Fluid replacement for high school sports safety and performance

By William O. Roberts, M.D., M.S.

Fluid replacement for sports activity can be divided into three phases: before, during, and after. Maintaining body fluid balance is important to preserve intravascular volume for oxygen, nutrient, waste product, and heat transport around the body, and for thermal control through sweating. Fluid balance can be monitored by thirst, by measuring and recording before and after practice body weights, and by noting urine color.

Fluid lost during practice or a game will be reflected by the drop in pre- to post-activity weight. This fluid loss should be replaced before the next activity. Urine color can give an indication of round-the-clock hydration status as dark urine, like apple juice, indicates dehydration and light yellow urine, like lemonade, indicates good hydration. Thirst kicks in when the serum osmolality rises to a preset level. Osmolality rises as body water content drops. Thirst is a marker of dehydration and should not be ignored during practices or games.

The biggest challenge to keeping fluid in balance occurs when there is more than one practice or game on the same day, especially if it is hot and sweat volumes are high. Replacing weight lost between sessions requires more than a pint per pound of weight loss and is difficult to accomplish if there are large fluid losses and less than three hours between events. As a general rule, 150 percent of weight loss replacement with fluid is necessary to be back to normal body water after an event. That translates to 24 ounces of fluid for each pound of weight loss for post-activity fluid replacement.

Ingesting that much fluid in a short time span can be difficult and requires an athlete to monitor urine color, weight, and thirst. One of the easiest fluids to use for post-event recovery and replacement is chocolate skim milk as it contains carbohydrate, protein, and salt in addition to water. When the next event is the following day, the replacement schedule is a little more relaxed and the regular meals help with fluid replacement. In a normal diet, half of the food content is water and this helps with fluid intake.

Replacing fluid during a practice or game helps maintain fluid balance for performance and heat safety, and replacement during the game decreases the need for aggressive post-game fluid intake. Water is fine for events lasting less than an hour and is adequate for longer events, too. For events that last an hour or more, there is some advantage to using a sports drink that contains carbohydrate for energy replacement, but the primary ingredient in a sports drink is water. There may be some advantage to using sports drinks when there is more than one game or practice on the same day.

The volume of fluid replacement needed is highly variable from athlete to athlete. Sweat rates vary from 400 to 2400 or more ml per hour (12 to 80 ounces) so a single statement of “x” ounces every 20 minutes is nearly impossible to determine and safely recommend. The body cannot absorb more than 32 ounces an hour, so athletes who sweat heavily will always end a longer session with a fluid deficit. Likewise, an athlete with a very low sweat rate who ingests more than needed over a longer period of time will run the risk of fluid overload, which can be fatal. Athletes can calculate their needs based on weight lost during practice and increase fluid intake during practice if the post-practice weight is greater than 2- to 3 percent lower than the pre-practice weight.

Fluid ingested before the game or practice will help start the activity fully hydrated, but humans do not store excess water, so timing is important. Drinking 12- to 16 ounces of water about two hours before the activity should give time for absorption of the fluid ingested and excretion of any excess through the kidneys before the event. An additional 4- to 6 ounces about 20 minutes before taking the field may help start replacement during the game.
Energy (stimulant) drinks are not sports drinks, and for athletes are best classified as supplements with the attached risks. Some common brands are Red Bull, Rock Star, Monster, Full Throttle, Jolt, and Go Girl. For athletes in training, nutritional supplements are purported to improve training adaptations, allow more intense training, promote recovery between training bouts, and enhance competitive performance.

Like nutritional supplements, energy drinks are not regulated by the Food and Drug Administration (FDA) due to the 1994 U.S. Dietary Supplement Health and Education Act. This means manufacturers are not required to prove either effectiveness or safety of the product and there is no oversight group that regulates the products for purity. Energy drinks are advertised to give users an “edge.”

However, recent work by Woolsey and associates using assigned double-blind placebo controlled study found that while subjects felt they were performing better, they really were making significantly more errors probably due to being over-aroused or over-focused. Energy drinks seem to reduce performance for technical skills that rely on timing and coordination; not attributes that help most athletes.

