EXTREME HEAT: WHEN OUTDOOR SPORTS BECOME RISKY

Source: U.S. Navy

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CLIMATE CENTRAL

Extreme Heat: When Outdoor Sports Become Risky

Extreme heat index days—when heat and humidity make it difficult for the body to cool itself off—have been increasing in cities across the country.

The National Weather Service heat index includes a combination of air temperature and the relative humidity to capture what it actually feels like outside (which is usually warmer than what the thermometer is reading). When the heat index reaches 90°F, the NWS advises individuals to use "extreme caution" if exercising or working in the outdoors (and that's for a heat index calculation that assumes a shady location with a slight breeze).

A Climate Central analysis of 239 locations in the United States shows that 198 cities have experienced an increase in the annual average number of days with heat index temperatures of 90°F or higher over the last four decades, based on a linear regression analysis. These extreme heat days are now comprising much of the summer for many cities in the South and Southwest, while areas of the country that had relatively few summer days reach the 90°F heat index in the past are now experiencing weeks of them. A "danger" day occurs when the combination of heat and humidity makes it feel like it's 105°F or hotter. Nearly a dozen U.S. cities experienced an increase of at least 4 danger days on average since 1979.

Climate change's impact is being felt throughout the world of sports as these extreme heat events become more common. On high heat index days, sports and heat become a dangerous mix. According to the Center for Disease Control, heat-related illnesses are a leading cause of death or disability among high school athletes. During hot, humid weather, sweat cannot evaporate as easily from the skin, so athletes are at greater risk of developing illnesses such as heat exhaustion and heat stroke - the latter being potentially fatal. With an estimated 8 million high school athletes across the U.S., late summer is the time when many head back to football, soccer, field hockey, or track and field practice -- and when parents, guardians and coaches need to be vigilant about the potential risk for exertional heat illnesses.

The increased intensity and frequency of high heat index days are also complicating professional and amateur sports events around the country. The July heatwave that affected Midwestern and Eastern states led to the cancellation of the New York City Triathlon, a number of running races, as well as horse races in New York, Maryland, Pennsylvania, and Kentucky.

WHAT IS THE HEAT INDEX?

The National Weather Service's heat index incorporates relative humidity with air temperature to measure what temperatures "feel like." For example, if the air temperature is 88°F and there is 75% relative humidity, the heat index indicates it will "feel like" 103°F degrees. Relative humidity is a calculation of temperature and dew point; the higher the dew point, the more moisture in the air, and the more uncomfortable it is to breathe and be active outdoors.

Humidity and dew point levels are critical to consider for outdoor sports events and practices because the higher the moisture in the air, the less efficient the human body is at cooling down. During exercise, the body heats up and perspires to release that heat. But the body can only get cooler if this perspiration or sweat evaporates. When the humidity is high, sweat can't evaporate as well and the body can't cool itself down as efficiently. To understand how "humid" or "muggy" it will feel outside, the dew point is an excellent indicator. A dew point in the 50s or lower indicates that the air will be drier and more comfortable; when it gets in the 60s, it really starts to raise the heat index; and when the dew point is in the 70s or higher, there is a lot of moisture in the air and it will feel oppressive.

The NWS heat index categories are based on how the heat and humidity will affect a healthy individual:

- **Heat index of 80°F-90°F**: Prolonged exposure or physical activity could lead to fatigue and "caution" is advised.
- **Heat index of 90°F-103°F**: A person can experience heat stroke, heat cramps, or heat exhaustion and "extreme caution" is recommended.
- **Heat index of 103°F/105°F-124°F** (depending on location): On "danger" days, a person is likely to experience heat cramps or heat exhaustion, and heat stroke becomes possible.
- **Heat index of 125°F**: On "extreme danger" days, heat stroke is highly likely.

