Research Report

Artificial Turf Surface

Temperature vs Grass

Surface Temperature

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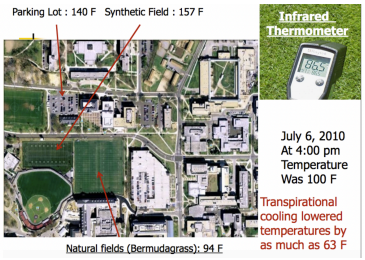
Abstract

This study investigates the differences in surface temperatures between artificial turf and natural grass to assess their broader impact on athletic safety and the environment. With artificial turf becoming increasingly popular due to its low maintenance costs, concerns about its heat retention properties have emerged. The hypothesis stated that artificial turf would have a significantly higher surface temperature than grass due to its polymer-based composition, which absorbs and retains more heat. Using infrared thermometers, surface temperatures of both artificial turf and natural grass were measured over multiple days under the same environmental conditions. The data revealed that artificial turf exhibited an average temperature increase of 3.34°C compared to grass. Additionally, while the temperature difference between air and grass showed a slight decrease of 0.48°C, the air-to-turf difference showed a 2.54°C increase, confirming that turf retains more heat. These findings align with external research, such as studies from Brigham Young University and Penn State, which have documented extreme heat levels on artificial turf, sometimes exceeding 76.7°C on hot days. The results indicate that artificial turf can pose significant heat-related risks, such as burns, heat exhaustion, and dehydration for athletes. While this study was conducted during colder months, future research could expand by examining temperature variations across seasons and testing heat-mitigating solutions for artificial turf. These findings have important implications for sports facility management, urban planning, and environmental policies, highlighting the need for alternative materials and cooling strategies to improve athlete safety on synthetic fields.

Intro: Artificial Turf vs Grass

Understanding how the surface temperatures of artificial turf and real grass compare to there surrounding air temperature is crucial for assessing the broader impacts on both athletes and the environment. Over recent years, many athletic fields that once were natural grass have transitioned to artificial turf, largely due to its lower maintenance requirements. Artificial turf is often seen as a more cost-effective option because it reduces the need for regular mowing, watering, and other upkeep associated with natural grass (Yalamanchili, 2024). However, while these benefits make artificial turf an appealing choice for sports facilities, there are significant, often overlooked, drawbacks associated with its use, particularly when it comes to temperature regulation, safety, and long-term environmental consequences.



(Mathias, 2010)

Several studies have highlighted the drastic difference in temperature between artificial turf and natural grass. For instance, researchers have found that the surface temperature of artificial turf can be exponentially higher than that of the surrounding environment or natural grass, creating serious risks for athletes. On a day with an air temperature of around 100°F, one study found that the surface temperature of artificial turf soared to 157°F, an alarming 63°F higher than that of

real grass, which sat at a more moderate 94°F (Mathias, 2010). The intense heat generated by turf surfaces can cause serious discomfort, including burning the skin or damaging footwear. In more extreme cases, the elevated temperatures are linked to increased occurrences of heat stroke and dehydration among athletes, posing significant health risks.

Beyond temperature-related concerns, research also points to higher injury rates on artificial turf compared to natural grass. One study found that athletes playing on artificial turf were nearly three times more likely to suffer a PCL (posterior cruciate ligament) injury than those playing on grass (STMA Institute of Sports Management, 2019). These findings suggest that the synthetic surface may alter the way athletes move, increasing the likelihood of certain types of injuries.

The environmental implications of artificial turf are also a cause for concern. The crumb rubber infill used in many turf systems, which is derived from recycled tires, has been shown to release harmful chemicals like zinc into the environment (Green Building Alliance, 2022). Additionally, the disposal of artificial turf at the end of its lifespan presents a significant environmental challenge. Many turf fields contain materials that are difficult to recycle, and some parts can take up to a decade to break down, contributing to long-term waste issues (Green Building Alliance, 2022).

Another commonly overlooked issue is the risk of "turf burn," which occurs when athletes slide or make direct contact with the rough, abrasive surface of artificial turf. While often regarded as a minor injury, turf burns are highly susceptible to infection, with some cases leading to serious conditions like Staph or MRSA (Kerska, 2023). The frequency of such injuries adds another layer of concern for both the health and safety of athletes playing on synthetic fields.

