2016 24th International Lightning Detection Conference &
6th International Lightning Meteorology Conference
18 - 21 April | San Diego, California, USA

Lightning-caused Deaths and Injuries Related to Agriculture

Ronald L. Holle
Holle Meteorology & Photography
Oro Valley, Arizona 85737
Email: rholle@earthlink.net

***Abstract*—Lightning casualties in developing countries often involve people working outside during manual labor-intensive agriculture. Multiple fatalities and injuries are often reported in such agricultural scenarios in less developed countries. To date, there has been no collection of such events. The present report summarizes 445 cases involving 969 fatalities and 597 non-fatal injuries related to agriculture outside the United States since 1993. More than half of the reported events are from India, followed by fewer events in Bangladesh and the Philippines. Events occurred most often in fields, farms, and paddy fields during falling rain. Somewhat more victims were males than females; males tended to be most often in the age range of 21 to 25 while females were most often in their early 30s. The most common crop type was paddy and rice production. While single-person events were most frequent, a number of cases involved more than ten people at a time. Most events occurred between noon and 1800 LST.**

Keywords-agricultural lightning fatalities; agricultural lightning injuries; agricultural lightning casualties

I. INTRODUCTION

The goal of this study is to examine lightning-caused casualties related to agriculture outside the United States. The present report focuses on agriculture, and uses some of the approaches used in previous studies of lightning casualties related to vehicles, dwellings, buildings, and bodies of water [Holle, 2012a]. Lightning safety recommendations identify two reliable safe places. One is inside a large substantially-built enclosed building. The other safe location is inside fully enclosed metal-topped vehicles [Holle, 2012a; Walsh et al., 2013].

In the United States, a comparison of the scenarios of lightning deaths and injuries has shown a major change over the last century (Fig. 1). Here is shown that agriculture accounted for 25% of lightning fatalities in the 1890s but is now a much smaller category [Holle et al., 2005; Holle, 2016]. Such a change has occurred in the United States during a reduction in the population from over 60% rural in the 1890s to less than 20% rural at the current time [Holle et al., 2005; Holle, 2016]. The shift from rural to urban in the United States during this period of time has not occurred in many lesser-developed regions where manual labor-intensive agriculture continues to be a main component of food production.

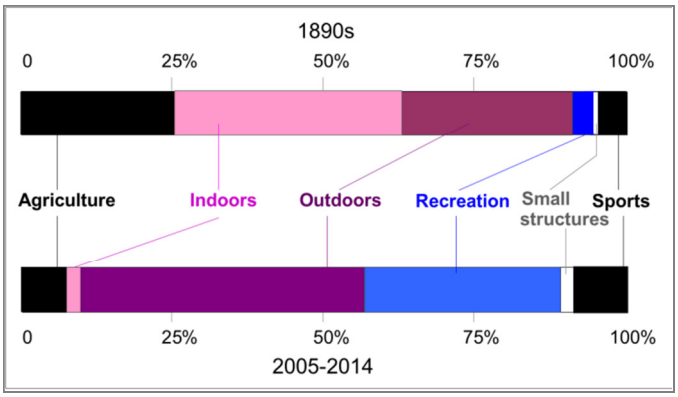

Fig. 1. Comparison of the percentage of types of United States lightning fatalities in the 1890s versus 2005 through 2014 [Holle et al., 2005; Holle, 2016].

II. DATA

The cases in the following sections were collected mainly through web reports, although some are from published papers [Grazulis, 1996] and other publications and sources. All reports have been collected since 1993, and most are since 2010 in order to identify lightning impacts on contemporary socio-economic situations. The reports may be biased by a number of issues including preconceived ideas of reporters, casualties, and witnesses about lightning and its effects. In addition, multiple casualty incidents may be considered more newsworthy [Grazulis, 1996; Cooper, 2012]. Cases involving deaths and non-fatal injuries in more remote areas may not reach journalists at all. The nature of the dataset precludes conversion to an absolute rate for each scenario. Nevertheless, relative values generally indicate which types of events are more common than others.

The type of crops being planted, cultivated, or harvested where people were killed or injured by lightning in the agricultural events summarized in this report are listed in Table 1. Paddy fields are the most common, followed by rice. Both groups are to be expected in India and Bangladesh, which are the two main countries in Fig. 1. The appearance of mango orchards is of particular note, since trees are a particularly dangerous location due to several types of threats in the presence of lightning [Holle, 2012b].

