

# Artificial turf

## literature review

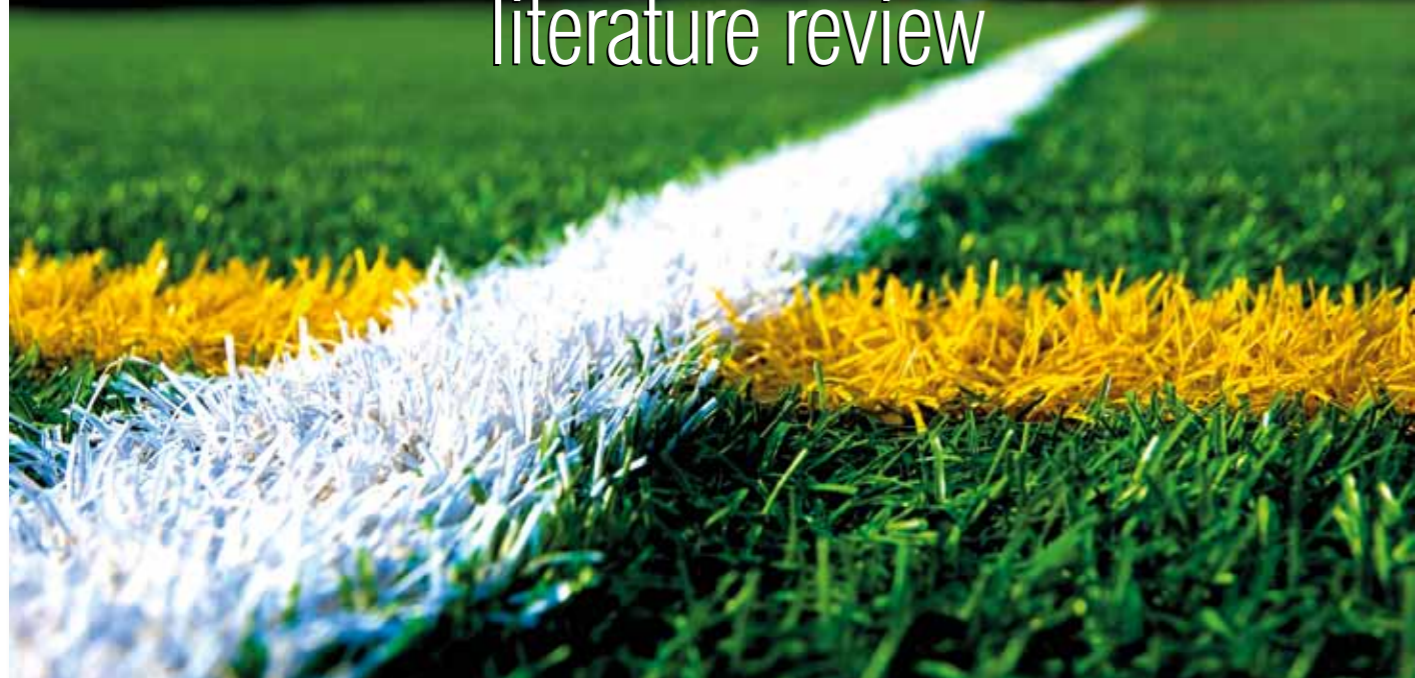


PHOTO: GETTY IMAGES

Throughout 2010 the University of NSW undertook a Horticulture Australia Limited funded project examining peer-reviewed literature on the development, use and issues surrounding artificial turf playing surfaces. Research project leader Dr Gavin Edwards provides a summary of the project.

The provision of a first class playing surface is one of the major challenges facing groundskeepers worldwide. Imperfect climatic conditions can play havoc with preparation and maintenance, and high-demand sports such as soccer can cause a well-prepared grass surface to wear quickly, especially in high-traffic areas such as the midfield and the goal areas.

