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Living with artificial grass: A knowledge update

Part 2: Epidemiology

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ABSTRACT

Part 2 of our study evaluated the effect of artificial grass on the athletes that play on it. In this section we have reviewed the epidemiological studies that have evaluated the influence that artificial grass has on the frequency and site of injury to American football players. From this review we have concluded that play and practice on an artificial surface is probably responsible for an increase in the relative risk of injury to the lower extremity of the participants. However, it is evident that more well controlled studies are necessary to completely clarify this issue.

In 1968, Monsanto published a report suggesting that artificial turf protected the athlete from injury.[10] Since then, the topic has been vigorously debated.[9] Part 2 of this study (see the July/August issue for Part 1) presents a critical assessment of the epidemiological evidence published to date evaluating injuries to athletes while playing American football on artificial turf.

METHODOLOGICAL ISSUES

Ascertainment techniques

Several surveillance data bases have been developed for monitoring athletic injuries.[2, 11, 12, 14, 15] The large number of players monitored by these data bases allows for both stability of annual rates of injury and statistical power for subgroup analyses. The National Athletic Injury/Illness Reporting System (NAIRS) was established in 1974.[2, 5] It was used to collect data on injuries in high school and college sports. The National Football League (NFL) has collected data on football injuries since the 1969 season.[11, 12] The National Collegiate Athletic Association (NCAA) began collecting data on member-school football injuries in 1982 (unpublished data: Walsh U, Peter T, 1987; Zemper E, 1984).

The reporting of incidents and exposures in large-scale, nonspecific data bases relies on the staffs of many teams, and therefore may not be as well controlled as if it were monitored by a single group of trained researchers. Identification of a presence of risk for injury on artificial turf should arise from these surveillance data bases. Further, since the NCAA, NFL, and NAIRS data bases were established to monitor sports injuries in general, and not to test hypotheses about the role of playing surfaces in sports injuries, there is little reason to expect biased reporting with respect to playing surfaces. The problems of variability in reporting practices can be avoided by special studies, that is, a research team, supervised by the investigators that collects information on exposures, related important conditions, and injuries. Such studies are difficult to mount on the large scale necessary for reasonable statistical power to detect uncommon events. However, confirming the risk and exploring the conditions leading to injury on artificial turf in order to determine if preventive measures could be effective is the purview of special studies, and should follow from surveillance reports.

Reports that compare injury frequencies before and after the installation of artificial turf have questionable validity because any intercurrent change in coaching, training, equipment, practice, and game strategies may confound the comparison.[3, 6] An intrinsically better design is one in which experience on artificial surfaces is compared with contemporaneous experience on natural surfaces.

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Definitions of injury: The numerator. Several definitions of injury have been employed in the studies reviewed. Most commonly, an injury was defined as an acute event occurring during training or competition and resulting in time lost from practice or play.[a] Generally, severity of injury was defined by the amount of time lost due to the acute event. In some cases, it was defined by time requirements for medical or surgical intervention.

Definition of exposure: The denominator. It is generally recognized that a quantification of exposure to the playing surfaces is essential to the interpretation of injury risk. But definitions of exposure vary. Exposure may be quantified as team-seasons, categorized according to home field surface without regard to the number of players on a team, time spent playing, surfaces played on during away games, the number of games played, or the amount of practice on the same surface or other surfaces. This is roughly acceptable when numbers of practices and games, and team sizes are the same across the comparisons. However, this is rarely the case. A more precise definition, which allocates exposures separately to practice and competition and to surface, allows for examination of differentials in practice and competition injury risk, comparisons of risks associated with playing on surfaces different from the home surface, etc. More precision would result from quantifying exposure in minutes on the surface in question, allowing valid comparisons of the risks associated with playing different positions. Again, this is virtually impossible in the context of a surveillance data base, and quite difficult even in the context of a heavily supported special study.

