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ARTIFICIAL TURF vs. NATURAL GRASS

An Interactive Qualifying Project Report

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

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Degree of Bachelor of Science

by

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Abstract

This Interactive Qualifying Project deals with the growing use of artificial turf for athletic fields as an alternative to natural grass. Many people feel that artificial turf causes more injuries to the players than grass, and some feel that it simply changes the game. The goal of this project is therefore to determine whether or not artificial turf is a practical alternative and whether or not it does in fact cause more player injuries.

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Introduction

Recreational artificial turf surfaces have been in use for over 30 years now. Many organizations, colleges, professional sports franchises and other sports and recreational facilities are converting their fields from natural turf surfaces into artificial turf surfaces. There are several reasons why these changes are taking place, ranging from short and long-term cost issues to maintenance issues, consistent play issues to land availability. Many people feel that artificial turf is far more cost effective than natural grass and therefore the preferred option for moneymaking organizations. It has been shown that the maintenance for artificial turf surfaces is relatively lower than that of natural turf. Furthermore, an artificial surface guarantees consistency throughout the playing surface, which a natural turf cannot guarantee unless the owner is willing to pay a substantially higher fee for construction. Also with the growing sports organizations and leagues around the country, especially among the youth, each available piece of land is becoming more and more valuable and hard to acquire.

Although there are several advantages to the implementation of artificial turf, there are some drawbacks as well. Some people feel that artificial turf causes more major injuries than grass. There are also certainly risks of abrasion and 'turf-toe' from the artificial surfaces, which are not considered risks on grass. The slightest of falls on even the best artificial turf can result in what is known as 'rug burn.'

At a broad glance, the advantages of artificial turf as opposed to natural grass may seem to outweigh the disadvantages, however, artificial turf is not for everyone. This IQP will deal primarily with who is using artificial turf and why. Cost analyses and injury reports will be included so as to make a conclusion on who needs artificial turf.

Chapter I

History of Artificial Turf

The implementation of artificial turf surfaces for recreational purposes is becoming more and more popular, especially among colleges of all divisions. However, the use of artificial turf is not quite so modern. It actually dates back to the 1950's when the Ford Foundation, a charitable organization founded by Henry Ford's family, began studies to find ways to improve the quality of the physical fitness of America's youth. The majority of information lay within the United States military, so the studies were conducted using examination records from young men who were entering the military (asrtroturf.com).

The Ford Foundation began by examining many characteristics of the young men including race, geographical upbringing, nationality, diet and physical qualities. Even from all these characteristics they looked at they were not able to sufficiently determine the largest influence on physical fitness. Naturally some men were far more fit than others, but at this point the reasons were undetected (astroturf.com).

Continued studies soon lead to some conclusions. It was discovered that young men that came from small towns, as opposed to urban areas, were generally more athletic. They were stronger, quicker and had more stamina. The reason being, kids growing up in the city had less room to play. They typically played on pavement and relatively closed in areas, simply because in the city there is far less room for recreational fields than that of rural areas. In the small towns there is plenty of grassy fields for

children to play. As a result the young men from small towns were more physically fit than the men from the cities (atroturf.com).

During the late 1950's the Chemstrand Company a division of Monsanto, was in the process of developing synthetic carpet. Dr. Harold Gores, head of the Ford Foundation's Educational Facilities Laboratory, was aware of Chemstrand's work with synthetic fibers and suggested that Chemstrand design an outdoor surface to be used for recreation in the cities (astroturf.com).

Chemstrand began work on developing such a product in the early 1960's. They performed many experiments to formulate the right surface for sports. In 1964, with the Ford Foundation as the sponsor, the first ever artificial turf surface was laid down in Providence, Rhode Island at the Moses Brown School (astroturf.com)

Thanks to Chemstrand's work the stage was set for the future of artificial playing surfaces. The Houston Astrodome opened in 1965 as the largest indoor sporting facility. It originally had a clear plastic roof, which allowed for natural grass to be planted. During the 1965 season players complained that glares from roof were interfering with routine flyballs. So the roof was painted, but as a result the grass died. Roy Hofheinz, owner of the Astrodome, challenged Monsanto and Chemstrand to develop a surface suitable for major league baseball. In 1966 the Houston Astros opened their season with an artificial turf infield. By the all-star break the outfield was complete (astros.com).

