a control trial. Watson et al., (2005) also investigated the effects of hypohydration on 400m sprint performance. Body mass was reduced by 1.9 ± 0.3 kg (equivalent to 2.5 ± 0.4% again by the administration of the diuretic furosemide. The study found no significant change in 400m sprint performance and reported a non-significant 0.33 ± 0.58 s increase in completion time. Taken together these studies suggest that body mass reductions of 2 to 3% have no significant effect on sprint performance. It is possible that sprinting would have been "easier" with the lower body mass, due to less mass for the runner to move. Thus, it is feasible that a reduction in physiological demand may promote improved performance which may counteract any affects hypohydration may have on sprinting.

**Hydration strategies for sprinting**

From the limited evidence available it appears that track sprinting performance is not affected by hydration status at least when body mass is reduced in the order of 2 to 3%. These athletes should therefore be advised to ensure that they start any sprint session (training or competition) in a situation of euhydration or with no more than a 2 to 3% body mass reduction that is due to water loss. Euhydration may best be ensured by consuming a 500ml bolus (or 6-8 ml per kg body mass) of sodium containing fluid, or sodium-free fluid together with solid food, approximately 2 h before their sprint. Water required by the body will be retained and excess will be excreted as urine over the 2 h period.

Recovery of body water losses after sprinting will be a major consideration only when a large body water deficit has developed, particularly when further sprinting is scheduled. A sufficient volume of fluid should be consumed to replace not only the sweat losses that have occurred but also to provide for the ongoing obligatory urine losses and potential further skin losses, which can particularly occur if the athlete is in a warm environment (Shirreffs et al., 1996).

**Hydration for Middle Distance Running**

The middle distance events of 800m up to and including the 3km events can range in duration from less than 2 min to close to 9 min in top level athletes. The brief duration of these races ensures that, like sprint events, there is no practical opportunity to for a hydration intervention during the event itself; by
the time gastric emptying and intestinal absorption of any drink takes place, the event would have long finished (Vist and Maughan, 1994).

**Sweat losses in middle distance running**

The environmental conditions, an athlete’s individual characteristics (including the extent to which any heat acclimation has taken place), together with the duration and intensity of exercise will influence most significantly the extent of sweat loss that occurs in middle distance running. The variability between individuals doing the exact same exercise in identical conditions can be so extensive (Shirreffs et al., 2006) that reporting mean values from laboratory- or field- derived studies of middle distance running events does not provide unique insights above the values estimated from generic sports activities of similar exercise durations. In middle distance running events, as for the sprints discussed above, the sweat volume lost during the event itself will be relatively small because of the duration of the event.

The training undertaken by middle distance athletes generally includes a significant endurance and interval component. Therefore, because of the duration and/or the intensity of running involved, significant sweat losses are likely to occur.

**Effects of hydration status on middle distance running performance**

A limited amount of research has been undertaken to investigate the influence of hydration status on middle distance running performance. However, some considerable time ago, Armstrong et al., (1985) studied the influence of hydration status in track races over 1.5km, 5km and 10km. Volunteers completed these races twice: once in a euhydrated state and once after reducing their body mass by 1.4 ± 0.3 kg (equivalent to 1.9 ± 0.4 %) by using the diuretic furosemide. The time to complete these races was increased by 0.16 ± 0.19 min, 1.31 ± 0.73 min and 2.6 ± 1.66 min respectively (equivalent to 3.1 ± 3.5 %, 6.7 ± 3.4% and 6.3 ± 3.9 %), relative to their finishing time when euhydrated.

**Hydration strategies for middle distance running.**

From the limited evidence available it appears that in middle distance events, at least those longer than 1.5 km, performance can be negatively effected by a loss of body water equivalent to 2% body mass. Middle distance athletes should therefore be advised to ensure that they start any run of these distances in a situation of euhydration or at least to limit any body water loss prior to exercise to probably less than this level. Euhydration may best be ensured using the same practices as described above for sprinting. The influence of ambient conditions, particularly temperature, on the any interaction between hydration status and performance in the middle distance events has not been studied systematically. Also, there are not enough studies of these events conducted across a range of ambient conditions to allow any conclusions regarding any interaction of body water loss, ambient conditions and performance in middle distance events to be made in the same way as they have been for distance events as is described below. As for sprinting, recovery of body water losses after a middle distance event will be a major consideration only when a large body water deficit has developed, particularly when further exercise is scheduled. Again a sufficient volume of fluid should be consumed to ensure it is enough to replace the ongoing water losses (Shirreffs et al, 1996).

