HYPONATREMIA, HYDRATION AND HEAT:
Preventing illness in the tactical athlete

By Adam Klaff, PA-C and Jeffrey Cain, MD

While operators are often referred to as "tactical athletes," due in large part to similarities to professional athletes in physical conditioning, nutrition and functional movement training requirements, the reality is that operators remain in a class by themselves. Unlike athletic teams with set schedules for scrimmages and contests, the operator often has little predictability for a tactical call out, let alone the amount of time an operation may span.

Tactical equipment is designed to provide maximum protection from ballistic and fire threats, and as such is much heavier and allows only a limited capacity for circulating air for cooling purposes. Mission preparatory cycles rarely present sufficient opportunity for the individual operator to anticipate and prepare for the physiological demands inherent in his upcoming mission and environment, specifically as relates to hydration.

Improper hydration and ongoing physiological demands can subsequently impact an operator's electrolyte balance, and all of these factors may combine to impede performance and cause *hyponatremia,* a medical condition associated with extended operations conducted in warm environments. This article will review the available sports medicine and military literature and provide recommendations that can reduce the incidence of this condition and help operators to optimize their preparation and maintain peak performance.

Photo courtesy of Colleen Popiny, NTOA Photographer

BACKGROUND

Hyponatremia is an electrolyte disturbance in which the sodium concentration in the serum falls to abnormally low levels. Normal blood sodium levels range from 135mEq/L-145mEq/L. Hyponatremia is, therefore, a concentration of sodium that is less than 135mEq/L. This article will address only the role that the extra-cellular sodium plays in the body's ability to regulate water in association with exertional or dilutional hyponatremia. Serum sodium levels are maintained within the normal physiologic range through a complex regulatory system that occurs predominantly by hormonal effects that regulate salt and water elimination through the kidneys, by the ingestion of sodium and water through the GI system, and by the composition of sweat.

These complex physiological mechanisms work together to maintain the serum sodium level within a normal physiological range. Low sodium produces a wide array of symptoms, ranging from headache, fatigue, confusion, nausea and vomiting to disorientation, breathing difficulty and seizures. These symptoms may affect operators in such ways that could jeopardize an operation or the safety of their teammates. Additionally, the symptoms of hyponatremia are strikingly similar to those of heat illness, making it difficult to diagnose this condition based purely on presentation.

What is interesting about this ion is the way it affects individuals. Different people will have different tolerances to changes in their sodium levels. This is to say that while Officer A might start to notice physiologic symptoms from a sodium level of 125mEq/L, Officer B might experience the very same symptoms with a sodium level of 132mEq/L. Most fit individuals will

Improper hydration and ongoing physiological demands can subsequently impact an operator's electrolyte balance, and all of these factors may combine to impede performance and cause *hyponatremia,* a medical condition associated with extended operations conducted in warm environments.

not see symptoms develop until the sodium level drops below 130mEq/L.

Heat exposure plays a significant role in developing hyponatremia. In addition to environmental exposure (such as the brutal and relentless heat experienced in many parts of the country this past year), exercise generates heat as a byproduct of muscle contraction.

The human body's primary and most efficient method of cooling is through the surface evaporation of sweat. The rate of sweat production is highly variable among individuals, as is the water and sodium content. Ideally, the most efficient sweat rate would be just enough to allow complete evaporation. However, the reality for anyone who has ever worn body armor for more than a few minutes is that sweat rates rapidly become excessive.

Ideally, the most efficient sweat rate would be just enough to allow complete evaporation. However, the reality for anyone who has ever worn body armor for more than a few minutes is that sweat rates rapidly become excessive.

Water and electrolyte loss may become significant enough to affect body composition, which may cause muscles to become weak or cramp.

We occasionally observe operators training in the gym or preparing for missions who are drinking water from gallon containers. While this is a valiant attempt to remain hydrated, it is a technique that may actually lead to a significant decrease in the body's sodium level. Operators frequently inquire about benefits or harm from supplementing with commercial sports drinks, commercial energy drinks and electrolyte tablets. Proper nutrition and hydration will not only address the significant fluid loss experienced with tactical operations, it should also account for replenishing electrolyte losses.

DISCUSSION

The longer an operator exerts himself under full kit, the more heat he generates. As his metabolic processes continue to generate heat, the body attempts to preserve core temperature by

surface cooling through the evaporation of sweat. Sweating results in the loss of water, sodium and other electrolytes. Sodium is, in fact, the most abundant mineral in our sweat (followed by potassium, calcium and magnesium).