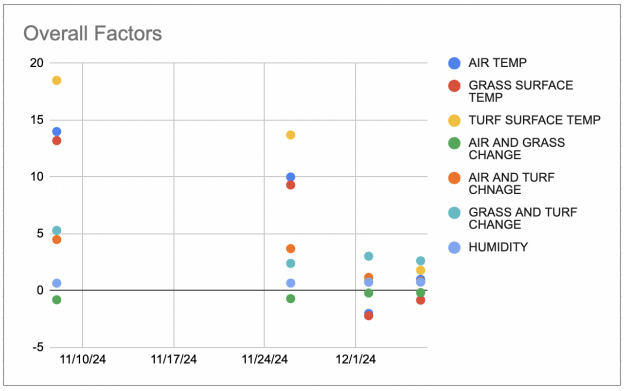
In light of these various factors—higher surface temperatures, increased injury rates, environmental concerns, and health risks—there is growing skepticism about the widespread use of artificial turf in sports. While the initial cost savings and reduced maintenance requirements may make it an attractive option for facilities, the long-term consequences of using synthetic surfaces may ultimately outweigh these benefits. That being said, heat being one of the leading concerns sparked the interest in this project. So, if the surface temperature of grass and artificial turf are taken under the same conditions then the turf will have a relatively higher temperature because it absorbs and releases more heat then grass does due to the polymers, making it warmer and more dangerous for athletics.

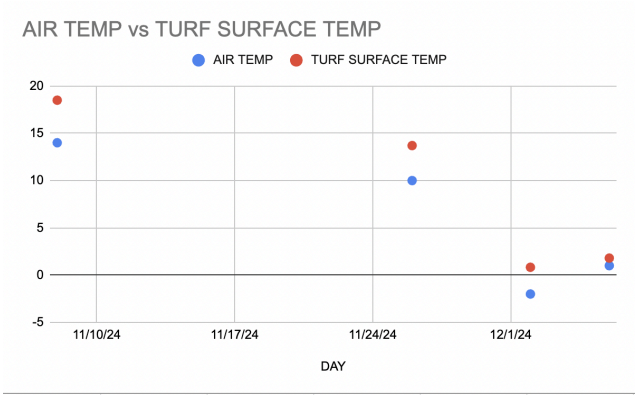
Methods and Materials

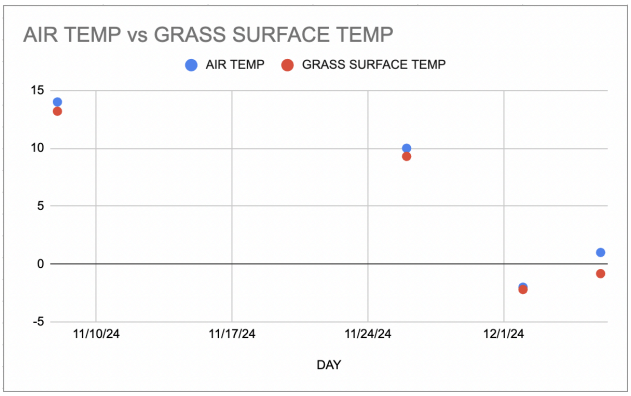
This Experiment requires the use of GLOBE's atmosphere protocols, utilizing both air temperature and surface temperature. They were both measured in degrees celsius and were measured by infrared thermometers made by ETEKCITY. Data was always collected in the same relative location as well as time. This was entered into GLOBE using their data collection tab. The process of collection included: First Creating a rough data collection sheet with a date box, time box, air temperature in celsius box, 6 surface temperature boxes for grass, 6 surface temperature boxes for artificial turf, the average percent change of air and grass + the average difference, the average percent change of air and turf + the average difference, and finally the average difference of grass to turf. The second step was to grab an infrared thermometer and make sure it was working and measuring in celsius by sticking your straight out with the laser point down, pressing the button, and looking at the screen to check the reading. Third step

