Sports Turf Alternatives Assessment: Preliminary Results
PHYSICAL AND BIOLOGICAL HAZARDS

Massachusetts Toxics Use Reduction Institute
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Introduction

The Massachusetts Toxics Use Reduction Institute (TURI) conducts alternatives assessments as part of its overall mission to help Massachusetts companies, communities, and municipalities identify and implement toxics use reduction options that will provide safer solutions to the use of toxic chemicals.

TURI has received numerous requests for information about artificial turf fields as an alternative to natural grass fields. In response, TURI is developing an alternatives assessment for sports turf. Preliminary sections of the assessment are being published in the order in which they are developed.

The section presented here covers physical and biological hazards associated with natural and synthetic turf options. It includes a discussion of heat, injuries, and skin infections. Information for this section has been drawn from peer reviewed literature and industry publications among other resources. This information may be updated over time as new information becomes available.

Heat

In sunny, warm weather, artificial turf can become much hotter than natural grass, raising concerns related to heat stress for athletes playing on the fields. Research indicates that all synthetic turf reaches higher temperatures than natural grass, regardless of the infill materials. Elevated temperatures can damage equipment and burn skin, as well as increasing the risk of heat-related illness.

The issue of elevated temperatures on artificial playing surfaces has been studied and documented since the 1970s. This discussion focuses on a sampling of relatively recent studies.

A 2009 report by the New York State Department of Environmental Conservation compared conditions on four playing surfaces: two synthetic, one grass, and one sand (baseball diamond). The synthetic surface was an average of 35^{o} F to 42^{o} F hotter than grass, and 26^{o} F to 40^{o} F hotter than sand. The authors noted that a greater potential for heat stress might exist for players on the synthetic surfaces (NYSDEC 2009).

A 2008 study compared natural grass with adjacent synthetic turf. The researchers measured temperatures at two elevations directly over the surfaces. They also took separate measurements of the temperature of the crumb rubber and the polyethylene and polypropylene blended fibers used to simulate grass. Measurements were also taken below the surface of the natural fields. The results confirmed that solar heating of the materials does occur. More specifically, the study

determined that the heating is most pronounced in the artificial grass (polyethylene and polypropylene) fibers themselves. Temperatures of 156° F were noted under direct sunlight for the fibers, while 101° F, or approximately 16 degrees greater than the observed ambient air temperature, was noted for the crumb rubber (Milone & MacBroom 2008).

Measurements taken at an artificial turf field at Brigham Young University provide additional information. Williams and Pulley reported that the surface temperature of the synthetic turf was 37° F higher than asphalt and 86.5° F hotter than natural turf. The hottest surface temperature recorded during the study was 200° F on a 98° F day. Even in October, the surface temperature reached 112.4° F, which was 32.4° F higher than the air temperature. It was also observed that the white lines and shaded areas of the field were less affected because of reflection and intensity of light (Williams & Pulley 2004). One other study found that the highest surface temperature measured on natural grass was 60.3°F cooler than the highest temperature measured on the synthetic turf (CSSR 2015).

Effect of infill type and color. Research indicates that all synthetic turf reaches higher temperatures than natural grass, regardless of the infill materials; however, choice of infill can lead to some variations in the amount of excess heat. Some studies indicate that temperature differences among synthetic turf options are insignificant, while others suggest there may be important differences among them.

A 2012 report by Penn State's Center for Sports Surface Research compared differing colors of fiber and infill under varying conditions. The results showed that no product in the test substantially reduced surface temperatures compared to the traditional system of green fibers filled with black rubber (CSSR 2012). The test did not include plant-based infill materials.

An Australian study presented at the 2014 conference of the International Sports Engineering Association found that surface temperatures of differing synthetic turf plots vary when exposed to the same environmental conditions. The study found that infill, shockpad and tuft gauge can all have an effect on the amount of heating that occurs. The study measured lower temperatures for fields with TPE infill than for those with SBR or plant-based infill. (Petrass 2014)

Weather conditions affecting temperature. Surface temperatures tend to be highest during clear, sunny conditions. A clear sunny day will produce higher surface temperatures than a hazy, humid day with higher air temperatures and filtered sunlight (CSSR 2012).

Irrigation. Irrigation is used as a means to reduce surface temperatures on synthetic turf temporarily. For institutions hoping to reduce water use through installation of artificial turf fields, it is particularly important to plan accurately for irrigation.

In 2015, researchers at Penn State's Center for Sports Surface Research investigated the effect of irrigation on artificial turf. That same study concluded that frequent, heavy irrigation (0.75") is the most effective regime for irrigating synthetic turf for surface temperature reduction. However, surface temperatures rebounded quickly (CSSR 2015).

It also had been noted in 2008 that applied water provided at least 20 minutes of effective cooling to synthetic fibers. The amount of cooling was generally between 10 and 20 degrees (Milone & MacBroom 2008).

