

Information for this article are taken from and/or adapted from two main sources, first, a paper presented by Kalen Abbott, from the Coaching and Sport Sciences Division, for the USOC - Dec 2005 entitled Hydration for Endurance Athletes and from a presentation by Larry Armstrong, Ph.D., FACSM, - entitled Heat and Humidity - (presented at the USA Cycling Coaching Summit Oct 2006) note - Dr. Armstrong's presentation on Sport Drink Consideration will also be discussed in the next report.

In Abbott's paper, provided to US Olympic athletes and coaches, Abbott states that sustaining proper hydration is one of the easiest and most important nutritional routines for optimizing performance and injury prevention. In fact, even a slight degree of dehydration (2-3% loss of body mass due to fluid loss) will result in a decrease in endurance performance. In Laboratory studies (Armstrong et al. 1985) subjects performed runs of 5000m and 10,000m in either normally hydrated or dehydrated state (by only 2% of their body mass). The dehydrated group had running velocities that decreased by 6% and 7% respectively in both events! It was also reported that muscle strength and endurance capacity was adversely affected in a state of dehydration.

To say that the body is in fluid balance means that the required amounts of water and solutes are present and are correctly proportioned among the various compartments. In homeostasis (balance), water loss equals water gain, so body fluid volume remains constant. Daily water loss occurs through four avenues: Urine production (1500ml), perspiration (600ml), respiration (300ml exhaled as water vapor) and excretion (100ml in feces).

In the normal day urine constitutes the majority of water loss. This is not true for the endurance athlete that can lose anywhere from 1500-3000 ml/ hour during exercise through sweat rates.

Endurance athletes may be more susceptible to dehydration (fluid loss during exercise), Hypo hydration (fluid loss prior to exercise), and hyponatremia (sodium loss during exercise), particularly athletes that compete at longer distances. Under homeostatic (balanced) conditions, interstitial and intercellular fluids have the same water and salt concentrations (osmolarity) and they do not shrink nor swell water intake equals water loss. Dehydration occurs when water loss is greater than water gain, thus the osmolarity of the body fluids is increased and volume is decreased. Blood plasma volume is also decreased, therefore blood pressure is decreased. This is one of the main causes of cardiac drift.

The total volume of fluid loss from the body is highly influenced by environmental conditions, size of the athlete, the athlete's metabolic rate, sport, sweat rate and diet. In response to this, properly functioning kidneys decrease urine production to conserve body fluids.

Human sweat contains small amounts of dozens of organic and inorganic substances (amino acids, urea, lactic acid, calcium, magnesium, iron). In MOST athletes, sweat loss is not profound enough to warrant an imbalance in minerals such as iron, calcium or magnesium. If you are someone that finishes races with large quantities of white residue on your shorts you might want to consider taking a closer look at supplementing these minerals.

Electrolytes are also lost in urine and sweat. The most important electrolytes are Sodium, Potassium and chloride. Electrolytes serve several important physiological

functions. They are responsible for maintaining proper fluid balance within various water-dependant tissues and organs of the body. In addition, the movement of electrolytes across cell membranes of nerve cells provides electrical impulse that ultimately triggers skeletal muscle and cardiac muscle contraction. Athletes loose a great deal of sweat on a daily a basis and consequently may loose significant amounts of electrolytes. The concentration of electrolytes across cell membranes must be strictly regulated to guarantee proper function of cells throughout the body. Repeated profuse sweating (through daily exercise and competition) can result in substantial electrolyte loss, especially sodium and chloride, which are the most abundant mineral loss, in sweat. If this loss of minerals is not adequately replaced, cramping and hyponatremia may result. Endurance athletes often require a large volume of salt intake in order to adequately replace sodium and chloride losses in sweat. The 2004 DRI recommendations suggested North Americans should restrict daily sodium intake to only 1.5 grams per day. These dietary recommendations are more than likely inadequate for endurance athletes due to this sweat loss.

Hyponatremia occurs when the body takes in more water than it loses, cells become hypotonic and swell with water to dangerous levels. The result is too much water and not enough sodium. Thus, hyponatremia generally results in low sodium levels in the blood. Brain cells are particularly susceptible to hyponatremia (as well as dehydration). When Hyponatremia occurs slowly, brain cells have time to adapt, so few symptoms occur. When hyponatremia occurs quickly, confusion, seizures, coma may develop, or may lead to dead if left untreated.

