Outdoor Action Guide to Heat-Related Illnesses& Fluid Balance

by Rick Curtis

Heat injuries can be immediately life-threatening. Be aware of the temperature conditions and your hydration levels. The information provided here is designed for educational use only and is not a substitute for specific training or experience. Princeton University and the author assume no liability for any individual's use of or reliance upon any material contained or referenced herein. This article is prepared to provide basic information about heat related illnesses for the lay person. Medical research is always expanding our knowledge of the causes and treatment. It is your responsibility to learn the latest information. The material contained in this article may **not** be the most current.

Fluid Balance

All the body's fluids make up one large body fluid pool. Losses of fluid from any one source is reflected in the levels of all the body's other fluids: e.g. profuse sweating will ultimately result in decreased blood volume. If a patient loses enough fluid through any manner-bleeding, sweating, vomiting, or diarrhea-the end result is the same: dehydration and, potentially, volume shock. Adequate fluid is also critically important in hot environments to help our body thermoregulate (see Heat Illnesses page 00). Remember, dehydration can kill!

If someone is chronically losing fluid (from diarrhea or vomiting), then you have a real emergency on your hands. Treat the cause of the fluid lose as best you can (see Shock page 00, Bleeding page 00, Heat Illnesses page 00, Abdominal Infections page 00) and rehydrate the patient. **Be prepared to evacuate your patient.**

Dehydration is always easier to prevent than it is to treat. So it is important to ensure that all members of your group replace their regular fluid losses by drinking adequate amounts of water (see below). Your body absorbs fluids best when you drink frequently and in small amounts rather than drinking large amounts at one time. It also helps with fluid absorption if you drink while eating. A pinch of salt and sugar in the water will do if no food is available. Very dilute mixtures of sports drinks like Gatorade® (add just enough to taste) work well for this purpose.

Don't depend on feeling thirsty to tell you when to drink. Thirst is a late response of the body to fluid depletion. Once you feel thirsty, you are already low on fluids. The best indicator of proper fluid levels is urine output and color. You, and all the people in your group should strive to be "copious and clear." Ample urine that is light colored to clear shows that the body has plenty of fluid. Dark urine means that the body is low on water, and is trying to conserve its supply by hoarding fluid which means that urine becomes more concentrated (thereby darker).

Basic Fluid Recommendations

Season/Weather	Quarts/day	Explanation
Fall & Spring Backpacking***<B/**	2-3 quarts 1.8-2.8 liters	This is what an average person will need on a daily basis in general temperate conditions.
Hot Weather Backpacking*****	3-4 quarts 2.8-3.7 liters	In hot and humid weather you are losing additional fluid through sweating which must be replaced.
Winter Backpacking*****	3-4 quarts 2.8-3.7 liters	In the winter time you are losing moisture through evaporation to the dry air and especially through respiration. Dry air entering the lungs heats up and is exhaled saturated with moisture.
***All Seasons**	Add 1quart 1.8 liters	At high altitude the body looses more fluid. Increase your fluid intake if you are traveling at high altitudes (over 8,000 feet/2,438 meters)

Table 9.1

Fluids & Salts:

Another factor in overall fluid balance is the replacement of salts lost to sweat. In most cases the salts found in normal food consumption is adequate for salt replacement. In the event of severe dehydration, a solution of ½ teaspoon salt and ½ teaspoon of baking soda per quart/liter of water can be used to replace lost fluid and salt. Use lukewarm fluids. Discontinue the fluids if the person becomes nauseated or vomits. Restart fluids as soon as the person can tolerate it.

Thermoregulation

The body has a number of mechanisms to properly maintain its optimal core temperature of 98.6° F (37° C). Above 105° F (40° C) many body enzymes become denatured and chemical reactions cannot take place leading to death. Below 98.6° F (37° C) chemical reactions slow down with various complications which can lead to death. Understanding thermoregulation is important to understanding Heat Illnesses and Cold Injuries.