Most operators are well versed in the need to consume fluids when operating in warm environments in order to prevent heat injury. However, the ingestion of water alone in the face of water and salt losses from sweat will dilute sodium in the blood and result in hyponatremia. While this dilutional process accounts for some of the reason that sodium levels will fall during prolonged physical activity, there are other mechanisms that affect these levels as well. Sodium replacement by the consumption of low-sugar electrolyte drinks is just as important as drinking water when active in warm environments.

Sports medicine literature is replete with studies regarding the incidence of hydration and hyponatremia among a wide variety of athletes, but interpreting them for tactical operations requires careful consideration of the conditions of the study. For example, very few triathletes are required to wear clothing that inhibits effective cooling or weighs a full half of their body weight. Likewise, studies with military populations should account for the subject's conditioning status. A new recruit simply does not mount the same response to a physiological stress such as a road march as would a seasoned Ranger who has experienced numerous combat deployments.

Articles by Montain, et al. and Sawka, et al. show that we may be able to prevent hyponatremia. These authors provide evidence to support the benefits of sodium replacement and appropriate hydration using sports drinks to athletes performing prolonged physical activity in hot environments. By avoiding fluid replacement using pure water and substituting sports drinks containing sodium, we should see less heat-related illness and less dehydration.

"When operating in warm environments, it is important for team members to observe each other for subtle changes in behaviors that could signal the onset of heat illness or hyponatremia."

Not all sports drinks are formulated equally, however, and one should carefully scrutinize the ingredients. The complexity of dietary concerns is beyond the scope of this brief article, but most authors recommend that effective oral hydration solutions should contain sodium, potassium and a small amount of carbohydrate to facilitate absorption.

Minor differences in the type and amount of carbohydrate or the electrolyte balances can affect the body's ability to absorb the needed water and nutrients, as well as affect how fast the drink moves through the digestive system. The most common carbohydrates contained in sports drinks are sucrose and fructose. These sugars are associated with a high osmotic load, which can potentially lead to abdominal cramping or other undesirable effects, such as diarrhea.

"Over-hydration can cause symptoms similar to heat illness, but actually results from a decreased sodium level (hyponatremia) from too much water intake. If the symptoms are confused with mild heat illness, drinking additional free water can actually worsen the condition."

The Institute of Medicine recommends sports drinks contain 20-30mEq/L sodium, 2-5mEq/L potassium and 5-10 percent carbohydrate. Certainly, there are many commercially available sports drinks, and more recently pure electrolyte solutions that can be mixed with water.

Based on extensive experience during training and combat operations with the U.S. Army's Ranger Regiment, Cera Products formulation for oral hydration has demonstrated the ability to hydrate operators working in warm environments without the GI distress associated with many sugar-laden sports drinks. Cera Products are low osmotic rice-based carbohydrate sports drinks that facilitate the absorption of water and electrolytes without causing GI upset.

There are several commercially produced electrolyte tablets that are also available. There is no compelling evidence to demonstrate that electrolyte tablets have definite benefits or advantages. In fact, many studies, such as Hew-Butler et al., show that taking sodium tablets made no difference in affecting serum sodium levels, blood pressure, rectal temperature or pre/post-event body weight, nor did taking sodium tablets have any benefit for preventing hyponatremia. Although there is no evidence to demonstrate potential harm in ingesting electrolyte tablets, we do not recommend routine use of these particular supplements.

Energy drinks and caffeinated beverages are also frequently consumed by thirsty operators. Energy drinks frequently contain high amounts of sugar, caffeine and/or Guarana, of which one gram equals approximately 40mg caffeine. While caffeine does not cause dehydration or electrolyte imbalances when used in moderation, it is a central nervous system stimulant. Side effects can include jitteriness, tremors and gastrointestinal distress — not ideal considering the already difficult requirements for dynamic

precision marksmanship under stress and adrenaline effects. These drinks certainly do not contribute meaningfully to hydration and we do not recommend their use.

CONCLUSIONS

As we discussed above, the condition known as hyponatremia may result from drinking too much water. Hyponatremia can cause symptoms ranging from headache, fatigue, confusion and vomiting to disorientation, breathing difficulty and seizures. Symptoms can vary based on how low the sodium level goes, how fast it decreases, and how long it stays abnormally low. Although these symptoms are often times very similar to those seen with heat-related illness, the treatment is significantly different. Treating heat illness requires cooling and hydration, while treating hyponatremia requires the restriction of free water intake and supplementation with electrolyte-rich solutions.

