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Athletic Turf as a Risk to Public Health

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As of January 2017, there were more than 12,000 synthetic turf playing fields being put to use in the United States (Howard 2017). An alarming statistic is the number of soccer players and other athletes who use these synthetic turf surfaces reporting incidences of cancer (Gutierrez 2016). This trend was first brought to light in 2009, when the University of Washington's women's soccer coach, Amy Griffin, recorded a list of 53 players who had developed lymphomas or related cancers in a short time span (Howard 2017). This list sparked a number of investigations by major organizations attempting to establish a link between turf fields and cancer. These agencies included state health departments and the Center for Disease Control. The topic was even able to capture the attention of the sports world itself, getting air time on ESPN. Currently, it is still unclear whether the turf fields are causing this spike in lymphoma cases, or if there is another culprit. The goal of this review is to investigate the available studies relating to synthetic turf fields and cancer. Findings from these studies may help determine the necessity for further concern or research regarding the topic, ultimately affecting whether or not these fields continue to be used in the future.

Methods

I conducted my research on several scientific databases, including Scopus, PubMed, and Web of Science. These databases were selected based on the subject matter that they encompass, as each is focused on biology, medicine, or public health. Within each database, search terms such as *turf*, *cancer*, *tire*, *rubber*, and *carcinogens* were used to identify relevant studies. These terms were selected based on the inference that cancer was the most prominent threat generated by these turf fields (as indicated by Amy Griffin's list), and that it was specifically the crumb rubber component, often from recycled tires, that was implicated. Articles discovered through this search were then evaluated further, and the ones selected were those that provided

significant insight into the risks that synthetic turf playing surfaces pose to human health as a result of exposure and those that analyzed the carcinogenic risk of turf materials. These final results are the studies that will be analyzed in this review to try to truly understand the potential risks (if any) that artificial turf playing surfaces pose to the public.

Investigating Turf's Risk to Public Health

Population Studies

After the emergence of Coach Cathy Griffin's list in 2009, it was clear to most public health experts what the next logical step had to be: to determine whether or not there was a statistical correlation between soccer players of this age group and elevated cancer incidence. The Washington State Health Department (WSHD), along with help from the university's School of Public Health, launched an investigation to assess whether or not Coach Griffin's report warranted further public health response. The researchers emphasized they were not trying to diagnose what caused these individuals' cancers, nor were they assessing the danger of turf surfaces to those who use them. They were attempting to determine if these cases qualified as a cluster, or a higher than expected number of the same type of cancer in the same area at the same time (Weisman and Lofy 2017).

The outcome of this study differed from the expectations of Coach Griffin and many others involved. The number of soccer players with cancer from the selected age group (6-24 years old) was far less than expected compared to the cancer rates in this age group from the entire state's population. The scope of this study was limited; the goal was not to pinpoint a cause for the seemingly increased case numbers nor to cite crumb rubber as a potential harm to soccer players. The researchers were simply comparing numbers to figures that would be indicative of a public health emergency. Also, they stated in their report that it is likely that not

all of the cases that would have fallen under their case definition (age group, cancer incidence, participation in soccer) were included. This could be the result of people not yet being diagnosed or even individuals simply electing not to take part in the study. However, with the distinct results produced, the authors stated that they would have had to miss hundreds of individuals for there to be any significant impact on the study.

A few things could be taken away from this particular study in regards to its importance for public health. First of all, the lack of a correlation between the number of cases and use of the turf fields suggests that a conclusion cannot be made regarding the role that these fields play in development of cancer in soccer players. The lack of association between these two variables actually opens up the possibility for something outside the scope of this review: that the physical activity being performed by these players is actually reducing their risk for cancer. The second general takeaway from this study is that more research needs to be done.

This was far from the only study looking into this puzzling inflation in the number of cases. Dr. Archie Bleyer from Oregon Health and Science University and Dr. Theresa Keegan from the University of California Davis Comprehensive Cancer Center conducted an analysis with the null hypothesis similar to that of the WSHD's initial study, that "regions in the U.S. with a higher prevalence of synthetic turf fields have had an increasing and higher incidence of lymphoma among adolescents and young adults" (Bleyer and Keegan 2017). They elected to focus their study on the 18 states in which the National Cancer Institute's Surveillance, Epidemiology, and End Results Program registries closely monitor cancer incidence rates by race/ethnicity and socioeconomic status, as well as on the counties within the state of California, due to accurate statistics on the current number of turf fields present at the time of the study, the county-level incidences of cancer since 2000, and the races and ethnicities of people within these

counties (a factor that is relevant because the type of cancer implicated is known to be race/ethnicity dependent).