Energy drinks contain, beyond water, various combinations of sugar, caffeine, and “other” ingredients that are reported to increase energy levels and improve alertness. These other ingredients include B vitamins (vit B6, vit B12, and niacin), taurine, guarana, ginseng, Tibetan goji berry, green tea, yerba mate, ginkgo biloba, policosan's, glucuronolactone, and vitamin C. None of these ingredients have known performance enhancing properties. Ginseng and niacin both cause a vasodilatation and flushing sensation that may give a feeling of “energy.” Much of the stimulant properties of the drink come from the caffeine or other stimulants in the mixture.

Amphetamines, ephedrine, Ma Huang, synephrine, bitter orange, citrus aurantium, zhi shi are all banned substances for athletic competition and may be found in stimulant drinks, although amphetamines are in the FDA-controlled substance category and ephedrine has been taken off the market. Stimulants can cause or have been associated with tachycardia, nervousness, laxative effects, sleep disturbance, anxiety, tremor, insomnia, aggressiveness, hallucinations, addiction, and an increased risk of stroke, heart attack, cardiac arrhythmia, and sudden death.

Caffeine is the most frequently used psychoactive drug in the world. Recent findings suggest that low doses of caffeine provide some ergogenic effects by directly affecting the central nervous system during exercise. Caffeine can cross the blood-brain barrier and antagonize the effects of adenosine, resulting in higher concentrations of stimulatory neurotransmitters. It does improve performance and endurance during long duration, heavy exercise, and also improves, to a lesser extent short-term, high-intensity athletic performance. Caffeine improves concentration, reduces fatigue, and enhances alertness. Regular repeated use does not moderate caffeine’s ergogenic properties. Chronic use of caffeine leads to dependence, tolerance, drug craving, and, upon abrupt cessation, unpleasant withdrawal symptoms. Its use is widespread by athletes as young as 11 years of age who are seeking a boost in performance, legal, and no longer on the WADA prohibited list.

There are down sides to drinks taken during activity, the most frequent being gastrointestinal (GI) complaints. Using sports drinks as a model, it was found that sport drink ingestion led to higher incidences of GI complaints compared to water. Adding caffeine to the sports drink has no effect on GI complaints and the carbohydrate component may be the culprit for the GI distress that occurred in some of the athletes. Sugar or carbohydrate is one of the main components in the non-diet energy drinks.

There are case reports and clinical observations that describe adverse cardiovascular adverse events, including sudden death, associated with the use of some performance-
enhancing substances, but these episodes have not been tied to energy drinks. The usual cardiovascular complaints involve racing heart or palpitations and many of these complaints were due to ephedrine and/or caffeine.

The ingredients in an energy drink that will help athletes are the water (but there is not much in each can), the sugar (although usually present it large quantities that cause GI upset in exercising athletes), and caffeine (as long as it does not cause heart palpitations or racing heart). The “other” ingredients may do more to upset an athlete’s concentration and focus than improve performance, so it is probably best for athletes to skip the energy drinks before practice and competition and concentrate their fluids on proven replacements like water and sports drinks.

**Summary**

Fluid replacement is critical for athlete safety and performance. Fluids and foods in the normal diet help maintain body water. An individual hydration plan to replace weight lost during practice will help ensure good hydration for the next day. Sports drinks may help performance in longer duration games and activities, but water is fine for most high school events. Energy drinks, as opposed to sports drinks, should be avoided and their use prior to and during sports events is not recommended.

**Hydration Tips**

- Water is fine.
- Sports drinks help with activity greater than an hour.
- Energy drinks should not be used for sports.
- Try to replace sweat losses during activity to remain within 2- to 3 percent of baseline weight.
- Replace weight losses with fluid before the next activity.
- There is adequate sodium and potassium in the normal diet.
- Weigh before and after activities.
- Keep urine light yellow like lemonade.
- Listen to your body and do not ignore thirst.

William O. Roberts, M.D., M.S. is a professor of Family Medicine and Community Health, Division of Sports Medicine, University of Minnesota Medical School, and also is chair of the League’s Sports Medicine Advisory Committee.