Hyponatremia in Endurance Athletes

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Abstract: The purpose of this paper was to identify the relationship between hyponatremia, or water intoxication, and endurance athletes. Athletic trainers and paramedics must be educated about this potentially fatal problem and be able to determine the appropriate treatment for a hyponatremic athlete.

Hyponatremia or water intoxication is a condition that most likely results from fluid overload and has become increasingly common in endurance athletes (Davis et al., 2001; Irving, Noakes, Buck, & Smit, 1991; Speedy, Noakes, & Schneider, 2001). Hyponatremia is associated with a decrease in plasma sodium due to overhydration with hypotonic solution (water) or an excess in sodium excretion through sweating. In either case, hyponatremia is an abnormal ratio of plasma sodium to water, which is defined by a sodium concentration less than 135 $\pm$5 mmol/L where normal plasma sodium is 135 - 146 mmol/L (Cleary & Casa, 2003; Davis et al., 2001; O'Brien, 2001; Speedy, Faris, Hamlin, Gallagher, & Campbell, 1997; Speedy et al., 1999). Hyponatremia ranges in severity from asymptomatic or mild (malaise, confusion, nausea, fatigue) to symptomatic or severe (seizures, coma, and even death). Hyponatremia has been described as a potentially dangerous and sometimes fatal problem for endurance athletes (Speedy et al., 1999).

Increasing awareness of hydration as a preventative measure for heat illness and the increased popularity of endurance events may have lead to the recent increase in cases of hyponatremia (Cleary & Casa, 2003). A large problem for the athletic population has been the prevention of heat illness and a great emphasis has been placed on avoiding dehydration. Dehydration is a severe problem, as demonstrated by the near 20,000 Egyptian deaths attributed to water deficit and heat illness in the Six-Day War of 1967 (O'Brien, 2001). Israeli troops who stressed rehydration have been successful in minimizing heat casualties (O'Brien, 2001). Army recruits are encouraged to drink large amounts of water to minimize heat illness caused by dehydration. With the increased awareness and emphasis on hydration, overhydration is becoming increasingly problematic. In 1997, a large Army training post in the southeast U.S. reported five cases of hyponatremia in July, one case ended in death (O'Brien, 2001). Increased emphasis on drinking large amounts of water to avoid heat-related illness may inadvertently contribute too many cases of hyponatremia. Therefore, the purpose of this paper was to identify the relationship between hyponatremia and endurance athletes, such as marathon runners and triathletes. We seek to educate allied health professionals, coaches, and athletes about this potentially fatal problem.

Methods

A MEDLINE® search was performed to acquire medical literature from 1990 – present. Data were reviewed with an emphasis on current research (since 1990). Empirical studies, case reports, and medical recommendations for physically active individuals that developed hyponatremia were reviewed and summarized. Data were collected by review and synthesis of clinical empirical studies, case reports, positions papers, and classic hydration/heat illness research.

Results

Prevalence of Hyponatremia

Triathlons and other ultra-distance events have increased in popularity in the last 15 years (Speedy et al., 1997). Occasionally, drinking requirements have been so emphasized that the ingestion of excessive volumes of hypotonic fluid during exercise has led to hyponatremia in ultra endurance athletes and in military recruits (Armstrong, Curtis, Hubbard, Francesconi, Moore, & Askew, 1993). For our purposes, an ultra-endurance event is considered an athletic event lasting over eight hours. However, new research indicates that hyponatremia may also be identified in events lasting under four hours. Case reports (O'Brien, 2001) of hyponatremia after ultra-endurance or shorter endurance exercise have accumulated in recent years. Increased participation by less well-trained athletes with resultant prolonged finish time and increased environmental exposure may be contributing factors (Hsieh, Roth, Davis, Larrabbee, & Callaway, 2002). Several studies in various Ironman triathlons have reported that up to 9% of runners that collapse during these events to be hyponatremic and that 13 to 29% of athletes treated at medical tents are hyponatremic (Hsieh et al., 2002; Noakes et al, 1990; O'Toole et al, 1995; Speedy et al, 1999;). Noakes et al., (1990) reported that symptomatic hyponatremia occurs in less than 0.3% of competitors during prolonged exercise and in as many as 9% of runners that collapsed during a 186 km ultra-marathon. Although most research suggests that hyponatremia may only be prevalent in ultra endurance events, hyponatremia has been reported to occur during marathon running. Hsieh et al. (2002) reported that 5.6% of marathoners requiring medical attention were hyponatremic and Davis et al. (2001) reported treating a total of 25 marathoners with hyponatremia during the marathons in 1998 and 1999. In many Army recruits, hyponatremia has been a result of overly aggressive rehydration (O'Brien, 2001). A report from the U.S. Army Inpatient Data system was used to identify all hospitalizations for hyponatremia from 1996 and 1997. Patients with water intake rates equal to or exceeding 2 quarts per hour and several cases of hyponatremia resulted from aggressive fluid replacement practice for soldiers in training (O'Brien, 2001).