When we typically talk about outdoor Temperature, we in fact are talking about "shade" temperature unaffected by sun or breeze or surrounding warm structures (like black top). There are many more climate factors influencing performance and sweat rates (or dehydration rate) than just shade temperature.

- 1.) High humidity
- 2.) Breeze
- 3.) Direct Sunshine
- 4.) The Sum effect of these conditions plus shade temperature is called Climatic Heat Stress
- 5.) Heat acclimatization
- 6.) Clothing
- 7.) Pre-exercise hydration status
- 8.) Intensity and duration of exercise

The Human body at rest is an average 98.6 degrees F. Enzymes function optimally at 102.2 degrees F (which is the core body temperature most of us reach during exercise) and at 105 degrees F performance declines as enzymes begin to break down. The acceptable margin for homeostasis is very narrow. Keep in mind that "Exercise Produces Heat", heat that must be dissipated.

There are basically four mechanisms for transferring heat to and from the body.

- 1.) Convection - contact with warm or cold objects
- 2.) Conduction - direct contact with gas or liquid (experts feel this could explain a performance enhancement by Landis - 70 water bottles dumped over ones head)
- 3.) Radiation - gain or loss of infra-red energy/heat
- 4.) Evaporation - heat dissipation from sweat - changing physical states (liquid to gas)

Evaporation occurs because sweat picks up heat off the skin and is turned from liquid to a gas and the result is heat dissipation. Evaporation (of sweat) is responsible for over 80% (up to 90%) of total heat dissipation: therefore evaporation is our most important heat loss mechanism. However, as temperature rises, the volume of sweat produced rises as well. For this reason, sweating cools the body more rapidly, but puts the athlete at greater risk of dehydration. Remember, in Hot-dry climates sweat losses account for virtually ALL fluid loss and dehydration.

Risks for Heat Illnesses:

- 1.) Elite Athlete (They usually have higher sweat rates which includes high electrolyte loss and the have higher work loads)
- 2.) Lack of Acclimatization (to be discussed- initial changes take a minimum of 3 -5 days, 95% complete at 14 days)
- 3.) Dehydration
- 4.) Glycogen depletion (Carbs help the body store water)
- 5.) Non-Porous clothing
- 6.) Sleep Loss
- 7.) History of heat illness (studies show once you have gotten heat illness you are more susceptible)
- 8.) Relatively Large Muscle Mass
- 9.) Females during luteal phase of menstrual cycle
 - Progesterone >> estrogen
 - Core temp increases by approx 1 degree F
 - Core temp peaks between 19th and 24th of a normal 28 day cycle
- 10.) Drugs/Medications
 - Sympathomimetics (eg. Ephedra)
 - Anticholinergics (eg. Antihistamines)
 - Diuretics
 - Cyclic antidepressants
 - Monoamine oxidase inhibitors
 - Alcohol

Acclimatization to Heat and Humidity:

Becoming acclimated to the training/competitive environment has many physiological benefits that will improve performance. Effective acclimatization requires at least 14 days for an athlete to become 95% acclimatized for warm or hot environments but many changes begin in 3-6 days.

<u>Changes when exposed to warm/hot environment</u>	<u>Number of days</u>
Heart Rate Decrease	3-6 days
Plasma volume expansion	3-6 days
Rectal temp decrease	5-8 days
Perceived exertion decrease	3-5 days
Sweat Na ⁺ and Cl ⁻ concentration decrease	5-10 days
Sweat rate increase	8-14 days
Renal Na ⁺ and Cl ⁻ concentration decrease	3-8 days

As you can see, taking training camp in Las Vegas in February (65-75 degrees and dry), if you do not acclimate to the climate prior to heading out your HR will be abnormally high, your plasma volume will be increasing (dehydrating you), your temp will be elevated, your perception of exertion will be high, and you will be losing

extra sodium and chloride in your sweat (further dehydrating you). This makes for a difficult transition and can lead to slower recovery and overtraining. Remember, training in a dehydrated state WILL NOT create physiological adaptation to competing in a dehydrated state.

