Unit 2 - Chapter 5

One of the primary responsibilities of an athletic trainer in preventing injuries is to make certain that the practice and playing environment is as safe as it can possibly be. Certainly no one has control over the weather. However, the potential dangers of having athletes engage in practices or competitions when adverse weather or environmental conditions exist cannot be ignored.[10] Ignoring or minimizing the potential threat to the health and well-being of athletes who are forced to practice or compete under adverse environmental conditions can have serious legal consequences should a situation arise that results in injury to an athlete.[22] Emergency action plans will be discussed in detail in Chapter 9. **It is essential that emergency action plans are in place for dealing with any injury or illness that occurs due to any of the environmental issues discussed in this chapter.** These EAPs should be developed for each separate venue. The adverse environmental conditions that tend to pose the greatest potential for injury in the athletic population are hot, humid, sunny conditions that cause **hyperthermia;** cold and windy conditions that cause **hypothermia;** overexposure to the sun; lightning and thunderstorms; altitude; jet lag; and, air pollution.

hyperthermia Increased body temperature.

hypothermia Decrease of body temperature.

Hyperthermia

An ever-present concern of practicing or competing in a hot humid environment is the problem of hyperthermia. **Hyperthermia** refers to an increase in body temperature. In recent years, particularly among football players and wrestlers, a number of deaths have been caused by hyperthermia.[17] It is vitally important to understand when environmental heat and humidity are at a dangerous level and to act accordingly. Remember that an individual does not have to be in the South to experience heat-related illnesses. Heat and humidity occur in every geographic region of the United States, and anyone who supervises athletes that practice and compete in these environmental conditions must be able to recognize the clinical signs of heat stress and manage them properly.[8]

Heat Stress

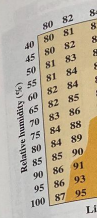
Regardless of the level of physical conditioning or age, extreme caution must be taken when exercising, particularly in hot, humid weather.[44] Prolonged exposure to extreme heat can result in heat illness.[47] Heat stress is certainly preventable, but each year many athletes suffer illness and, occasionally, death from some heat-related cause.[38] Athletes who exercise in hot, humid environments are particularly vulnerable to heat stress. Some athletes have medical conditions such as sickle-cell trait (a disorder of red blood cells) that make them more susceptible to the dangers of exercising in hot humid conditions. The physiological processes in the body can continue to function only as long as body temperature is maintained within a normal range.[45]

Maintenance of normal temperature in a hot environment depends on the ability of the body to dissipate heat. Heat can be dissipated from the body through four mechanisms: *conduction* (direct contact with a cooler object); *convection* (contact with a cooler air or water mass); *radiation* (heat generated from metabolism); and *evaporation* (sweat evaporating from the skin surface). The body can also gain heat through conduction, convection, and radiation if the surrounding environment is hotter than the body temperature or if the body is exposed to direct sunlight. By far most of the heat that is dissipated from the body is through the process of evaporation.

Heat can be gained or lost through:

- Metabolic heat production
- Conductive heat exchange
- Convective heat exchange
- Radiant heat exchange
- Evaporative heat loss

Sweat glands in the skin allow water to be transported to the surface, where it evaporates, taking large quantities of heat with it. When the temperature and radiant heat of the environment become higher than body temperature, loss of body heat becomes highly dependent on the process of sweat evaporation. The sweat must evaporate for heat to be dissipated. But the air must be relatively free of water for evaporation to occur. Heat loss through evaporation is severely impaired when the relative humidity



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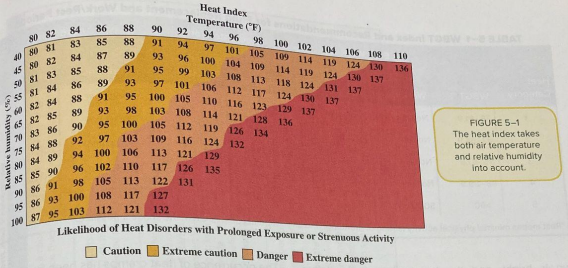

FIGURE 5–1
The heat index takes both air temperature and relative humidity into account.

reaches 65 percent and virtually stops when the humidity reaches 75 percent.[39] The heat index takes both ambient air temperature and relative humidity into account and attempts to determine how hot it actually feels to the human body (Figure 5–1).

It must be emphasized that although heat illness is most likely to occur in a hot, humid environment, it is possible that heat illnesses can also occur in colder environments when the athlete allows himself or herself to become dehydrated and the body cannot dissipate heat through sweating.[12]

Monitoring the Heat Index

Common sense must be exercised when overseeing the health care of athletes training or competing in the heat. Obviously, when the combination of heat, humidity, and bright sunshine is present, extra caution is warranted.[16] The universal *wet bulb globe temperature (WBGT) index* provides an objective means for determining necessary precautions for practice and competition in hot weather.[7]

An instrument used to measure the heat index is a **psychrometer**. A psychrometer has two different thermometers: a dry bulb and a wet bulb. The dry bulb thermometer measures ambient air temperature, and the wet bulb measures the temperature when water evaporates. The difference between the two thermometer readings is used to calculate the relative humidity. A digital psychrometer is easy to use (Figure 5–2). Simply pushing a button allows the user not only to find the temperature, relative humidity, and dew point, but also to calculate the heat index.

psychrometer An instrument with two thermometers that is used to measure the heat index.

The WBGT index can be calculated using charts that are provided with the psychrometer. The digital psychrometer calculates the heat index automatically. Once the WBGT index has been calculated, Table 5–1 can be used to make recommendations relative to fluid replacement and the length of work and rest periods.

Heat Illnesses

It should be obvious that heat-related problems have the greatest chance of occurring on days when the

FIGURE 5–2
A digital psychrometer may be used to determine the WBGT heat index.