During training for middle distance events, when the duration and/or intensity of exercise may result in significant body water losses, drinking should be considered when an athlete knows their sweat rate will lead to a significant body water deficit over the course of the session and also when a significant portion of the training has yet to take place once this has developed. This is particularly important in the case of a high quality training session involving a
“performance” element. Drinks that are consumed for the purpose of influencing hydration during a session should meet the characteristics of being emptied from the stomach and be absorbed in the intestine relatively quickly.

Recovery of body water losses after training for middle distance running will be a major consideration only when a large body water deficit has developed and when further training is scheduled for the relatively near future. Given the endurance and interval training frequently undertaken by middle distance athletes, the volumes of sweat that may be lost and the likelihood that drinking during training may frequently be limited for logistical or stomach comfort reasons, this will not be an uncommon scenario. In addition to consuming a sufficient volume of fluid to replace all ongoing water losses (Shirreffs et al, 1996), sodium should also be consumed at this time if the fluid is to be retained in the body (Shirreffs and Maughan, 1998). This sodium could be an ingredient of the drink selected or it may come from solid food consumed with the drink (Ray et al., 1998; Maughan et al., 1996).

Hydration for Distance Events
The distance events are those greater than the 3km and include both the running events and the walks. In comparison to the other athletics events there has been a considerable amount of both descriptive research into sweat losses of athletes during some of the distance events (in particular the marathon) and also intervention studies investigating the effects of hydration status, and particularly body water loss, on aspects of endurance exercise performance. However, in the shortest of these distance events there is likely to be little benefit of drinking during the exercise because of the time required for gastric emptying and intestinal absorption to occur.

Sweat losses in distance running and walking
The extent of sweat losses in distance events are influenced by environmental conditions, an athlete’s individual characteristics (including the extent to which any heat acclimation has taken place), and the duration and intensity of the exercise. Again the variability of sweat rates between individuals doing the exact same exercise in identical conditions can be so extensive (Shirreffs et al., 2006) that reporting mean values from distance running events assessed either in the laboratory or in field studies provides little specific insight. Nevertheless, with normal sweat rates being anything up to two to three litres per hour, and the longest of the championship distance events (the 50km walk) lasting more than 3.5 hours for the top level athletes, it is clear that significant sweat losses can occur. All distance athletes should assess their own sweat rates so they have an understanding of their response to both their training and competition runs in a variety of environmental conditions.

It is clear from the published literature that significant sweat losses do occur in marathon runners. As described in detail by Coyle (2004), the findings of Cheuvront and colleagues (Cheuvront, 2001; Cheuvront and Haymes, 2001; Cheuvront et al., 2003; Cheuvront et al., 2007) show that many fast marathon runners experience significant body mass loss over the course of the marathon, with values ranging from 2 to 8% body mass loss by the end of the race.

Effects of hydration status on distance running and walking performance
Cheuvront et al., (2003) have recently published an excellent review of the literature which has investigated fluid balance and endurance exercise performance, from protocols ranging in duration from 1 to 6 h. However, even though only one of the 13 evaluated studies involved running as the sole mode of exercise, this is probably the best available data set to draw any
reliable conclusions as to the effect of hydration status on endurance running and walking performance. It is important to bear in mind the influence a lower body mass has on the physiological demands of running as discussed above.

The review of Cheuvront et al., (2003) concludes that dehydration equivalent to between 2% and 7% of body mass loss significantly reduces exercise performance and this is particularly true in hot environmental conditions (i.e. more than 30°C). There is no data to indicate what happens with reductions in body mass greater than 7% but there is no reason to suspect it will improve performance. The authors also concluded that dehydration equivalent to a body mass reduction of between 1 and 2% body mass loss did not have any influence on endurance exercise performance when the exercise duration was less than 90 min and the environmental conditions were temperate (20-21°C) but if the dehydration was equivalent to a body mass loss greater than 2% of body mass, endurance performance was impaired in these temperate conditions especially if the exercise duration was longer than 90min.