In 1967 the 3M Company began producing synthetic surfaces. Monsanto and their Astro Turf now had to compete with 3M and their product, known as Tartan Turf. By the end of 1968 Monsanto and 3M began installing outdoor surfaces, including one

for the spring training field of the St. Louis Cardinals and the New York Mets. It seemed that artificial turf was becoming the new trend sports (asrtotuf.com).

Over the next decade many other turf product surfaced. The American Biltrite Company produced "PolyTurf", SuperTurf International had "SuperTurf", and "WycoTurf", "DuraTurf", "Gras" and "Lectron" were other available surfaces. Many others soon joined in, including several in Europe and Asia, however, none of them could compete with AstroTurf and soon nearly all of them disappeared. Even 3M stopped production of artificial turf in 1975 (asrtoturf.com).

With the acquisition of many overseas contracts in the early 1970's, Monsanto began installing AstroTurf all over the world. Their first order of business was the installation of a soccer field in Islington, a borough of London. From there Monsanto went on to install many fields in Europe, Australia and Asia (asrtoturf.com).

In 1975 Monsanto installed AsrtoTurf in Montreal at McGill University for the "8-Nations" field hockey tournament. This was the first time that an international hockey tournament was held on artificial turf. The 1976 Olympic hockey games were played on the same field and since then the International Hockey Federation decided that all international hockey competitions would be played on artificial turf (astroturf.com). Since the 1976 Olympics the artificial turf business has blossomed. Many more colleges, universities and professional sports teams have made the change from natural grass to artificial turf.

Chapter II

Different Types of Artificial Turf

2.1 – Considerations

Generally all artificial turf systems have the same makeup. The systems include, the surface layer of grass-like fibers, a backing layer which holds the fibers in place and provides stability, and a shock absorbing pad underneath to cushion falls and control ball bounce. Some systems are sand-based, where sand is used as the shock absorber. Some systems are equipped with drainage systems in the event of rain or snow, and some are simply crowned, or sloped down from the middle, to allow water to drain off to the sides. Since natural grass is porous and tends to naturally drain out excess water, it is ideal to simulate this in the use of artificial turf. All artificial turf systems are laid down over some sort of subbase, such as concrete or compact soil. See fig. 1 for a typical cross section.

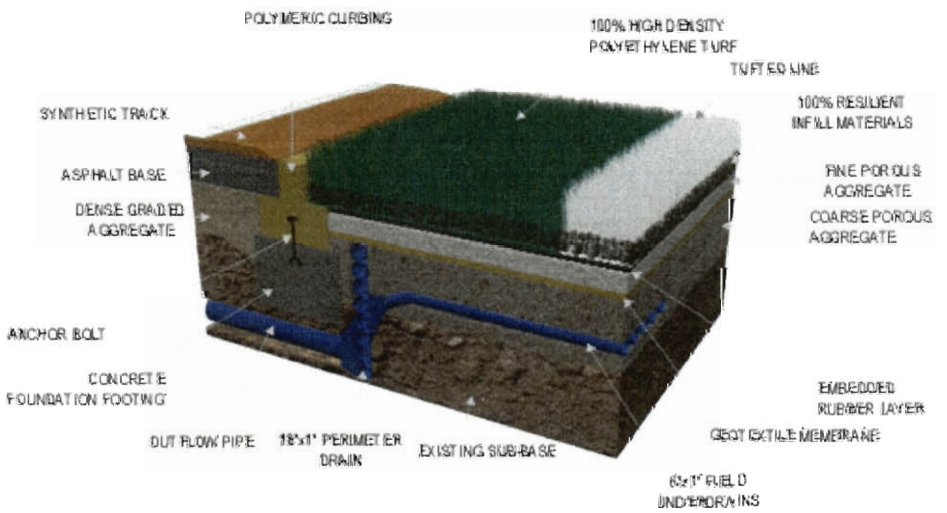


Figure 2.1 Cross sections of a synthetic turf system complete with drainage (artificialturf.com).

