Inflatable bounce houses are popular activities for young children at parties and other functions, particularly in the summer. However, the emerging literature suggests that bounce houses may be hazardous to children. Thompson et al. (2012) found that the rate and number of pediatric injuries from bounce houses have increased in recent years (Thompson et al. 2012). In one of the more comprehensive studies on the matter, they used records (1990–2010) from the National Electronic Injury Surveillance System to analyze emergency room visits by patients under 17 years of age treated for inflatable bounce house injuries. One of the most staggering findings is that during the period from 1995 to 2010, a 15-fold increase was observed in the rate and number of bounce house injuries (roughly 5.28 injuries per 100,000 children in the United States annually). The injuries included fractures (27.5%), sprains/strains (27.3%), and other injuries to the lower (32.9%)/upper (29.7%) extremities. On top of this, recent reports and legal actions have highlighted hazards associated with high winds (Weather to Bounce 2016). Finally, in 2013, a Texas child suffered heatstroke in a bounce house (Gutierrez 2013). While this is the only documented case we could find, we believe that heat-related illnesses are an underreported hazard associated with inflatable bounce houses.

Ferro et al. (2016) recently noted a relationship between bounce house injuries and seasonality. In their analysis of Italian patients, they found that the majority of the emergency department injuries were during April–June (i.e., the warm season). This pattern would likely be similar in the United States with increased bounce house deployments during the warm season months when children are on summer break. The timing also coincides with the hottest time of the year, which would enhance possible heat-related hazards.

Importantly, children are particularly vulnerable to heat and epidemiologic studies show increased risk of heat-related morbidity for children (e.g., Kovats and Hajat 2008; Knowlton et al. 2009; Rhea et al. 2012). This is related to a combination of factors including their physiology (Falk and Dotan 2008) and the various microclimatic environments where they often play, such as parks with surface materials that increase radiative heat fluxes and have greater air temperatures (Vanos 2015). Additionally, microclimates within parked motor vehicles have been well documented to cause serious heat injuries to children (e.g., McLaren et al. 2005; Grundstein et al. 2010; Duzinski et al. 2013). Our study aims to investigate potential heat-related risks associated with bounce houses, which is a microclimatic environment that has not yet been investigated but like automobiles may create hazardous conditions by altering radiative and convective energy exchanges.

Do Inflatable Bounce Houses Pose Heat-Related Hazards to Children?

**Andrew Grundstein, J. Marshall Shepherd, and Sarah Duzinski**

**DATA AND METHODS.** The study was conducted on 16 July 2015 on the campus of the University of Georgia in Athens, Georgia, from 1210 to 1700 eastern daylight time (EDT). A bounce house (4 m × 4 m × 4.6 m) was placed in the middle of a grassy courtyard, bordered on three sides by buildings and on one side by a vegetated berm. The bounce house...
was constructed of polyvinyl chloride (PVC) with flaps over the entryway and mesh vents on the four sides (Fig. 1). It was unoccupied for most of the study, except for a 35-min period when 2–3 adults jumped in the bounce house. We did not detect a discernible influence on the conditions in the bounce house from their presence as temperature variations over time paralleled those outside the structure and dewpoint temperatures remained nearly constant. Kestrel 4400 heat stress meters were placed inside the bounce house and outside in a shaded location. The sensors measured air temperature, humidity, wind speed, and computed heat index values at 5-min intervals.

Weather conditions were representative of a typical summer day in the area, with the daytime maximum air temperature of 33.3°C recorded at the nearby Athens Automated Surface Observing Station (ASOS) identical to the long-term mean. Over the study period, cloud cover was light and ranged from clear (0% cloud cover) to few clouds (1/8–2/8 cloud cover).

### RESULTS AND DISCUSSION

We collected 59 measurements over the nearly 5-h period (Table 1). Bounce house air temperatures were consistently greater than ambient conditions. Average temperatures of 33.4°C were more than 2°C greater than average temperatures outside the bounce house. Further, peak bounce house temperatures exceeding 38°C were 3.7°C more than outside temperatures. Dewpoint temperatures were similar but slightly greater in the bounce house, with an average of 22.9° ± 0.6°C compared with ambient values of 22.3° ± 0.7°C. Wind speeds were near zero in both locations. The light winds outside the bounce house in part may have been due to the sheltering effect from the surrounding buildings. Finally, we consider the heat index, which integrates both air temperatures and humidity, and is used as a heat exposure metric by the National Weather Service (NWS). The magnitude of the difference inside versus outside the bounce house was larger for the heat index than for air temperatures alone. The average heat index in the bounce house was almost 40°C and peaked at 47°C, exceeding the ambient average and values by 3.9° and 4.5°C, respectively.