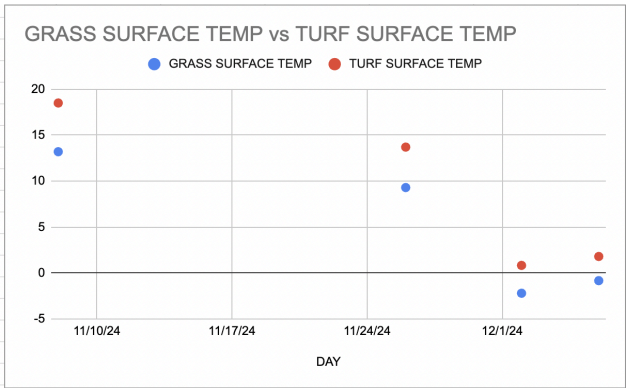
included going to the classroom weather screen, where a reading in Celsius was made of the outside air temperature, and recording that in its dedicated box. Then the fourth step was to proceed outside to the dedicated grass areas (inside the stadium) and record the surface temperature in 6 different areas by using the infrared thermometer and sticking your arm straight out with the laser pointing at the ground. Once that was done, I then proceeded to the turf field and repeated the same steps as for grass. After all data was collected for that particular day I would then calculate the average temperatures of both grass and turf separately by adding all 6 numbers up and dividing by 6. Once those were found I was able to calculate the percent change of them both compared to the air temperature by subtracting air by surface temperature, then dividing that by air temperature, and finally multiplying by three. Then to find the average difference I simply subtracted the surface temperature of each by the air temperature. I then proceeded to find the difference of grass surface temperature and turf using the same steps. Finally all this data was entered into GLOBE, and the entire process was repeated for every day of data collection starting at 11/8/24 up until 12/6/24 with four data collections in between that time period (N=4.) The only risk or safety precautions to be aware of for this experiment is too NEVER under any circumstances point the laser on the infrared thermometer at anyone, especially their face, and more specifically their eyes because it can cause damage to the retina.

Presentation of Data and Results









A	B	C	D	E	F	G	H	I
DAY	AIR TEMP	GRASS SURFA	TURF SURFACE	AIR AND GRAS	AIR AND TURF	GRASS AND TU	CONDITION	HUMIDITY
11/8/24	14	13.2	18.5	-0.8	4.5	5.3	fair	66%
11/26/24	10	9.3	13.7	-0.7	3.7	2.4	mostly cloudy	67%
12/2/24	-2	-2.2	0.83	-0.2	1.17	3.03	cloudy	75%
12/6/24	1	-0.83	1.8	-0.17	0.8	2.63	fair	75%

The results of the experiment indicate a clear trend where artificial turf exhibits higher surface temperatures than natural grass under the same conditions. Across all recorded dates, the turf surface temperature (represented by yellow data points) consistently shows the highest values compared to grass surface temperature (red data points) and air temperature (blue data points). This supports the hypothesis that artificial turf absorbs and retains more heat due to its polymer composition. Notably, the greatest differences in temperature are observed on earlier dates,

particularly on November 8th, where the turf surface temperature significantly exceeds both air and grass surface temperatures. As time progresses, the temperature differences decrease, likely due to changing weather conditions or seasonal variations. The data also show that temperature changes between air and grass (green), air and turf (orange), and grass and turf (cyan) fluctuate, but the turf continues to maintain a relatively higher temperature than grass. One outlier appears in the earlier dates, where the turf surface temperature reaches its peak, standing out significantly compared to the rest of the data points. This suggests that under certain conditions, turf may absorb and retain extreme levels of heat, which could pose a risk for athletes. The humidity values (light blue) remain relatively stable throughout the experiment, indicating that changes in surface temperature are likely not driven by variations in humidity but rather by the properties of the surfaces themselves. Overall, the data strongly support the hypothesis, confirming that artificial turf reaches higher temperatures than natural grass, making it potentially more hazardous for athletic activities.

Analysis and Results

My findings suggest that when comparing the surface temperature of real grass to that of artificial grass or turf, the turf consistently exhibits a higher temperature. The first evidence of this was found by calculating the average daily temperature of both surfaces and determining the difference. I found that the temperature of the turf was, on average, 3.34°C higher than that of grass, indicating that turf is relatively warmer. Additionally, I analyzed the temperature differences between air and surface temperatures for both grass and turf. My data showed that the air-to-grass temperature