TABLE 5–1 WBGT Index and Recommendations for Fluid Replacement and Work/Rest Periods

		Easy Work		Moderate Work		Hard Work	
Heat Category	WBGT °F	Work/Rest*	Water Per Hour	Work/Rest*	Water Per Hour	Work/Rest*	Water Per Hour
1	78–81.9	No limit	½ qt.	No limit	¾ qt.	40/20 min	¾ qt.
2	82–84.9	No limit	½ qt.	50/10 min	¾ qt.	30/30 min	1 qt.
3	85–87.9	No limit	¾ qt.	40/20 min	¾ qt.	30/30 min	1 qt.
4	88–89.9	No limit	¾ qt.	30/30 min	¾ qt.	20/40 min	1 qt.
5	>90	50/10 min	1 qt.	20/40 min	1 qt.	10/50 min	1 qt.

*Rest means minimal physical activity (sitting or standing) and should be accomplished in the shade if possible.

sun is bright, and the temperature and relative humidity are high. But it is certainly true that various forms of heat illness, including heat syncope and exercise, associated muscle (heat) cramps, heat exhaustion, and heatstroke, can occur whenever the body's ability to dissipate heat is impaired.[17]

Heat Syncope Heat syncope, or heat collapse, is associated with rapid physical fatigue during overexposure to heat. It is usually caused by standing in heat for long periods or by not being accustomed to exercising in the heat. It is caused by peripheral vasodilation of superficial vessels, hypotension, or a pooling of blood in the extremities, which results in dizziness, fainting, and nausea.

Treatment Heat syncope is quickly relieved by laying the athlete down in a cool environment, elevating the lower extremities, and replacing fluids.[53]

Exercise Associated Muscle (heat) Cramps Exercise associated muscle cramps are extremely painful muscle cramps that occur during or after exercise most commonly in the calf and abdomen, although any muscle may be involved. (Table 5–2) Other symptoms may include pain, dehydration, thirst, sweating, or fatigue.

Heat cramps occur due to muscle overload and fatigue

The occurrence of heat cramps has been traditionally attributed to excessive loss of water and depletion of electrolytes or ions (sodium, chloride, potassium, magnesium, and calcium) by sweating. Profuse sweating involving losses of large amounts of water and small quantities of these ions was thought to interfere with the concentration of these elements within the body resulting in painful muscle contractions and cramps.[25] However, more recent evidence suggests that cramping may be more likely due to altered neuromuscular control that occurs with muscle overload and fatigue rather than a fluid and/or electrolyte imbalance. Muscle cramps appear to occur most often in those muscle groups under high demand during the activity. Muscle fatigue alters neuromuscular control thus facilitating a reflex contraction or cramp of the muscle.[46]

Treatment The most current recommendation for immediate treatment of exercise-associated muscle cramps is ingestion of fluids, preferably a sports drink, and mild, prolonged stretching with ice massage of the cramping muscle. While ingestion of fluids and electrolytes may not necessarily prevent muscle cramps it is certainly critical in preventing other exertional heat illnesses.[6] Avoiding fatigue and overexertion during exercise may reduce the likelihood of altered neuromuscular control.[56] An athlete who experiences muscle cramps may have difficulty returning to practice or competition for the remainder of the day, because cramping is likely to reoccur with physical exertion.[49]

TABLE 5–2 Summary and Comparison of Heat Disorders, Treatment and Prevention

Disorder	Cause	Clinical Features and Diagnosis	Treatment	Prevention
Heat syncope (fainting)	Rapid physical fatigue in heat and blood pooling in extremities	Dizziness, nausea, fainting	Lay athlete down in a cool environment, replace fluids	Acclimatize athlete and make sure he or she is appropriately hydrated
Exercise associated muscle cramps	Hard work in heat; sweating heavily; overload and fatigue of the muscle	Muscle twitching and cramps, usually after midday; cramps in calves, abdomen, hamstrings quadriceps	Ingesting large amounts of water and sodium, mild stretching, and ice massage of affected muscle	Acclimatize athlete properly; provide large quantities of water; avoid muscle overload and fatigue
Exertional heat exhaustion	Prolonged sweating; inadequate replacement of body fluid losses; diarrhea; intestinal infection	Excessive thirst, dry tongue and mouth; weight loss; fatigue; weakness; incoordination; mental dullness; small urine volume; slightly elevated body temperature; high serum protein and sodium; reduced swelling	Bed rest in cool room, immediate oral fluid replacement, increase fluid intake to 6 to 8 liters/day; sponge with cool water; keep record of body weight; keep fluid balance record; provide semiliquid food until salination is normal, IV fluids if drinking is impaired	Supply adequate water and other liquids Provide adequate rest and opportunity for cooling
Exertional heatstroke	Thermoregulatory failure of sudden onset	Abrupt onset; CNS abnormalities, including headache, vertigo, and fatigue; flushed skin; relatively less sweating than seen with heat exhaustion; rapidly increasing pulse rate that may reach 160 to 180; increased respiration; blood pressure seldom rises; rapid rise in temperature to 105°F; athlete feels as if he or she is burning up; diarrhea, vomiting; can lead to permanent brain damage; circulatory collapse may produce death	Take immediate emergency measures to reduce temperature below 102°F within 30 minutes of collapse (e.g., immediate full-body immersion in ice-water bath or sponge cool water and air fan over body, massage limbs); transport to hospital as soon as possible	*Ensure proper acclimatization, proper hydration* *Educate those supervising activities conducted in the heat* *Adapt activities to environment* *Screen participants with past history of heat illness*

Exertional Heat Exhaustion Heat exhaustion results from inadequate replacement of fluids lost through sweating (Table 5–2). Clinically, the victim of heat exhaustion collapses and manifests profuse sweating, pale skin, mildly elevated temperature (101°–104°), dizziness with loss of coordination, stomach cramps with nausea, hyperventilation, and rapid pulse.[26]

Heat exhaustion results from dehydration.