Though most systems have the same general makeup, there are different types of artificial turf to choose from. It is important for the buyers and designers to account for important factors such as, specifically what the turf will be used for, how often it will be used and even climate. Some surfaces used for a large quantity of sporting events, such as the one here at Worcester Polytechnic Institute, undergo extremely heavy foot traffic and it is important to realize this so that the proper surface can be produced. Here at WPI the artificial turf experiences approximately 8 football games, 8-12 boys soccer games, 8-12 girls soccer games, 8-12 field hockey games and daily practices from each of these sports teams, in the fall season alone. If such high volume of traffic is not accounted for in the design and fabrication process, the surface might fail quite easily after a short period of time. If traffic is significantly less then strength could be less, and therefore the price could be significantly less. Also it has been shown that climate and ultavilolet exposure can significantly affect performance, and so it is important to account for that as well.

2.2 – Materials and Properties

The difference between different types of artificial turf lies in the chemical composition. It is important for the suppliers to understand how each combination acts, physically and chemically. The materials used for artificial turf are all organic materials, which means they are made up of some combination of hydrogen, oxygen, carbon and nitrogen. Knowing the intended use of a particular facility, the designer can compose the

right mix so as to achieve maximize performance, which is the single most important thing (astroturf.com).

Monsanto generally produces three different kinds of fibers for field use. They produce nylon fibers, polyolefin fibers and polyester fibers. They produce two different types of nylon fibers, nylon 6-6 and nylon 6. Nylon is a family of polyamide materials, which are combinations of organic acids and organic amines. Polyamides are similar to proteins in their chemical makeup and act similar to that of wool and silk. Nylon 6-6 is the polymerization of adipic acid and hexamethylene diamine. Each compound of nylon 6-6 has six carbon atoms. Adipic acid with acid groups on both ends and diamine with amine groups on both ends. If the proper conditions are applied the acid groups and the amine groups will bond together which builds chains of acids and amines (astroturf.com).

Nylon 6 is organically the same as nylon 6-6 but acts very differently. This is because of the arrangement of acids and amines. In a compound of nylon 6 each there is an acid group on one end and an amine group on the other, instead of an adipic acid with an acid group on each end and a diamine with an amine group on each end. Because of its chemical makeup nylon 6 has a lower melting point than that of nylon 6-6. Which means that it has less horizontal strength and mats or compacts easier than nylon 6-6. This ultimately means that is it less durable than nylon 6-6. Producing nylon 6 is easier than producing nylon 6-6 so it less expensive to the customer. However, it will not likely last as long as a surface made with nylon 6-6 (astroturf.com).

Polyolefin fibers are made from polypropylene. They are members of the wax family of compounds and have long chains of carbon and hydrogen atoms. They can be colored with pigments fairly easily and tend to hold their pigments well. On the other

hand, they have significantly lower melting points than nylons and therefore mat much more easily under heavy traffic. Polyolefins have lower density values than nylons and therefore appear bulky and seemingly have more material than they actually do (astroturf.com).

Polyester fibers are produced when a dibasic acid reacts with a polyol. These fibers have melting points comparable to nylons and have high densities, therefore they have high strength. However, these high densities cause the fibers to splinter under significant usage (astroturf.com).

As previously mentioned it is important to take into consideration the climate of a particular facility, particularly in the case of outdoor facilities. The reason is primarily because of ultraviolet exposure. Without proper inhibitors the sun can damage the artificial turf. Some of the important properties of the fibers can be permanently damaged and the surface can fade changing its appearance. So it is extremely important to properly select stabilizers to best suit the conditions the surface will face.

There are many factors that go into producing the right surface for a particular use and it is vitally important to design the right surface in order to ensure maximum performance for a maximum lifetime.

2.3 Astroturf Systems

When a community, school or organization decide to have an artificial turf field installed it is important for the planning committee to understand exactly what the field will be used for. Different systems have different applications and the buyer must

understand this so that the right system will be implemented. There are systems designed for field hockey, soccer, football, baseball, and some for multi-purpose use, where the field will be used for several different sports as well as other functions such as band practice, etc. Below are drawings of seven different Astroturf systems produced by Southwest Recreational Industries.