When operating in warm environments, it is important for team members to observe each other for subtle changes in behaviors that could signal the onset of heat illness or hyponatremia. Watch for even slight changes in irritability and restlessness when on a mission that requires a prolonged tactical presence. Watch for any team member who is not sweating, as this is a sign of poor hydration status. Operators need to be mindful of their partner's gait and ability to perform tasks.

Finally, pre-hydrating prior to deployment for a mission will help create a baseline level of hydration. It is extremely important for operators to not start behind the curve.

HYDRATION RECOMMENDATIONS

1. Hydrate prior to training or an unannounced mission using water and sports drinks. These drinks should include sodium and potassium that will help replenish losses and stave off the untoward effects described above.

2. Do not over-hydrate. Over-hydration occurs when the consumption of free water intake is greater than sensible and insensible losses (the operator will be taking in more fluid than he is urinating or sweating out). This will be a different volume from operator to operator. Over-hydration can cause symptoms similar to heat illness, but actually results from a decreased sodium level (hyponatremia) from too much water intake. If the symptoms are confused with mild heat illness, drinking additional free water can actually worsen the condition. Consuming sports drinks instead of water may help operators prevent hyponatremia. Additionally, consuming slightly salty snacks may help maintain sodium levels as well as stimulate thirst.

3. Watch for symptoms of heat illness. If operators realize they are starting to have problems, fix them quickly. The longer an operator waits, the more likely he is to progress towards more a more severe illness, which may jeopardize the mission and the lives of teammates. Hydrate appropriately if the above symptoms are noted and make a teammate, team leader or tactical medic aware of the issue.

4. Avoid diluting sports drinks with water. This is often advocated as a means to reduce the GI distress that some experience when consuming these drinks (due to the high sugar content). This practice dilutes the sodium and potassium needed to replenish electrolytes lost in sweat.

REFERENCES

Carter R., Cheuvront S., Williams J., et al. "Hospitalizations and Death from Heat Illness in U.S. Army Soldiers, 1980-2002." *Medicine and Science in Sports and Exercise,* August 2005; 37: 1338-1344.

Cheuvront, S., Carter, R., Sawka, N. "Fluid Balance and Endurance Exercise Performance." *Current Sports Medicine Reports,* Aug. 2003; 2: 202-208.

Epstein Y., Cohen-Sivan Y. "Exercise-Associated Hyponatremia: Facts and Myths." *British Journal of Sports Medicine,* February 2007; 41(2): 111; author reply 111-3.

Hew-Butler, TD, Sharwood, K, et al. "Sodium Supplementation is not Required to Maintain Serum Sodium Concentrations During an Ironman Triathlon." *British Journal of Sports Medicine,* March 2006; 40(3): 255-259.

Institute of Medicine, "Fluid Replacement and Heat Stress." 1994.

Montain S, Cheuvront S, Sawka M. "Exercise Associated Hyponatremia: Quantitative Analysis to Understand Aetiology." *British Journal of Sports Medicine,* February 2007; 39(2): 377-390.

Mudambo KS, Leese GP, Rennie M. "Dehydration in Soldiers During Walking/Running Exercise in the Heat and the Effects of Fluid Ingestion During and After Exercise." *European Journal of Applied Physiology and Occupational Physiology,* Spring 1997; 76(6): 517-524.

O'Connor RE., "Exercise-induced Hyponatremia: Causes, Risks, Prevention and Management." *Cleveland Clinic Journal of Medicine,* September 2006; 73 Suppl 3:S13-18.

Sawka M, Burke L, Eichner R. "Exercise and fluid replacement." *Medicine and Science in Sports and Exercise,* February 2007; 39(2): 377-390.

ABOUT THE AUTHORS

Adam Klaff is an emergency medicine physician assistant in McKinney, Texas. He also provides tactical medicine support and education to the McKinney Police SWAT unit and serves as adjunct faculty at UT Southwestern School of Allied Health.

Dr. Jeff Cain is a board-certified emergency medicine physician in McKinney, TX. A former Army Ranger and Ranger physician with combat deployments to Afghanistan and Iraq, he provides medical direction for McKinney SWAT. He is the former Vice Chairman for the Committee on Tactical Combat Casualty Care and current member of the Committee on Tactical Emergency Casualty Care.