Cold Temperatures:

Cold Environments can pose a threat to the hydration levels of endurance athletes. Cold air can increase water loss and augment dehydration. Athletes drink too little fluids in cold weather because the thirst center's signal can be curbed. Urine output is increased with cold environmental exposure. Cold air also has less water vapor or in other words a lower relative humidity. This leads to water loss through the body's need to warm and moisturize the incoming air.

Altitude:

When living or training at Altitude hydration issues need to be addressed. Water loss is increased greatly at altitude due to increased respiratory water loss and increased urinary water loss due to the down-regulation of water retention hormonal mechanism (this is similar to the effect of alcohol on urinary water loss). Respiratory water loss ranges from 1900 ml/day for men and 850 ml/day for women and urinary water loss may be as high as 500ml. That is a staggering 2400ml/day for men and 1350ml/day for women.

Air Travel:

Air travel effects hydration in much the same way as altitude. Airplane cabins are pressurized to 6000-9000 ft and the relative humidity is as low as 1% and averages 6%. This low relative humidity enables water loss that may be as high as 750-1000ml higher than normal. The best way to combat this is to plan ahead by bringing your own beverage.

Assessing Hydration Status:

While there is a long list of ways to assess hydration status Dr. Armstrong recommends using techniques that require little to no expertise, no sophisticated equipment, are accurate, safe and inexpensive.

- 1.) Body Mass Loss (measuring your sweat loss during exercise)
- 2.) Measuring the Specific gravity of your Urine (you need a refractometer -if interested let me know)
- 3.) 24 hour Urine loss (taking into account sweat loss and this you can account for the VAST majority of water loss)
- 4.) Monitoring Urine Color - (I am in the process of trying to get color cards from Dr. Armstrong - his book *Performing in Extreme Environments* has a color chart in the back cover.)

Summary:

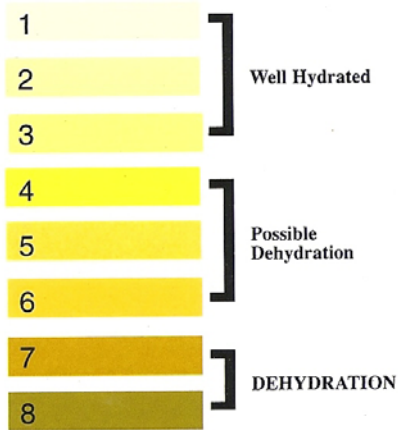
Knowledge is power and knowing this information and addressing your body's need to stay hydrated and control core temperature can make all the difference between winning or getting dropped. Small changes in water mass (2-3%) can negative effect

performance and in hot conditions this can 2-3% loss if very possible and more than likely. The steps you need to take are:

- 1.) If you know you are going to be competing or training in a warm climate and are not acclimated take steps to acclimate if possible or at minimum be aware of your needs when in this environment when you are not acclimated.
- 2.) Wear loose, lightweight, "breathable" clothing.
- 3.) Know the signs and symptoms of heat illness.
- 4.) Avoid lengthy warm ups in hot, HUMID weather. (humid conditions are not good for evaporation - this is why tents and fans are useful during warm ups)
- 5.) Monitor your body's core temperature.
- 6.) Perform intense workouts at cooler times of day whenever possible.
- 7.) Avoid strenuous exercise in the heat after experiencing factors that lower tolerance (sleep loss, infectious illness, alcohol abuse, carbo depletion, diarrhea, vomiting etc.)
- 8.) Know your sweat rate and the fluid needed to replace your losses (you need 150% of loss due to increase urine production after drinking and exercise).
- 9.) Develop and test a hydration strategy and experiment with drinks for palatability.

On the next page is a Urine Color Chart developed by Dr. Larry Armstrong. By comparing your urine color to the color gradient on this chart you have a simple yet very effective tool for testing your level of hydration:

Urine Color Chart



Collect sample in clear plastic container.
Hold up to bright light for comparison.

The urine color chart is reproduced with permission from Lawrence Armstrong and Human Kinetics and was originally published in Lawrence Armstrong's book titled *Performing in Extreme Environments*. The book may be purchased from Human Kinetics by calling (800) 747-4457 or online at www.humankinetics.com



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