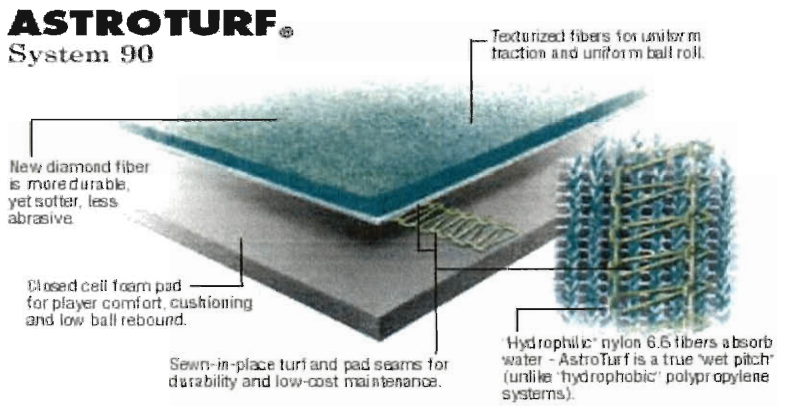


Figure 2.2 (astroturf.com)

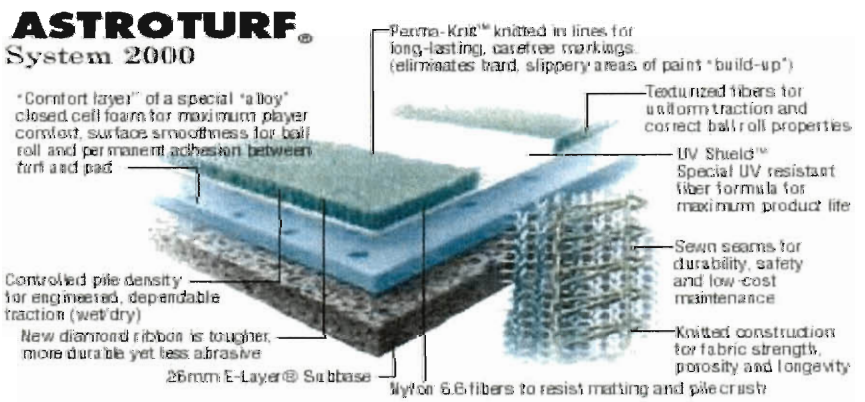


Figure 2.3 (astroturf.com)

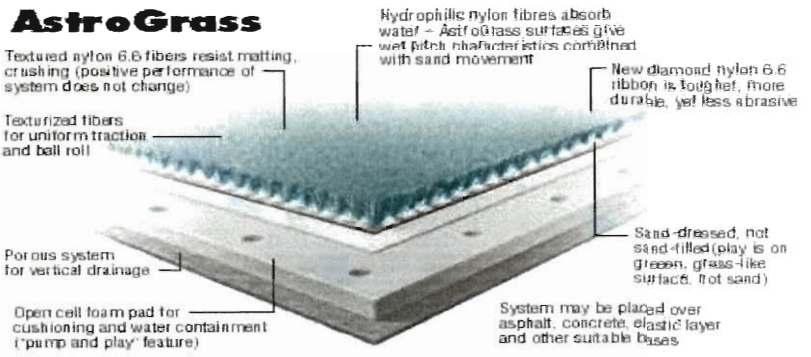


Figure2.4 (astroturf.com)

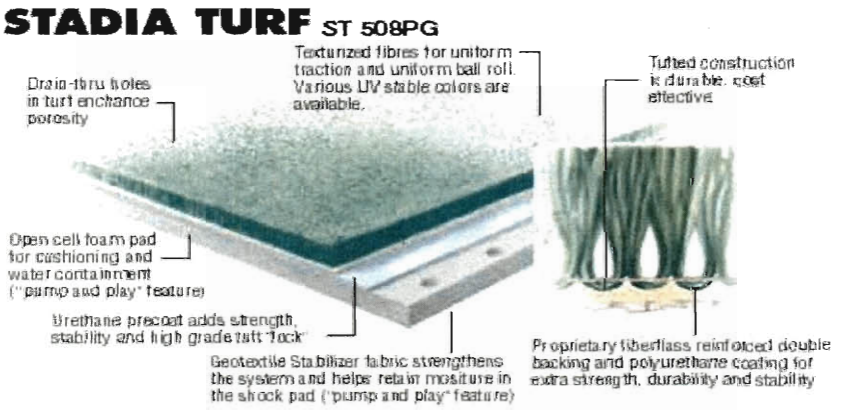


Figure 2.5 (astroturf.com)

