Lightning and Severe Thunderstorms in Event Management

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Abstract
There are a few national position stands/guidelines that address environmental conditions in athletics, yet they do not govern all outdoor sports. Extreme heat and cold, lightning, and severe wind can all be fatal, yet the majority of outdoor sports have no published guidelines addressing these conditions in relation to activity. Available research on extreme heat and cold conditions in athletics provides prevention strategies, to include acclimatization. Lightning and severe wind are two environmental conditions to which humans cannot accommodate, and they both can be deadly. There are strong positions on extreme heat/cold and lightning safety in athletics, but none affiliated with severe winds. Medical personnel involved in planning large outdoor sporting events must know of the presence of nationally published weather-related documents and apply them to their event. In addition, research needs to be expanded in the realm of establishing guidelines for safety to participants and spectators in severe wind conditions.

INTRODUCTION
Data from the National Weather Service tracking weather-related deaths over the past 10 years in the United States, Puerto Rico, Guam, and the Virgin Islands report that extreme heat caused an average of 115 deaths annually, wind produced 41 deaths a year, lightning yielded an average of 39 deaths, and extreme cold caused 25. Whereas there are no data specifically linking these deaths to sporting activity, these trends must be taken into account for those in charge of planning outdoor events. In large-scale outdoor sporting events, the danger of inclement weather always must be considered to protect the safety of both participants and spectators.

Some weather conditions seem not to be particularly dangerous to athletes; for example, rain itself is not dangerous. It is the addition of sport tools — bats, clubs, sticks, etc. — that raises the risk factor, as wet conditions make holding the implement more challenging. Specific sports have rules preventing activity in certain weather situations (e.g., rain in baseball or softball). Temperature — be it excessive heat or cold — can pose a significant risk to athletes, but there are no position stands that address prevention of injury and adaptation to these environments (1–8,23,24,26). This article will focus on weather-related situations where one cannot adapt to the changing environment, and severe injury or death could be a result of continuing activity in these conditions.

The purpose of this article was to explore weather-related dangers in sport that cannot be prevented, may be predictable, and can cause fatalities. Both lightning and severe winds are largely predictable and potentially deadly conditions that affect sporting events. Each of these situations will be discussed.

NATIONAL ENVIRONMENT SAFETY POLICIES GOVERNING SPORT
Although individual leagues, stadiums, or venues may have weather-related policies that govern sports within their domain, there is a dearth of published weather safety policies at the national level for all outdoor athletics. A review (Table 1) of popular national outdoor sports demonstrates that only the National Collegiate Athletic Association (NCAA) and the National Athletic Trainers’ Association (NATA) have written guidelines or position stands that regulate all their sports in events of excessive heat and cold environments and lightning. The National Federation of State High School Associations has brief guidelines for activity in excessive heat conditions and lightning. Both the American College of Sports Medicine and NATA have position stands in the form of research papers and written by experts in their respective fields; the other organizations’ guidelines are brief summaries (1–8,22–26,35). The position stands/guidelines on extreme heat and cold focus largely on prevention, recognition, treatment, and adaptation aspects, whereas the lightning position stand provides guidelines for monitoring, delaying, suspending, or postponing activity.
There actually is a “lightning season,” and it coincides with a time of year when many people are pursuing outdoor activity (20,22,34,35). The afternoons through early evenings in the late spring through early fall are the time of the most lightning strikes in the United States. As with lightning, severe wind is a condition to which one cannot acclimatize. Currently, there is no published national position stand addressing severe wind and sports.

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**Table 1.**

Published national weather safety guidelines for sport.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Lightning</th>
<th>Heat</th>
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(1–8,22–26,35). The lightning position stand also provides recommendations for venue-specific emergency action plans that address lightning and specific safe locations for each site (Table 2). In addition to lightning, severe wind is an environmental state that can be unpredictable and may cause serious injury or death. As with lightning, severe wind is a condition to which one cannot acclimatize. Currently, there is no published national position stand addressing severe wind and sports.

**Table 2.**

General recommendations for lightning safety in sport.

- Establish a lightning-specific emergency action plan for each venue.
- Ascertain a chain of command that identifies a specific person/role who makes the decision to remove participants and spectators.
- This person must have recognized unchallengeable authority to put the emergency action plan into action.
- Use reliable means of monitoring the local weather.
- Prior to the event, locations safe from the lightning hazard must be identified and be made available.
- Safe locations are substantial fully enclosed buildings that contain wiring and plumbing. Fully enclosed metal vehicles with solid rooftops, such as a bus, may be used if necessary.
- Suspend or postpone activity if a thunderstorm seems imminent.
- Participants and spectators should be evacuated to previously identified safe locations if lightning is seen or thunder is heard in the area.
- Activities may resume after a 30-min period free of either thunder or lightning. The 30-min clock restarts after each lightning flash is seen or thunder is heard.
- Rescue personnel must take into consideration their own safety prior to attempting to reach a victim of lightning.
- If there is a lightning victim, activate the emergency management system and move the victim(s) cautiously to a safer location.
- Evaluate and aggressively administer cardiopulmonary resuscitation if warranted.

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strikes an object in close proximity to a person, and some of the force of the strike flashes over the victim. Typically, this happens when people seek shelter under a dugout, open stadium, or tree. An upward leader causes the third most common cause of injury due to lightning. In this situation, energy from the earth is pulled upward toward the downward lightning strike, and a person happens to be in the path of the upward energy force (10). Lightning trauma by both direct strike and contact are about equal in the percentage of injury these types of strikes cause people (3% to 5%) (10,12).