Study design

Retrospective studies in which the exposures of injured and noninjured athletes are reconstructed are susceptible to biases of recall with respect to both injuries and exposures. Prospective studies (or surveillance reports), in which reporting occurs concurrently with events, represent a stronger design. Both of these designs are observational and suffer from the limitations that a team that plays on an artificial surface at home may have different play characteristics than a team that plays on natural grass at home. Ultimately these differences in play characteristics may be the real cause of any injury differential noted. Experimental or interventional studies are the strongest design for avoiding such confounding of interpretation of study results, but are rarely feasible in the context of athletic playing surfaces.

RESULTS OF STUDIES REPORTED TO DATE

Overall injury rates

The overall injury rate comparisons that follow are drawn mainly from large-scale surveillance studies, because those studies have sufficient numbers of athlete exposures to provide stability of study results.

NAIRS issued a substantial report on the 1975 to 1977 seasons.[2] The report covered 53 high school teams and 148 college teams, with a total of approximately 16,000 athletes. Reportability and severity of injury were defined with respect to time lost from practice and/or game play. Specifically, a reportable injury was one that kept a player from participating in practice or game play for at least 1 day. Reportable injuries were further subdivided into minor (<7 days missed) and significant (≥7 days missed). The severity of significant injuries was further categorized as moderate (8 to 21 days missed), major (≥21 days missed), and severe (permanent disability or death), largely on the basis of time lost for the immediate injury-related episode. Exceptions were head injury (which was reported if any period of observation before return to play was required) and dental injury (which was reported if professional attention was required). There was an increased rate of injury for artificial turf, but the increase in annual injury rates was not statistically significant. It should be noted that the observed increase in injuries was confined to injuries of the knees, ankles, and feet. Only these exceeded the a priori designated critical increase of one injury per team per season.

In a more detailed report, annual injury rates were reported for the years 1975 to 1977, and separately by part of body injured.[5] Examining annual injury rates establishes the stability of injury frequency. Given a stable injury frequency, the statistical power intrinsic in accumulation of a large number of athlete exposures is best employed by comparing cumulative rates. The NAIRS authors have made this possible by detailed reporting of their injury and exposure data. The data presented for college play permit a reanalysis, such that the total number of meniscus injury/knee sprains was 517/647,091 total athlete exposures for a rate of 0.8 per 1000 athlete exposures on natural surfaces. The pooled meniscus/knee injury rate was 348 per 338,212 or 1.0 per 1000 athlete exposures on AstroTurf (Monsanto, St. Louis, MO). Combining the injury rates across years is appropriate, given the stability of rates across years. In this case, the relative risk for meniscus injury/knee sprains is 1.2. That is, in these 3 years meniscus injury/knee sprains on AstroTurf were 20% more common than on natural surface. While this pooled 3 year difference is statistically significant ($P < 0.05$), it represents a very small increase in risk.

Reanalysis of ankle and foot injury rates yielded similar results, with the pooled relative risk for ankle sprains being 1.4 (0.45 per 1000 versus 0.32 per 1000) on AstroTurf versus grass, and for foot sprains being 3.35 (0.06 per 1000 versus 0.02 per 1000) on AstroTurf versus natural surface.

The NCAA has developed and maintained its own research data base (Zemper E, unpublished data, 1984). It formed the basis of a report in 1984 on the 1982 to 1983 and 1983 to 1984 seasons. An injury was reportable if it resulted in at least 1 day of missed practice or game play. In NCAA play, there was an overall injury rate of 7.2 reportable injuries per 1000 athlete exposures (practice sessions and

[a] For a compilation of complete data broken down by various data bases regarding injury and exposure definition, please write to Dr. Levy, whose address is listed on the first page of this article.

games). The rate for game play was 39.6 per 1000 athlete exposures, and for practice it was 4.4 per 1000. Of particular interest, the overall injury rate on artificial surfaces was 9.74 per 1000 athlete exposures and on grass 6.54 per 1000; the risk ratio (relative risk) was 1.5. That is, injuries were 50% more common on artificial turf. In a continuation, for the 1984 to 1985 season a relative risk for all injuries of 1.64 was determined. (*The Washington Post,* December 19, 1986, p D6).