Hydration strategies for distance running and walking.
Because of the large variation between athletes and the different events that occur in distance running and walking, general guidelines will be meaningless for many individuals. However, from the evidence available it appears that distance exercise performance is likely to be impaired with a body water loss equivalent to 2% body mass loss or more in both temperate and warm environmental conditions. These athletes should therefore be advised to ensure that they start any distance walk or run in a situation of or close to euhydration. Euhydration may best be ensured using the same practices as described above. The influence of ambient conditions, particularly temperature, on the interaction between hydration status and distance events means that extra care to limit the development of hypohydration must be taken if at all possible when the environmental conditions are hot.

During the longer distance events, provision is made to allow athletes to obtain drinks. When athletes can select the composition of the drink they consume they should take into consideration how much they expect to sweat during the event with regard to both the volume and sodium losses. During the event, replacement of sweat volume and sodium losses are not going to be the only nutritional concern of the athletes but in events where this is the major concern or at the specific times when it is in other events, the drink selected should be emptied from the stomach and be absorbed in the intestine relatively quickly. This means that the drink should not have a high energy density or osmolality; ideally, it should probably be hypotonic with respect to the body fluids, in the range of 200 to 260 mosmol kg\(^{-1}\) (Leiper, 2001) and perhaps contain sodium and glucose at concentrations of around 30-50 mmol l\(^{-1}\) and no more than 200 mmol l\(^{-1}\) respectively to promote rapid intestinal absorption (Leiper, 2001). In some of the longer distance events, where solid food is favoured at intervals by the athletes, water or sodium-free drinks consumed at those times will still meet these requirements. Of course, in some situations, distance runners and walkers chose the characteristics of fluid consumed during an event based on the desire to address fuel needs rather than optimal hydration concerns (see Burke, Millet and Tarnopolsky 2007).

Recovery of body water losses after either distance training or competition will be a major consideration when either a very large body water deficit has developed or when it is more moderate but when further training is scheduled for the relatively near future. As described previously, rehydration strategies
should address the volume of fluids consumed and the replacement of sodium losses (Shirreffs et al, 1996; Shirreffs and Maughan, 1998).

**Hydration for Jumps and Throws**
The jumps events are the long jump, triple jump, high jump and pole vault. The throws events are the shot put, hammer throw, discus throw and javelin throw. None of these field events appear to have been subject to systematic study with regard to any aspect of hydration.

There are perhaps more similarities in the training and competition for the throws and jumps events than there are in many other athletic events. During both training and competition there are periods of intense activity and periods of little activity: in training these may be rest breaks, in competition these are breaks between rounds. Therefore, during both training and competition the period in the field can last for a number of hours.

**Sweat losses in the jumping and throwing events**
As with other athletes, the sweat loss that occur in jumpers and throwers will be determined by the athlete’s individual characteristics, the environmental conditions, the time spent in the field and the intensity of exercise itself. However, as many athletic events do take place in warm conditions, the sheer length of time spent in the field, even though no exercise is being performed, can have a great impact on the sweat losses that occur in these field athletes.

The lack of data on “typical” sweat losses of jumpers and throwers again is of little consequence given the variability that would be predicted to occur between individual athletes (Shirreffs et al., 2006). Therefore, all jumps and throws athletes should be encouraged to assess their own sweat losses in a variety of exercise scenarios and so understand their own sweating response to their training and competition.

**Effects of hydration status on the jumping and throwing events**
There appear to be no published studies that have systematically evaluated the influence of hydration status or sweat loss on the performance of any of the athletic jumping and throwing events. Therefore any conclusions must be drawn from information from related sources.

Jumping performance has frequently been investigated as a means of assessing the influence of a body water loss on muscle power; jump power and jump height have been most frequently measured (eg Viitasalo et al., 1987; Hoffman et al. 1995; Kraemer et al, 2001; Gutiérrez et al., 2003; Watson et al., 2005). In the majority of these studies, the level of body mass loss has been between 1 and 3% (Hoffman et al, 1995; Gutiérrez et al, 2003, Watson et al, 2005) although a 6% body mass loss has been investigated when energy restriction has been combined with dehydration (Viitasalo et al., 1987; Kraemer et al., 2001). The majority of these studies have found no significant effect of the body mass reduction on jumping power or height. As discussed above with sprinting, jumping will also become “easier” as hypohydration progresses as the jumper must move less mass. Therefore it is possible that if any negative effects of hypohydration on jumping performance exist, they might be masked by the decrease in physiological demand and the improved performance achieved by a loss of body mass. Furthermore, if hypohydration does not reduce muscle force or power then jumping performance may be actually be improved with hypohydration. However, systematic research is required to investigate this.