How Your Body Regulates Core Temperature:

- **Vasodilation** - increases surface blood flow which increases heat loss (when ambient temperature is less that body temperature).
- **Vasoconstriction** - decreases blood flow to periphery, decreases heat loss.
- **Sweating** - cools body through evaporative cooling
- **Shivering** - generates heat through increase in chemical reactions required for muscle activity. Visible shivering can maximally increase surface heat production by 500%. However, this is limited to a few hours because of depletion of muscle glucose and the onset of fatigue.

- **Increasing/Decreasing Activity** will cause corresponding increases in heat production and decreases in heat production.
- **Behavioral Responses** - putting on or taking off layers of clothing will result in thermoregulation

Cold Challenge

Whenever you go into an environment that is less than your body temperature, you are exposed to a Cold Challenge. As long as your levels of Heat Production and Heat Retention are greater than the Cold Challenge, then you will be thermoregulating properly. If the Cold Challenge is greater than your combined Heat Production and Heat Retention, then you susceptible to a cold illness such as hypothermia or frostbite (see Table 9.3).

Cold Challenge - (negative factors)

- Temperature
- Wet (rain, sweat, water)
- Wind (see Table 9.3 Wind Chill Table)

Heat Retention - (positive factors)

- Body Size/shape - your surface to volume ratio effects how quickly you lose heat.
- Insulation - type of clothing layers
- Body Fat - amount of body fat also effects how quickly you lose heat.
- Shell/Core Response - allows the body shell to act as a thermal barrier

Heat Production - (positive factors)

- Exercise
- Shivering

Heat Retention	+	Heat Production	<	Cold Challenge	=	Cold Injury
Body Size/shape Insulation Body Fat Body shunting blood to the core		Exercise Shivering		Temperature Wetness Wind		Hypothermia Frostbite

Table 9.2

Wind Chill

Wind Chill can have a major impact on heat loss through convection (see Chapter 2 - Equipment: Regulating Your Body Temperature). As air heated by your body is replaced with cooler air pushed by the wind, the amount of heat you can lose in a given period of time increases. This increase is comparable to the amount of heat you would lose at a colder temperature with no wind. The Wind Chill factor is a scale that shows the equivalent temperature given a particular wind speed.

Heat Challenge

In hot weather, especially with and humidity, you can lose a great deal of body fluid through exercise. This can lead to a variety of heat related illnesses including Heat Exhaustion and Heat Stroke. Heat Challenge is a combination of a number of external heat factors. Balanced against this Heat Challenge is your body's methods of Heat Loss (passive and active). When Heat Challenge is greater than Heat Loss, you are at risk for a heat-related injury (see Table 9.4). In order to reduce the risk you need to

either decrease the Heat Challenge or increase your Heat Loss. Fluids are a central part of exercising in a Heat Challenge (see Fluids above).

Heat Challenge - (negative factors)

- Temperature
- Exercise
- Humidity (see Table 9.5 Heat Index Table)
- Body Wetness from sweating
- Wind (see Table 9.3 Wind Chill Table)

Passive Heat Loss - (positive factors)

- Body Size/shape - your surface to volume ratio effects how quickly you lose heat.
- Insulation - type of clothing layers
- Body Fat - amount of body fat also effects how quickly you lose heat.
- Shell/Core Response - allows the body shell to act as a thermal barrier
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Active Heat Loss - (positive factors)

- Radiant Heat from the body.
- Sweating which causes heat loss through evaporation. Amount of sweating is limited by:
    - Fluid Levels
    - Level of Fitness

Passive Heat Loss	+	**Active Heat Loss**	<	**Heat Challenge**	=	**Heat Injury**
Body Size/shape Insulation Body Fat Body shunting blood to the core		Radiant Heat Sweating		Temperature Exercise Humidity Body Wetness Wind		Heat Syncope Heat Exhaustion Heat Stroke

Table 9.4

The Heat Index:

Ambient temperature is not the only factor that plays a role in creating the potential for heat injuries, humidity is also important. Since our bodies rely on the evaporation of sweat as a major method of cooling, high humidity reduces our ability to cool the body, increasing the risk of heat illnesses. The Heat Index shows the relative effects of temperature and humidity (see Table 9.5).

