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National Athletic Trainers' Association Position Statement: Lightning Safety for Athletics and Recreation

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Objective: To educate athletic trainers and others about the dangers of lightning, provide lightning-safety guidelines, define safe structures and locations, and advocate prehospital care for lightning-strike victims.

Background: Lightning may be the most frequently encountered severe-storm hazard endangering physically active people each year. Millions of lightning flashes strike the ground annually in the United States, causing nearly 100 deaths and 400 injuries. Three quarters of all lightning casualties occur between May and September, and nearly four fifths occur between 10:00 AM and 7:00 PM, which coincides with the hours for most athletic or recreational activities. Additionally, lightning casualties from sports and recreational activities have risen alarmingly in recent decades.

Recommendations: The National Athletic Trainers' Association recommends a proactive approach to lightning safety, including the implementation of a lightning-safety policy that identifies safe locations for shelter from the lightning hazard. Further components of this policy are monitoring local weather forecasts, designating a weather watcher, and establishing a chain of command. Additionally, a flash-to-bang count of 30 seconds or less should be used as a minimal determinant of when to suspend activities. Waiting 30 minutes or longer after the last flash of lightning or sound of thunder is recommended before athletic or recreational activities are resumed. Lightning-safety strategies include avoiding shelter under trees, avoiding open fields and spaces, and suspending the use of land-line telephones during thunderstorms. Also outlined in this document are the prehospital care guidelines for triaging and treating lightning-strike victims. It is important to evaluate victims quickly for apnea, asystole, hypothermia, shock, fractures, and burns. Cardiopulmonary resuscitation is effective in resuscitating pulseless victims of lightning strike. Maintenance of cardiopulmonary resuscitation and first-aid certification should be required of all persons involved in sports and recreational activities.

Key Words: lightning, policies and procedures, lightning casualties, severe-storm hazards, environmental hazards, emergency action plan, thunderstorms, lightning-safety policy, athletics, recreation

Over the past century, lightning has consistently been 1 of the top 3 causes of weather-related deaths in this country.[1,2] It kills approximately 100 people and injures hundreds more each year.[2–5] Lightning is an enormous and widespread danger to the physically active population, due in part to the prevalence of thunderstorms in the afternoon to early evening during the late spring to early fall and a societal trend toward outdoor physical activities.[2,3,6] Certain areas of the United States have higher propensities for thunderstorm activity, and thus, higher casualty rates: the Atlantic seaboard, southwest, southern Rocky Mountains, and southern plains states.[2,7]

Worldwide, approximately 2000 thunderstorms and 50 to 100 lightning flashes occur every second.[8] In 1997, the National Lightning Detection Network recorded nearly 27 000 000 cloud-to-ground lightning strikes in the United States (Christoph Zimmerman, Global Atmospherics, Inc, Tucson, AZ, unpublished data). Many of these strikes caused fires, power outages, property damage, loss of life, and disabling injuries. Property damage from lightning is estimated to cost $5 000 000 000 to $6 000 000 000 annually in this country.[9] While print and television news reports of lightning-strike incidents to recreational athletes are frequent during the thunderstorm season, many people are unsure about what to do and where to go to improve their safety during thunderstorms. It is incumbent on all individuals, particularly those who are leaders in athletics and recreation, to appreciate the lightning hazard, learn the published lightning-safety guidelines, and act prudently, wisely, and in a spirit that will encourage safe behavior in others.

The guidelines presented in this article govern all outdoor activities, as well as indoor swimming-pool activities. The purpose of this position statement is to recommend lightning-safety policy guidelines and strategies and to educate athletic trainers and others involved with athletic or recreation activities about the hazards of lightning.