The authors found in their research that neither in these 18 states nor in the counties of California studied could a link between installation of turf fields and prevalence of lymphoma amongst older adolescents and young adults be established. This data supports the claim made by the WSHD in their investigation, but Bleyer and Keegan went on to suggest that if such an increase in lymphoma cases were present, it would likely be due to the race/ethnicity or socioeconomic status of the individuals, not the fields. This is based on the fact that turf fields are more likely to be installed in regions with higher numbers of non-Hispanic white individuals of higher socioeconomic status, where the community can afford to install these fields. This would produce a false-positive correlation since the disease is heavily dependent upon race/ethnicity; locations with higher proportions of people of Caucasian descent would naturally have a higher incidence rate, and these locations would also have higher numbers of turf fields, but the two are unrelated. Though this concurrent data would seem like a bit of a relief to both researchers and the general public, the investigation into turf fields could not stop here. Something was causing these players to develop cancer, and the suddenness and frequency of the cases was too high to be ignored. It was clear that more analysis was needed regarding these fields' potential impacts on public health. An analysis of the components of the crumb rubber itself was the next logical step.

Toxic Potential of Crumb Rubber

As the population studies alone provided no concrete explanation as to the cause of the increased incidence of cancer among these soccer players, I turned my focus to the research done on the nature of the crumb rubber itself. Crumb rubber has long been implicated as a potential

hazard to human health. As far back as 40 years ago, researchers questioned the carcinogenic capacity of rubber additives such as N-methyl-N,4-dinitrosoaniline; N,N dinitrosopentamethylenetetramine; N-nitrosodiphenylamine; and others (Boyland et al. 1968).

Over the years, the composition of rubber has been altered, but so have concerns regarding its safety. The focus has now shifted to compounds like polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and several metals found within this crumb rubber. As Luz Claudio touches on in his review of this issue, 42 of 50 states have restrictions regarding the disposal of tires in landfills due to the risk of tire fires that would release these toxins into the air (Claudio 2008). He elaborates on this idea, referring to a paper submitted by the Norwegian Institute of Public Health and the Radium Hospital. In this paper, the authors demonstrated that these VOCs can be released by the turf in a form that could be breathed in by not only the athletes on the field, but also the onlookers watching the event (Norwegian Institute of Public Health and the Radium Hospital 2006). Although their study concluded that there was no evidence to indicate that exposure to these inhalants caused an elevated health risk, they noted that there was limited knowledge of the toxicological properties of these VOCs and that not all organic compounds present in venues that utilize these turf fields have been identified. This further highlights the need for more research to be done to fully understand the impact that this rubber could be having on the health of the public.

In a paper published in *Nature* in 2008, Zhang et al. attempted to provide some insight into the potency of some of the contaminants named by the Norwegian study. They looked at this issue in terms of bioaccessibility of these hazardous chemicals. Bioaccessibility is a measure of the ability of a compound to be absorbed into the body via ingestion, inhalation, or dermal contact. In this paper, the authors specifically studied the ingestion route. Also within this article,

the authors explored the risk of potentially harmful lead concentrations found in the plastic polyethylene grass fibers, a concern that was first brought forth by a 2008 New Jersey Department of Health and Senior Services (NJDHSS) report. From this analysis of lead concentrations in grass fibers, they found lead levels to be low relative to the study conducted on the old AstroTurf materials studied by the NJDHSS. However, they do note that "some health scientists believe that *any* Pb is harmful to children's neurocognitive development, and that *no* new Pb should be added to their surroundings." The authors also found that levels of chromium, cadmium, and arsenic were present in concentrations that fell below standards set by the New York Department of Environmental Conservation (NYDEC) despite the fact that only arsenic levels seemed to diminish over time. This suggests that all of these metals pose a minimal threat to the health of individuals exposed to the crumb rubber on synthetic turf playing fields.

Finally, in their analysis of the bioaccessibility of the hazardous compounds via ingestion, the authors provide several notable findings. The first of these refers to the contents of PAHs in the rubber granules. They discovered that the concentrations of PAHs appeared to decrease with the age of the turf field (similar to the levels of arsenic). However, they also remark that these fields regularly have their rubber granules refilled due to portions being lost from runoff, degradation, and tracking away by humans. This would continually reintroduce PAHs into the turf field. The authors also found that when compared to the limit set by the NYDEC, a majority of their samples contained PAH concentrations at levels that would qualify as hazardous enough in soil to require the removal of the soil from residential sites. The authors went on to explain that all of these PAHs that were found at or above safety limits in their samples are known, probable, or possible human carcinogens as defined by the International Agency for Research on Cancer. All of these findings combined appear concerning without

considering the results from their bioaccessibility simulation. From these simulations they were able to deduce that absorption of these contaminants by way of ingestion is rather unlikely, with many of the bioaccessibility numbers falling below detection limits, or less than 3%. This indicates that although the actual contents of the rubber component of turf fields are harmful and largely carcinogenic, it should not necessarily raise concern as these contaminants cannot enter the body's vital systems where they would cause harm. Zhang et al. did mention that their study has one key limitation: "the human digestive tract is not as simple as a glass vessel containing synthetic biofluids. Its surfaces contain lipids that can enhance the absorption of lipophilic PAHs. Once ingested, PAHs in rubber granules would interact with foods, which may increase PAHs bioavailability." This falls in line with any biological experiment that is performed in an environment that is not the actual human body. It is hard to account for the many variables that come into play in the human body, so even these somewhat reassuring results must not be taken as absolute proof that crumb rubber is effectively harmless to humans.