The Heat Index											
	Environmental Temperature Fº (Cº)										
	70º (21)	75º(24)	80º(27)	85º(29)	90º(32)	95º(35)	100º(38)	105º(41)	110º(43)	115º(46)	120º(49)
Relative Humidity	**Apparent Temperature Fº (Cº)**										
0%	64&ord	69&ord	73&ord	78&ord	83&ord	87&ord	91&ord	95&ord	99&ord	103&ord	107&ord

	m;(18)	m;(20)	m;(23)	m;(26)	m;(28)	m;(31)	m;(33)	m;(35)	m;(37)	m;(39)	m;(42)
10%	65º(18)	70º(21)	75º(24)	80º(27)	85º(29)	90º(33)	95º(35)	100º(38)	105º(41)	111º(44)	116º(47)
20%	66º(19)	72º(22)	77º(25)	82º(28)	87º(30)	93º(33)	99º(37)	105º(41)	112º(44)	120º(49)	130º(54)
30%	67º(19)	73º(23)	78º(26)	84º(29)	90º(33)	96º(36)	104º(40)	113º(45)	123º(51)	135º(57)	148º(64)
40%	68º(20)	74º(23)	79º(26)	86º(30)	93º(34)	101º(38)	110º(43)	123º(56)	137º(58)	151º(66)	
50%	69º(20)	75º(24)	81º(27)	88º(31)	96º(36)	107º(42)	120º(49)	135º(57)	150º(66)		
60%	70º(21)	76º(24)	82º(28)	90º(33)	100º(38)	114º(46)	132º(56)	149º(65)			
70%	70º(21)	77º(25)	85º(29)	93º(34)	106º(41)	124º(51)	144º(62)				
80%	71º(22)	78º(26)	86º(30)	97º(36)	113º(45)	136º(58)					
90%	71º(22)	79º(26)	88º(31)	102º(39)	122º(50)						
100%	72º(22)	80º(27)	91º(33)	108º(42)							

Apparent Temperature	**Heat-stress risk with physical activity and/or prolonged exposure.**
90º-104º (32-40)	Heat cramps or Heat Exhaustion possible
105º-130º (31-54)	Heat cramps or Heat Exhaustion likely. Heat Stroke possible.
130º and up (54 and up)	Heat Stroke very likely.
Caution: This chart provides guidelines for assessing the potential severity of heat stress. Individual reactions to heat will vary. Heat illnesses can occur at lower temperature than indicated on this chart. Exposure to full sunshine can increase values up to 15º F.	

Table 9.5

Heat Illnesses

Heat illnesses are the result of elevated body temperatures due to an inability to dissipate the body's heat and/or a decreased fluid level. Always remember that mild heat illnesses have the potential of becoming severe life threatening emergencies if not treated properly (See Fluid Balance above).

Heat Cramps

Heat cramps are a form of muscle cramp brought on by exertion and insufficient salt.

Heat Cramps Treatment

Replace salt and fluid (see Fluid Balance) and stretch the muscle (See Chapter 6 - Wilderness Travel & Camping: Stretching). Kneading and pounding the muscle is less effective than stretching and probably contributes to residual soreness.

Heat Syncope

Heat Syncope (fainting) is a mild form of heat illness which results from physical exertion in a hot environment. In an effort to increase heat loss, the skin blood vessels dilate to such an extent that blood flow to the brain is reduced, resulting in symptoms of faintness, dizziness, headache, increased pulse rate, restlessness, nausea, vomiting, and possibly even a brief loss of consciousness. Inadequate fluid replacement which leads to dehydration contributes significantly to this problem.

Heat Syncope Treatment

Heat Syncope should be treated as fainting (See Fainting). The person should lie or sit down, preferably in the shade or in a cool environment. Elevate the feet and give fluids, particularly those containing salt (commercial "rehydration" mix or ½ teaspoon salt and ½ teaspoon baking soda per quart/0.9 liter) (see Fluid Balance page 00). **The patient should not engage in vigorous activity for at least the rest of that day.** Only after s/he has completely restored his/her body fluids and salt and has a normal urinary output should exercise in a hot environment be resumed (and then cautiously).