TABLE I. TYPE OF CROPS DURING AGRICULTURAL ACTIVITIES RESULTING IN LIGHTNING FATALITIES OR NON-FATAL INJURIES (N=163)

Crop	Number of events
Paddy field	65
Rice	23
Mango orchard	10
Fodder for cattle	8
Cotton	5
Maize/corn	5
Vegetables	4
Cassava	3
Tobacco	3
Other	34

III. COUNTRY

There are 445 events included in this summary that involve 969 fatalities and 597 injuries. More than half of the available reports are from India (Fig. 2). The next most frequent sources of reports are Bangladesh and the Philippines. Not all countries in this compilation are considered to be developing, but for the sake of completeness, all events that occurred outside the United States are included. In addition, the dominance of India does not represent a particularly dangerous threat in that county, but that reports were posted on India websites more often than elsewhere. It is certain that many cases in other developing countries also occur but do not reach the web reporting system as often. In particular, countries that are not well covered by news reporting will not often be sources of such reports. And, non-English-language reports are less likely to reach the news collection sources available to the author. Another result of the reporting system is that events with multiple casualties are much more likely to be disseminated than those with one or a few casualties. As a result this is not a complete dataset allowing comparison among countries, or is it representative of the annual total that occurs worldwide. It is only a listing of those cases that are currently known.

IV. DEATHS AND INJURIES PER EVENT

The number of deaths, non-fatal injuries, and total casualties per event are shown in Fig. 3. There are numerous cases with several deaths and/or injuries in one event. There are multiple events with 11 or more injuries. The largest number of fatalities in a single case was 22 farmers who died while planting seeds near Nanchang, China in May 1994 [Grazulis, 1996]. These multiple-casualty are in contrast to the United States where 90% of all deaths and injuries due to lightning are to one person at a time [Curran et al., 2000]. The dataset is likely biased toward events with multiple casualties that reach media more often than one-person events. Nevertheless such large numbers of people killed or injured per event is very different from any category that has been studied in the United States or other developed countries [Holle, 2012a; Curran et al., 2000].

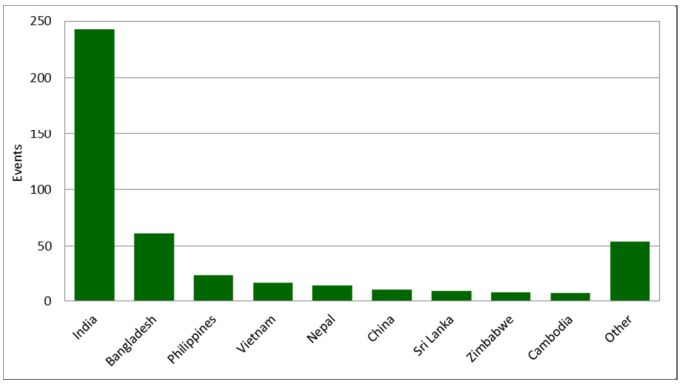

Fig. 2. Agricultural events by country (n=445).