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RECOMMENDATIONS

1. Formalize and implement a comprehensive, proactive lightning-safety policy or emergency action plan specific to lightning safety.[1,7,10–14] The components of this policy should include the following:
   A. An established chain of command that identifies who is to make the call to remove individuals from the field or an activity.
   B. A designated weather watcher (ie, a person who actively looks for the signs of threatening weather and notifies the chain of command if severe weather becomes dangerous).
   C. A means of monitoring local weather forecasts and warnings.
   D. A listing of specific safe locations (for each field or site) from the lightning hazard.
   E. The use of specific criteria for suspension and resumption of activities (refer to recommendations 4, 5, and 6).
   F. The use of the recommended lightning-safety strategies (refer to recommendations 7, 8, and 9).
2. The primary choice for a safe location from the lightning hazard is any substantial, frequently inhabited building. The electric and telephone wiring and plumbing pathways aid in grounding a building, which is why buildings are safer than remaining outdoors during thunderstorms. It is important not to be connected to these pathways while inside the structure during ongoing thunderstorms.
3. The secondary choice for a safer location from the lightning hazard is a fully enclosed vehicle with a metal roof and the windows closed.[1,7,10,11,13,14] Convertible cars and golf carts do not provide protection from lightning danger. It is important not to touch any part of the metal framework of the vehicle while inside it during ongoing thunderstorms.
4. Seeking a safe structure or location at the first sign of lightning or thunder activity is highly recommended. By the time the flash-to-bang count approaches 30 seconds (or is less than 30 seconds), all individuals should already be inside or should immediately seek a safe structure or location.[1,13–15] To use the flash-to-bang method, the observer begins counting when a lightning flash is sighted. Counting is stopped when the associated bang (thunder) is heard. Divide this count by 5 to determine the distance to the lightning flash (in miles). For example, a flash-to-bang count of 30 seconds equates to a distance of 6 miles (9.66 km).
5. Postpone or suspend activity if a thunderstorm appears imminent before or during an activity or contest (regardless of whether lightning is seen or thunder heard) until the hazard has passed. Signs of imminent thunderstorm activity are darkening clouds, high winds, and thunder or lightning activity.
6. Once activities have been suspended, wait at least 30 minutes after the last sound of thunder or lightning flash before resuming an activity or returning outdoors.[1,13–15] A message should be read over the public address system and lightning-safety tips should be placed in game programs alerting spectators and competitors about what to do and where to go to find a safer location during thunderstorm activity.[13,15]
7. Extremely large athletic events are of particular concern with regard to lightning safety. Consider using a multidisciplinary approach to lessen lightning danger, such as integrating weather forecasts, real-time thunderstorm data, a weather watcher, and the flash-to-bang count to aid in decision making.
8. Avoid being in contact with, or in proximity to, the highest point of an open field or on the open water. Do not take shelter under or near trees, flag poles, or light poles.[1,8,10,13–15]
9. Avoid taking showers and using plumbing facilities (including indoor and outdoor pools) and land-line telephones during thunderstorm activity.[1,8,10,13–15] Cordless or cellular telephones are safer to use when emergency help is needed.
10. Individuals who feel their hair stand on end or skin tingle or hear crackling noises should assume the lightning-safe position (ie, crouched on the ground, weight on the balls of the feet, feet together, head lowered, and ears covered). Do not lie flat on the ground.[1,8,10,13–15]
11. Observe the following basic first-aid procedures, in order, to manage victims of lightning strike[16]:
    A. Survey the scene for safety. Ongoing thunderstorms may still pose a threat to emergency personnel responding to the situation.
    B. Activate the local emergency management system.
    C. Move the victim carefully to a safer location, if needed.
    D. Evaluate and treat for apnea and asystole.
    E. Evaluate and treat for hypothermia and shock.
    F. Evaluate and treat for fractures.
    G. Evaluate and treat for burns.
12. All persons should maintain current cardiopulmonary resuscitation (CPR) and first-aid certification.
13. All individuals should have the right to leave an athletic site or activity, without fear of repercussion or penalty, in order to seek a safe structure or location if they feel they are in danger from impending lightning activity.[13,15]

BACKGROUND

Lightning-Flash Development

Within a developing thunderstorm cloud, updrafts promote the collision of rising and descending ice and water particles, and the positive and negative charges are separated into distinct layers. Positive charges are taken via updrafts to the top of the cloud, while negative charges accumulate in the bottom of the cloud, creating the equivalent of a giant atmospheric battery.[8]

A cloud-to-ground lightning flash is the product of the buildup and discharge of static electric energy between the charged regions of the cloud and the earth. The negatively charged lower region of the cloud induces a positive charge on the ground below. The tremendous electric forces between these 2 opposite charges initiate the lightning flash, which begins as a barely visible step leader moving in a series of steps downward from the cloud. Various objects on the ground (trees, chimneys, people, etc) can produce positively charged, upward streamers. The connection of the step leader with an upward streamer determines the connection point on the ground. After contact, a bright return stroke propagates upward from the ground, while electrons move downward toward the earth.[8] This entire phenomenon happens in less than a fraction of a second,[8] but a large amount of charge is transferred to the earth from the cloud.