difference resulted in a 0.48°C decrease, whereas the air-to-turf temperature difference showed a 2.54°C increase. This further supports the conclusion that turf retains more heat than natural grass. Based on my hypothesis—if the surface temperature of grass and artificial turf is measured under the same conditions, then the turf will have a relatively higher temperature because it absorbs and releases more heat than grass due to its polymer composition, making it warmer and more dangerous for athletics—my data supports this claim. While my research was conducted under varying weather conditions, including cold temperatures, slight snow, and cloud cover, which may have limited the overall temperature differences, other studies show a more pronounced effect. Research from NRPA.org in the article "Synthetic Sports Fields and the Heat Island Effect" references a study from Brigham Young University, which found that on a hot, sunny day, artificial turf can be up to 30.28°C (86.5°F) hotter than natural grass. Additionally, research from Penn State suggests that while real grass rarely exceeds 37°C (100°F) on the hottest days, artificial turf frequently reaches temperatures between 60°C and 76.7°C (140°F to 170°F). Overall, both my findings and those from other studies confirm that artificial turf surfaces are significantly warmer than natural grass. This is primarily due to the polymer-based fibers used in turf, which prevent it from undergoing the same natural cooling processes as grass. These results highlight important considerations for athletic safety and urban planning, emphasizing the need for further research into cooling solutions for artificial turf.

Conclusion

Based on my analysis and results, it is evident that artificial turf retains significantly more heat than natural grass. My findings demonstrated that the average surface temperature of artificial turf was consistently higher than that of real grass, with an average increase of 3.34°C. Additionally, the difference in temperature between the air and the turf showed a 2.54°C increase, whereas the air-to-grass temperature difference showed a slight decrease of 0.48°C. These results align with my hypothesis, confirming that artificial turf absorbs and retains more heat due to its polymer-based composition, making it considerably warmer and potentially hazardous for athletes. While my research was influenced by colder weather conditions, the overall trend supports existing studies. Research from Brigham Young University found that on hot, sunny days, artificial turf temperatures can be over 30°C higher than natural grass. Similarly, Penn State studies indicate that while real grass rarely exceeds 37°C, artificial turf frequently reaches between 60°C and 76.7°C. These findings reinforce my results, suggesting that artificial turf surfaces pose a significant heat-related risk. Ultimately, my study, supported by external research, confirms that artificial turf surfaces are substantially warmer than natural grass due to their material properties and inability to cool naturally. This has important implications for athletic safety and urban planning, emphasizing the need for further research into cooling solutions for artificial turf surfaces.

Discussion

While my research effectively demonstrated that artificial turf retains significantly more heat than natural grass, there are several ways the study could be improved if repeated. One major limitation was the weather conditions during data collection. Conducting the study in colder temperatures, with occasional snow and cloud cover, may have limited the temperature differences observed. Repeating the experiment in consistently warmer weather or across multiple seasons would provide a more comprehensive understanding of how artificial turf reacts to varying environmental conditions. Additionally, collecting data from different locations with varying levels of sunlight exposure and surface materials could further validate the findings.

Beyond the classroom, this research has practical implications for sports facilities, urban planners, and environmental policymakers. With artificial turf becoming increasingly popular in schools, parks, and professional sports fields, understanding its heat-retaining properties is crucial for ensuring athlete safety. High surface temperatures on turf fields can increase the risk of heat-related illnesses, burns, and dehydration, particularly in regions with extreme heat. This research highlights the need for heat reducing strategies, such as incorporating cooling technologies, using alternative materials, or increasing shaded areas around turf fields.

Comparing my findings with other studies reinforces the broader concern about artificial turf temperatures. Research from Brigham Young University and Penn State has documented extreme heat levels on turf surfaces, supporting my data and conclusions. However, further research could explore potential solutions, such as testing different types of artificial turf with improved cooling properties, examining the effects of watering turf surfaces to reduce heat, or investigating

the long-term impact of high turf temperatures on player performance and injury rates. Future studies could also extend this research by analyzing other environmental effects of artificial turf, such as its contribution to the urban heat island effect or its impact on surrounding air quality. Additionally, exploring the trade-offs between artificial and natural grass in terms of maintenance, water usage, and durability could provide a more balanced perspective for decision-makers considering turf installations.Overall, this study contributes to the growing body of evidence highlighting the heat-retaining properties of artificial turf and its potential hazards. Further research is necessary to explore effective ways to lower these risks and develop safer alternatives for athletic and recreational spaces.

Acknowledgments

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