Hydration by Richard A Josephson, MS, MD

Hydrate! Hydrate! Hydrate!

Cyclists hear these words repetitively from many sources, including their SMBC ride leaders! This column will first cover the physiology of body fluids, sweating, and dehydration. Understanding these processes will provide a solid basis for understanding the rationale and ways to hydrate effectively. Knowledge is power.

Body Fluids and Perspiration

Body fluids body are typically categorized as intravascular (within the vasculature or blood vessels), extracellular (outside of or between the body cells) and intracellular (within the actual cells of the body). Each of these fluid compartments has different concentrations of electrolytes (such as sodium and potassium), and while water molecules and electrolytes can move between each compartment, this movement typically requires minutes to hours.

The bodies of couch potatoes typically lose 1-2 liters (or quarts) of water each day via perspiration, urine, bowel movements, and respiration (the moisture in the air we exhale). The bodies of cycling enthusiasts in sunny Florida can lose considerably more than 1-2 liters because of enhanced perspiration! Exercising muscles generate heat because of the chemical reactions involved in muscle contraction. This heat must be dissipated into the environment, or our bodies will reach dangerous and literally deadly temperatures. Body temperatures above 104° F are typically considered medical emergencies. The most effective way our body removes this excess heat generated by exercising muscles is via perspiration and the subsequent evaporative cooling of the moist skin. The more vigorous the exercise, the more perspiration. The larger the person, the more perspiration. Interestingly, better physically trained individuals perspire about 10-20% more while exercising than typically sedentary individuals. Persons acclimated to a warm environment sweat more than persons not acclimated. Perspiration is typically greater in dry environments than in humid environments. Thus, those who cycle regularly in sunny Florida, on average, perspire more than their sedentary northern friends.

It is difficult to measure total sweat volume outside of laboratory conditions, but an average person may perspire approximately 3/4 liter while exercising at a moderate to vigorous level for 1 hour in a 70° F environment. Large persons, hot weather, and more vigorous cycling (think Steers & Beers) would push this volume even higher (see below). Sweat is predominantly water, but contains electrolytes (sodium, potassium, magnesium, etc.) as well. The amount and concentration of these electrolytes vary based upon many factors but note that the sodium concentration of sweat is much less than that of blood. Again, the purpose of sweat is evaporative cooling—-and thus ultimately sweat evaporates into the air and cools the body. This is especially important to be aware of while cycling. The sweat may evaporate into the air so quickly while riding with fresh air constantly bathing our moving bodies that we don't see a large amount of liquid perspiration, and our clothes don't become damp. We may therefore be less aware of the large fluid losses. We should assume we are always losing water (and to a lesser extent sodium and other electrolytes) while we are cycling, even if we aren't damp or wet with perspiration. To this point, we may be dry the moment we finish cycling in the heat, but if we quickly go indoors or into our air-conditioned car we will notice our body and clothes becoming damp as the continued perspiration, which is cooling our body, doesn't evaporate quickly without the air movement caused by riding down the road.

The amount of perspiration during a typical 2-hour ride is influenced by many variables. Some are intrinsic to the individual cyclist such as body size and overall level of fitness. Others are specific for the particular ride such as the level of exertion (e.g. speed), air temperature, humidity, and wind. Reasonable estimates of sweat and other (bladder, exhaled moisture) fluid losses for our two-hour

rides for the average-sized SMBC cyclist is 2 liters when the weather is cool (65-70°F) and much more in the heat—perhaps 3-4 times as much on hot (90°F) rides.

Importantly, many commonly prescribed drugs affect the body's ability to perspire (ask your physician or pharmacist); this will be covered in more detail in future columns.

The Physiology of Dehydration

The water/fluid secreted by our sweat glands is supplied by a rich network of microscopic blood vessels in the skin. Water and electrolytes go rather quickly from within the blood vessels to the fluid and tissues surrounding the sweat glands and then are excreted quickly by the sweat glands onto the skin surface. All perspiration produces fluid loss, but only that which evaporates (and doesn't drip on to the floor) will cool the body.

As the intravascular (blood stream) volume decreases, a variety of physiologic processes of adaptation occur. Fluids will be drawn from the extracellular spaces, typically areas away from sweat glands, into the circulation. With continued fluid losses this process will be insufficient to maintain blood (intravascular) volume. The first circulatory/hemodynamic response will be an increase in heart rate, this is a mechanism to maintain perfusion to organs and other tissues. This may not be easily perceived while cycling. As fluid losses continue, normally positive adaptive responses may become maladaptive. Various smaller blood vessels constrict, and compromise perfusion of the digestive system (abdominal cramps), kidneys (low urine production and potential actual kidney damage), impaired blood flow to large muscles (cramping and increased lactic acid production), and then skin (leading to less perspiration, less evaporative cooling, and potentially a large rise in body temperature and heat stroke). Blood pressure is often reduced or low, but except in the extreme is a poor measure of body fluids and circulatory perfusion.

Human bodies are typically 50-60% water, the rest being bone, fat, and components of cells. Recall that fluid losses from the body will impact the intravascular or circulating blood volume, described above. Body fluid losses of 2% can produce some of the changes described above, and fluid losses of 10% will almost sure produce many of them. For a 120-pound person 2% is about 0.65 liters or 22 ounces, and 10% is about 3.3 liters or quarts. For a 200-pound person the corresponding values are about 1 liter or quart and 6 liters or quarts.