Most lightning flashes have several return strokes, separated by only 0.004 to 0.005 seconds.[8] The human eye can barely

resolve the intervals between the strokes that cause the lightning flash to appear to flicker. A lightning flash is essentially a brief spark, similar to that received from touching a doorknob after walking across a carpeted room. The lightning channel is approximately 2.54 cm (1 inch) in diameter and averages 4.83 to 8.05 km (3 to 5 miles) in vertical height but can be 9.66 km (6 miles) or higher.[8] Cloud-to-ground lightning flashes typically have peak currents ranging from 10 000 to 200 000 Å, and the electric potential between the cloud and ground can be 10 000 000 to 100 000 000 V.[8]

Thunder is created when lightning quickly heats the air around it, sometimes to temperatures greater than approximately 27 800°C (50 000°F), which is about 5 times hotter than the surface of the sun.[8] The rapidly heated air around a lightning channel explodes, which in turn creates the sound we hear as a clap of thunder.[8] The audible range of thunder is about 16.09 km (10 miles) but can be more or less depending on local conditions.[1] Heat lightning is intracloud or intercloud lightning that is too distant for the accompanying thunder to be heard.[8] Although it is possible to have lightning without thunder, thunder never occurs in the absence of lightning.

Lightning Casualty Demographics

On average, lightning kills approximately 100 people each year in this country, while many hundreds more are injured.[2–5] The death toll from lightning for 1940 to 1973 was greater than that from tornadoes and hurricanes combined.[17] Ninety-two percent of lightning casualties occur between May and September, while July has the greatest number of casualties.[2,3,7,18] Furthermore, 45% of the deaths and 80% of the casualties occurred in these months between 10:00 AM and 7:00 PM,[2,3,7,8] which coincides with the most likely time period for athletic or recreational events. For these reasons, it is accurate to say that lightning is the most dangerous and frequently encountered severe-storm hazard that most people experience each year.[10,11]

The statistics on lightning casualty demographics compiled from the National Oceanographic and Atmospheric Administration publication *Storm Data* for the state of Colorado over the last few decades demonstrate an increase in the number of lightning casualties in persons involved in sports and outdoor recreation.[7,10,18,19] Fifty-two percent of lightning casualties were people involved in outdoor recreation.[7,18] In addition, these authors noted that the highest number of casualties from lightning was recorded in recreational and sports activities for each year of the study.[18] During the 1960s, more than 30% of lightning casualties occurred during outdoor recreation activities; during the 1970s, that figure rose to 47%.[17] Furthermore, the rate of increase of lightning casualties during sports was higher than the general United States population rate of increase during the same time period.[7,18]

Lightning casualty statistics from Colorado demonstrate that the most common sites for fatalities were open fields (27%), near trees (16%), and close to water (13%).[7,8,18] Statistics from the country as a whole mimic the numbers from Colorado. Open fields, ballparks, and playgrounds accounted for nearly 27% of casualties, and under trees (14%), water-related (8%), and golf-related (5%) deaths associated with lightning followed.[19] All these fatalities had 1 common denominator: being near the highest object or being the tallest object in the immediate area. This single factor accounted for 56% of all fatalities from Colorado. Thus, it is imperative to avoid high ridges and high points on the terrain, and conversely, it is important to seek low-lying points on the terrain.[1,3,8,13–15]

The height above ground has been demonstrated to play a prominent role in determining the strike probability. Therefore, it is important to understand why minimizing vertical height is critical in decreasing the chances of becoming a victim of lightning. Warning signs of a high electromagnetic field and imminent lightning strike include hair standing on end and sounds similar to bacon sizzling or cloth tearing.[8] If these conditions occur, a cloud-to-ground lightning flash could strike in the immediate area. Therefore, one should immediately crouch in the lightning-safe position: feet together, weight on the balls of the feet, head lowered, and ears covered.[1] This position is intended to minimize the probability of a direct strike by both lowering the person's height and minimizing the area in contact with the surface of the ground. Taller objects are more likely to be struck (but not always) because their upward streamer occurs first, so that it is closer in proximity to the step leader coming downward from the cloud.

The ultimate message is that individuals in dangerous lightning situations should never wait to seek a safe location and pursue safety measures. It is important to be proactive by having all individuals inside a safe structure or location long before the lightning is close enough to be threatening.