In a direct strike, the lightning bolt directly hits a person, whereas in a contact injury, the victim is holding onto an object that is struck by lightning (a bat, club, umbrella, fence, bleachers, etc.). A consequence of lightning strike is the final mechanism of injury, termed a blunt injury created by the repercussive forces created by the lightning's energy that result in ruptured tympanic membranes, fractures, concussions, and other acute trauma from falling, being thrown, or violent muscular contractions (9).

The written lightning position stand from NATA and sports medicine guideline from NCAA both call for monitoring the weather in advance and having a specific emergency action plan tailored to the venue. Both plans support participant as well as spectator safety and evacuation and stress identifying safe structures and evacuation times (4,7,22,35).

Knowledge of the different ways lightning strikes can cause injury assists with determining what structure is safe. Places termed shelters are rarely a safe haven from lightning. Bus, rain, or park shelters as well as dugouts, open-air press boxes, and tents are not safe areas to mitigate the threat of lightning (4,7,35). Spectators waiting under bleachers or within open garages also are not safe from lightning hazards. The NATA report encourages the use of reliable weather monitoring systems to determine when to vacate a venue for a safe place, but without proven technology, planners are urged to evacuate as soon as lightning is seen or thunder is heard (4,7).

The position stand and guideline can be formatted easily to provide safety for any outdoor event, as having a venue-specific lightning emergency action plan is the foundation of the documents. Those in charge of large event planning should look to these reports to provide safety for both participants and spectators in the event of lightning.

SEVERE WIND

There is a paucity of literature on severe winds causing sport-associated injury or death. Wind parachuting injuries, worsening cold-associated trauma, and weather disasters are a few of the injuries tenuously linked to wind by published works (18,19,33). There are, however, media reports connecting severe wind and deaths. In 2010, a student from Notre Dame died when the hydraulic scissor lift from which he was filming the university's football team practice fell over in the strong winds. Prior to his fall, he commented on the fierce winds that eventually were blamed for his demise (13,37). At the Indiana State Fair in the summer of 2011, high winds were to blame for the concert stage collapse that killed five and injured more than 40 (31). Marathons, golf tournaments, and rowing events have had events delayed or canceled because of wind (15–17,21), but there are no national standards published that define what exactly constitutes dangerous wind conditions for participants and spectators versus what makes the event more challenging. As with lightning, a very brief discussion of the properties of wind is pertinent for this article.

Wind is a by-product of weather and most often discussed in relation to thunderstorms or specific wind-associated conditions. Generally, hurricane winds are sustained circular winds over 75 mph, whereas tornados are an intense rotating column touching both the earth and clouds, and cyclones typically circulate as a closed low-pressure mass. This article discusses severe winds not associated with the aforementioned climatic conditions but more likely are approximated with local thunderstorms (27,30).

There are several descriptions of wind not contained within hurricanes, tornados, or cyclones. Straight-line winds are any air movement not associated with rotation (30). Downbursts are horizontal downdrafts 4 km (2.5 miles) or larger. The end result of a downburst is severe damaging winds at the earth's surface. In contrast, microbursts also produce outward winds at the surface but are smaller in diameter and shorter in duration than the downburst. A microburst may also occur in the absence of rain. A gust front occurs when the front of rain-cooled air collides with warmer air of the thunderstorm inflow (30). Since most wind varieties usually are affiliated with a specific thunderstorm, many can be detected via Doppler radar, but it should be noted that not all damaging winds are entirely predictable. According to the National Oceanic and Atmospheric Administration, the typical thunderstorm lasts approximately 30 min in duration and is about 15 miles in diameter (30). In accounts that proved deadly, severe wind had been present prior to the fatal blow (13,31,37). Knowledge of the intensity of an approaching storm and action to avoid being caught in it may prevent injuries.

The problem becomes identifying specific wind speeds that are dangerous to participants and spectators. For example, in a non-sport-related but highly populated annual gathering, the Macy's Thanksgiving Day Parade in New York City has forbidden the appearance of the giant balloons because of winds over 34 mph (36). However, the 2010 Champions' Challenge in the British Open was delayed because of 30-mph gusts, which were strong enough to move stationary golf balls (17), and the 2009 crew championships for the Eastern College Athletic Conference were canceled because of 20-mph winds (16). Whereas officials seem to have a handle on the wind impact for optimal performance in individual sports, it does not seem that participant or spectator safety is a national consideration. The NCAA Track Manual has a nebulous rule (6-1.18) that states, “In the event of unsafe wind conditions once competition has begun, competition may be suspended, but the event venue (e.g., direction of jumping) shall not be changed” (14).

The National Weather Service issues three levels of advisement in weather: warning, watch, and advisory (29). Specifically relating to the wind, the High Wind Watch is issued when there is a possibility of either sustained winds over 40 mph for an hour or longer or wind gusts over 58 mph for an hour or more. A High Wind Warning is announced when either of the following is imminent: sustained winds over 40 mph for an hour or more or wind gusts over 58 mph for an hour or longer (29). To confuse matters, a Severe
Thunderstorm Watch is issued when there is a possibility of winds over 58 mph (with no time limit) or hail three-fourths of an inch or larger. Since other researchers have come together to publish weather-related safety recommendations for athletics, it may be time to look to the possibility of establishing guidelines pertaining to the protection of athletes and spectators, not just to augment athletic performance.

CONCLUSIONS

There are established national position stands that provide guidance to prevent injury or adapt to extreme temperatures in sport. There also are national standards addressing lightning safety in athletics. Unfortunately, these policies are not focused on either professional or youth sporting events. There is no formal safety policy for sporting events on excessive winds, although they can be predictable and have been fatal. It is time to broaden the scope of existing national safety policies pertaining to both weather and sports and look to established documents and apply them more liberally in sport and recreation.

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References