It is sometimes possible to spot athletes who are having problems with heat exhaustion. Sometimes but not always they may begin to develop heat cramps. They may become disoriented and light-headed, and their physical performance will not be up to their usual standards when fluid replacement has not been adequate. In general, persons in poor physical condition who attempt to exercise in the heat are most likely to get heat exhaustion.

Treatment An athlete who has exertional heat exhaustion must be immediately removed from play and taken to a shaded or air-conditioned area. Excess clothing or equipment should be removed, and the athlete should lie down with his or her legs elevated.[17] Rehydration should begin immediately with water or a sports drink as long as the athlete is not nauseated or vomiting. If the athlete cannot take fluids orally, intravenous fluid replacement should be initiated by a physician. It is essential to obtain an accurate core temperature. A rectal temperature is the most accurate indicator of core temperature to differentiate heat exhaustion from heatstroke.[38] Oral and tympanic membrane thermometers do not provide an accurate reading of actual core temperature.[26] Cooling efforts should continue until rectal temperature has lowered to 102°.[16]

Exertional Heatstroke Unlike heat cramps and heat exhaustion, heatstroke is a serious, life-threatening emergency (Table 5–2).[14] The specific cause of heatstroke is unknown; however, it is clinically characterized by sudden collapse with alteration of consciousness; flushed, hot skin; less sweating than is seen with heat exhaustion; shallow breathing; a rapid, strong pulse; and, most important, a core temperature of 105° F or higher.[14] Basically heatstroke is a breakdown

Heatstroke is a life-threatening emergency.

of the thermoregulatory mechanism caused by excessively high body temperature; the body loses the ability to dissipate heat through sweating.[14]

Heatstroke can occur suddenly and without warning. *The athlete may or may not show signs of heat cramps or heat exhaustion.* **The possibility of death from heatstroke can be significantly reduced if body temperature is lowered to 102° or less within 30 minutes of collapse.**[2,14] The longer the body temperature is elevated to 105° F or higher, the higher the mortality rate.[17]

Managing heatstroke requires a heroic effort to lower body temperature.

Treatment The key to managing this condition is aggressive and immediate whole-body cooling. After determining rectal temperature and assessing airway, breathing, and circulation, **immediately immerse the athlete in a cold water bath** (35–58°F) up to their neck, and then remove equipment and clothing.[13] If it is not possible to immerse the athlete in cold water, sponge him or her down with cool water and fan with a towel. Also ice bags may be placed at the neck, and over other major arterial vessels.[61] Call the rescue squad. It is imperative that the victim be transported to a hospital as quickly as possible. However, **it is recommended that the victim be cooled down first until the temperature is lowered to 102°F and then transported if on-site rapid cooling and adequate medical supervision are available.**[37]

Preventing Heat Illness

It is essential to understand that heat illness is preventable. Exercising common sense and caution will keep heat illnesses from occurring.[8] The following suggestions should be considered when planning a practice or competitive program during hot weather.

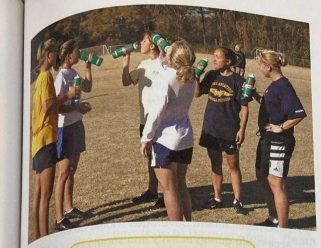

FIGURE 5–3
Athletes must have unlimited access to water or sports drinks, especially in hot weather.

5–1 Critical Thinking Exercise

A high school athletic director in southern Louisiana is concerned about the likelihood that several of the football players will suffer heat-related illness during preseason practice the first 2 weeks of August.

What intervention strategies can be implemented to help the athletes avoid heat-related illnesses?

Fluid Replacement **The single most important step that can be taken to minimize the chance of heat illness is to make absolutely certain that athletes are appropriately hydrated.**[41] Regardless of whether the athlete is practicing or competing in a hot humid environment or a cold damp environment, the athlete needs to continually rehydrate by replacing fluids lost through evaporation of sweat[21] (Figure 5–3). Unfortunately, dehydration occurs frequently during physical activity because athletes do not ingest enough fluid to match sweat loss, even though unlimited fluids are readily available.[62] In fact, seldom is more than 50 percent of this fluid loss replaced.[32] **Ideally, fluid replacement should match sweat loss.** Fluid is most effectively replaced at regular intervals of about 15 minutes.[40]

The problem in fluid replacement is how rapidly the fluid can be eliminated from the stomach into the intestine, from which it can enter the bloodstream. Water is absorbed rapidly from the intestine. If carbohydrates are included in the fluid, the optimal concentration for fluid absorption is between 3% and 8%, but concentrations greater than 5% to 8% may slow gastric emptying.[41] Cold drinks (45° to 55° F [7.2° to 12.8° C]) tend to empty more rapidly from the stomach than do warmer drinks; they are not more likely to induce cramps, nor do they offer any particular threat to a normal heart.[10] Drinks that contain alcohol and caffeine act as diuretics and act to promote dehydration.

The prevention of hyperthermia involves:

- Unrestricted fluid replacement
- Gradual acclimatization
- Identification of susceptible individuals
- Lightweight uniforms
- Routine weight record keeping

Athletes can tell whether they are appropriately hydrated by paying attention to the color and volume of their urine. Within 60 minutes of exercise, a nearly clear urine of normal to above-normal output indicates that the athlete is appropriately hydrated.