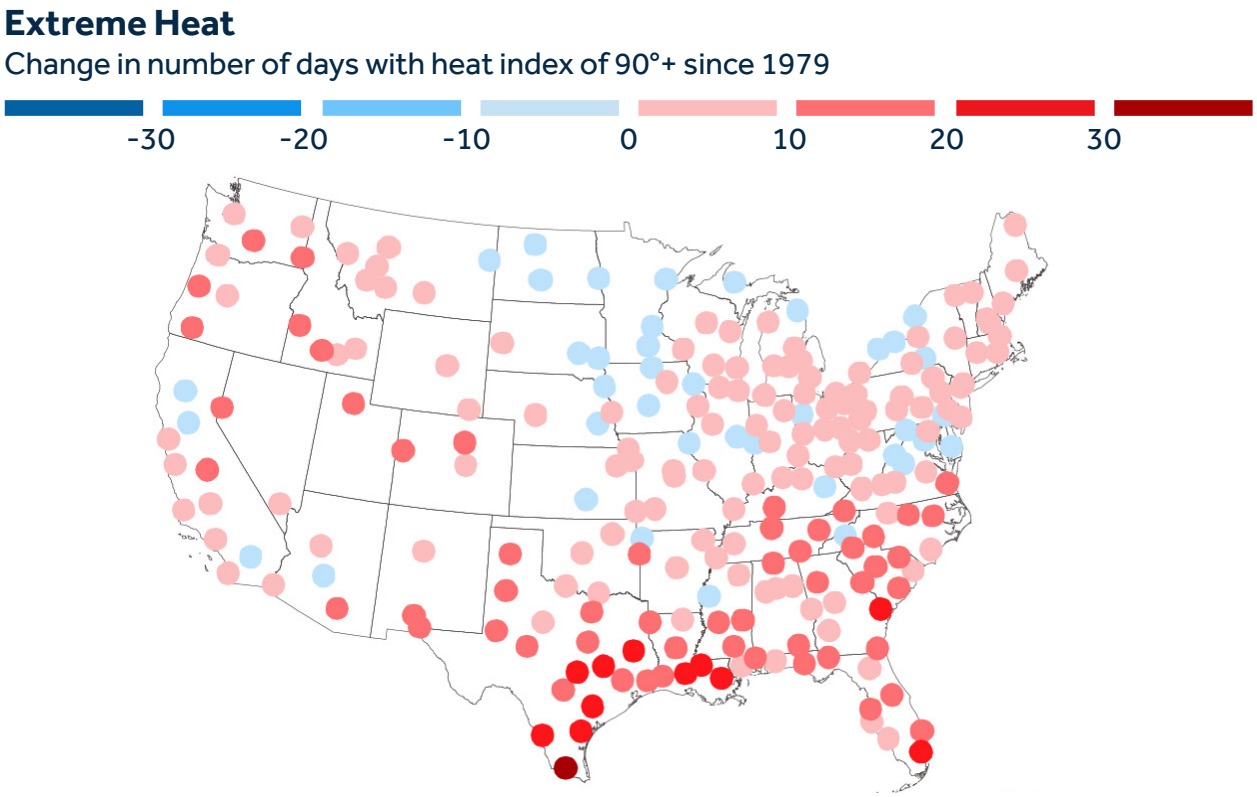
The threshold for issuance of alerts for extreme heat conditions varies across the country, and NWS offices work with local partners to decide when alerts will be issued for a certain area. For example, a day that reaches a heat index of 90°F in Houston will have different impacts than one reaching 90°F in Portland, Maine, where local residents may not be as acclimated to the heat.

Another thing to remember—conditions might actually be worse than what the NWS heat index is indicating. Values are calculated for shady locations with a slight breeze. The heat index value can increase by up to 15°F if the same conditions are exposed in direct sunlight—which is often the case for playing fields, running tracks, and other sports venues.

For the purpose of this report, we use the term "extreme heat days" to describe the days in which the heat and humidity combine to reach a 90°F heat index or hotter.

EXTREME HEAT DAYS ARE INCREASING IN MOST U.S. CITIES

Looking at gridMET heat and humidity data for 239 cities in the contiguous United States, we found 83% of these areas had an annual average increase in 90°F+ heat index days over the past four decades.



Annual days with a heat index of 90°F+
Source: gridMET minimum relative humidity & maximum temperature datasets

The map shows the change in days since 1979 that reached a heat index of at least 90°F (and includes danger days that reached 105°F or higher).

The top 10 cities with the largest increases in annual 90°F+ heat index days since 1979 are:
In addition to using linear regression analysis to measure the change in heat index days, we compared average 90°F+ heat index days over the first five years (1979-1983) of the 40-year period to the most recent five years (2014-2018). A number of regional trends emerged:

- **Cities across the Pacific Northwest experienced substantial increases in extreme heat index days**. In Yakima, Washington, the average number of such days each year more than doubled, rising from 13 to 29.4 days. In Medford, Oregon, they increased from 27.6 to 44.8 days.
- **Extreme heat days are increasing in most cities in the West**. Salt Lake City is now experiencing an additional two weeks of extreme heat days, notching an increase from 21 days on average to 35 days. Reno, Nevada has seen its number of extreme heat days go from 12.8 days to 24.4 days, on average. And Fresno, California has gone from experiencing an average of 78 such days to 92.6 days annually.
- **In the Northeast, most cities experienced increases of extreme heat days over the last four decades, although the upward trends were less dramatic than in other parts of the country**. Atlantic City, New Jersey, averaged 22.4 days annually from 1979-1983, a figure that rose to 28 days over the last five years. In Boston, extreme heat days were slightly higher, rising from an average of 13.6 to 14.8 days. Wilkes-Barre, Penn., experienced 11 extreme heat days on average from 1979-1983 and bumped up to 15.8 days from 2014-2018.
- **In a number of cities in the South, extreme heat now extends well beyond the summer months**. Austin, Texas, had 126 extreme heat days on average over the last five years, Savannah, Georgia, had 113.8 days, and Miami had 160.6 days, on average. Laredo, Texas, now experiences an average of 170.4 days above 90°F; among those days, 1 in 5 was a danger day, with a heat index higher than 105°F.
- **The Midwest has a mixed record, with a number of cities in the upper Midwest experiencing a decrease in extreme heat days over this time period**. Temperatures are still rising in this region, but the biggest rise in temperatures is happening during winter rather than summer. Scientists have found that the intensification of agricultural practices in the Midwest are playing a role in decreased temperatures and increased rainfall in the summer. However, cities across Ohio, Michigan, Kentucky, Illinois, and Indiana are encountering upward trends in extreme heat days.

