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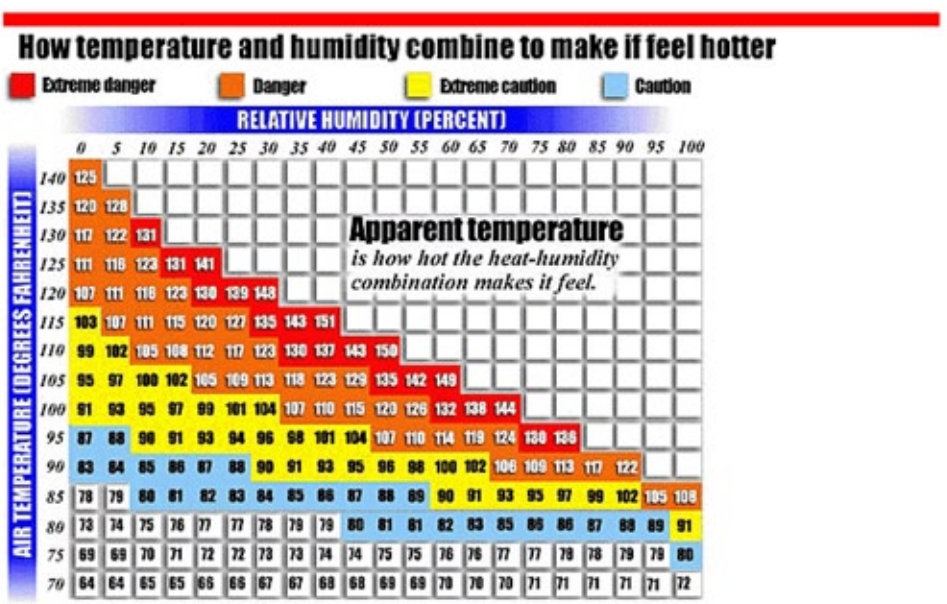
$$HI = -42.379 + 2.04901523(Tf) + 10.14333127(RH) - 0.22475541(Tf)(RH) - ((6.83783 \times 10^{-3})(Tf^2) - ((5.481717 \times 10^{-2})(RH^2) + ((1.22874 \times 10^{-3})(Tf^2)(RH)) + ((8.5282 \times 10^{-4})(Tf)(RH^2)) - ((1.99 \times 10^{-6})(Tf^2)(RH^2))$$

By Diane Haupt, MS, PT

Now that I have your attention from the numbers above by making you wonder if this article was misplaced from a high school calculus book, read on to see how it relates to training during the dog days of summer. With the weather we' ve had lately, the majority of us have been ready to throw in the towel after yet another miserable run through Seashore. You know the feeling. No wind to be found to cool off your body. The horseflies and mosquitoes out in full force attacking your sweat soaked body like a scene out of a horror picture. Your pace slowed down 2 minutes per mile or more than similar runs in December, and the only PR your are setting is the reading on your HR monitor. Your mind begins to wonder and you question how you will be ready for your next race and what is " wrong" with your body. Next time you are struggling through such a workout, slow down and remember this article and take the above formula into consideration where HI stands for Heat Index, RH for relative humidity as a whole number, and Tf for air temperature in degrees Fahrenheit. If you don' t want to bother carrying a calculator with you during your workout, you can cheat and use the table below to determine the apparent temperature (HI) and necessary precautions. Locate the relative humidity across the top of the chart and the environmental temperature down the left side of the chart. Follow across and down to find the HI or the body' s sensation of heat caused by the temperature and humidity (the reverse of the " wind chill factor"). Exposure to full sunshine can increase the heat index values by 15 degrees.



Source: National Oceanic and Atmospheric Administration

Physical activity and/or prolonged exposure to apparent temperatures of 90-105 degrees lead to an increased risk of heat cramps and possibly heat exhaustion while exertion in apparent temperatures of 105-130 degrees, heat cramps and heat exhaustion are likely and heatstroke possible. In apparent temperatures above 130 degrees, heatstroke is highly likely. Heat cramps are painful spasms of skeletal muscles that usually involve the arms, legs, or abdominal muscles and typically occur after several hours of exertion with the loss of large volumes of sweat. The exact cause of heat cramps are not known but numerous electrolytes have been blamed, including sodium, potassium, and magnesium. Heat exhaustion is caused by excessive water loss that has been inadequately replaced. Common symptoms include the inability to continue exercising, a throbbing headache, nausea, chills, dizziness, unsteadiness, and fatigue. Heat stroke is the most dangerous of heat related illnesses and can be fatal. Athletes are at increased risk of exertional heat stress when the environmental heat stress and internal heat stress from exertion overwhelm the body' s heat cooling mechanisms. The diagnosis of heatstroke is based on mental status changes in the form of incoherent speech and confusion, headache, rapid pulse, core temperature greater than 105 degree F, and possibly unconsciousness (Source:Fluids 2000 by the Gatorade Company).