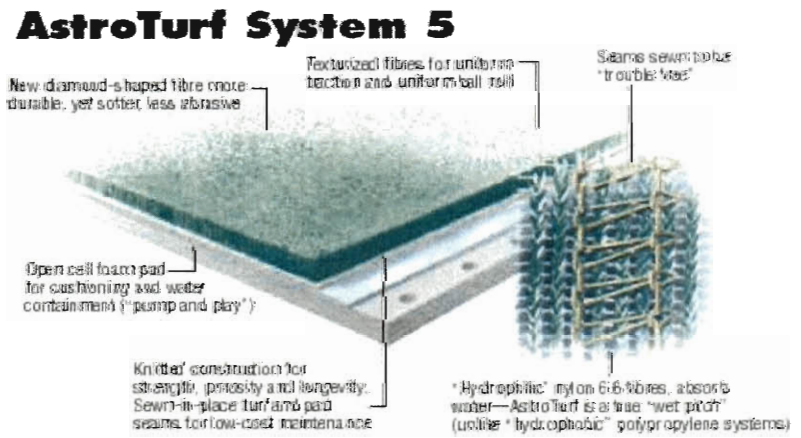


Figure 2.6 (astroturf.com)

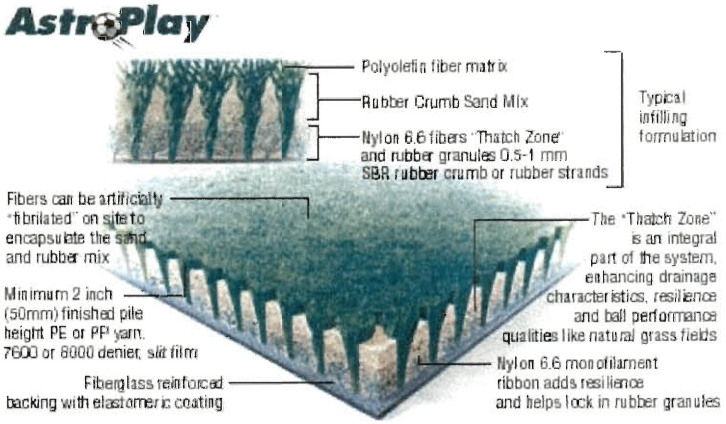


Figure2.7 (astroturf)

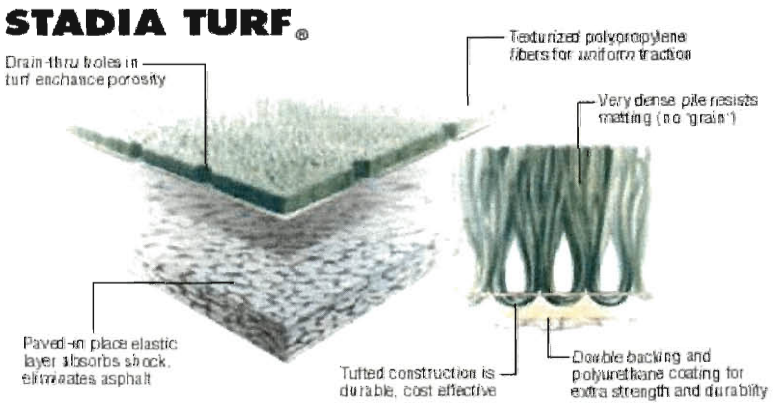


Figure 2.8 (astroturf.com)