Exercise-Associated Hyponatremia Hyponatremia is a condition involving a fluid/electrolyte disorder that results in an abnormally low concentration of sodium in the blood.[55] It is most often caused by ingesting so much fluid before, during, and after exercise that the concentration of sodium is decreased. It also can occur due to too little sodium in the diet or in ingested fluids over a period of prolonged exercise. An individual with a high rate of sweating and a significant loss of sodium who continues to ingest large quantities of fluid over a several-hour period of exercise (as in a marathon or triathlon) is particularly vulnerable to to developing hyponatremia. Hyponatremia can be avoided completely by making certain that fluid intake during exercise does not exceed fluid loss and that sodium intake is adequate.[43]

The signs and symptoms of exertional hyponatremia may include a progressively worsening headache; nausea and vomiting; swelling of the hands and feet; lethargy, apathy, or agitation; and low blood sodium. Ultimately, a very low concentration of sodium can

compromise the central nervous system, creating a life-threatening situation.[55]

Treatment If hyponatremia is suspected and blood sodium levels cannot be determined on-site, measures to rehydrate the athlete should be delayed, and the athlete should be transported immediately to a medical facility.[43] At the medical facility, the delivery of sodium, certain diuretics, or intravenous solutions may be necessary. A physician should clear the athlete before he or she is allowed to return to play.

Using Sports Drinks Research has shown that replacing lost fluids with a sports drink is more effective than using water alone.[34] Because of the flavor of the sports drinks, an athlete is likely to drink more than plain water. In addition, sports drinks replace both fluids and electrolytes that are lost in sweat and also provide energy to the working muscles.

Water is a good thirst quencher, but it is not a good rehydrator because water "turns off" your thirst before you're completely rehydrated. Water also "turns on" the kidneys prematurely so you lose fluid in the form of urine much more quickly than when drinking a sports drink. The small amount of sodium in sports drinks allows the body to hold onto the fluid consumed rather than losing it through urine.[41] Sodium can be also be ingested by adding a little extra salt to the foods consumed throughout the day.

Not all sports drinks are the same. How a sports drink is formulated dictates how well it works in providing rapid rehydration and energy. The optimal level of carbohydrate is 14 grams per 8 ounces of water for quickest absorption and energy.[45] Thus, sports drinks should be used without diluting. Research has shown that full-strength sports drinks are absorbed just as fast as water. Most contain no carbonation or artificial preservatives, making them satisfying during exercise and causing no stomach bloating. Also, most sports drinks contain a minimal number of calories. It has been shown that sports drinks are effective in improving performance during both endurance activities and short-term high-intensity activities such as soccer, basketball, and tennis that last from 30 minutes to an hour.[57] *Focus Box 5–1* provides recommendations for fluid replacement.

Gradual Acclimatization Gradual acclimatization is a critical consideration in avoiding heat stress. Acclimatization should involve not only becoming accustomed to heat but also becoming acclimatized to exercising in hot temperatures.[1] The first 2 to 3 weeks of preseason present the greatest risk of exertional heat illnesses, particularly in equipment-intensive sports.[15] A good preseason conditioning program—started well before the advent of the competitive season and carefully graded as to intensity—is recommended. During the first 5 or 6 days, an 80 percent acclimatization can be achieved on the basis of a 2-hour practice period in the morning and a 2-hour

Focus Box 5–1

Recommendations for fluid replacement*

- Athletes should begin all exercise sessions well hydrated[115] (determined by light yellow color of urine).
- A hydration protocol for fluid replacement should be established.
- To ensure proper hydration, the athlete should consume 17 to 20 ounces of water or a sports drink 2 to 3 hours before exercise and then 7 to 10 ounces 10 to 20 minutes before exercise.
- Fluid replacement beverages should be easily accessible during activity and should be consumed at a minimal rate of 7 to 10 ounces every 10 to 20 minutes.
- During activity, the athlete should consume the maximal amount of fluid that can be tolerated, but it is important that fluid intake does not exceed fluid loss.
- A cool, flavored beverage at refrigerator temperature is recommended.[22]
- The addition of proper amounts of carbohydrates and electrolytes to a fluid replacement solution is recommended for exercise events that last longer than 50 minutes or are intense.
- For vigorous exercise lasting less than 1 hour, the addition of carbohydrates and electrolytes does enhance physical performance.
- A 3-8 percent carbohydrate solution appears to be optimal (14 grams of carbohydrate per 8-ounce serving). A concentration greater than 8 percent slows gastric emptying.
- Adding a modest amount of sodium (0.3 to 0.7 gram per liter) is acceptable to stimulate thirst and increase fluid intake.

*Based on recommendations from the National Athletic Trainers' Association,[41] American College of Sports Medicine,[3] and Gatorade Sport Science Institute.[45]

practice period in the afternoon. Complete acclimatization may take a minimum of 10 to 14 days.[15] Special considerations and modifications may be necessary for those wearing protective equipment during periods of high environmental stress.[15]

Identifying Susceptible Individuals Athletes with a large muscle mass are particularly prone to heat illness.[8] Body build must be considered when determining individual susceptibility to heat stress. Overweight individuals may have as much as 18 percent greater heat production than underweight individuals because metabolic heat is produced proportionately to surface area. It has been found that heat illness victims tend to be overweight. Death from heatstroke increases at a ratio of approximately four to one as body weight increases.[47]

Women are apparently more physiologically efficient in body temperature regulation than are men. Although women possess as many heat-activated sweat glands as men do, they sweat less and manifest a higher heart rate when working in heat.[39] Although slight differences exist, the same precautionary measures apply to both genders.

Other individuals who are susceptible to heat stress include children and older adults, those with relatively poor fitness levels, those with a history of heat illness, and anyone with a febrile condition.[17]

Keeping Weight Records Careful weight records of all players must be kept. Weights should be measured both before and after practice for at least the first 2 weeks of practice. If a sudden increase in temperature and/or humidity occurs during the season, weight should be recorded again for a time. A loss of 2 percent of body weight reduces blood volume and could lead to a health threat.[41] A rule should be established that the athlete should be held out of practice until normal body weight has been regained.