For throwing events, any effects hypohydration may have could perhaps be gleaned from research investigating muscle strength and power or from studies where other types of throwing has been studied. For example, in a
study investigating the motor skill performance of cricket bowling (Devlin et al., 2001), subjects were dehydrated by 2.5 ± 0.6 kg (equivalent to 2.8 ± 0.5% of their body mass) and their performance was compared to when they had drunk flavoured water and limited their dehydration to 0.5 ± 0.5 kg (equivalent to 0.5 ± 0.4% of body mass). The results of the study indicated that there was no influence of hydration status on bowling speed, but bowling accuracy, as determined by line and distance, was significantly worse when undertaken in the dehydrated state. It is, however, the bowling speed that is more relevant to the throwing events in athletics.

**Hydration strategies for jumping and throwing events**

Although the breaks in training or between jumps and throws in competition prolong the “exercise” period, and so particularly in warm environmental conditions will increase the sweat losses that occur, these breaks also generally provide ample opportunity for drinking to take place. For this reason, it is essential that each athlete understands their own individual sweat losses and fluid requirements. At present there are not enough data to determine if there is a level of dehydration that negatively effects performance in the jumps and throws, so the best advice to athletes may be for them to try to maintain their hydration status to somewhere between euhydration and a 2% of their body mass loss. Some care must be taken by these athletes, particularly the jumpers, to ensure that they do not “overdrink” during the long hours they may spend in the field. Although they are not likely to do this to the extent that they will have any health concerns, there is anecdotal evidence that some may tend to do so to a small extent. In the same way that a reduction in body mass reduces the work of jumping, an increase in body mass will increase the work and unnecessary unchecked drinking may be enough to increase body mass by a kilogram or more over a number of hours if sweating rate is not high and drinks are freely available. This may, in theory at least, have a negative impact on performance.

**Hydration for Multi-Events**

The multi-events of pentathlon, heptathlon and decathlon combine events from all the categories discussed above with the exception of the endurance events. There appear to have been no studies investigating the effects of hydration status on multi-events nor have there been any descriptive studies of the effects of training or competing in the multi-events on any aspect of hydration. This includes descriptions of the typical sweat losses that may occur and the effects a change in hydration status or a body water loss may have on the events.

Competition in these events generally takes place over a period of one or two days and it is reasonable to expect that sweat losses may be high as a result of the repeated bouts of exercise. However, there are also repeated rest periods throughout the competition time: between events and between jumps and throws in the field events. These breaks should provide ample opportunity for fluid intake sufficient to keep body water loss within a close enough level to euhydration (perhaps between euhydration and a body mass loss of 2%) for the majority of athletes.

Athletes who compete in these events will have training programs that encompass the types of training undertaken by athletes competing in the individual events that make up these multi-events. As such the sweat losses are likely to vary with the type of training that is being undertaken.

Multi-sport athletes would normally be advised to ensure that they start any training session or competition event in a situation of euhydration. As before, euhydration may best be ensured by consuming a 500ml bolus (or 6-8 ml per kg body mass) of sodium containing fluid, or sodium-free fluid together with
solid food, approximately 2h before their sprint. Water required by the body will be retained and excess will be excreted as urine over the 2h period.

When a multi-event athlete expects their sweat losses to become significant during training or competition they should ensure they have a supply of the drink or drinks of their choice with them through the training or competition day. When drinking for hydration reasons and sweat losses are high, it may be cautious to ensure some of the drink available for consumption will have a formula appropriate to promote rapid assimilation into the body. Again, this means that the drink should not have a high energy density or osmolality and ideally should probably be hypotonic with respect to the body fluids. If an athlete knows their sweat sodium losses to be high, they should also ensure they have a sodium containing drink, or easily consumed foods that provide sodium.

Recovery of body water losses after the first day of a multi-event competition may be one of the recovery priorities for many of these athletes. Again, a sufficient volume of fluid should be consumed to ensure it is enough to replace not only the sweat losses that have occurred but also to provide for the ongoing obligatory urine losses and potential further skin losses, which can occur particularly, if the athlete is in a warm environment (Shirreffs et al., 1996). Sufficient sodium should also be consumed with this fluid to replace the sweat sodium losses (Shirreffs and Maughan, 1998).