Over the past 50 years, providers of natural grass surfaces have faced increasing competition from the artificial turf industry. While the original artificial turf surfaces were often manufactured from relatively short nylon fibres and were quite unforgiving, the 'third generation' surfaces now available typically have longer fibres (>40mm) which look like longer blades of 'grass', and are manufactured from polymers that can be engineered to give a softer feel, normally polypropylene or polyethylene.

The 'third generation' surfaces also incorporate subsurface shock pads and crumb rubber or sand infill material to ensure the artificial blades stand erect; crumb rubber infill also enhances the shock absorbency of the surface. Artificial turf has now been used for sports as varied as soccer, American football, tennis, hockey, and rugby union, to name a few.

### INJURY RATES

The inherently different nature of artificial turf, compared with natural grass, has raised questions about the relative merits of each surface. While for many years it was accepted that playing sports on artificial turf resulted in more injuries than equivalent

play on natural grass, advances in technology and the availability of 'third generation' synthetic surfaces are blurring the distinctions.

Some relatively long-term studies have highlighted different injury rates on artificial turf versus natural grass and there has not always been agreement between the studies, in part because of the very different demands on surfaces and athletes and the variation in surface types.

There are many variations in artificial surfaces, with even 'third generation' surfaces having considerable differences in their construction; likewise, natural grass surfaces can vary dramatically in quality. Nonetheless, while some studies have reached different conclusions, the general picture shows that a higher rate of injuries occurred on the earlier versions of artificial turf, often resulting from their more primitive construction where they had a poorer ability to absorb impact and the grass 'blades' were constructed from harder polymers.

Third generation surfaces show improved performance because of subsurface shock pads and crumb rubber infill, and this is important in reducing the risk of mild traumatic head injury; one disadvantage of excessive cushioning is that high-speed play becomes more arduous, and players either tire more quickly, or other injuries can potentially develop.

One research group suggested that the more uniform nature of artificial turf actually encourages faster play and this, combined with the higher level of cushioning in some artificial surfaces, can increase injuries resulting from fatigue and

overextension. Despite the technological advances in cushioning, compaction or loss of the infill through time can lessen the cushioning effect and result in a harder surface; in some cases, FIFA Two-Star rated soccer pitches were shown not to measure up to specifications after the passage of time, possibly due to loss of infill.

Injury patterns can vary dramatically between sports and, even within a particular sporting code, significant differences have been observed depending on skill levels or the gender of the players. Contact sports that require rapid acceleration and deceleration and turns, and also result in heavy impact with the playing surface, such as American football, have shown increases in lower limb and head and neck injuries on artificial turf. More lower limb injuries, especially ankle injuries, were also seen in soccer. Poor choice of footwear may be a significant contributing factor, with different types of footwear being developed for the different surfaces.

However, especially on more modern surfaces, the overall injury rates are quite similar even if the types of injury do differ compared with natural grass. One interesting observation is that injury rates can be significantly higher when players change frequently between surfaces because of the different biomechanical demands of the surfaces; if players regularly train and compete on a single surface type, they adapt and injury rates are lower.

While there is no consistent trend in number or type of most injuries observed on artificial turf versus natural grass, there are two unique injuries that are worthy of note. The occurrence of a type of sprain that typically occurs to the large toe (called 'turf toe') has seen a dramatic increase since the introduction of artificial surfaces.

Another injury more commonly seen on artificial turf is an abrasive burn known as a turf burn; its unique characteristics result from a combination of the abrasiveness of the artificial surface and the heat that generates from the friction. Serious turf burns have been proposed as a unique entry point for infective agents, and more stringent infection control measures are recommended. Recent advances in artificial turf construction with the introduction of softer polymers for the grass 'blades' is lessening the severity of turf burns.

The effect of the surface on a particular sport is one factor that has received some attention. The more uniform nature of artificial turf can provide for more uniform and predictable behaviour in factors such as ball roll and bounce, as well as the interaction of a player's foot with the surface.

Pressures on a player's foot can differ depending on the surface, and some artificial surfaces can provide added rotational resistance when a player turns; this could result in higher levels of ankle and knee injuries. Some studies have shown that the nature of a soccer game actually changes subtly on artificial turf, with fewer sliding tackles or long passes, for instance.