Walsh and Petr,[14] in a brief report of NCAA injuries during 1987 to 1988, suggested that in Division I play, injury rates on natural turf are higher than on artificial turf. The authors used the data of the NCAA surveillance system, systematically selecting 15 of 23 reporting teams so that the total number of games played on each type of surface was similar. This method introduced the potential for selection bias in that excluded teams may have had different surface-related injury rates than selected teams. Time-loss injuries of the selected teams were compared. Not distinguished, however, was whether only injuries occurring in the 77 natural turf and 77 artificial turf games were counted or whether injuries during practice were also counted. Counting injuries during practice could distort the comparison if the total practice exposures to natural and artificial turf were not equal. Furthermore, the authors report higher overall numbers of time-loss injuries on natural turf also found that there were significantly more serious knee injuries on natural turf, than on artificial, but no significance testing of the observed injury frequencies was done. Because of the limitations noted, the cited results are not interpretable.

The National Football League has been monitoring injuries and suggested that, during the period 1969 to 1974, the overall relative risk for time-loss injuries (≥2 practices or ≥1 game) was 1.3 based on injury rates of 2.8 per game on artificial turf and 2.2 per game on grass. This report also suggested, although the data were not presented, that stadia with the lowest injury rates for both home and visiting teams had all-grass fields. In addition, it was observed that injury rates were highest when teams practiced on one type of surface and played on another.[12]

Powell and colleagues[11] have published a more recent report of the NFL data indicating a small increase in significant (>7 days missed) injuries occurring on artificial surface during the period 1980 to 1985. During this period, the surface-associated relative risk of significant injuries was 1.14, based on rates of 1.94 per team game on artificial turf and 1.78 per team game on grass. The increased injury rates on artificial turf were confined to lower extremity injuries. The 6 year average relative risk of any knee injury was 1.18 (0.47 per team game on artificial turf, 0.40 per team game on grass); for significant injuries it was 1.24 (0.31 versus 0.25), and for major knee injuries (>21 days missed) it was 1.33 (0.20 versus 0.15). A similar pattern was seen for ankle/foot injuries: the reported injury relative risk was 1.39; significant injury relative risk was 1.43, and major injury (>21 days missed) relative risk was 1.8. While the authors did not report significance testing, they established a priori a critical effect size, as was done in the NAIRS report. That is, an excess of one reportable injury per team per year on artificial turf was considered the minimum increased risk of concern. Such an excess would be reflected in an increase in injury rate of 0.05 injuries per team game.

In addition to the surveillance data base reports described above, there have been several special studies in the scientific literature. Adkison and colleagues,[1] for instance, have reported results for high school teams in Portland, Oregon, and Seattle, Washington, in 1971. Injuries were defined by time lost, exposure was defined by game play, and information was collected prospectively. There were 0.56 injuries per team during games on artificial turf and 0.51 injuries per team during games on grass, for a relative risk of 1.1. Although based on a small number of exposures (424 on grass, 236 on artificial turf), this slight increase in overall risk of reportable injuries is consistent with the surveillance reports of college and professional play and in the same direction as the relative risk of 1.25 reported in their pilot study.[4]

Kanter[7] reported on a mixed ascertainment study of NFL play in the 1984 and 1985 seasons. Injuries in 1984 were ascertained from *The Sporting News* and 1985 injuries were from videotapes. Injury rates were defined per game. The author concluded that increased injury rates were associated with the team being played against rather than with the playing surface. Because of the potential for observer bias in the ascertainment of 1985 injuries and the absence of data in published reports, the validity of the study conclusions cannot be assessed.

Bowers[3] reported an observational study of injuries in college players at West Virginia University. Injuries were compared for a period before an artificial surface was installed (fall 1967 through spring 1969) and afterwards (fall 1969 to spring 1972). The author concluded that the introduction of AstroTurf resulted in more frequent and more severe injuries. These results, too, must be cautiously interpreted: play in away games on grass fields during the "post" period may have diluted the comparison, and changes in coaching, team competition, or practice may explain the findings.