Mechanisms of Lightning Injury

Injury from lightning can occur via 5 mechanisms.[16] A direct strike most commonly occurs to the head, and lightning current enters the orifices. This mechanism explains why eye and ear injuries in lightning-strike victims are abundantly reported in the literature.[16] The shock wave created by the lightning channel can also produce injuries, such as rupture of the tympanic membrane, a common clinical presentation in the lightning-strike victim.[16,23,24] Recommending that individuals cover their ears while in the lightning-safe position may help to mitigate this type of injury.

The second mechanism, contact injury, occurs when the lightning victim is touching an object that is in the pathway of a lightning current.[16] Side flash, the third mechanism, occurs when lightning strikes an object near the victim and then jumps from that object to the victim. This is the main danger to a person who is sheltered under an isolated, tall tree.[6] An upward streamer is triggered by the tree but when this connects with the step leader, the resulting stroke jumps to the victim, who represents an additional pathway to ground.

The fourth mechanism, a step voltage or ground current, occurs when the lightning current flowing in the ground radiates outward in waves from the strike point. If 1 of the individual's feet is closer to the strike than the other, a step voltage is created.[6,16] Humans are primarily salt minerals in an aqueous solution, and a lightning current preferentially travels up from the earth through this solution (that is, the person) rather than through the ground. The greater the differential step voltage (ie, the greater the distance between the 2 feet), the greater the likelihood of injury. Placing one's feet close together while in the crouched position and not lying flat on the ground are crucial in reducing the likelihood of injury from a step voltage or ground current.

Blunt injury is the fifth mechanism for lightning-strike injuries. Lightning current can cause violent muscular contractions that throw its victims many meters from the strike point.

Explosive and implosive forces created by the rapid heating and cooling by the lightning current are also enough to produce traumatic injuries.[16]

Common Effects of Lightning Injury

While lightning kills nearly 100 people annually in this country, the protracted suffering of the survivors should not be underestimated. Although the only acute cause of death from lightning injury is cardiac arrest,[20] the anoxic brain damage that can occur if the person is not rapidly resuscitated can be devastating. In addition, even for the survivor who did not sustain a cardiac arrest, permanent sequelae can include common brain-injury symptoms such as deficits in short-term memory and processing of new information, as well as severe and ongoing headaches, hyperirritability, sleep disturbances, and distractibility.[21,22] Others may develop chronic pain syndromes or absence-type seizures. Frequently, survivors are unable to return to their previous level of function. They may not be able to continue in their jobs or in their educational pursuits and may be permanently disabled.

Components of a Lightning-Safety Policy

The purpose of formalizing a policy on lightning safety is to provide written guidelines for safety during lightning storms. Ninety-two percent of National Collegiate Athletic Association Division I athletics departments responding to a survey did not have a formal, written lightning-safety policy.[12] The best means of reducing the lightning hazard to people is to be proactive. Athletic and recreational personnel should formalize and implement an emergency action plan specific to lightning safety before the thunderstorm season.[1,11,13–15] Dissemination of the plan is paramount, so that all persons will know what to do and where to go to improve their own safety during thunderstorms. The 6 components of a lightning-safety policy or emergency action plan for lightning are discussed in the following paragraphs.

The first component in an emergency action plan or policy for lightning safety is the establishment of a specific chain of command that identifies the person who has the authority to remove participants from athletic venues or activities. The second is to appoint a weather watcher who actively looks for signs of developing local thunderstorms, such as high winds, darkening clouds, and any lightning or thunder.

The third element of a lightning-safety policy is the stipulation for monitoring local weather forecasts. One method is to use weather radios that broadcast information on daily forecasts and approaching storm systems. Weather radios are an excellent informational tool for general storm movement and strength. While this information is extremely important in decision making, the National Weather Service does not broadcast information on specific storm cells or lightning. Therefore, in addition to monitoring weather radios, it is essential that the weather watcher be on constant lookout for conditions in the immediate vicinity of the athletic event and compare these conditions with the weather radio information.

When a local area is placed under a severe-storm watch or warning by the National Weather Service, weather radios can be programmed to give audible alert tones. A watch indicates conditions are favorable for severe weather; a warning means severe weather has been detected in the locale, and all persons should take the necessary precautions to preserve their own safety. If severe storms are in the vicinity, all individuals should more intently monitor thunderstorm activity, such as severity and direction of movement of the storm. It may also mean that steps should be taken to remove athletes from the field or perhaps to postpone or suspend athletic or recreational activities during the event or before the storm begins.

