Heat-Related Disorders

Exposure to the combination of external heat stress and the inability to dissipate metabolically generated heat can lead to three heat-related disorders (see figure 2):

- Heat cramps
- Heat exhaustion
- Heat stroke

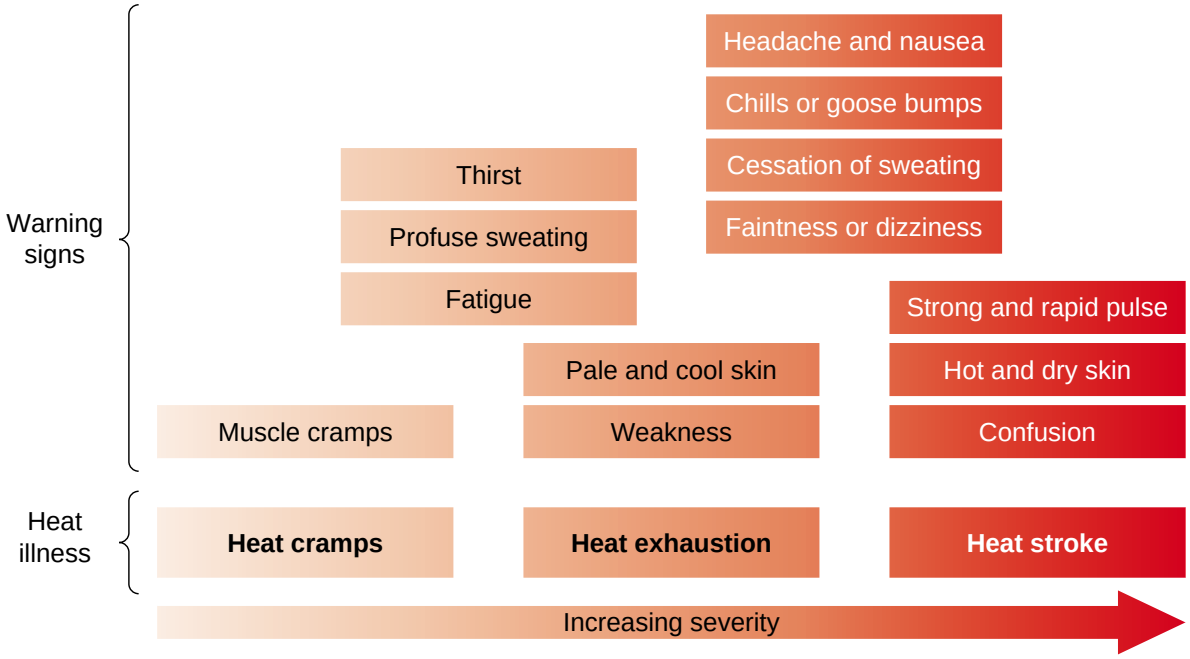

Figure 2 The warning signs of heat cramps, heat exhaustion, and heat stroke. ©PepsiCo 1995. Reprinted with permission.

Heat Cramps

Heat cramps, the least serious of the three heat disorders, is characterized by severe cramping of the skeletal muscles. It involves primarily the muscles that are most heavily used during exercise. This disorder is probably brought on by the mineral losses and dehydration that accompany high rates of sweating, but a cause-and-effect relationship has not been fully established. Heat cramps are treated by moving the stricken individual to a cooler location and administering fluids or a saline solution.

Heat Exhaustion

Heat exhaustion is typically accompanied by such symptoms as extreme fatigue, breathlessness, dizziness, vomiting, fainting, cold and clammy or hot and dry skin, hypotention (low blood pressure), and a weak, rapid pulse. It is caused by the cardiovascular system's inability to adequately meet the body's needs. Recall that during exercise in heat, your active muscles and your skin, through which excess heat is lost, compete for a share of your total blood volume. Heat exhaustion results when these simultaneous demands are not met. Heat exhaustion typically occurs when your blood volume decreases, by either excessive fluid loss or mineral loss from sweating.

With heat exhaustion, the thermoregulatory mechanisms are functioning but cannot dissipate heat quickly enough because there is insufficient blood volume to allow adequate distribution to the skin. Although the condition often occurs during mild to moderate exercise in the heat, it is not generally accompanied by a high rectal temperature. Some people who collapse from heat stress exhibit symptoms of heat exhaustion but have internal temperatures below 39 ˚C (102.2 ˚F). People who are poorly conditioned or unacclimatized to the heat are more susceptible to heat exhaustion.

Treatment for victims of heat exhaustion involves rest in a cooler environment with their feet elevated to avoid shock. If the person is conscious, administration of salt water is usually recommended. If the person is unconscious, medically supervised intravenous administration of saline solution is recommended. If allowed to progress, heat exhaustion can deteriorate to heat stroke.

Heat Stroke

Heat stroke is a life-threatening heat disorder that requires immediate medical attention. It is characterized by

- a rise in internal body temperature to a value exceeding 40 ˚C (104 ˚F),
- cessation of sweating,
- hot and dry skin,
- rapid pulse and respiration,
- usually hypertension (high blood pressure),
- confusion, and
- unconsciousness.