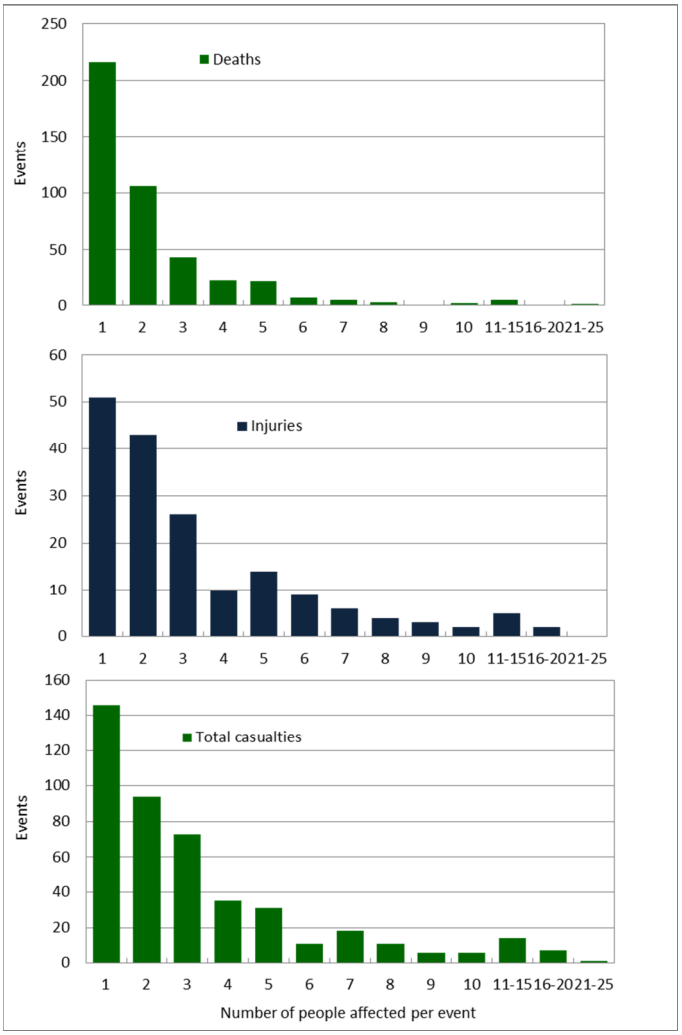

Fig. 3. Deaths, injuries and casualties per agricultural event.

V. AGE AND GENDER

The age distribution of lightning casualties shows the most frequent occurrence between the age range of 16 and 35 (Fig. 4). The distribution is somewhat shifted toward older ages in comparison with the typical range of the late teens to middle twenties in the United States and other developed countries [Curran et al., 2000].

The gender of casualties is fairly similar (Fig. 5). Once again, this is in full contrast with United States and other developed countries where the gender has been about 75% male [Curran et al., 2000].

Combining age and gender, males tend to be in the younger age group in their 20s while females tend to have a peak in frequency about a decade later (Fig. 6).

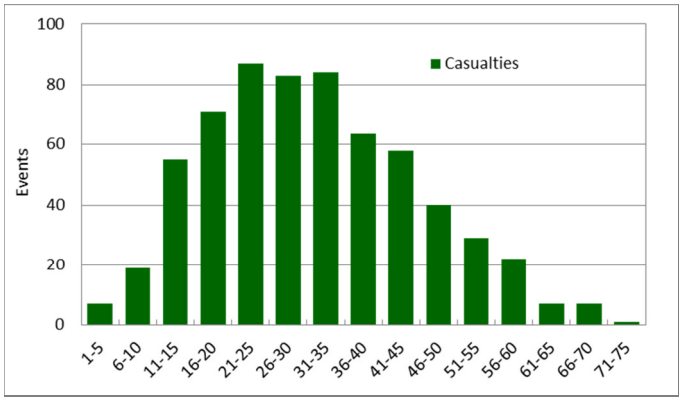

Fig. 4. Ages of agricultural lightning fatalities and injuries (n=634).

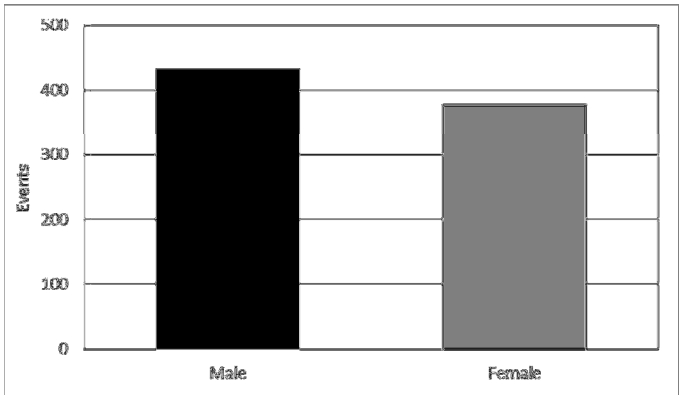

Fig. 5. Gender of agricultural lightning fatalities and injuries (n=812).

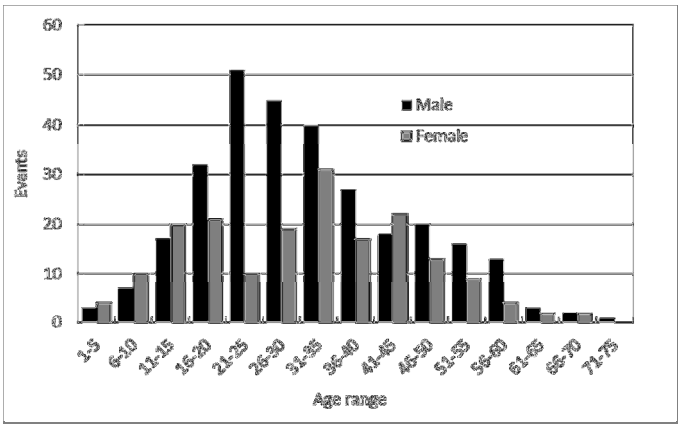

Fig. 6. Age and gender of agricultural lightning fatalities and injuries (n=295 male, 184 female).