### SURFACE COMPOSITION

The synthetic nature of artificial turf has given rise to concerns about possible toxic effects from some of the chemical components in the surface. Certainly, older artificial fields have faced problems with lead and chromium contamination, due to the high levels of lead chromate used to colour the artificial grass blades. This has led to intensive research to reduce or eliminate the need for lead.

One of the more ongoing sources of concern is the crumb rubber used as infill. This crumb rubber is usually manufactured from recycled car tyres, often by a cryogenic process that involves freezing, shredding and grinding of the tyres to produce small, relatively uniform granules. The origin of the crumb – old car tyres – has led to significant concern not just because of the chemical composition of the tyres, but also the potential for the tyres to have picked up other contaminants in their lifetime.

In addition to the relatively inert polymer matrix, tyres are manufactured containing metals that are used in the production process such as zinc, calcium and magnesium; crumb rubber has also been shown to contain trace amounts of more problematic heavy metals such as lead, chromium, arsenic and cadmium.

Tyres and, by extrapolation crumb rubber, can also contain vulcanisation accelerants and a range of other relatively volatile organic compounds including polycyclic aromatic hydrocarbons (PAHs). Most concern has centred on the PAHs, some of which are known carcinogens. One possible problem is that artificial turf fields, when exposed to the elements, will produce runoff containing both organic contaminants and metals, potentially having

Opposite page: Artificial turf has now been used for sports as varied as soccer, American football, tennis, hockey, and rugby union

## TALKING ABOUT THE GENERATIONS

Rigid and unequivocal definitions for each 'generation' of artificial turf are often difficult to determine, as various manufacturers have developed products with quite different features. The following are broad definitions of the different generations of artificial turf surfaces since their first appearance in the 1960s.

**First generation:** As the name suggests, this term relates to the first styles of artificial turf, typified by the product introduced as Chemgrass and later renamed AstroTurf in the 1960s. First generation turf was constructed of short, relatively hard and stiff 'blades', often with no in-fill. While some authors claim that the first generation were made from polypropylene, it is generally accepted that the first artificial surfaces were manufactured from nylon. Interestingly, some authors do state that some first generation pitches had sand as in-fill.

**Second generation:** This product generally saw the introduction of infill, or material that was placed between the (still relatively short) artificial fibres. The fibres were somewhat softer than first generation fibres, manufactured from polypropylene. The infill most often used in second generation surfaces was sand, and a problem that was observed was that the infill was readily compacted.

**Third generation:** The currently-available artificial surfaces are frequently referred to as 'third generation'. They typically involve longer fibres (>40mm), giving the appearance of longer blades of 'grass', and they are manufactured from either polypropylene or (preferably) polyethylene, giving a softer feel. Additionally, they are carefully engineered, with subsurface shock pads and significant infill material that is either sand, or (more usually) rubber, or both.



higher levels of zinc were detected in runoff from older samples; the reason for this is not known. Research is being undertaken to determine if pre-leaching contaminants from crumb rubber, or coating the granules with an inert polymer, is a viable approach to improve the safety of these materials. Nonetheless while more research is warranted, based on the available evidence fears over the toxicological safety of artificial turf appear to be unfounded.

### PLAYER PERCEPTION

Players' perceptions of artificial surfaces, and their preference for one type of surface over another, are interesting. While solid research is limited, most player surveys show a definite preference for natural grass. Players believe injuries are more prevalent on artificial turf, and more effort is needed to play on artificial surfaces, both in terms of execution of skilled manoeuvres and onset of fatigue. Fear of abrasive turf burns is one factor that is believed to contribute to the preference.

These opinions are no doubt dependent on the quality of the natural grass surface; in an Italian study where soccer players compete on fields that are little more than compacted earth, a definite preference for artificial turf was noted.