A report in *ASPA Turf News* (November-December, 11-12, 1985) compared numbers of injuries in game play on an artificial surface (Temple University) and natural grass (West Chester University) based on NAIRS data for the 1983 football season. While injury rates were not reported, a larger number of injuries of all parts of the body occurred at Temple than at West Chester. These results should be interpreted cautiously as the number of games played on artificial surfaces by these teams may not have been equal.

Of particular interest among the small studies is a randomized trial conducted in intramural college football at the University of Michigan.[13] Sixty-four teams were randomly assigned to play on Tartan Turf (3M, St. Paul, MN) fields or on natural grass. That is, 32 teams played 4 games on Tartan Turf and the 32 other teams played 4 games on natural grass, for 128 team-games on each type of surface.

Injuries occurring during games were noted. The total injury relative risk was 1.8 for artificial turf. The minor injury (e.g., contusions, sprains, strains, abrasions) relative risk was 2.0. The major injury (fractures, dislocations, concussions, serious lacerations) relative risk was 1.4. As a randomized assignment experimental study, it is a valuable confirmation of the increased risk of injury associated with artificial turf. The small number of game exposures on each surface does not permit stable estimates of injury frequencies to specific parts of the body.

Several studies have compared injury risks on different types of artificial surfaces. The NAIRS and NFL reports indicate that all types of artificial surface are associated with increased lower extremity injury risk, and that the increase is slightly larger on Tartan Turf and Superturf (SuperTurf Inc., Garland, TX) than on AstroTurf.[5,11] All of the artificial surfaces in the Stevenson and Anderson report[13] were Tartan Turf, thereby indicating an increased risk associated with that surface. Keene et al.[8] reported reduced risk playing on Tartan Turf compared with grass. However, this report compared total numbers of injuries without correcting for an approximately 30% longer duration of play on grass than on Tartan Turf.

The roles of protective clothing and equipment and field condition have been explored as possible contributors to turf-associated injuries. The results of the relevant reports are described below.

Surface wetness. Adkison et al.[1] reported a three-fold increase in injury risk from play on dry artificial turf compared with play on a wet artificial surface, which was higher than the 50% increase reported in their earlier pilot study. This would suggest that turf-associated injury rates could be reduced by wetting down the artificial playing surface before the game. The report of Stevenson and Anderson,[13] on the other hand, indicated that wet field conditions were associated with increased rates of injury on both artificial turf and grass. One reason given was that in intramural play, athletes tend to wear sneakers rather than specialized athletic shoes.

Types of shoes. There is little epidemiological information on the role of shoe type on injury risk associated with playing surface. Of note is the study of English soccer players by Adams and colleagues (unpublished data, 1980) in which teams wearing shoes designed for play on artificial turf did not suffer an increased risk of injury compared with teams playing on grass.

CONCLUSIONS

The weight of the epidemiological evidence described above indicates that play and practice on artificial turf are associated with an increase in risk of time-loss injuries to the lower extremities of 30% to 50%. Increased injury risks for other parts of the body have not been consistently demonstrated. In particular, the absence of a demonstrable increase in head injuries suggests that surface hardness does not explain the increased risk associated with playing on artificial turf. Turf-associated risk of abrasion is not consistently present and appears to be controlled when protective padding and skin coverings are worn. The increased risk of time-loss injury to the lower extremity, amounting to relative risk in the range of 1.3 to 1.5 associated with artificial turf, is not large. In fact, the criterion of one excess injury per team per season is not always met. In addition, the lack of a consistent increase in risk of other injuries suggests that a targeted investigation of lower extremity injuries on artificial turf would be productive. In particular, the role of shoe type in football injuries on artificial turf should be addressed.

Two final cautions are in order. Most of the data indicating increased injury frequencies on artificial turf are from the late 1970s and early 1980s. Since then (see Appendix 2, Part 1, July/August issue) newer turfs have been designed that may be safer. Continued surveillance should focus on the safety of those newer surfaces. Also, investigations and preventive intervention around injuries specifically attributable to artificial turf are only the beginning of the attack on football injuries in general, of which lower extremity injuries are a part.

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