Gaining an understanding of how the body reacts to heat and why it is highly unlikely that you will set a PR in 85 degree temperatures with 80% humidity is important in preventing heat injury. The physiological response to exercise in the heat is determined by the degree of heat stress and the intensity of the exercise. At the same power output, exercise in the heat results in a higher heart rate and a higher cardiac output, as well as higher core and skin temperatures, higher blood lactate concentration, and possibly a faster rate of depletion of muscle glycogen compared with the same exercise in a cooler environment (Rowell, L.B. , 1983, Cardiovascular aspects of human thermoregulations. Circ. Res. 52, 367-379). With such physiological responses, performance in events lasting longer than 20-30 minutes under extreme conditions of heat stress are likely to lead to impaired performance despite your best efforts.

The body is designed to work within a very narrow range of temperature fluctuation and is constantly striving to keep the core temperature close to 98.6 degree F. About 75% of the energy produced during exercise is wasted as heat, causing the body temperature to rise. By far, the most important part of the body' s cooling system, accounting on average for about 75% of all cooling, is your ability to produce and excrete sweat. In cool environments, the body heat is transferred to the air, but when the environmental temperature exceeds skin temperature, heat is gained and body temperature rises and evaporative cooling must do all the work and becomes the body' s major means of heat transfer. Problems develop if sweat cannot easily evaporate as with high humidity, when the body is actually being heated by the environment as with temperatures above 99 degrees, or when water loss from sweat and respiration is not replaced and dehydration occurs. On humid days, sweat evaporates more slowly because the air is already saturated with water and doesn' t want to absorb the sweat accumulated on your skin and clothing. Although soaking, dripping sweat may give you a psychological boost and the feeling of a putting in a hard effort, it has no cooling effect as the sweat must evaporate to effectively remove heat.

Heat injuries should not happen and are preventable through several methods:

1. Acclimization: Acclimization will reduce the negative impact of heat on performance. The major physiological adjustments to heat acclimatization take about 7-14 days and may be carried out by exercising in a hot room or by training in a hot climate. Wearing extra clothing to increase sweating during training in a cool climate has also shown some degree of heat acclimization (Dawson, B.,1994, Exercise training in clothing in cool conditions. Sports Med. 17: 233-44). The workouts should initially be short and then gradually increase in length and

intensity. Acclimization to heat leads to earlier onset of sweating, increased blood volume, and enhanced ability to sweat. In addition, the sodium content of sweat tends to be reduced with acclimization as the body attempts to retain sodium to help conserve extracellular fluid volume (Source: Fluids 2000 by Gatorade Company).

2. Clothing: Fabrics (Coolmax) that minimize heat storage and enhance sweat evaporation should be selected as well as white or light colors. Minimal, loose-fitting clothing also helps promote heat loss.

3. Fluid Replacement: Unfortunately, the thirst stimulus producing the desire to replace lost fluid is inadequate for the body' s needs and athletes generally only get thirsty when they are already in danger. The American College of Sports Medicine recommends the intake of 500 ml (about 17 oz.) of fluid 2 hours before exercise and that fluid ingestion during prolonged exercise should match fluid losses from sweating with a generic guideline of 5-10 oz. every 15 minutes during vigorous activity and using cold fluids as much as possible as your body absorbs them more rapidly than warm fluids. However, these are general guidelines and it is best to determine your personal sweat rate to take the guess work out of hydration. In general, if you finish an event weighing the same or more than when you started, you are likely to have overhydrated. Water is definitely a good thing, but you can get too much of a good thing as the body is only able to absorb about 34 oz. of fluid per hour at most so excessive fluid consumption can lead to water intoxication and hyponatremia. Bloated stomach, puffy fingers and ankles, a bad headache, and confusion are warning signs of hyponatremia. If you' ve dropped 3% or more, dehydration has occurred. Up to 2% weight loss is safe and reasonable. Optimal postexercise rehydration requires higher fluid volume replacement (more than 150% of weight loss) and higher sodium content (60 vs. 20 mmol/L of sodium) compared with rehydration during exercise (Shirreffs SM, Post exercise rehydration: effects of volume consumed and drink sodium content. Med Sci Sports Exerc 1996; 28(10) : 1260-1271). Although caffeine has ergogenic benefits, use it with caution in hot environments since it acts as a diuretic which may deplete fluid stores more rapidly. If you use gels to replenish your glycogen stores during training/racing, make sure that you also drink 10-12 oz. of plain water as gel alone will pull water into your gut to aid digestion and lower the amount available to maintain blood volume, causing dehydration.

4. Modifying training sessions: Trying to balance work, family life, and training often leaves us with few options for when to train but going out at the right time of the day can make recovery from the heat easier. Although humidity is often higher in the early morning, it is usually the coolest part of the day and best time to exercise. The next best option is running late in the evening with the worst case scenerio being that lunchtime midday run when the temperature is high and the sun directly overhead. Consider hitting the dreaded treadmill or indoor trainer in extreme conditions if this is your only option for that day. When the weather is unbearable for extended periods of time, consider altering your training plan by inserting more recovery days to allow your body to fully recover and using a heart rate monitor on those easy recovery days to make sure you are keeping it easy. Both the warm-up and training/racing session should be modified during hot weather training. In hot climates, it is undesirable to have the body temperature markedly increased during warm up, possibly leading to reduced performance because of hyperthermia and dehydration.

So next time you are out exercising in the heat, remember there is no real way to beat the heat and give those 2-4 million sweat glands in your body a break!