Various irrigation and tarping regimes were studied on their reduction of surface temperatures on fields in Pennsylvania. Several regimes did reduce temperatures, but the low temperatures could not be maintained for the length of any standard sporting event. However, synthetic surfaces receiving irrigation did measure lower in surface temperature after three hours compared to unirrigated synthetic surfaces (McNitt et al., n.d.).

The group at Brigham Young University also studied cooling techniques during their 2002 research. They found that irrigation of the synthetic turf had a significant result cooling the surface from 174^{o} F to 85^{o} F. However, the temperature rebounded to 120^{o}F after five minutes, and to 164^{o}F minutes later (Williams & Pulley 2004).

Heat Injuries. As noted above, exposure to excessive heat can lead to heat stress and skin injuries.

A 2002 report noted that a coach at Brigham and Young University's football practice field where synthetic turf had been installed developed blisters on the bottom of his feet through his tennis shoes (Williams & Pulley 2002). More recently on the east coast, high schools have had an issue with excessive heat and injuries. In 2015, players on the Stratford CT High School football team were blistered and burned through contact with the artificial turf field in late summer (NBC Connecticut 2015). In 2016, more than a dozen (out of over 90) players received blisters and "turf burns" during a practice on their artificial turf field (Framingham Source 2016).

The American Academy of Pediatrics has issued guidance on climate heat stress and its impacts on children and adolescents exercising. Their Committee on Sports Medicine and Fitness states that a wet bulb globe temperature (WBGT – which monitors humidity, radiation, and air temperature) of >85^{o}F warrants the cancellation of all athletic activities (AAP 2000).

Heat-related illness can be a life-threatening emergency. Experts note that athletic coaches and other staff need to be educated about heat-related illness and understand how to prevent it, including cancelling sport activities when appropriate (Howe and Boden 2007; Johns Hopkins Medicine 2016; CoachSafely 2016).

Injury

Sports-related injuries are a significant burden on the health care system, with the annual cost of treating injuries among U.S. high school athletes alone estimated to be greater than $2 billion per year (Goldberg et al. 2007). Injury rates can be affected by a variety of factors, including the type and condition of the playing surface as well as equipment used and type and level of sport. Studies show variable outcomes in the rates and types of injuries experienced by athletes playing on natural and on artificial turf.

A review of recent studies suggests that there are many variables that affect injuries – not only the type and condition of the playing surface, but also the shoes and other equipment used, type and level of sport, and environmental conditions. The generation of turf examined in each study may also affect results. One recent study concluded that the overall rate of injury on third-generation turf surfaces is similar to that of natural grass, despite differences in injury types (Dragoo & Braun 2010).

The types of injuries sustained by athletes playing on synthetic and natural turf vary due to the different physical characteristics of the surfaces. One prospective cohort study examined patterns of injury among football players playing on synthetic turf with a sand/crumb rubber infill, compared with those playing on natural grass. The study found increased incidence of injuries over all, but decreased incidence of the most serious subset of injuries, associated with playing football on synthetic versus natural turf (Meyers & Barnhill 2004).

NFL Opinion Survey. A 2010 opinion survey by the National Football League (NFL) evaluated the subjective experience of NFL players. Related to injury, over 80% of the respondents believed that an artificial infill surface is more likely to contribute to injury. The related issues of soreness and fatigue were also evaluated and over 89% indicated an artificial infill surface is more likely to cause soreness and fatigue (NFL Players Association 2010). Limitations of this study include its focus on an elite group of players for a single sport, and the fact that it is based strictly on statements of opinion.

Structural injuries. A 2012 review of studies concluded that it is unclear how the trend of increased use of artificial turf affects the health and safety of the players. Biomechanical studies indicate that the shoe-surface interface has a significant impact on the incidence and type of sports-related injury. These studies suggest that the amount of torque and resulting strain generated when playing on artificial surfaces is greater than that generated when playing on natural grass. The clinical literature, however, presents a more complicated picture because of the many confounding variables. Recent studies also suggest a possible correlation between the incidence of injury and the level of play (elite versus amateur) (Taylor et al. 2012).

A Michigan State University (MSU) study published in 2008 found that grass fields hold less potential for structural injury than synthetic turf fields. MSU studied the effects that size and structure of infill materials would have on the rotational resistance of cleated shoes. Results found that torque was significantly affected by field surface. Native soil reported the lowest torque overall (Villwock 2008). In contrast, a 2014 study by the Penn State Center for Sports Surface Research found that "shoe selection has a greater influence on rotational traction and potentially lower extremity injury risk," and that field surface played a less important role. (Serensits and McNitt 2014)

A 2005-2006 study of soccer players found no significant differences between male and female players in the overall incidence of game injury on grass or artificial turf. A significantly higher incidence of head and neck injuries was observed for men on artificial turf, though none of these were caused by player-surface contact. In contrast, the incidence of ankle sprains in women was significantly lower on artificial turf than on grass (Fuller et al. 2007).

A 2010 review of research concluded that overall injury incidence does not differ between the two surfaces. However, the review found that ankle injuries, abrasions, and concussions resulting from player-to-player contact occur more often on artificial turf, while there was a higher incidence of knee injuries on natural grass. Muscle strains and chronic pain complaints were found to occur more often on artificial turf, although the increased risk was not statistically significant. (Wright & Webner 2010).