Safe Locations

The fourth aspect of a lightning-safety policy, defining and listing safe structures or locations to evacuate to in the event of lightning, is of utmost importance. While there are reports of people being injured by lightning inside buildings,[8] evacuating to a substantial building can considerably lower the risks of lightning injury compared with those of remaining outside during the thunderstorm. The lightning-safety policy should identify the safe structure or location specific to each venue. This information will enable individuals to know where to go in advance of any thunderstorm situation and appreciate how long it takes to get to the specific safe location from each field or event site.

The primary choice for a safe structure is any fully enclosed, substantial building.[1,3,8,13–15] Ideally, the building should have plumbing, electric wiring, and telephone service. The lightning current is more likely to follow these pathways to ground, which aids in electrically grounding the structure.[8] If a substantial building is not available, a fully enclosed vehicle with a metal roof and the windows completely closed is a reasonable alternative.[1,3,13–15] It is not the rubber tires that make the vehicle safe but the metal enclosure that guides the lightning current around the passengers, rather than through them. Do not touch any part of the metal framework while inside the vehicle.[8] Convertible vehicles and golf carts do not provide a high level of protection and cannot be considered safe from lightning.

Unsafe Locations

Unfortunately, those properties that serve to define a safe structure and improve the safety of its inhabitants also present a potential risk. Lightning current can enter a building via the electric or telephone wiring. It can also enter via a ground current through the incoming plumbing pipelines. This condition makes locker-room shower areas, swimming pools (indoor and outdoor), telephones, and electric appliances unsafe during thunderstorms because of the possible contact with current-carrying conduction. While such reports are rare, people have been killed or injured by lightning in their homes while talking on the telephone, taking a shower, or standing near household appliances such as dishwashers, stoves, or refrigerators.[1,3,8,13–15]

From 1959 through 1965, lightning killed 4 people and injured 36 others while they were talking on the telephone. These numbers comprised 0.42% (n = 960) of deaths and 2.1% (n = 1736) of injuries for the period.[5] Studying reports from *Storm Data*, researchers found that between 1959 and 1994, 2.4% of lightning casualties were telephone related.[2] Because they are not connected directly to a land-line phone, cellular and cordless telephones are reasonably safe alternatives for summoning help during a thunderstorm. It should be noted that injury from acoustic damage can occur via explosive static from the earpiece caused by a nearby lightning strike.

Even though a swimming pool may be indoors and apparently safe, it can be a dangerous location during thunderstorms.[25] The current can be propagated through plumbing and electric connections via the underwater lights and drains of most swimming pools. Lightning current can also enter the building, either into the electric wiring inside the building or through underground plumbing pipelines that enter the building.[8] If lightning strikes the building or ground nearby, the current will most likely follow these pathways to the swimmers through the water. Thus, indoor-pool activities are potentially dangerous and should be avoided during thunderstorms.[25]

Small structures, such as rain or picnic shelters or athletic storage sheds, are generally not properly protected and should be avoided during thunderstorms. These locations may actually increase the risk of lightning strike via a side flash and cause injury to the occupants.

Criteria for Postponement and Resumption of Activities

The fifth component of any lightning-safety policy is to clearly describe criteria for both the suspension and resumption of athletic or recreational activities. Various technologies currently on the market propose to assist in determining when lightning is in the immediate area. Within the developing area of this lightning technology, data-based research is insufficient to either support or dispute companies' claims regarding establishing when one is in danger of a lightning strike. Therefore the National Athletic Trainers' Association promotes the flash-to-bang standard to warn people of imminent lightning danger. The flash-to-bang method is the easiest and most convenient means for determining the distance to a lightning flash and can also be used to determine when to suspend or postpone activities. The flash-to-bang method is based on the fact that light travels faster than sound, which travels at a speed of approximately 1.61 km (1 mile) every 5 seconds.[1,8,13,14] To use the flash-to-bang method, begin counting on the lightning flash, and stop counting when the associated clap of thunder is heard. When storms have a high flash rate, it is important to correlate a specific flash with the thunder it produced. Divide the time to thunder (in seconds) by 5 to determine the distance (in miles) to the lightning flash.[1,8,13,14] For example, an observer obtains a count of 30 seconds from the time he or she spots the flash to when the thunder is heard. Thirty divided by 5 equals 6; therefore, that lightning flash was 6 miles (9.66 km) from the observer.