The health implications of the greater heat exposure can be considered within the context of categorical risks for heat injuries associated with the NWS heat index chart (National Weather Service 2016). These risks range from moderate “caution” and increase in severity to “extreme caution,” “danger,” and “extreme danger” (Table 2). We determined the frequency

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**Table 1. Inflatable bounce house and on-site ambient meteorological conditions.**

<table>
<thead>
<tr>
<th></th>
<th>Air temperature (°C)</th>
<th>Heat index (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bounce house</td>
<td>Outside</td>
</tr>
<tr>
<td><strong>Avg</strong></td>
<td>33.4</td>
<td>31.1</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>33.1</td>
<td>31.0</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>38.2</td>
<td>34.6</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>30.0</td>
<td>28.3</td>
</tr>
<tr>
<td><strong>Std dev</strong></td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Count</strong></td>
<td>59.0</td>
<td>59.0</td>
</tr>
</tbody>
</table>

---

[Fig. 1. Bounce house employed in the study.]
of these different categories inside and outside the bounce house. Ambient conditions mostly indicated the lowest levels of risk, “caution” (7%) and “extreme caution” (85%), with only 7% at “danger.” In contrast, more than half the measurements (53%) in the bounce house were at the more hazardous “danger” level.

To help those involved in public safety, the media, and parents/caregivers assess the possible heat-related hazard to children, we developed a modified NWS heat index table (Table 3). The axes include the ambient air temperature and relative humidity but the corresponding heat index values have been increased by 4.5°C (about 8°F), the maximum difference found in our study so as to provide conservative safety recommendations. Table 3 is presented in the Fahrenheit scale to be consistent with current practices at the NWS. As an example of how to use the table, the potential heat index inside a bounce house on a day with an ambient temperature of 32.2°C (90°F) and a relative humidity of 55% would be 40.6°C (105°F) and fall within the “danger” category. Thus, parents or caregivers should be advised to provide extra scrutiny to the child’s activities by either canceling or reducing the length of time the child plays in the bounce house.

It is important to consider some limitations to our study. First, the results represent only conditions on a single, albeit typical, summer day in a southeastern U.S. city and may vary with weather conditions. Nevertheless, the relatively clear skies would promote more heating than a cloudy day and we believe our results provide conservative estimates from a safety standpoint. Second, we focus on the heat index, in particular, as it is a common heat exposure metric used in the United States and one that a parent or caregiver could easily access on a phone weather app. Yet, the heat index makes several assumptions that may not be representative of the particular circumstances of a child playing in a bounce house and lead to underestimates of the actual heat stress of the child: there is an effective wind speed of 2.57 m s⁻¹ (5.75 mph) and the individual is an adult and is only moderately active (Rothfusz 1990). In fact, the walls of the bounce house substantially reduce ventilation and therefore evaporative cooling as well as gain energy from solar absorption and emit large amounts of longwave radiation toward the child. Also, the heat index model does not account for the less efficient thermoregulatory systems of children or their greater physical activity when playing in a bounce house (Vanos 2015). Finally, our measurements did not consider the metabolic heat generation and subsequent increase in air temperatures from a large number of children playing simultaneously in the bounce house.

**CONCLUSIONS.** Our study is the first to investigate heat-related hazards posed by bounce houses. We found bounce houses are hotter and more oppressive than ambient conditions based on both air temperature and the heat index.
Indeed, peak heat index values exceeded ambient conditions by 4.5°C and “danger” conditions, where serious heat-related injuries such as heat exhaustion and heatstroke are possible, occurred much more frequently in the bounce house. Further, our heat index values may even underestimate conditions as they do not account for the metabolic heat production of the child. Many parents and caregivers may not perceive health threats posed to their children from heat because bounce houses are shaded from the sun. We hope that our study will raise awareness of this hazard and encourage parents to closely monitor their children for signs of heat-related distress in addition to providing frequent rest breaks and plenty of fluids, especially as conditions become more oppressive.

**ACKNOWLEDGMENTS.** We would like to thank the University of Georgia Athletic Association for providing funding in support of this work.

**FOR FURTHER READING**


Rothfusz, L. P., 1990: The heat index “equation” (or more than you ever wanted to know about the heat index). NWS Tech. Attachment SR 90-23, 2 pp. [Available online at www.weather.gov/media/ffc/ta_htindx.PDF.]


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