**Hydration Considerations for Mental and Cognitive Readiness**

One of the deleterious effects of moderate or severe dehydration is a reduction in cognitive function, mental readiness, reaction time, and motor control. However, mild dehydration, defined as 1–2% loss of body mass, has not been shown to be associated with mental function decrements or reduced reaction time (Leibowitz et al., 1972). Edwards and colleagues determined whether moderate water loss (1.5 - 2% of body mass loss) represents a significant impairment mental concentration tests. They showed that moderate dehydration did not impair mental concentration. (Edwards et al., 2007).

Furthermore, global cognitive readiness and decision making is preserved during water deprivation in up to a moderate dehydration level of 2.6% loss of body mass, without severe hot weather conditions and intense exercise (Szinnai et al., 2006). Szinnai and colleagues assessed whether mental performance is affected by slowly progressive moderate dehydration induced by water deprivation. They demonstrated that cognitive-motor function is preserved during water deprivation in young healthy humans up to a moderate dehydration level of 2.6% of body mass. However, increased tiredness and reduced alertness may be consequences of prolonged moderate dehydration. Similar experiments were conducted by Petri and colleagues in a study that assessed if there is deterioration in mental and psychomotor performance during voluntary fluid intake deprivation for 24 hours (Petri et al., 2006). During the dehydration period, there was not a significant deterioration in mood self-estimate scales and subjective measures of mental status. Taken together, these data suggest that mild to moderate dehydration, without adverse heat stress is likely not associated with reductions in cognitive function, mood, and mental readiness. However, this level of dehydration may be approaching the limits of compensatory mechanisms to preserve alertness and mood status.

After short-term exercise or heat-induced dehydration, decrements in cognitive aptitude have been observed in normal healthy individuals at moderate dehydration level of 2.5 % or more (Cian et al., 2000; Cian et al., 2001; Sharma et al., 1986). Cian et al. (2001) showed an initial drop in short-
term memory immediately after acute exercise induced-dehydration (2.8% body mass loss) which returned to baseline levels 3.5 h later independent of water intake. Decrement in mental function have been also shown during longer exercise durations in the heat (Ekbolm et al., 1970).

Dehydration (> 3% of body mass losses) will likely negatively affect cognition, mood, and mental status during exercise and at rest (Cian et al., 2000). The reduction in performance and mental readiness is proportionate to the degree of dehydration beyond 3% of body mass losses. In addition, during longer duration exercise events, dehydration is likely one of several stressors contributing to exercise performance decrements (Doppelmayr et al., 2005). Thus, athletes should limit dehydration to less than 2.5% body mass losses to preserve alertness and cognition function at all times, in particular during days with high ambient temperatures.

Summary of recommendations for fluid intake for track and field athletes

| Clear consensus for | • Euhydration may best be optimised by consuming a 500ml bolus (or 6-8 ml per kg body mass) of a sodium containing fluid, or sodium-free fluid together with solid food, approximately 2h before exercise. Water required by the body will be retained and excess will be excreted as urine over the 2h period.

• Individual sweat responses to exercise are so variable that each athletes should assess their own individual sweat losses to determine if these are likely to be a cause for concern.
  o This applies to athletes in all events.
  o Ideally this would be repeated in a variety of the athlete’s regular training and competition scenarios so that their “normal” response in these condition can be established.

• In events where body mass must be carried, care should be taken to avoid overdrinking. The drink volume consumed should never be so much that an athlete gains mass over the course of an event, unless perhaps there is evidence that they started the event already hypohydrated.
  o This may be a particular concern in the field events and multi-event when competition can be spread over a number of hours and when there are significant rest periods between periods of activity.

| Clear consensus against | The thoughtless following of general recommendations of the volumes of fluid consumed should be discouraged when it is so simple for athletes to assess their own drinking requirements for hydration provision.

| Issues that are equivocal | The influence of hydration status, and in particular hypohydration at different
levels, in many athletic events has not been systematically studied. If this research were to be undertaken it would assist the making of recommendations. Additionally, the additive influence of exercise in the heat while hypohydrated must be assessed for a multitude of athletic events.
Reference list


Burke, Millet, Tarnopolsky (2007) to be added from current issue