VI. LOCATION AND ACTIVITY

The most common situation was in the fields, when location was reported (Fig. 7). The next most common place was on a farm or in paddy fields. None of these reports are especially instructive about the activity; that is the information provided in the news reports.

Two notable groups in Fig. 7 are under trees [Holle, 2012b], and inside a hut or shed in the fields [Holle, 2012a]. In particular, these events represent situations when the lightning and/or rain threat was perceived, but the action was to go to an unsafe location. Properly-designed lightning-safe structures are needed within the agricultural fields to protect from lightning if there are no fully enclosed metal-topped vehicles available. Enough lightning-safe structures need to be available such that workers can reach them on very short notice, since it is apparent that workers are waiting too long unitl they are in rain and storm situations. In addition, a procedure needs to be implemented so that people involved in agriculture know when it is time to go to a lightning-safe structure.

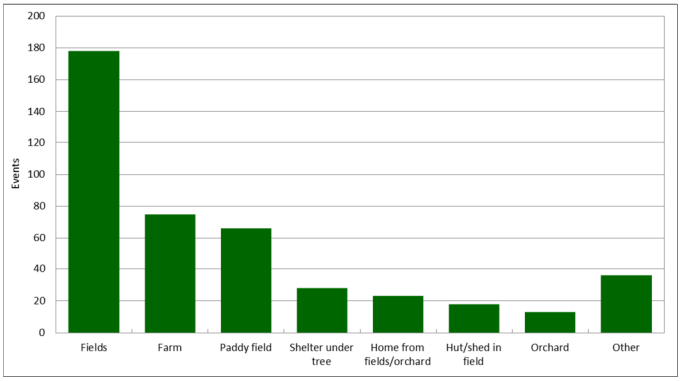

Fig. 7. Location and activity of agricultural lightning fatalities and injuries (n=437).

VII. Weather

The type of weather stated in the news reports, when provided, shows a wide variety of situations (Fig. 8). Nearly every case was marked by the presence of rain, thunderstorms, or storm. Only a few events occurred after rain had stopped - such reports indicate that workers went back outside too soon. The conclusion can be made that agricultural activities continue regardless of the weather. The unfortunate consequence is that lightning accompanies these tropical and monsoon thunderstorm events and result in death or injury.

The range of situations in Fig. 8 differs significantly with those found in the United States where lightning casualties occurred more equally before, during, and after the maximum lightning rate at the time and location of the death or non-fatal injury [Holle et al., 1993; Lengyel et al., 2005]. In the agricultural situations (Fig. 8), most events occurred during the presence of rain or a thunderstorm, and only a few events were after the occurrence of rain.

VIII. Time of Year, Week, and Day

The month of the year when these events occur is skewed toward the meteorological conditions of the main countries in the dataset, mainly India and Bangladesh (Fig. 2). Most of the events occur between April and October (Fig. 9). Moving to the day of the week, Fig. 10 shows minimal variation through the week.

The time of day is shown in two groupings in Fig. 11. Most reports do not have an exact time of the event but instead a broad category of afternoon, for example. The result is that most events are during the afternoon hours. The agriculture activity, then, is primarily a daytime activity that coincides with the typical afternoon occurrence of lightning [Holle 2014].

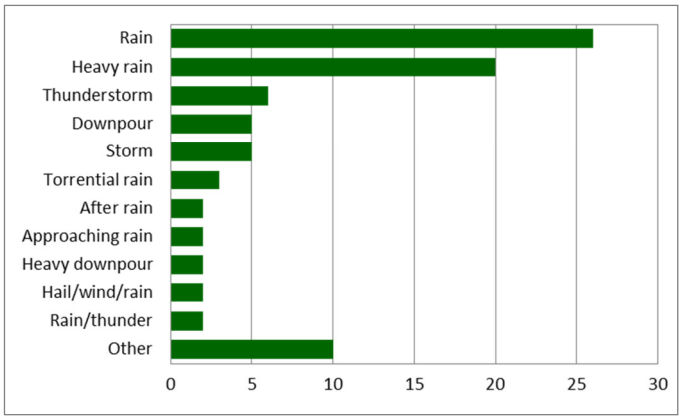

Fig. 8. Weather reported at the time of agricultural lightning fatalities and injuries (n=85).