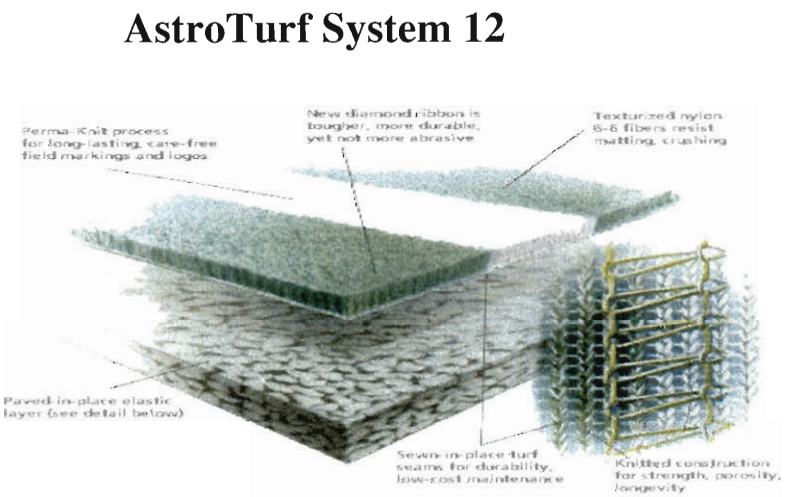


Figure 2.9 Astro turf system 12 is used at WPI at Alumni field (muhlberg.edu).

Some characteristics that separate one system from another are water drainage, fiber absorbsion, type of fiberand texture, fiber resilience, fiber density and underpad compression and resilience. Characteristics such as these become very important depending on which sports one is preparing for. Sports like field hockey, soccer, and baseball are very concerned with the ball rolls and bounces on the surface. Consequently, systems designed for these sports pay particular attention to the properties that control the balls in each sport. From the above figures you can see that systems 5, stadia 508PG, asrograss, and 90 are all geared towards sports where effects on the ball are vital. American football on the other hand, is less concerned with ball bounce and roll because the ball is rarely on the ground. American football is instead concerned with how players will fall on the surface. Due to the nature of the game many players fall on the surface on every play and therefore a system designed for football is concerned more with the cushioning and rebound characteristics of the underpads and fibers (astroturf.com). Systems 2000 and 12, figures 2.3 and 2.9, are generally multi-sport systems but they account for football use with a special "comfort layer," or shock absorbing pad to aid hard falls to the turf (muhlberg.edu). These underpads are specifically designed to minimize head trauma injuries.

Chapter III

Who is using artificial turf?

Major Uses of Artificial Turf

Since its introduction to the world of major sports by the Houston AstroDome, the use of artificial turf has grown to serve many purposes. The use of this type of surface has become so widespread that it graces the fields of professional and college athletic facilities, as well as serving many domestic purposes.

Part I: The National Football League

In the National Football League 14 out the 30 teams use an artificial surface. Out of these 14 teams, 6 of them play outdoors.

Teams in the NFL that use Turf

AFC:

Buffalo Bills

New York Jets

Indianapolis Colts

Pittsburgh Steelers

Seattle Seahawks

Figure 3.1 Drew Bledsoe of the New England Patriots

NFC:

New Orleans Saints

St. Louis Rams

New York Giants

Detroit Lions

Dallas Cowboys

Philadelphia Eagles

Atlanta Falcons

Cincinnati Bengals

Minnesota Vikings

Figure 3.2 : TWA Dome, Home of the St. Louis Rams

Part II: Major League Baseball

In Major League Baseball there are currently thirty teams, out of those thirty there are eight teams that use artificial turf. Out of those eight there are only 2 ballparks that are outdoor facilities, the rest are fully enclosed or retractable domes. Baseball, however, is a game of tradition and history, and has lagged behind in the use of artificial surfaces.

There are two organizations that have actually used turf and changed back to grass. Those two teams are the St. Louis Cardinals and the Kansas City Royals. Below is a list of those teams that do use an artificial surface.

Teams in Pro Baseball that use Turf

American League:

Seattle Mariners

Minnesota Twins

Toronto Blue Jays

Tampa Bay Devil Rays

Figure 3.3 : Tropicana Stadium, Home of the Tampa Bay Devil Rays

Tropicana Stadium (pictured on the previous page) is the most recent team in professional baseball to use an artificial surface. The Devil Rays opened their first season in 1998. Since the stadium's production it has served a number of purposes ranging from football to baseball to hockey.