Uniforms Uniforms should be selected on the basis of temperature and humidity. Initial practices should be conducted in light-colored, short-sleeved T-shirts, shorts, and socks, moving gradually into short-sleeved net jerseys, lightweight pants, and socks as acclimatization proceeds. All early-season practices and games should be conducted in lightweight uniforms. Because of the specialized equipment worn by the players, football requires particular consideration. In hot, humid environments, the helmet should be removed as often as possible.

Focus Box 5–2

Recommendations for preventing heat illness*

- Ensure that appropriate medical care is available.
- Conduct a thorough physician-supervised preparticipation exam to identify susceptible individuals.
- Acclimatize athletes over 10 to 14 days.
- Educate athletes and coaches regarding prevention, recognition, and treatment of heat illnesses.
- Educate athletes to balance fluid intake with sweat and urine losses to maintain adequate hydration.
- Encourage athletes to sleep 6 to 8 hours per night in a cool environment.
- Monitor environmental conditions and develop guidelines for altering practice sessions based on those conditions.
- Provide an adequate supply of water or sports drinks to maintain hydration.
- Weigh high-risk athletes before and after practice to make certain they are not dehydrated.
- Minimize the amount of equipment and clothing worn in hot, humid conditions.
- Minimize warm-up time in hot, humid conditions.
- Allow athletes to practice in shaded areas, and use cooling fans when possible.
- Have appropriate emergency equipment available (e.g., fluids, ice, immersion tank, rectal thermometer, cell phone or two-way radio).

*From Casa D, et al.: National Athletic Trainers' Association Position Statement: Exertional heat illness, *Journal of Athletic Training* 50(9):986–1000, 2015.

Focus Box 5–2 provides recommendations for preventing heat illness.

Hypothermia

Cold weather is a frequent adjunct to many outdoor sports in which the sport itself does not require heavy protective clothing; consequently, the weather becomes a pertinent factor in injury susceptibility.[18] In most instances, the activity itself enables the athlete to increase the metabolic rate sufficiently for normal physiological functioning and to dissipate the

resulting heat and perspiration through the usual physiological mechanisms.[9] An athlete may fail to warm up sufficiently or may become chilled because of relative inactivity for varying periods demanded by the particular sport, during either competition or training. Consequently, the athlete is predisposed to hypothermia or a lowered body temperature.[11]

Low temperatures alone can pose some problems, but when such temperatures are further accentuated by wind, the chill factor becomes critical (Figure 5–4).[48] A third factor, dampness or wetness, further increases the risk of hypothermia. Air at a temperature of 50° F is relatively comfortable, but water at the same temperature is intolerable. Certainly the combination of cold, wind, and dampness creates an environment that easily predisposes the athlete to hypothermia.[24]

Many sports played in cold weather do not require heavy protective clothing; thus, weather becomes a factor in injury susceptibility.

As muscular fatigue builds up during strenuous physical activity in cold weather, the rate of exercise begins to drop and may reach a level at which the body heat loss to the environment exceeds the metabolic heat protection, resulting in definite impairment of neuromuscular responses and exhaustion. A relatively small drop in body core temperature can induce shivering sufficient to materially affect the athlete's neuromuscular coordination. Shivering ceases below a body temperature of 85° F to 90° F (29.4° F to 32.2° C). Death is imminent if the core temperature rises to 107° F (41.6° C) or drops to between 77° F and 85° F (25° F to 29° C).[9]

Low temperatures accentuated by wind and dampness can pose major problems for athletes.

Cold Disorders

Athletes need to replace fluids when working out in a cold environment as much as they do in a hot environment.[19] Because dehydration reduces blood volume, less fluid is available for warming the tissues. Athletes performing in a cold environment should be weighed before and after practice, especially in the first 2 weeks of the season.[18] Severe overexposure to a cold climate occurs less often than hyperthermia does in a warm climate; however, it is still a major risk of winter sports, long-distance running in cold weather, and swimming in cold water.[19]

Frostnip Frostnip involves ears, nose, cheeks, chin, fingers, and toes. It commonly occurs during a high

Cold injuries in sports include:
- Frostnip
- Frostbite

Temperature (°F)

Wind (mph)	Calm	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45
5		36	31	25	19	13	7	1	−5	−11	−16	−22	−28	−34	−40	−46	−52	−57	−63
10		34	27	21	15	9	3	−4	−10	−16	−22	−28	−35	−41	−47	−53	−59	−66	−72
15		32	25	19	13	6	0	−7	−13	−19	−26	−32	−39	−45	−51	−58	−64	−71	−77
20		30	24	17	11	4	−2	−9	−15	−22	−29	−35	−42	−48	−55	−61	−68	−74	−81
25		29	23	16	9	3	−4	−11	−17	−24	−31	−37	−44	−51	−58	−64	−71	−78	−84
30		28	22	15	8	1	−5	−12	−19	−26	−33	−39	−46	−53	−60	−67	−73	−80	−87
35		28	21	14	7	0	−7	−14	−21	−27	−34	−41	−48	−55	−62	−69	−76	−82	−89
40		27	20	13	6	−1	−8	−15	−22	−29	−36	−43	−50	−57	−64	−71	−78	−84	−91
45		26	19	12	5	−2	−9	−16	−23	−30	−37	−44	−51	−58	−65	−72	−79	−86	−93
50		26	19	12	4	−3	−10	−17	−24	−31	−38	−45	−52	−60	−67	−74	−81	−88	−95
55		25	18	11	4	−3	−11	−18	−25	−32	−39	−46	−54	−61	−68	−75	−82	−89	−97
60		25	17	10	3	−4	−11	−19	−26	−33	−40	−48	−55	−62	−69	−76	−84	−91	−98

Frostbite times: 30 minutes; 10 minutes; 5 minutes

FIGURE 5–4
Wind chill factor. Low temperatures can pose serious problems for the athlete, but wind chill could be a critical factor.

and, severe cold, or both. The skin initially appears very firm, with cold, painless areas that may peel or blister in 24 to 72 hours.