One undeniable difference is that artificial surfaces, in hot weather, get much hotter than natural grass. The desire to produce rich, natural-looking dark green artificial grass means that the blades, as well as the black crumb rubber infill, absorb light energy and radiate it back as heat.

Especially on sunny days, the difference in surface temperatures between an artificial surface and a neighbouring natural grass one can be staggering: artificial turf can be up to 40°C hotter. While this heat effect does depend on the type of artificial turf, all commercial products result in elevated temperatures.

As expected, applying water to the surface can lower the temperature, but this result is temporary; within a few minutes the temperature starts to rebound, though they do not return to the original

a negative impact on the surrounding environment if not properly managed.

The presence of potentially dangerous chemicals, while not ideal, is not necessarily an issue; to be a cause for concern, the chemicals must be absorbed into a living organism. Ordinarily, this means the chemicals must be swallowed, inhaled or absorbed through the skin. The likelihood that significant amounts of crumb rubber would be accidentally swallowed reduces any exposure via this route, minimising any bioavailability of PAHs by ingestion.

Inhalation and skin absorption were studied in football players; while slightly higher levels of a standard compound were observed in urine, the study's authors concluded that uptake of PAHs was within the range expected for normal, day-to-day activities.

One factor that complicates the picture is that many of these contaminants are lost over time, either by degradation or by loss to the environment. This suggests that any dangers of exposure are at their highest levels either soon after installation of a new artificial pitch, or immediately after periodic replenishment of the crumb rubber infill (the gradual loss of which seems to be unavoidable).

Certainly, volatile organic hydrocarbons outgas very rapidly, with levels falling dramatically within two weeks. The one exception was zinc, where

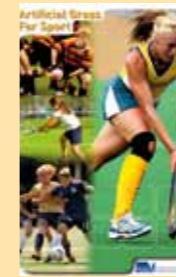
The 'third generation' surfaces also incorporate subsurface shock pads and crumb rubber or sand infill material to ensure the artificial blades stand erect

While for years it was accepted that playing sports on artificial turf resulted in more injuries than equivalent play on natural grass, advances in synthetic turf technology is blurring the distinction



## ARTIFICIAL GRASS FOR SPORT GUIDE

Sport and Recreation Victoria (SRV) has recently released a comprehensive guide for the use of artificial turf for sport. Titled Artificial Grass for Sport, SRV hopes that the guide will provide a key resource for sporting clubs, local councils, even schools set to undertake an artificial grass sports surface project.



The guide was commissioned in response to inadequate information and support for local councils, schools and their communities to plan for, select, and install new artificial grass surfaces. As a result SRV has consulted with the sports industry and has developed the 156-page report which provides an overview of artificial turf surfaces before looking at the specific issues of planning, design, project delivery, operational and maintenance issues.

The Artificial Grass for Sport guide is available for download through the Department of Planning and Community Development website [www.dpcd.vic.gov.au/sport/](http://www.dpcd.vic.gov.au/sport/)

levels within a reasonable period of time. While watering artificial surfaces does provide a potential solution to the issue of heat, in drought-prone Australia this is problematic.

Player preferences have shown, in general, that players prefer natural grass for their sporting endeavours, believing that artificial turf provides a less forgiving surface, resulting in more injuries, or less effective play. The picture is not always clear cut: when natural grass cover is minimal, perhaps from degradation by overuse, artificial turf can become the favoured surface.

While significant research has already been carried out on artificial turf, more remains to be discovered. In particular, as the industry develops newer generations of artificial surfaces, their impacts on players will need to be evaluated. However, before artificial surfaces become more accepted in Australia, issues such as the higher temperatures that inevitably develop must be addressed. It is likely, for the foreseeable future, natural grass will remain the surface of choice for many.

**Editor's Note: This research (Horticulture Australia Limited Project TU09037) was funded by the Turf Industry Levy with matching funding from the Australian Government. The full 38-page report can be obtained from Horticulture Australia Limited – [www.horticulture.com.au](http://www.horticulture.com.au). Full references for this research project are contained within the final report.**