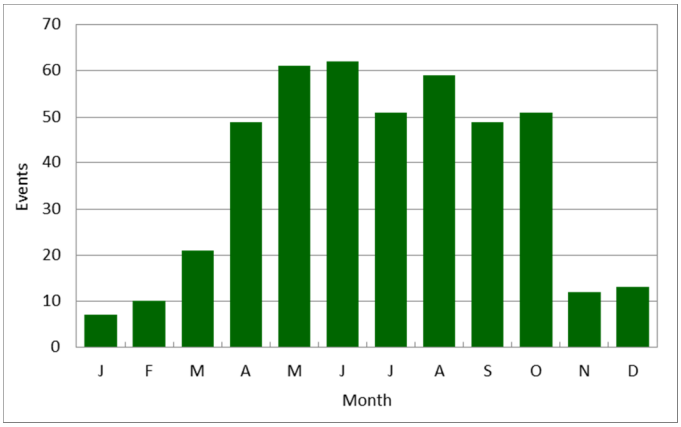

Fig. 9. Month of agricultural lightning fatalities and injuries (n=445).

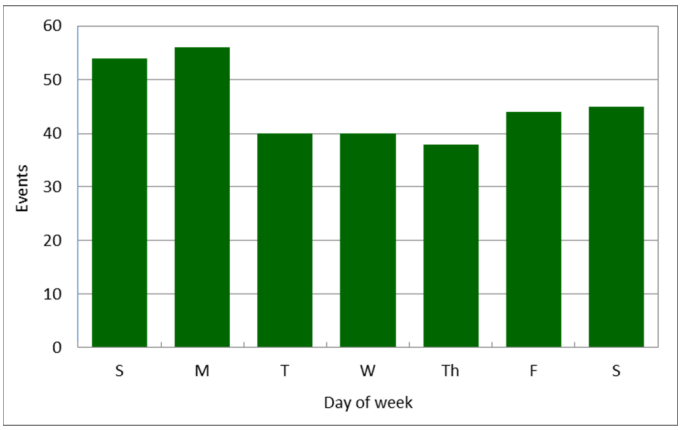

Fig. 10. Day of week of agricultural lightning fatalities and injuries (n=317).

IX. Discussion

There were frequent agriculture-related deaths and injuries associated with lightning in the United States a century ago when the population was primarily rural. It was expected that a substantial number of similar lightning-associated scenarios would be found at the present time in lesser-developed countries. The expectation was confirmed with a large dataset that these locations continue to have a large percentage of their population living in rural locations, and are vulnerable to lightning while engaged in labor-intensive manual agriculture. Further, such activities are mainly daytime efforts that coincide with the daily cycle of increased lightning during the afternoon hours.