Treatment Affected areas can be treated early by firm, sustained pressure of the hand (without rubbing), by blowing hot breath on the spot, or if the injury is to the fingertips, by placing them in the armpits.

Chilblain Chilblain result from prolonged and constant exposure to cold for more than 60 minutes with the temperature at 50 degrees or less. In time, there is skin redness, swelling, tingling, and pain in the toes and fingers. This adverse response is caused by problems of peripheral circulation and can be avoided by preventing further cold exposure.

Treatment Treatment involves removing wet or constrictive clothing and cover with warm, loose, dry clothing or blankets. Do not disturb blisters, apply friction massage, apply creams or lotions, use high levels of heat. Continually monitor the affected area for return of circulation and sensation.

Frostbite Superficial frostbite involves only the skin and subcutaneous tissue. The skin appears pale, hard, cold, and waxy. Palpating the injured area reveals a sense of hardness but with yielding of the underlying deeper tissue structures. When rewarming, the superficial frostbite at first feels numb, then stings and burns. Later the area may produce blisters and be painful for a number of weeks.[11]

Treatment Deep frostbite is a serious injury indicating that tissues are frozen. This medical emergency requires immediate hospitalization. As with frostnip and superficial frostbite, the tissue is initially cold, hard, pale or white, and numb. Gradual rewarming is required, including hot drinks, heating pads, or hot water bottles that are 100° F to 110° F (38° C to 43° C).[9] During rewarming, the tissue becomes blotchy, red, swollen, and extremely painful. Later the injury may become develop tissue necrosis, causing a loss of tissue (Figure 5–5).

FIGURE 5–5 Deep frostbite of the fingers with necrosis.

Prevention

Apparel for competitors must be geared to the weather.[24] The clothing should not restrict movement, should be as lightweight as possible, and should consist of material that wicks moisture from sweat away from the body, thus permitting the free passage of body heat and sweat that otherwise accumulates on the skin or the clothing and provides a chilling effect when activity ceases.[23] **The athlete should routinely dress in thin layers of clothing that can easily be added or removed to prevent sweating as the temperature decreases or increases.**[11] To prevent chilling, warm-up suits should be worn before exercise, during activity breaks or rest periods, and at the termination of exercise.[24]

Overexposure to Sun

Athletes, along with coaches, athletic trainers, and other support staff, frequently spend a great deal of time outdoors in direct sunlight. Applying sunscreens to protect these individuals from overexposure to ultraviolet radiation (UVR) is often totally ignored.[54]

Long-Term Effects on Skin

The most serious effects of long-term UVR exposure are premature aging of the skin and skin cancer.[60] Lightly pigmented individuals are more susceptible. Premature aging of the skin is characterized by dryness, cracking, and a decrease in the elasticity of the skin. Skin cancer is the most common malignant tumor found in humans and has been epidemiologically and clinically associated with exposure to UVR. Fortunately, the rate of cure exceeds 95 percent with early detection and treatment.[60]

Using Sunscreens

Sunscreens applied to the skin can help prevent many of the damaging effects of UVR.A sunscreen's effectiveness in absorbing the sunburn-inducing radiation is expressed as the sun protection factor

(SPF). An SPF of 15 indicates that an athlete can be exposed to UVR fifteen times longer than without a sunscreen before the skin will begin to turn red. Higher numbers provide greater protection. However, athletes who have a family or personal history of skin cancer may experience significant damage to the skin even when wearing an SPF 15 sunscreen. Therefore, the American Academy of Dermatology recommends that everyone should wear a sunscreen with a minimum SPF of 30, in addition to being water resistant.

Sunscreen should be worn regularly by athletes, coaches, and athletic trainers who spend time outside.[36] This caution is particularly relevant for individuals with fair complexions, light hair, or blue eyes, or those whose skin burns easily. People with dark complexions should also wear sunscreens to prevent sun damage.[60]

Sunscreens are needed most between the months of March and November but should be used year-round. Sunscreens are needed most between 10 a.m. and 4 p.m. and should be applied 15 to 30 minutes before sun exposure.[36] Although clothing and hats provide some protection from the sun, they are not a substitute for sunscreens (a typical white cotton T-shirt provides an SPF of only 5). Reflected sunlight from water, sand, and snow may effectively increase sun exposure and risk of burning.

SPF stands for sun protection factor.

5–2 Critical Thinking Exercise

A triathlete is competing in a triathlon. She is extremely concerned about getting sunburned and has liberally applied sunscreen with an SPF of 30 during the early morning. It is a very hot, sunny day, and she is sweating heavily. She is worried that her sunscreen has worn off and asks her workout partner for more sunscreen. Her partner hands her sunscreen with an SPF of 15, and the triathlete complains that it is not strong enough to protect her.

Will she be well protected by the sunscreen she has been given?

Safety in Lightning and Thunderstorms

Research indicates that lightning is the number-three cause of death by weather phenomena, accounting for 30 deaths per year.[33] As a result of the inherent danger associated with electrical storms to athletes and staff who practice and compete outdoors, each institution should develop a specific emergency action plan.[63] This plan should be implemented in case of a lightning storm, that includes establishing a chain of command to determine who should monitor both the weather forecast and changing weather of a threatening nature, and to determine who makes the decision both to remove from and ultimately to return a team to the practice field, based on specific preestablished criteria.[63]

If you hear thunder or see lightning, you are in immediate danger and should seek a protective shelter in an indoor facility at once. An indoor facility is recommended as the safest protective shelter. However, if an indoor facility is not available, an automobile (not a convertible) is a relatively safe alternative.