A research review of the risk of ACL injuries concluded that high-quality studies supported an increased rate of ACL injury on synthetic playing surfaces in football, but no apparent increased risk in soccer (Balazs 2014). This study included both earlier-generation and modern, third-generation surfaces.

Skin abrasions. Athletes playing on synthetic turf have increased risk of skin abrasions compared with those playing on natural turf (Meyers & Barnhill 2004). The incidence of laceration or skin lesions was significantly higher for men on artificial turf in a 2005-2006 study of soccer players. (Fuller et al 2007) A CalRecycle report from 2010 comes to the same conclusion: abrasion rates were approximately two- to three-fold higher on artificial turf compared to natural turf in their study. Abrasion seriousness was similar on the two surfaces (CalRecycle 2010).

There are many factors that make the research on skin abrasions difficult to interpret. The type of sport being played on the surface, as well as the weather, footwear, field conditions, and dynamics of the players themselves all play a role.

A comprehensive list of many studies related to injuries on synthetic turf can be found on the website of the Penn State Sports Surface Research Center (Penn State 2016).

Skin Infection

This section of the report looks at the issue of infections for athletes and summarizes current research on the role of playing surface on the rate and spread of infections.

Staphylococcus aureus is a bacterium that is a commonly found on human skin and can cause various infections. Some strains of this bacterium that are resistant to common antibiotics are becoming more common – including in athletes. *Methicillin-resistant S. aureus* or MRSA is an infection of particular concern. This is leading to increased concern over synthetic turf infills and their potential role in transferring the bacteria (McNitt et al. 2008).

It is often a manufacturer's recommendation that regular application of antibacterial treatments take place on synthetic turf. Synthetic turf needs to be disinfected and decontaminated when bodily fluids such as blood or vomit are present. However, according to a California study, such efforts may have little effect given the lower numbers of bacteria detected on artificial turf relative to natural turf and the literature suggesting that body-to-body contact is the primary mode of MRSA transmission. (OEHHA 2010).

A 2011 Pennsylvania State University study concluded, after surveying 20 synthetic turf fields, that *S. aureus* colonies were not found to be present on any field; however, *S. aureus* colonies

were found on other tested surfaces, including blocking pads, used towels, and weight equipment. It also was noted that the abrasive surface of the synthetic turf can break the skin more easily, creating a pathway for infection if exposed (Serensits 2011).

In 2010 CalRecycles commissioned a report through their Office of Environmental Health Hazard Assessment and concluded that bacterial population including the family of *Staphylococci* was significantly smaller on artificial turf fields compared to natural turf fields. Considering the data collected in the study on *Staphylococci* and MRSA, it is likely that artificial turf harbors fewer of these bacteria than natural turf, making fewer available for transmission to athletes during field use. However, other characteristics of artificial turf, such as abrasiveness, may influence the frequency of bacterial infections in athletes using these fields (CalRecycle 2010).

In 2008, the Pennsylvania State University conducted a survey for the presence of *S. aureus* in synthetic turf infill. The results showed generally lower numbers of total microbes present in the infill or fibers of the synthetic turf systems tested compared to natural turfgrass root zones, and *S. aureus* was not found on any of the playing surfaces. It was noted in the survey, however, that microbes were present on most surfaces that humans come into contact with and the presence of microbes alone should not be cause for concern. In fact, higher microbial populations actually were considered healthier for natural grass fields. It also was noted that *S. aureus* was not found on any playing surface, since the outdoor temperatures on the playing surfaces tended to exceed the optimal growth temperature for the bacterium (McNitt et al. 2008).

A 2005 study examined an outbreak of MRSA that occurred among members of a professional football team in Missouri in 2003. MRSA was found on the turf, and all abscesses developed at the site of turf burns on the athletes. The authors note that the turf burns are one important factor that "could have facilitated the spread" of the infection (Kasakova et al. 2005). In a study in 2004 of college football players, it was found that those who experienced abrasions as a result of playing on artificial turf were seven more times more likely to have a MRSA infection than those who did not suffer an abrasion (Beiger et al. 2004).

Summary

In summary, it is important to consider physical and biological hazards when making decisions about playing surfaces.

Synthetic turf fields clearly introduce hazards related to heat. For this reason, institutions choosing to install synthetic turf need to plan carefully for heat-related closures, training for sports personnel, irrigation, and other measures to protect players from heat injury.

Regarding injuries, the evidence is mixed. A variety of factors can affect players' injury rates and the specific types and severity of injuries they experience. Institutions should be aware of both the advantages and the disadvantages of any playing surface.

Synthetic turf clearly increases risk of skin abrasions. In any case in which players develop skin abrasions, it is important to be aware of the risk of serious skin infections and to ensure sports personnel are trained to act quickly to address any infection outbreaks.

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The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs and provides technical support to help Massachusetts companies and communities to reduce the use of toxic chemicals.

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