The 30-second rule is not an arbitrary guideline. López and Holle[26] studied storms in Oklahoma, Colorado, and Florida and found that in larger thunderstorms, the distance between successive flashes can be up to 6 miles (9.66 km) (ie, a flash-to-bang count of 30 seconds) in approximately 80% of the flash pairs. The authors also found the distance between successive flashes may be as great as 9 miles (14.48 km) or more, depending on local geography and atmospheric conditions. If a flash-to-bang count of 30 seconds is observed, the next flash could conceivably be at the observer's location.

Another important factor to consider when using the flash-to-bang method is that, although a relatively rare occurrence, lightning has been reported to strike 16.09 km (10 miles) or more from where it is raining.[1] Therefore, a flash-to-bang count of at least 30 seconds is strongly recommended as a determinant of when to suspend or postpone athletic or recreational activities.[13–15] As the flash-to-bang count approaches 30 seconds, all persons should be seeking, or already inside, a safe structure or location. This is the minimal guideline when using the flash-to-bang method to halt athletic or recreational activities. Seeking a safe location at the first sign of thunder or lightning activity is also highly recommended.

Another facet of the lightning-safety policy is embodied in the "30–30 rule" (Table 1), which relies on the flash-to-bang method. If a game, practice, or other activity is suspended or postponed due to lightning activity, it is important to establish strict criteria in the lightning-safety policy for resumption of activities. Waiting at least 30 minutes after the last lightning flash or sound of thunder is recommended.[13–15] When storm reports and flash data at the time of death or injury were compared, researchers found that the end of the storm, when the flash-rate frequency began to decline, was as deadly as the middle of the storm, when the lightning flash rate was at its peak. The authors postulated that once the flash rate begins to decline, people do not perceive the thunderstorm as dangerous and are struck by lightning when they return outdoors prematurely.[1] An important adage for athletic trainers, coaches, and officials to remember is, "if you see it (lightning) flee it, if you hear it (thunder), clear it."

The 30-minute rule can also be explained in another way. A typical thunderstorm moves at a rate of approximately 40.23 km (25 miles) per hour. Experts believe that 30 minutes allow the thunderstorm to be about 16.09 to 19.31 km (10 to 12 miles) from the area, minimizing the probability of a nearby, and therefore dangerous, lightning strike.[15] Blue sky in the local area or a lack of rainfall are not adequate reasons to breach the 30-minute return-to-play rule. Lightning can strike far from where it is raining, even when the clouds begin to clear and show evidence of blue sky.[1] This situation is often referred to as a "bolt out of the blue." Each time lightning is observed or thunder is heard, the 30-minute clock should be reset.

Obligation to Warn

The recommendation for reading lightning-safety messages over public address systems and placing placards conspicuously around each venue resulted from a fatal lightning strike in Washington, DC, in May 1991.[27] During a high school lacrosse game, a dangerous thunderstorm swept into the local area, and the game was suspended. Lightning killed 1 young person and injured 10 others who sought refuge under a tree. Many people stated that they did not know what to do or where to go to protect themselves from the dangers of lightning.

According to the basic principles of tort law, an individual has a duty to warn others of dangers that may not be obvious to a guest or subordinate of that person.[28] Black et al[29] defined the legal principle of "foreseeability" as "the ability to see or

Table 1. The 30-30 Rule[15]

Criteria for suspension of activities	By the time the flash-to-bang count approaches 30 seconds, all individuals should already be inside a safe shelter.
Criteria for resumption of activities	Wait at least 30 minutes after the last sound (thunder) or observation of lightning before leaving the safe shelter to resume activities.

know in advance, eg, reasonable anticipation, that harm or injury is a likely result from certain acts or omissions." With regard to dangerous lightning situations, it could be argued that an institution (or athletic department) has the duty to warn spectators, invited guests, and participants if conditions are such that lightning activity may be an imminent danger in the immediate area. Whereas lightning is understood by all to be a dangerous phenomenon, the importance of seeking safe shelter and the specific time that one should vacate to safety are generally not known. Based on research presented in this article regarding the number of lightning casualties resulting from the erroneous tendency of people to seek shelter under trees, it would be wise for an organization to promote lightning safety to its clientele and participants, including a list of specific safe locations or structures.