If neither of these is available, the following guidelines are recommended:[5,28,63]

- Avoid standing near large trees, flagpoles, or light poles.
- Additional unsafe locations include most places termed shelters, such as picnic, park, sun, bus, and rain nonmetal shelters and storage sheds.
- Open areas such as tents, dugouts, refreshment stands, gazebos, screened porches, press boxes, and open garages are unsafe.
- People inside a building should not use plumbing, showers, sinks, locker rooms, indoor pools, appliances, or electronics during an electrical storm.

If thunder can be heard, lightening is close enough to be a potential danger and everyone should move to a safe location. The misconception that it is possible to see lightning coming and have time to act before it strikes could prove to be fatal. When you see the lightning strike, it has already hit.[52]

Specific criteria and guidelines should be developed for both suspending play and resuming activity in the Emergency Action Plan. The athletic trainer should watch the sky looking for approaching storms that

have not been observed to produce lightening and be prepared to suspend or postpone activities if a thunderstorm appears imminent. Decisions regarding suspending play should be based on the recommendation from the National Weather Service or commercial lightning detection service.[1]

The rule for resuming activity is very clear. Activities should be suspended until 30 minutes after the last strike of lightning is seen (or at least 5.75 miles away) and after the last sound of thunder is heard. This 30-minute clock restarts for each lightning flash within 5.75 miles and each time thunder is heard.[5,63]

Lightning Detectors A lightning detector is a handheld instrument with an electronic system to detect the presence and the distance of lightning/thunderstorm activity occurring within a 40-mile (64 km) distance (Figure 5–6).[52] It allows you to know the level of activity of the storm and determines whether the storm is moving toward, away from, or parallel to your position. When the lightning detector detects a lightning stroke, it emits an audible warning tone and lights the range indicator, allowing you to see the distance to the last, closest detected lightning strike. Lightning detectors are an inexpensive alternative to contracting with a weather service to provide information on potentially dangerous weather conditions over a pager system.

FIGURE 5–6
Portable hand-held lightning detector.

5–3 Critical Thinking Exercise

A lacrosse team is practicing on a remote field with no indoor facility in close proximity. The weather is rapidly worsening, with the sky becoming dark and the wind blowing harder. Twenty minutes are left in the practice session when suddenly, there is a bolt of lightning and an immediate burst of thunder.

How should this extremely dangerous situation be handled?

Circadian Dysrhythmia (Jet Lag)

Air travel makes it possible to travel thousands of miles in just a few hours. Athletes and athletic teams are quickly transported from one end of the country to the other and overseas.

For some athletes, such travel induces a particular physiological stress, resulting in a syndrome that is identified as **circadian dysrhythmia** and that reflects a desynchronization of the athlete's biological and biophysical time clock.[59] The term jet lag refers to the physical and mental effects caused by traveling rapidly across several time zones.[4] It results from the disruption of both circadian rhythms and the sleep-wake cycle. As the length of travel increases over several time zones, the effects of jet lag become more profound.[23] Jet lag has been shown to cause fatigue, headache, problems with the digestive system, and changes in blood pressure, heart rate, hormonal release, endocrine secretions, and bowel habits.

Athletic Trainers Checklist

The following checklist includes basic guidelines that should be followed during an electrical storm.

- ☐ In situations in which thunder or lightning may be present and you feel your hair stand on end and skin tingle, immediately assume a crouched position: Drop to your knees, place your hands and arms on your legs, and lower your head. Do not lie flat.
- ☐ If thunder and/or lightning can be heard or seen, stop activity and seek protective shelter immediately. An indoor facility is recommended as the safest protective shelter. However, if an indoor facility is not available, an automobile is a relatively safe alternative. If neither of these options is available, you should avoid standing under large trees and telephone poles.
- ☐ Avoid standing water and metal objects at all times (e.g., metal bleachers, metal cleats, umbrellas, etc.).
- ☐ Allow 30 minutes to pass after the last sound of thunder or lightning strike before resuming play.

Any of these changes may have a negative effect on athletic performance and may predispose the athlete to injury.[59] The negative effects of jet lag can be reduced by paying attention to the guidelines in Focus Box 5–3: "Minimizing the effects of jet lag."

Altitude Illnesses

At higher altitudes the amount of oxygen in the air is less than at sea level. The higher the altitude the lower the percentage of available oxygen. When the body is suddenly without its usual oxygen supply, there are an insufficient number of red blood cells to adequately capture the available oxygen in the air. This becomes an issue when an athlete goes to an area of high altitude to train and compete.[29] Over time the body will adjust by forming additional red blood cells to carry more oxygen. Some experts believe this may take 2 to 3 weeks to occur, while others maintain that the athlete can adjust physiologically and psychological in as little as 3 days. Athletic trainers must understand that some of their athletes may become ill when suddenly subjected to high altitudes. These illnesses include acute mountain sickness, high altitude pulmonary edema (HAPE), high altitude cerebral edema (HACE), and an adverse reaction to the sickle-cell trait.[30,35]

Symptoms of these illness may include headache, nausea, vomiting, sleep disturbance, dyspnea, cough, weakness, mental dysfunction, and unconsciousness. For those who have sickle-cell trait when the abnormal hemoglobin molecules become deoxygenated as a result of exercise at a high altitude, the cells tend to clump together. This process causes an abnormal sickle shape in the red blood cell, which can be destroyed easily. This condition can cause an enlarged spleen, which has been known to rupture at high altitudes.[58]

The treatment of choice is to move the athlete to a lower altitude as soon as possible and give oxygen. The condition rapidly resolves once the athlete is at a lower altitude.[58]

Air Pollution

Air pollution is a significant problem everywhere in the world but particularly in urban areas with large industries and heavy automobile traffic. Because athletes are outside for long periods of time during training or competition, they may be more susceptible to the effects of air pollution than is a sedentary individual who remains indoors.[42] The pollutants of greatest concern include ozone, nitrogen dioxide, carbon monoxide, sulfer dioxide, and particulate matter (e.g. dirt, soil dust, pollens, molds, ashes, soot).