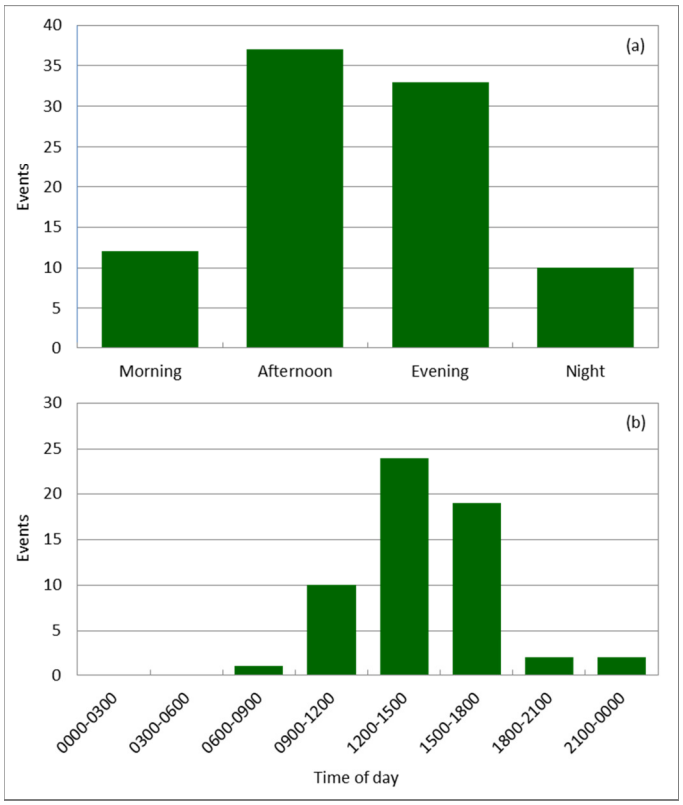

Fig. 9. Time of day of agricultural lightning fatalities and non-fatal injuries. The general time (a) was included in 92 reports, and the more specific time in Local Standard Time (b) was provided in 58 reports.

X. CONCLUSIONS

For the current study, 445 cases were summarized involving 969 fatalities and 597 non-fatal injuries related to agriculture outside the United States since 1993. The most common non-United States agricultural event was in the fields, often paddy fields. Multiple casualties in the same event were common. Nearly as many females were killed or injured as males. The age for males peaks in the low twenties, and in the low thirties for females. Most events occurred during the afternoon when lightning is to be expected in a tropical or monsoon environment of the most frequent countries in this study of India and Bangladesh.

A primary concern is the availability of safe structures in the agricultural fields. Nearly all events had rain and/or a thunderstorm occurring when laborers were killed or injured, or sought a lightning-safe place. Fully enclosed metal-topped vehicles can provide such a lightning-safe location [Holle, 2012a] but they may not be available nearby when needed during the afternoon. Quite a few deaths and injuries occurred when workers went under trees [Holle, 2012b] or inside sheds or huts [Holle, 2012a] that are very unsafe from lightning. Properly-designed lightning-safe structures within the fields, or a short distance away at the perimeter of the fields are necessary to reduce the large toll of lightning deaths and injuries in agricultural activities in the developing world.

REFERENCES

Cooper, M. A. (2012), Whether the medical aspects of lightning injury are different in developing countries, paper presented at 31st Intl. Conf. Lightning Protection, Vienna, Austria, 6 pp.

Curran, E. B., R. L. Holle, and R. E. López (2000), Lightning casualties and damages in the United States from 1959 to 1994, J. Climate, 13, 3448-3453.

Grazulis, T. P. (1996), Significant tornadoes update, 1992-1995, Environmental Films, St. Johnsbury, Vt., 1327-1444, ISBN 1-879362-04-X.

Holle, R. L. (2012a), Recent studies of lightning safety and demographics, paper presented at 31st Intl. Conf. Lightning Protection, Vienna, Austria, 14 pp.

Holle, R. L. (2012b), Lightning-caused deaths and injuries in the vicinity of trees, paper presented at 31st Intl. Conf. Lightning Protection, Vienna, Austria, 8 pp.

Holle, R. L. (2014), Diurnal variations of NLDN-reported cloud-to-ground lightning in the United States, Mon. Wea. Rev., 142, 1037-1052.

Holle, R. L. (2016), A summary of recent national-scale lightning fatality studies, Weather, Climate, and Society, 8, 35-42.

Holle, R. L., R. E. López, and B. C. Navarro (2005), Deaths, injuries, and damages from lightning in the United States in the 1890s in comparison with the 1990s, J. Appl. Meteor., 44, 1563-1573.

Holle, R. L., R. E. López, R. Ortiz, C. H. Paxton, D. M. Decker, and D. L. Smith (1993), The local meteorological environment of lightning casualties in central Florida, paper presented at 17th Conf. Severe Local Storms and Conf. on Atmospheric Electricity, Amer. Meteor. Soc., St. Louis, Mo., 779-784.

Lengyel, M. M., H. E. Brooks, R. L. Holle, and M. A. Cooper (2005), Lightning casualties and their proximity to surrounding cloud-to-ground lightning, paper presented at 14th Symposium on Education, Amer. Meteor. Soc., San Diego, Cal., 7 pp.

Walsh, K. M., M. A. Cooper, R. Holle, V. A. Rakov, W. P. Roeder, and M. Ryan (2013), National Athletic Trainers' Association Position Statement: Lightning Safety for Athletics and Recreation, J. Athletic Training, 48, 258-270.