City	Increase in annual 90°F days since 1979
1. McAllen, Texas	31.6
2. Baton Rouge, La.	24.2
3. New Orleans	23.6
4. Miami	23
5. Savannah, Ga.	22.8
6. Lafayette, La.	22.2
7. Tyler, Texas	22.1
8. Victoria	22.0
9. Austin, Texas	21.8
10. Corpus Christi, Texas	20.6

DANGER DAYS: RARE BUT DEADLY

Climate Central also used the gridMET data to study "danger" days, when the heat index rises to 105°F or higher. While these days occur infrequently, they have been trending upward since 1979 in 106 out of the 239 cities analyzed in the contiguous United States. The NWS works with local partners and may issue an "Excessive Heat Warning" if the maximum heat index temperature is forecast to be 105°F or higher for at least two days and the night time air temperature is not expected to fall below 75°F. An excessive heat warning indicates that if you don't take precautions in these conditions, you may become seriously ill or die, particularly in areas of the country where residents are not acclimated to heat.

Our analysis looked at danger day conditions occurring back to 1979, and found that 11 cities have experienced an increase of at least 4 danger days. Residents of McAllen, Texas, have seen an increase of 21.9 danger days since 1979, the most across the country.

City	Increase in annual 105°F days since 1979
1. McAllen, Texas	21.9
2. Laredo, Texas	14
3. Victoria, Texas	12.3
4. Houston, Texas	9.6
5. Yuma, Ariz.	9
6. Lake Charles, La.	8.1
7. Tyler, Texas	6.7
8. Pensacola, Fla.	5.9
9. Austin, Texas	5.9
10. Lafayette, La.	4.7

EXTREME HEAT AND DANGER DAYS ARE INCREASING DUE TO CLIMATE CHANGE

The most recent decade was the warmest in the United States since record keeping began in 1895. And 2019 saw some of the hottest months on record globally. Extreme heat is intensifying with climate change, and even small increases in averages can have big impacts on extreme temperatures.

All regions of the country are projected to experience higher temperatures in the future, with the magnitude of temperature increase largely determined by the amount of emissions we produce now and in the near future. In July, the Union of Concerned Scientists published research that projected the effect that global warming will have on the number of days per year in which the heat index will rise above 90°, 100°, and 105°F through the end of the century. The UCS analysis found that in many U.S. cities, extreme heat conditions will rise from just a few days each year to weeks or months by 2050. By the end of the century, much of the summer could become dangerous for millions of Americans to work or be active outdoors.

EXTREME HEAT AND SPORTS: A POTENTIALLY LETHAL MIX

Exercising outdoors when the heat index is high can add increased stress to your body. Body heat production rises during strenuous exercise, compared to when you are at rest. During intense exercise, maintaining a healthy body

heat balance is highly dependent on the evaporation of sweat. On high humidity days, when sweat cannot evaporate from your skin, you are at risk of a variety of heat-related illnesses, from heat exhaustion to heat stroke.

SCHOOL SPORTS

According to the Center for Disease Control, heat illness is a leading cause of death among high school athletes. Since 1995, 64 football players have died from heat stroke (47 high school, 13 college, two professional, and two organized youth), with nearly all of them (90%) occurring during practice. Although successful treatment strategies are being implemented, athletes are still succumbing to exertional heat illness (EHI), and heat stroke is a leading cause of sudden death during sports activities. As climate change threatens to increase high heat index days around the country, athletic trainers, coaches, and medical professionals will need to be educated and prepared to respond to, prevent, recognize, and treat EHI in athletes of all ages.