Summarizing the above information, cyclists can easily lose several liters of fluid while cycling two hours, and the amounts may easily exceed values known to produce serious problems with heart rate, blood pressure, and other bodily processes. Hydration is essential for safe cycling.

Hydrate! Hydrate! Hydrate!

Recapping prior information: A 2-hour SMBC ride can result in fluid losses of as little as 2 liters or as much as 8 liters. Individual factors, including body size, and outside temperature are important but are not the only factors influencing fluid loss.

Net (unreplaced) fluid losses of less than one liter may impact our bodies, and net fluid losses of 3-6 liters may produce significant and life-threatening complications.

How much to hydrate? I suggest a thoughtful approach based upon the above information. Key features are how much time one will be cycling, the temperature, and one's body size. How vigorous the ride is has a modest effect when considering the typical SMBC routes (all are likely moderate and rare is the Olympian effort level). One can try to figure out if one perspires more or less than average, but this is difficult, particularly since most perspiration evaporates. It is much better and safer to err on the side of overestimation of fluid losses and needed replacement than to underestimate. As noted above, the amount of fluid losses on our 2-hour rides will vary considerably between individuals (large=more perspiration) and between rides (hotter=more perspiration), but values between 1.5 to 6

liters are reasonable. One should aim to replace all or nearly all our fluid losses while riding, but as explained above, there is a margin of fluid reserve in our bodies. For example, if a 200-pound person perspires 4 liters, but only replaces 3 liters, the 1-liter deficit would be about 2% of total body water and unlikely to cause substantial problems.

Our body keeps the score. If one doesn't have to urinate during or after a ride, likely one is at least mildly dehydrated. If one feels the need to drink more than 1-2 liters of fluid after a ride, one was likely dehydrated. If one experiences any of the previously described signs or symptoms (lightheadedness, muscle cramps, GI cramps, lack of appropriate perspiration) these are warning signs that dehydration may be substantial. If you are unfortunate enough to have experienced any of these, please use these as a warning sign to hydrate more in the future.

How Much and What Fluids to Drink

The consequences of dehydration are common, and may be severe, and there is little risk to drinking a modest excess of fluids and zero risk of carrying too much fluid in one's water bottles (plural) or Camelbak bladder. Perhaps a useful analogy is scuba diving and air; divers do not want to run out of air, and cyclists should not want to run out of water. In fact, if a diver completes a dive without a reserve of extra air (i.e. if the tank is empty) many dive masters consider this sufficiently dangerous to prohibit that person from future dives. In fact, most dive masters and recreational divers have supplies and equipment for sharing air with those in need. On hot days, an extra bottle of water or two for each riding group would provide a similar safety margin.

A first principle should be to never start a ride with dehydrated. Drink prior to the ride: at home, while driving to the start, and even while gearing up and chatting with the ride leader and others. Importantly, caffeine (present in coffee, tea, some soft drinks) is a diuretic and causes fluid loss. Drinking coffee alone is not adequate nor wise. Drink throughout the ride---at most red-light full stops, and certainly during more formal rest stops. Ride leaders should strongly consider brief water breaks every 30 minutes when the temperature is high (above 85°F). There is an adage that if one feels thirsty, it is too late. One should drink during our rides, even if not feeling thirsty. Use the main rest stop to assess the situation. What was your planned total fluid intake, what has been your actual fluid intake, do you feel thirsty, are your kidneys working (and do you have to empty your bladder-a good sign) and does your water supply need to be refilled (err on the side of safety!!)? Drinking after the ride is important to make sure that any potential deficits are replaced. Recall from the above two key facts. The first is that one is replacing total body water, and it takes time for the various compartments (intravascular, extracellular, intracellular) to equilibrate. The second is that one should ideally replace all lost fluids. Plan your hydration strategy and volume. Note that the typical bike water bottle is about 22 oz = 0.65 liters. Most riders should drink 2 or more water bottles during a 2-hour ride, and even more in the heat. If one is large (e.g. 200 pounds), if it is hot (above 80°F), if it is windy and/or the ride is long, plan for all the fluid you will need. Do you need to refill at rest stops? Should you get a Camelbak or other large reservoir? Always err on the side of caution.

A major topic in the sports and exercise world is what should be the hydration fluid of choice---plain water, sports drinks with electrolytes (sodium, potassium) and/or carbohydrates (sugar), coconut water, etc., etc. Key facts are that perspiration is overwhelmingly water. There is sodium sweat, but the value is considerably less than within the bloodstream and varies substantially between individuals. Carbohydrates are needed as an energy source during prolonged exercise, but typically not during a 2-hour SMBC ride and can be in the form of a granola bar or similar during the rest stop. Carbohydrates can serve a second function; they facilitate water absorption from the GI track. For most SMBC rides plain water is just fine, though sports drinks (either straight up or diluted with water) are a perfectly acceptable option. Longer rides, individuals with exceptional sodium losses during to

copious sweating, races, and other competitions all favor additional attention to hydration solutions, but most of us can keep it simple and be safe on our 2-hour rides.

Key points

- Cyclists may perspire 1.5 to 6+ liters on a 2-hour SMBC ride.
- Larger individuals perspire more.
- We all perspire more in warmer weather.
- Total body fluid losses (if inadequately replaced) from our rides can cause significant symptoms and dangerous medical problems.
- Hydrate before, during, and after riding. Err on the side of more!
- Pure water is generally adequate; electrolyte or sports drinks are ok.
- A single 22-oz. cage bottle is often inadequate.

"Thousands have lived without love, not one without water" W.H. Auden