Warnings should be commensurate with the age and understanding of those involved. Announcements should be repeated over the public address system and colorful notices and safety instructions both placed in the event programs and posted in visible, high-traffic areas. Safety instructions should include the location of the nearest safe shelter, similar to airline pocket diagrams of nearest emergency exits. Being proactive with regard to the lightning threat demands not putting individuals at risk if a hazardous situation could have been prevented. If thunderstorm activity looks menacing before or during an event, consider canceling or postponing the event until the complete weather situation can be ascertained and determined to no longer be a threat. The first lightning flash from the thunderstorm cloud and storms that produce only a few flashes still pose a potential threat and should be treated as such. Every cloud-to-ground lightning flash is dangerous and potentially deadly and should not be taken lightly or viewed complacently. Therefore, it is the recommendation of the National Athletic Trainers' Association to postpone or suspend athletic and recreational activities before their onset, if thunderstorm activity appears imminent.

Prehospital Care of Victims

If a lightning-strike victim presents in asystole or respiratory arrest, it is critical to initiate CPR as soon as safely possible.[23] Because lightning-strike victims do not remain connected to a power source, they do not carry an electric charge and are safe to assess.[30] However, during an ongoing thunderstorm, lightning activity in the local area still poses a deadly hazard for the medical team responding to the incident. The athletic trainer or other medical personnel should consider his or her own personal safety before venturing into a dangerous situation to render care.

If medical personnel assume the risk of entering a dangerous lightning situation to render care, the first priority should be to move the victim to a safe location. In this way, a hazardous situation can be neutralized for the athletic trainer, as well as the victim. It is unlikely that moving a victim to an area of greater safety for resuscitation will cause any serious injury to the victim.[16] The primary and secondary survey of the victim's condition can then be conducted once safety is reached.

It is not uncommon to find a lightning-strike victim unconscious, with fixed and dilated pupils and cold extremities and in cardiopulmonary arrest. Case studies of individuals with prolonged apnea and asystole after a lightning strike have demonstrated successful resuscitations using CPR.[23,24,31] Once stopped, the heart will most likely spontaneously restart, but breathing centers in the brain may be damaged. Respiratory arrest lasts longer than cardiac arrest, leading to secondary asystole from hypoxia.[16] Therefore, the basic principle of triage, "treat the living first," should be reversed in cases involving casualties from a lightning strike. It is imperative to treat those persons who are "apparently dead" first by promptly initiating CPR. See Table 2 for quick-reference guidelines in evaluating and treating victims of lightning strike.

Table 2. Recommended Prehospital Care for Treating Lightning-Strike Victims[16]

Perform the following steps in order:
1. Survey the scene for safety.
2. Activate the local emergency management system.
3. Carefully move the victim to a safe area, if needed.
4. Evaluate and treat for apnea and asystole.
5. Evaluate and treat for hypothermia and shock.
6. Evaluate and treat for fractures.
7. Evaluate and treat for burns.

CONCLUSIONS

Due to its pervasiveness during the times that most athletic events occur, lightning is a significant hazard to the physically active population. Lightning-casualty statistics show an alarming rise in the number of lightning casualties in recreational and sports settings in recent decades.[2,3,9] Each person must take responsibility for his or her own personal safety during thunderstorms.[10] However, because people are often under the direction of others, whether they are children or adults participating in organized athletics, athletic trainers, coaches, teachers, and game officials must receive education about the hazards of lightning and become familiar with proved lightning-safety strategies. A policy is only as good as its compliance and unwavering, broad-based enforcement.

It is important to be much more wary of the lightning threat than the rain. Lightning can strike in the absence of rain, as well as from apparently clear blue skies overhead, even though a thunderstorm may be nearby. The presence of lightning or thunder should be the determining factor in postponing or suspending games and activities, not the amount of rainfall on the playing field. Lightning should be the only critical factor in decision making for athletic trainers, umpires, officials, referees, and coaches.

Athletic trainers, umpires, officials, referees, coaches, teachers, and parents can make a difference in reducing the number of lightning casualties if they (1) formalize and implement a lightning-safety policy or emergency action plan specific to lightning safety; (2) understand the qualifications of safe structures or locations, in addition to knowing where they are in relation to each athletic field or activity site; (3) understand the 30–30 rule as a minimal determinant of when to suspend activities and follow it; being conservative and suspending activities at the first sign of lightning or thunder activity is also prudent and wise; (4) practice and follow the published lightning-safety guidelines and strategies; (5) and maintain CPR and standard first-aid certification.

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