The authors of a similar article do attempt to build on this argument as they explore the two alternate means of exposure not studied by Zhang et al. In their piece, Pavilonis and his co-authors consider bioaccessibility via all three methods, including dermal contact and inhalation. The authors performed experiments that parallel those performed by the authors of the *Nature* article, but this time with the addition of synthetic sweat and lung biofluids (Pavilonis et al. 2013). The data from this study shows that PAHs were found at levels below the limit of detection in all three biofluids and even appear to be lower than the concentrations found by Zhang et al. Semivolatile organic compounds were also found to be insignificant in regards to their risks for long term exposure despite two of them being detected at significant levels in sweat and lung extracts. The lack of concern arises from the fact that one of them, butylated

hydroxytoluene (BHT), has few adverse toxicological effects and is even found in cosmetics and as a food additive. The other, 4-tert-ocyl phenol, is a compound that is not regulated or even present in the toxicological databases searched. Lastly, when it came to metals, the authors also found that there was little to no risk from exposure. Despite metals being detected in the biofluid samples, the risk levels fell below EPA criteria. The authors even went as far as to calculate cancer risk for the metals that had a known cancer slope factor (arsenic, cadmium, chromium, and lead), and for each metal the risk of cancer from exposure to these metal compounds was less than 1 in 1,000,000. These results concurred with those of Zhang et al. and provided even further validity to the idea that, though harmful in nature, the contaminants cited have minimal destructive potential due to their inability to access the body's systems and cause any actual harm.

Discussion

The purpose of this review was to explore the existing literature in an attempt to better understand the debate around the safety of the continued use of synthetic turf playing fields by the public. Prior to my review, it appeared unclear whether or not the scientific community had come to a distinct conclusion regarding this issue, an issue that is relevant to anyone who has children who are exposed to these turf fields or those who utilize these fields themselves. This issue became especially pertinent when Coach Amy Griffin linked these turf fields to cancer. However, with the results found in my research on the topic, it appears that, for the most part, these concerns can be alleviated.

From the population studies reviewed, both yielded results that indicate turf fields do not represent a significant danger to human health in the way that Coach Griffin's list would lead one to believe. Weisman and Lofy's 2017 study with the WSHD showed that within the state of

Washington, the number of soccer players who reported developing cancer was not significantly higher than in the general population. In fact, there were actually fewer than expected cases of cancer in this group when compared with all other citizens of Washington in the same age group. This data was supported by the findings of the other population study that was cited from the state of California. In that paper, the authors' data demonstrates that in states and counties with higher numbers of turf fields installed, there was no correlation to the number of reported cases of lymphoma (Bleyer and Keegan 2017). Together these reports indicated that there was likely no link between synthetic turf playing surfaces and cancer incidence. However, these studies did not completely absolve these fields from potential culpability as there was still the question of whether or not the components of the fields could indeed represent potential hazards to human health.

The studies that analyzed the crumb rubber component of these fields also yielded somewhat surprising results. Knowing the toxicological history of rubber, it may seem logical that it would be cited as a health hazard, especially with consistent or repeated exposure that many of these soccer players likely experienced. However, despite the carcinogenic nature of the chemicals within the recycled tire rubber, there appears to be no threat. As both papers reveal, this lack of danger stems from the fact that these compounds are unable to enter the body, whether from ingestion, inhalation, or direct dermal contact (Pavilonis et al. 2013). The authors tested these chemicals' carcinogenicity in the concentrations they found present in the field components and found that the odds of developing cancer were as small as 1 in 1,000,000.

Despite all of these "positive" results, though, it would still be erroneous to completely assume that these synthetic turf fields are 100% safe. The authors themselves even stated several limitations to their findings. As far as the population studies are concerned, there is almost

always the chance that not all of the data was accurately reported and that not all data was included. There is also the potential for external factors affecting the data, as the authors of the California study noted. Then, with the toxicological studies, the authors noted that it is unlikely that studies performed in simulated environments of the human body translate perfectly to actual body conditions. These limitations were mentioned in hopes of illustrating the idea that this conversation is likely far from finished. As with any public health issue, the scientific community cannot afford to rest at the first sign of a resolution. Though the data seems clear in suggesting that turf fields produce a minimal threat to health, it is important that biologists remain ever vigilant in the search for the truth. Some unknown factor led to an increase in cancer incidence enough for Coach Griffin to feel the need to compile her list in 2009. The data compiled up to this point may not be able to explain exactly what it was, but that is precisely the reason that more research must still be done until it can be conclusively said that there is no link between synthetic turf playing fields and cancer.

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