If left untreated, heat stroke progresses to coma, and death quickly follows. Treatment involves rapidly cooling the person's body in a bath of cold water or ice or wrapping the body in wet sheet and fanning the victim.

Heat stroke is caused by failure of the body's thermoregulatory mechanisms. Body heat production during exercise depend on exercise intensity and body weight, so heavier athletes run a higher risk of overheating than lighter athletes when exercising at the same rate and when both are about equally acclimatized to the heat.

For the athlete, heat stroke is a problem associated not only with extreme conditions. Studies have reported rectal temperatures above 40.5 ˚C (104.9 ˚F) in marathon runners who successfully completed race conducted under relatively moderate thermal conditions (e.g., 21.1 ˚C [70 ˚F] and 30% relative humidity). Even in shorter events, the body's core temperature can reach lift-threatening levels. As early as 1949, Robinson observed rectal temperatures of 41 ˚C (105.8 ˚F) in runners competing in events lasting only about 14 minutes, such as the 5-km race. Following a 10-km race conducted with an air temperature of 29.5 ˚C (85.1 ˚F), 80% relative humidity, and bright sun, one runner who collapsed had a rectal temperature of 43 ˚C (109.4 ˚F)! Without proper medical attention, such fevers can result in permanent central nervous system damage or death. Fortunately, this runner was rapidly cooled with ice and recovered without complication.

When exercising in the heat, if you suddenly feel chilled and goose bumps form on your skin, stop exercising, get into a cool environment, and drink plenty of cool fluids. The body's thermoregulatory system has become confused and think that the body temperature needs to be increased even more! Left untreated, this condition can lead to heat stroke and death.

Prevention of Hyperthermia

We can do little about environmental conditions. Thus, in threatening conditions, athletes must decrease their effort in order to reduce their heat production and their risk of developing hyperthermia (high body temperature). All athletes, coaches, and sports organizers should be able to recognize the symptoms of hyperthermia. Fortunately, our subjective sensations are well correlated with our body temperatures, as indicated on table 2 below. Although there is generally little concern when rectal temperature remains below 40 ˚C (104 ˚F) during prolonged exercise, athletes who experience throbbing pressure in their heads and chills should realize that they are rapidly approaching a dangerous situation that could prove fatal if they continue to exercise.

Subjective Symptoms Associated with Overheating

Rectal Temperature	Symptoms
40 ˚C – 40.5 ˚C (104 ˚F – 105 ˚F)	Cold sensation over stomach and back, with piloerection (goose bumps)
40.5 ˚C – 41.1 ˚C (105 ˚F – 106 ˚F)	Muscular weakness, disorientation, and loss of postural equilibrium
41.1 ˚C – 41.7 ˚C (106 ˚F – 107 ˚F)	Diminished sweating, loss of consciousness and hypothalamic control
≥42.2 ˚C (≥108 ˚F)	Death

To prevent heat disorders, several precautions should be taken. Competition and practice should not be held outdoors when the WBGT (see page 59) is over 28 ˚C (82.4 ˚F). As mentioned earlier, because WBGT reflects the humidity as well as the absolute temperature, it reflects the true physiological heat stress more accurately than does standard air temperature. Scheduling practices and contest either in the early morning or at night avoids the severe heat stress of midday. Fluids should be readily available, and athletes should be required to drink as much as they can, stopping every 10 to 20 minutes for a fluid break in warm temperatures.

Clothing is another important consideration. Obviously, the more clothing that is worn, the less body area exposed to the environment to allow heat exchange. The foolish practice of exercising in a rubberized suit to promote weight loss is an excellent illustration of how a dangerous microenvironment (the isolated environment inside the suit) can be created in which temperature and humidity can reach a sufficiently high level to block all heat loss from the body. This can rapidly lead to heat exhaustion or heat stroke. Football uniforms are another example. Areas that are covered by sweat-soaked clothing and padding are exposed to 100% humidity and higher temperatures, reducing the gradient between body surface and the environment.

Athletes should wear as little clothing as possible, when heat stress is a potential limitation to thermoregulation. The athlete should always underdress because the metabolic heat load will soon make extra clothing an unnecessary burden. When clothing is needed or required, it should be loosely woven to allow the skin to unload as much heat as possible and light colored to reflect heat back to the environment.

The American College of Sports Medicine (ACSM) has provided guidelines to help distance runners prevent heat-related injuries. A modified list of these recommendations appears in table 3 below.

Table 3 Guidelines for Distance Runners Competing Under Conditions of Heat Stress

1. Distance races should be scheduled to avoid extremely hot and humid conditions. If the WBGT index is above 28 ˚C (82 ˚F), canceling the race should be considered.
2. Summer events should be scheduled in the early morning or evening to minimize solar radiation and unusually high air temperature.
3. An adequate supply of fluid must be available before the start of the race, along the racecourse, and at the end of the event. Runners should be encouraged to replace their sweat losses or consume 150 to 300 ml (5.3 – 10.5 oz) every 15 minutes during the race.
4. Cool or cold (ice) water immersion is the most effective means of cooling a collapsed hyperthermic runner.