Female endurance athletes reportedly have the highest risk for the development of hyponatremia. As many as 45% of female race finishers in the New Zealand Ironman triathlon developed hyponatremia compared to 14% of male race finishers (Speedy et al., 2001). Hyponatremic marathoners were reported to be more often to be female, use non-steroidal anti-inflammatory drugs, and have slower finishing times than normonatremic race finishers (Speedy et al., 2001). Females may be more susceptible then males because they have lower fluid requirements, as they are usually smaller, have smaller fluid compartments, and take longer to finish the race (Davis et al., 2001; Speedy et al., 2001). Other populations at risk for hyponatremia are individuals that are unable to accurately estimate sweat loss and slower racers (Noakes, 1992).

Etiology of Hyponatremia

The etiology of hyponatremia remains enigmatic. Three main theories exist, the first theory, states that hyponatremia is caused by large water and salt losses through sweat during prolonged exercise so that athletes with this condition are both dehydrated and sodium depleted. Large sodium chloride and fluid losses in urine and sweat occur either chronically before or acutely during exercise (Noakes, 1992; Speedy et al., 2001). Research (Noakes, 1992; Speedy et al., 2001) on the first theory of large water and salt losses does not have much validity since pre-exercise and post-exercise body mass were not measured in theses studies. The second theory has become more accepted and appears to have more supporting evidence. This theory states that hyponatremic athletes have normal sodium plasma concentrations and osmolality but become over hydrated by consuming more fluid than needed (Douglas, Laird, & Hiller, 1995; Noakes, 1992; O'Toole, 1995; Speedy et al., 2001). Irving et al., (1991) reported conclusively that eight subjects who collapsed with hyponatremia in an 88 km ultra-marathon were fluid overloaded and had an extremely low average plasma sodium concentration of 122.4 $\pm$2.2 mmol/L. During a New Zealand Ironman Triathlon, of the 95 athletes requiring medical care, hyponatremia accounted for 9% of the total athletes treated in the medical tent. One athlete had gained 2.5 kg of body fluid by the end of the race (Speedy et al., 1996). One final theory that is not as well researched postulates that hyponatremia develops from fluid retention from potentially abnormally increased antidiuretic hormone secretion during prolonged exercise in athletes drinking excessive volumes of fluid. Excess fluid may not be processed by the kidneys during endurance exercise raising the possibility of some abnormality in renal function or antidiuretic hormone balance (Speedy at al., 1996). This theory needs more research to be considered. The etiological mechanisms of hyponatremia are still under considerable debate. However, the overall consensus is that hyponatremia is caused by fluid overload, resulting from high rates of fluid intake with an inappropriate renal response causing fluid retention (Speedy et al., 2001).

Treatment of Hyponatremia

Signs and symptoms of hyponatremia are very similar to those of many other heat related illnesses; therefore it is of utmost importance for athletic medical professionals to make an accurate differential diagnosis for appropriate treatment. Athletes competing in ultra endurance events are shown to have a 2-3% of body weight loss unrelated to fluid loss (O'Toole et al., 1995). Since a 2-3% loss of body weight for an ultra endurance event is not uncommon, an athlete with no loss in body weight may be susceptible to developing hyponatremia. Symptoms of mild or moderate hyponatremia include malaise, nausea, light-headedness, and fatigue. The most common symptoms of army recruits with severe hyponatremia were: change in mental status (88%), vomiting (65%), nausea (53%), and seizures (31%) associated with an average plasma sodium concentration of 122 $\pm$5 mmol/L (O'Brien, 2001).