There are two types of pollution: photochemical haze and smog. Photochemical haze consists of nitrogen dioxide and stagnant air that are acted on by sunlight to produce ozone.[51] Smog is produced by the combination of carbon monoxide, sulfur dioxide, and particulate matter that emanates from the combustion of coal and petroleum.[42]

Symptoms

When exposed to air pollution, the athlete may experience shortness of breath, coughing, chest tightness, pain during deep breathing, nausea, eye

Focus Box 5–3

Minimizing the effects of jet lag

- Depart for a trip well rested.
- Preadjust circadian rhythms by getting up and going to bed 1 hour later for each time zone crossed when traveling west and 1 hour earlier for each time zone crossed when traveling east.
- When traveling west, eat light meals early and heavy meals late in the day. When traveling east, eat a heavy meal earlier in the day.
- Drink plenty of fluids to avoid dehydration, which occurs because of dry, high-altitude, low-humidity cabin air.
- Consume caffeine in coffee, tea, or soda when traveling west. Avoid caffeine when traveling east. (Caffeine is only a mild diuretic and causes no greater increase in urine output than drinking water)
- Exercise or training should be done later in the day if traveling west and earlier in the day if traveling east.
- Reset watches according to the new time zone after boarding the plane.
- If traveling west, get as much sunlight as possible on arrival.
- On arrival, immediately adopt the local time schedule
- for training, eating, and sleeping. Forget aboutwhat time it is where you came from.
- Avoid using alcohol before, during, and after travel.

irritation, fatigue, lung irritation, and a lowered resistance to lung infections. Exposure to particulate matter can trigger asthma attacks and cause wheezing, coughing, and respiratory irritation in individuals who have chronic obstructive pulmonary disease (COPD), including emphysema and bronchitis.[28,51]

Prevention

To avoid problems created by air pollution, the athlete must stop or significantly decrease physical activity during periods of high pollution. If activity is conducted, it should be performed when commuter traffic has lessened and when ambient temperature has lowered. Ozone levels rise during dawn, peak at midday, and are much reduced after the late-afternoon rush hour. Running should be avoided on roads containing a concentration of auto emissions and carbon monoxide.[31]

Chapter 5

Summary

- Environmental stress can adversely affect an athlete's performance and pose a serious health problem.
- Regardless of the athletes' level of physical conditioning, use extreme caution when conducting exercises in hot, humid weather. Prolonged exposure to extreme heat can result in heat cramps, heat exhaustion, heatstroke, or hyponatremia.
- Heat illness is preventable. Exercising common sense and caution will keep heat illnesses from occurring. Athletic trainers can prevent heat illness by encouraging adequate fluid replacement, acclimatizing athletes gradually, identifying susceptible individuals, keeping weight records, and selecting appropriate uniforms.
- Hypothermia is most likely to occur in a cool, damp, windy environment. Extreme cold exposure can cause conditions such as frostnip and frostbite.
- Athletes, coaches, and athletic trainers should be protected from overexposure to ultraviolet radiation (UVR) by the routine application of sunscreens.
- Thirty minutes should be allowed to pass after the last sound of thunder is heard or last lightning strike is seen before play is resumed.
- Circadian dysrhythmia, or jet lag, can place a serious physiological stress on the athlete disrupting biological rhythm and adversely affect performance and producing health problems.
- An athlete going from a low to a high altitude in a short time may encounter problems with performance and may experience some health problems. An athlete who experiences a serious illness because must be returned to a lower altitude as soon as possible.
- Air pollution can be a major decrement to performance and can cause illness.

Solutions to Critical Thinking Exercises

S-1 It is essential to understand that heat-related illnesses are preventable. The athletes should come into preseason practice at least partially acclimatized to working in a hot, humid environment and during the first week of practice should become fully acclimatized. Temperature and humidity readings should be monitored, and practice should be modified according to conditions. Practice uniforms should maximize evaporation and minimize heat absorption to the greatest extent possible. Weight records should be maintained to identify individuals who are becoming dehydrated. Most important, the athletes must keep hydrated by constantly drinking large quantities of water or a sports drink both during and between practice sessions.

5-2 The sun protection factor (SPF) indicates the sunscreen's effectiveness in absorbing the sunburn-inducing radiation. An SPF of 15 indicates that an athlete can be exposed to UVR fifteen times longer than without a sunscreen before the skin begins to turn red. Therefore, the athlete needs to understand that a higher SPF doesn't indicate a greater degree of protection. She must simply apply the SPF 15 sunscreen twice as is often as is necessary with an SPF 30 sunscreen.

5-3 As soon as lightning is observed, practice should end immediately and the athletes should seek shelter. If an indoor facility is not available, an automobile is a relatively safe alternative. The athletes should avoid standing under large trees or telephone poles. Athletes should avoid any standing water or metal objects around the fields.

Review Questions and Class Activities

1. How do temperature and humidity cause heat illnesses?
2. Describe the symptoms and signs of the most common heat disorders.
3. What steps should be taken to avoid heat illnesses?
4. How is heat lost from the body to produce hypothermia?
5. Identify the physiological basis for the body's susceptibility to a cold disorder.
6. Take a wet-bulb globe temperature (WBGT) using a digital psychrometer and make suggestions for safe practice guidelines.
7. How should athletes protect themselves from the effects of ultraviolet radiation?
8. Create the thunder and lightning EAP for a specific outdoor venue.
9. Discuss the types of equipment that can be used to prevent, and manage environmental injury/illnesses.
10. Discuss techniques to decrease the risk of environmental injuries.

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