EXERCISE THEORY: HYDRATION SCIENCE

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Here are 4 key concepts that underpin the science of hydration and its practical relevance:

1. Water is weird.

Water is not just a simple solvent that gives form to cells and transports molecules in the blood. The intricate complexity of water's many roles in the body is why even small changes in hydration status can affect physiological function and performance.

Water is a solvent and a transporter, but it's so much more. Water can be a solute, a coolant, a catalyst, a reactant, a product, a lubricant, a controller, a messenger, an ionizing agent, a shock absorber, and a volumerizer. Water allows everything in the body to work; enzymes, other proteins, DNA, RNA, and virtually every other molecule in the body owes their form and function to water.

Much of water's uniqueness is due to it's bipolar charge characteristics. Keep in mind that water is a very light molecule yet mostly exists not as a gas, but in liquid or solid form. Water's bipolarity ensures that adjacent molecules remain close, reducing vaporization. Within cells, water molecules serve as structural extensions to some protein molecules, stiffen or make flexible other molecules, and form clusters called metabolons in which biochemical pathways such as glycolysis are "housed". The notion that the cellular interior is an ocean of free-flowing molecules that randomly interact is a notion of the past.

Water's physicochemical uniqueness is particularly important during exercise where water's high heat capacity, high thermal conductivity, and high latent heat of evaporation ensure that contracting skeletal muscle isn't destroyed by local overheating.

It's little wonder that hydration plays such an important role in physiology and performance. And little wonder that the body relies on intricate control mechanisms to ensure that water (and salt) balance is maintained within tight limits.

2. Dehydration is not always bad, but it's never good.

Research shows that a variety of cardiovascular and thermoregulatory functions begin to deteriorate within the first 20 minutes of exercise in the heat if subjects abstain from drinking. Keep in mind that not much dehydration typically occurs in the first 20 minutes of exercise, yet there can be enough water loss in that short time to compromise function. That tidbit of knowledge alone speaks volumes about the importance of staying well hydrated during vigorous physical activity.

As water is lost from the body as sweat (or urine), central blood volume progressively falls, causing a decline in venous return, stroke volume, and cardiac output (when the increase in heart rate can no longer compensate for the fall in stroke volume.) As cardiac output declines, so does blood flow to active muscles and skin. These responses result in increases in core body temperature as less heat is transported to the skin. Complicating matters further, dehydration can result in lower sweating rates and evaporative cooling, adding to the rise in internal temperature. The end result is either impaired performance (as exercise intensity is reduced to protect against overheating) or increased risk of heat exhaustion or heatstroke if exercise intensity is maintained.

Despite those potentially dire outcomes, it is important to remember that there are times when dehydration is of little consequence. For example, during light workouts, when performance is not critical, and whenever it's cool and sweat rates are low are three occasions when dehydration is not a critical issue. But when performance is important - or any time sweating rates are high - it's always better to be well hydrated than dehydrated.

3. Hydration = Performance

There is no cheaper, easier, or more effective way to protect performance and safeguard health than staying well hydrated during exercise.

Any time athletes want to get the most from their bodies during training and competition, remaining well hydrated is essential. This is especially true when the weather is warm or whenever sweating rates are high.

In warm weather, dehydration of as little as -1% of body weight can impair performance. That should not be surprising because exercise in the heat puts a great strain on the cardiovascular and thermoregulatory systems. On those occasions, every drop

of sweat that is not replaced counts against peak performance.

Dehydration is thought to impair performance by limiting the peripheral capacity to maintain exercise intensity (i.e., via reduced blood flow to active muscles and concomitant reductions in metabolic energy production) and by alterations in central drive (i.e., loss of motivation resulting from the conscious and subconscious desire to continue exercise despite growing discomfort).

Fortunately, proper hydration cures most of these ills. The easiest way for athletes to learn how much fluid they need to drink during exercise is to periodically weigh themselves before and after training sessions. Weight loss of more than 1 to 2% of body weight indicates a need to increase fluid intake in subsequent training sessions. Weight gain indicates a need to reduce fluid intake. Athletes soon become adept at understanding how much to drink under varying conditions.

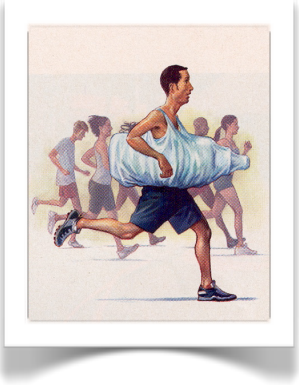
4. Things don't often go wrong, but when they do, fast action saves lives.

Dehydration is a risk factor for heat illness and over-hydration increases the risk of hyponatremia. Both heat illness and hyponatremia have been deadly, both are easily preventable, and both can be successfully treated if correct action is taken quickly.

In terms of statistical risk, heat illness is far more common than hyponatremia, but both occur infrequently as characterized by the number of incidents per 1,000 participants (e.g., an incidence rate of roughly 4/1000 for heat illness and <1/1000 for hyponatremia).

Dehydration does not cause heat illness, but it does drastically increase it's risk. For that reason, most victims of heat illness are dehydrated. Heat illness (as heat exhaustion or heat stroke) is typically characterized by unusual fatigue, irritability, lightheadedness, and sometimes collapse; sweating may or may not be present. Overheated athletes must be cooled quickly and the best way to accomplish that is immersion of the torso in an ice-water bath. If a bath is not available, placing ice around the torso and neck or keeping the skin wet and fanning the athlete will encourage heat loss. The overall goal for sports health professionals is to educate athletes and coaches about the necessity of hydration and the warning signs of heat illness so to prevent it from occurring. When heat illness does occur, the goal is to cool first and transport to emergency care second. Quickly lowering core body temperature saves lives.

Most hyponatremia in athletes is mild (plasma sodium 130-135 mEq/L) and self-correcting with subsequent food (sodium) intake and urine output. Severe,



symptomatic hyponatremia can be deadly because when blood sodium level drops below 130 mEq/L, a substantial volume of water can move from the blood to the brain, causing cerebral edema that leads to death. Not surprisingly, common signs of hyponatremia are physical incoordination and confusion - not knowing the day of the week or inability to recognize family members. Hyponatremia is prevented by drinking only enough fluid during exercise to replace sweat loss. Treating hyponatremia requires emergency medical attention that usually takes the form of intravenous sodium replacement along with diuretic medication.

Suggested Reading

American Dietetic Association. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. *J Am Diet Assoc* 100:709-731, 2009.

Murray R. Hydration and physical performance. *J Amer College Nutr* 26:542S-548S, 2007.

Murray R. Fluid, electrolytes, and exercise. In, Sports Nutrition: A Guide for the Professional Working with Active People, 4th edition. M. Dunford, editor. Chicago: American Dietetic Association, 94-115, 2005. (Revised chapter in the 5th edition)

Sawka MN, LM Burke, ER Eichner, RJ Maughan, SJ Montain, and NS Stachenfeld. American College of Sports Medicine Position Statement: Exercise and fluid replacement. *Med Sci Sports Exerc* 39:377-390, 2007.