The University of Connecticut's Korey Stringer Institute (KSI) studies heat stress in sport and is named after the Minnesota Vikings offensive lineman who died from exertional heat stroke in 2001. Dr. Douglas Casa, the chief executive officer of KSI, is working with high school athletic associations in all 50 states to promote instituting state level policies for preventing heat illness, as there is no one national governing body. Casa's research has found that states have very mixed records in terms of high school sports safety policies, including for practices or competitions on high heat and humidity days. Two years ago, KSI issued a report ranking all the states on meeting best practices for safety, and since then, about 30 states have instituted changes to upgrade safety policies. Many of the state-level high school association governing bodies are made up of former coaches or athletic trainers, and KSI's mission is to bring professional medical expertise and evidence-based research to direct state policies.

One of KSI's top recommendations is for schools to institute wet bulb globe temperature (WBGT) monitoring to more accurately measure local heat and humidity conditions. Long in use by the military, a WBGT device measures and incorporates ambient temperature, relative humidity, wind, and solar radiation from the sun. A shadeless, artificial-turf football field, surrounded by an 8-lane blacktop running track can have a microclimate of its own, says Casa. He acknowledges about a dozen states are using WBGT devices to monitor heat conditions for high school sports.

IT'S MORE THAN JUST HIGH SCHOOL SPORTS

Extreme heat is impacting sporting events around the world—at all levels, from youth to amateur to professional. Japan's deadly summer heat waves have caused the 2020 Tokyo Olympic organizers to reschedule the Olympic marathon to begin at 6 a.m. to avoid the highest heat at mid-day and to put in place measures to keep spectators and participants safe from the heat and humidity next summer. Last September, for the first time, the heat rule was extended to male players at the U.S. Open, allowing male competitors to take 10-minute breaks between sets. But five players withdrew from competition due to the heat that day, which reached a heat index of 102°F.

Cancellation of major events can also be costly for participants, the organizers, and the cities that host them. In July, the Haskell Invitational, the biggest horse race of the year for Monmouth Park Racetrack in New Jersey, was delayed for several hours due to extreme heat, and a number of other races that day were cancelled to protect the horses. The decision caused a financial hit, with the park taking in $8.6 million in betting instead of an expected intake of $20 million.

PARENTS, GUARDIANS, AND COACHES: WHAT YOU CAN DO

The National Athletic Trainers' Association has developed a series of recommendations for the prevention, recognition, and treatment of exertional heat illness, and the Centers for Disease Control provides an online course for coaches. These recommendations cannot guarantee full protection, as individuals' conditions and responses will vary, but they offer ways to mitigate risk of heat exertion illness. The NATA website provides a number of handouts and other guidance for parents and coaches.

- Prior to exercise, athletes should undergo medical screenings for previous heat illness incidents and other conditions. Any current sickness, such as a virus or fever, should disallow participation.
- Identify individuals who may be at more risk for exertional heat illness and monitor them closely. Keep

emergency equipment onsite, such as tubs for cold-water immersion.

- Design workouts and physical activities to mitigate risks.
- Heat acclimatization—progressively increasing the intensity and duration of physical activity—should be done gradually, over 7 to 14 days.
- Rest breaks in the shade or in a cool area should be planned, include fluids, and allow athletes to remove equipment like helmets.
- Fluids should be made available at all times, not just during designated breaks, and instruction should be given to athletes on eating and drinking appropriately to replace sodium loss in sweat.
- Educate all personnel (coaches, trainers, medical staff, athletes) on preventing and recognizing exertional heat illness and stroke, and develop policies for organized sports and events taking place in hot, humid conditions.

ATHLETES: WHAT YOU CAN DO

The Korey Stringer Institute provides guidance for heat acclimatization, for athletes and others planning to train or participate in an event when high heat and humidity are forecast, with acclimating to the heat over 7 to 14 days a top recommendation. Their website also provides detailed advice, videos, and resources to prevent, recognize, and treat heat-related illnesses, including heat exhaustion, heat cramps, heat stroke, and heat syncope (fainting and dizziness).

The Center for Disease Control also offers advice for athletic activities in extreme heat. Among CDC's tips:

- "Limit outdoor activity, especially during the middle of the day when the sun is hottest.
- "Pace activity. Start activities slow and pick up the pace gradually.
- "Drink more water than usual, and don't wait until you're thirsty to drink more.
- "Monitor a teammate's condition, and have someone do the same for you.
- "Wear loose, lightweight, light-colored clothing."

METHODOLOGY

The daily maximum temperature and minimum relative humidity was assessed from 1979 to 2018 at the 239 contiguous U.S. stations typically analysed by Climate Central, using the gridMET modeled dataset and based on the findings of Dahl et al. 2019. Heat index temperatures were calculated using the National Weather Service's heat index algorithms. The change in the number of 90°F+ and 105°F+ days are based on linear regression. Local graphics were not produced for Eureka and Monterey, California or Flagstaff, Arizona due to a lack of days in which the calculated daily heat index met or exceeded 90°F during the study period.