The correct treatment for hyponatremia is currently under debate. Hyponatremia ranges from asymptomatic to very severe resulting in death. Whenever possible, athletes should first have a history of fluid ingestion prior to and during competition. Since hyponatremia is usually due to a fluid overload, body mass loss or gain should be assessed. Plasma sodium levels should be measured to determine the severity and thus the appropriate treatment. Asymptomatic hyponatremia treatment consists of close observation with fluid restriction while allowing spontaneous diuresis to ensure that the athletes' condition does not deteriorate. An athlete with symptomatic hyponatremia who is clinically stable and without signs or symptoms of cerebral or pulmonary edema, on-site management in the medical tent may be appropriate (Speedy et al., 2001). However, severely hyponatremic athletes with central nervous system dysfunction should immediately be hospitalized for further evaluation and treatment.

Once hospitalized, controversy exists regarding appropriate treatment of the hyponatremic athlete. The rate at which the sodium level should be corrected is currently under debate by emergency physicians. Rapid correction could cause cerebral demyelination while slow correction could result in the detrimental effects of persistent hyponatremia (Abraham & Jabob, 2001). Rapid correction of exercise induced hyponatremia using hypotonic saline solution with a final target of 130 mEq/L not exceeding 155 mEq/L appears to be both safe and effective. Hypotonic saline solution has advantages by both replenishing the salt deficit and redistributing intracellular water to relieve cerebral edema (Abraham & Jacob, 2001; Davies et al, 2001). However, danger may exist in the potential for overcorrection of hyponatremia once antidiuretic hormone secretion has ceased in response to administration of the saline. Other physicians take a more conservative approach (Davies et al., 2001). Regardless, the rate at which plasma sodium should be corrected depends on the clinical presentation and the duration of symptoms (Abraham & Jacob, 2001).

Recommendations and Prevention

Endurance athletes are often aware of the dangers of dehydration but are rarely aware of the potential complications associated with overhydration. Appropriate individualized fluid replacement strategies should be implemented, particularly since standard recommendations for fluid replacement may be too high for athletes with low sweat rates or too low for those with high sweat rates (Cleary & Casa, 2003). Noakes et al., (1992) has suggested that a fluid intake of 500 mL/hr is appropriate for most non-competitive athletes during prolonged exercise. The American College of Sports Medicine's (Convertino et al., 1996) position statement recommended between 600 mL/hr and 1200 mL/hr. Current recommendations on fluid replacement are based on short events and no guideline for ultra endurance events exists at this time. Consuming fluids rich in sodium is advisable since it is possible that sodium deficiency may play a role in athletes that develop hyponatremia (Speedy et al., 2001).

All studies reviewed agree that prevention of hyponatremia in endurance and ultra endurance athletes is necessary. Increasing the awareness of dehydration and hyponatremia must continue for effective prevention. Decreases in the prevalence of hyponatremia occur when athletes are aware of the conditions and its associated problems (Speedy at al., 2001). As previously mentioned, disagreement exists in the recommended appropriate fluid intake (Noakes et al., 1990). Agreement does appear to exist with including fluids rich in sodium may help to prevent hyponatremia. Water replacement guidelines have been revised, and water consumption based on both physical activity and weather conditions were implemented throughout the Army due to increased incidences of hyponatremia (O'Brien, 2001). Precise fluid replacement guidelines have yet to be determined for the recreational and competitive endurance athletes.

Clinical Implications

More research is needed in the prevalence, etiology, and treatment of hyponatremia in endurance athletes. Information about hyponatremia must be disseminated to all athletes participating in marathons or ultra endurance events. Coaches should be made more aware of the possible severe complications of hyponatremia and relay those concerns to athletes. Coaches should also be aware that females are at a greater risk and should individualize fluid replacement strategies based upon body size, race speed, and weather conditions. Nutritionists may recommend a sport drink including sodium as fluid replacement during endurance and ultra endurance events. It is of great importance for athletic trainers and paramedics to be aware of the signs and symptoms of hyponatremia and that fluid replacement is an inappropriate treatment for an athlete with hyponatremia. Pre- and post-body event weights should determine and if possible, a portable clinical sodium analyzer should be on site at all major endurance events. Coaches, nutritionists, athletic trainers, and athletes must be educated about this potentially fatal problem.

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