Heat Exhaustion

This occurs when fluid losses from sweating and respiration are greater than internal fluid reserves (volume depletion). Heat Exhaustion is really a form of volume shock. The lack of fluid causes the body to constrict blood vessels especially in the periphery (arms and legs). To understand Heat Exhaustion think of a car with a radiator leak pulling a trailer up a mountain pass. There is not enough fluid in the system to cool off the engine so the car overheats. Adding fluid solves the problem.

The signs and symptoms of Heat Exhaustion are:

- Sweating
- Skin - Pale, clammy (from peripheral vasoconstriction)
- Pulse - Increased
- Respirations - Increased
- Temperature - normal or slightly elevated
- Urine Output - Decreased
- Patient feels weak, dizzy, thirsty, "sick," anxious
- Nausea and vomiting (from decreased circulation in the stomach)

Heat Exhaustion Treatment

Victims of Heat Exhaustion must be properly re-hydrated and must be very careful about resuming physical activity (it is best to see a physician before doing so). Treatment is as described above for Heat Syncope, but the person should be **more** conservative about resuming physical activity to give the body a chance to recover. Have the person rest (lying down) in the shade. Replace fluid with a water/salt solution (commercial "rehydration" mix or ½ teaspoon salt and ½ teaspoon

baking soda per quart/0.9 liter) (see Fluid Balance page 00). Drink slowly, drinking too much, too fast very often causes nausea and vomiting.

Evacuation usually is not necessary. Heat Exhaustion can become Heat Stroke if not properly treated (see Heat Stroke below). **A victim of Heat Exhaustion should have be closely monitored to make sure that their temperature does not go above 103° F (39° C) If it does so, treat the person for Heat Stroke as described below.**

Heat Stroke - Hyperthermia

Heat Stroke is one of the few life threatening medical emergencies. A victim can die within minutes if not properly treated. Heat Stroke is caused by an increase in the body's core temperature. Core temperatures over 105° (41° C) can lead to death. The rate of onset of Heat Stroke depends on the individual's fluid status. To understand Heat Stroke think of that same car pulling a trailer up a mountain pass on a hot day. This time the radiator has plenty of fluid, but the heat challenge of the engine combined with the external temperature is too much. The engine can't great rid of the heat fast enough and the engine overheats. There are two types of Heat Stroke-fluid depleted (slow onset) and fluid intact (fast onset).

- **Fluid depleted** - The person has Heat Exhaustion due to fluid loss from sweating and/or inadequate fluid replacement, but continues to function in a heat challenge situation. Ultimately, the lack of fluid has minimized the body's active heat loss capabilities to such an extent that the internal core temperature begins to rise. Example: a cyclist on a hot day with limited water.

- **Fluid intact (fast onset)** - The person is under an extreme heat challenge. The heat challenge overwhelms the body's active heat loss mechanisms even though the fluid level is sufficient. Example: a cyclist pushing hard on a 104° F day (40° C).

Signs & Symptoms of Heat Stroke

- **The key to identifying Heat Stroke is hot skin**. Some victims may have hot, dry skin, others may have hot, wet skin because they have just moved from Heat Exhaustion to Heat Stroke.

- Peripheral vasoconstriction (skin gets pale)

- Pulse Rate - increased

- Respiratory Rate - increased

- Urine Output - decreased

- Temperature - increased (may be over 105° F/41° C)

- Skin - may be wet or dry, flushed

- AVPU - Severe changes in mental status and motor/sensory changes, then the person may become comatose, possibility of seizures.

- Pupils - may be dilated and unresponsive to light

Heat Stroke Treatment

- **Efforts to reduce body temperature must begin immediately!** Move the patient (gently) to a cooler spot or shade the victim. Remove clothing. Pour water on the extremities and fan the person to increase air circulation and evaporation. Or cover the extremities with cool wet cloths and fan the patient. Immersion in cool **(not cold)** water is also useful. During cooling the extremities should be massaged vigorously to help propel the cooled blood back into the core.

- After the temperature has been reduce to 102° F (39° C), active cooling should be reduced to avoid hypothermia (shivering produces more heat). The patient must be monitored closely to make sure that temperature does not begin to go up again.

- Volume replacement - the victim will probably need fluid regardless of the type of onset.
- Basic life support, CPR if needed.
- Afterwards there can be serious medical problems. **Prepare to evacuate your patient.**
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