(continued)

Guidelines for Distance Runners Competing Under Conditions of Heat Stress, *continued*

5. Runners should be aware of the early symptoms of hyperthermia, including
   - dizziness,
   - chilling,
   - headache or throbbing pressure in the temporal region, and
   - loss of coordination.
6. Race officials should be aware of the warning signs of an impending collapse in hot environments and should warn runners to slow down or stop if they appear to be in difficulty.
7. Organization personnel should reserve the right to stop runners who exhibit clear signs of heat stroke or heat exhaustion.

Note: These recommendations are based on the position stands published by the American College of Sports Medicine in 1987 and 1995.

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Keeping Your Players Hydrated

You may think that you've heard enough about the importance of drinking plenty of fluids and the benefits of staying well hydrated. After all, your players seem to drink a lot of water during exercise and most tend to avoid severe problems such as cramping or overheating. Yet many well-trained and informed tennis players continue to have hydration problems. The symptoms of inadequate or inappropriate hydration management range from simply feeling a little "off" and not quite playing at one's best to suffering painful heat cramps or heat exhaustion. These symptoms are commonly observed at many tennis tournaments, especially when it's hot.

The three primary nutritional factors related to keeping your players hydrated are **water**, **electrolytes**, and **carbohydrates**. These are also the nutrients that have the most immediate effect on performance—positive or negative, depending on management of their intake.

Water

Facts:

- Many players *begin* exercising while dehydrated.
- On-court sweat losses can be extensive—1 to 2.5 liters (~35-88 ounces) *per hour* is typical.
- *Any* water deficit can have a negative effect on a player's performance and well-being. The effects of a progressive water deficit due to inadequate fluid intake and/or excessive sweat losses include the following:

- Increased cardiovascular strain—your heart has to work harder.
- Decreased capacity for temperature regulation—you heat up more.
- Decreased strength, endurance, and mental capacity—your intensity is lower, you tend to lose control, and you make inappropriate shot selections.
- Increased rate of carbohydrate metabolism—you fatigue faster.

- Many players do not adequately *rehydrate* after play.

What you can do:

- Drink plenty of fluids (water, juice, milk, sport drinks) throughout the day.
- Don't forget to drink regularly during all practice and warm-up sessions.
- Drink another 12 to 16 ounces about one hour before you play.
- Drink at each changeover—typically, older adolescents and adults can comfortably drink up to 48 ounces or so per hour. This rate of fluid intake can prevent large fluid deficits from developing for most players.
- After play, drink about 150 percent of any fluid deficit that still remains. For example, if your weight is down 1 pound at the end of play, you will need to drink another 24 ounces.

Electrolytes

Facts:

- Players lose far more sodium and chloride (salt) from sweating than any other electrolyte.
- Sodium and chloride losses are greater with higher sweating rates.
- Players who are accustomed (acclimatized) to the heat tend to lose less sodium and chloride than players who are not acclimatized to the heat.
- Sodium deficits can lead to incomplete rehydration and muscle cramps.
- If players don't replace the salt they lose, they can't completely rehydrate.
- Excessive water consumption, combined with a large sweat-induced sodium deficit, can lead to severe hyponatremia (low blood sodium)—a very dangerous situation. Even mild hyponatremia can cause fatigue, apathy, nausea, or a headache.

What you can do:

- When you play in a hot environment (or any time you sweat a lot), add some salt to your diet, or eat certain high-salt foods, before and after you play. Salt contains 590 milligrams of sodium per 1/4 teaspoon (or 1.5 grams). Good food sources of sodium and chloride include:
  - salted pretzels,
  - many types of soups,
  - cheese,
  - salted sport drinks (or Pedialyte),
  - tomato sauce (pizza!), and
  - tomato juice.

Carbohydrates

Facts:

- Adequate carbohydrate intake is crucial to optimal tennis performance.
- Consuming carbohydrates before and after exercise can help restore some of your body water reserves.
- Playing tennis in the heat causes the body to use carbohydrates fast. So, even if you eat well before playing, after 60 to 90 minutes of intense singles play you'll probably need some supplemental carbohydrate to continue playing your best.
- Ingesting too many carbohydrates or too much of an inappropriate carbohydrate (e.g., fructose) can delay carbohydrate and fluid absorption and may cause gastrointestinal distress.

What you can do:

- Generally, 7 to 10 grams of carbohydrate per kilogram of body weight (~500 to 700 grams per day for a 155-pound player) is recommended for periods of intense training or competition.
- During exercise, 30 to 60 grams of carbohydrate per hour is most effective. Choose a sport drink whose *primary* carbohydrate is sucrose, glucose, or a glucose polymer (e.g., maltodextrin).

Adequate and well-timed water, electrolyte, and carbohydrate intake should be a priority for any athlete expecting to play well and safely. Yet athletes often overlook or underestimate the importance of these nutrients.

Adapted from Keeping Your Players Hydrated: What Are the Key Points? By Michael Bergeron, MD. From *High-Performance Coaching*, the USTA newsletter for tennis coaches, vol. 2, no. 2/2000. Used with permission of the USA Tennis Coaching Education Department.