National League:

Montreal Expos

Philadelphia Phillies

Pittsburgh Pirates

Houston Astros

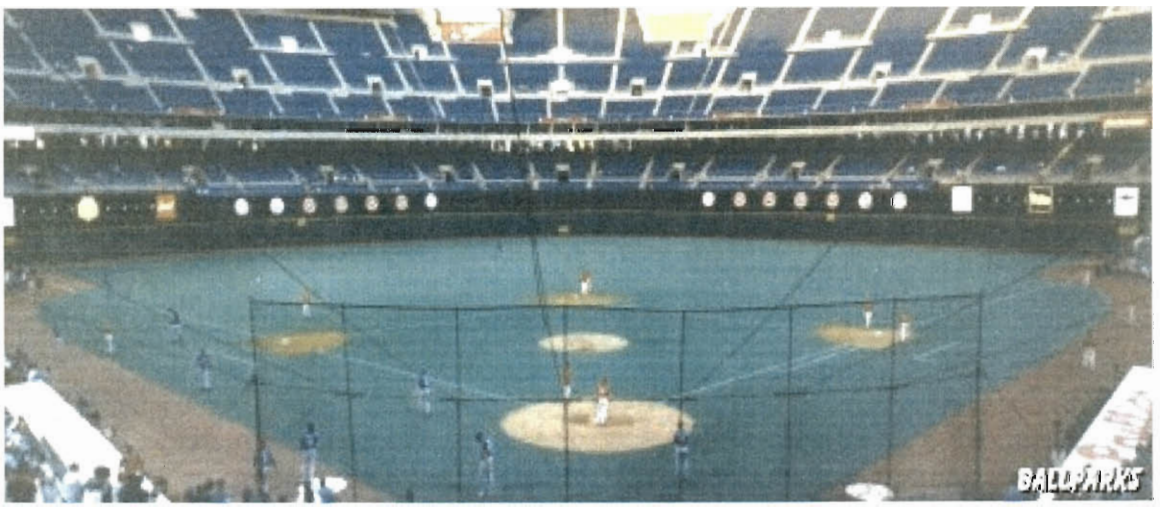


Figure 3.4 : Veterans Memorial stadium, Philadelphia PA

Part III: NCAA Division 1

In the NCAA, Division 1, there are 12 major conferences of competitive athletics. Compared to professional sports there is a much larger percentage of facilities that use artificial turf. The only conference to not have any of its teams using artificial turf is the ACC where 0 out of 9 colleges use turf.

In the Big10 there are 5 out of 11 colleges that use turf. In the Big12, 7 out of 12 schools have turf. The Big East has 5 out of 8, the Big West has 3 out of 6. In the Conference USA the are 3 out of 8, in the Ivy League there are also 3 out of 8. In the

MAC there are 7 out of 12, in the PAC10 there are 4 out of 10. In the SEC there are 2 out of 12, and in the WAC there are 5 out of 12.

Overall there are 43 teams in Division 1 College football with artificial turf. Below they are listed out by conference.

Listing of Schools by Conference:

Figure 3.5 : Univ. of Iowa's Kinnick Stadium

BIG 10

University of Illinois

University of Iowa

Michigan State University

University of Minnesota

University of Wisconsin

BIG 12

University of Colorado

University of Kansas

University of Nebraska

Baylor University

Texas Tech.

Oklahoma State

Figure3.6 : Baylor U's Floyd Casey Stadium

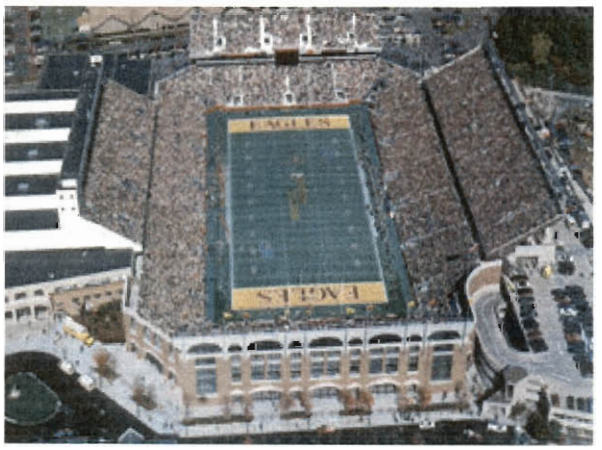


Figure 3.7 : BC's Alumni Field

BIG East

Boston College

Syracuse University

West Virginia University

University of Pittsburgh

Temple University

BIG West

Boise State University

University of Northern Texas

University of Idaho

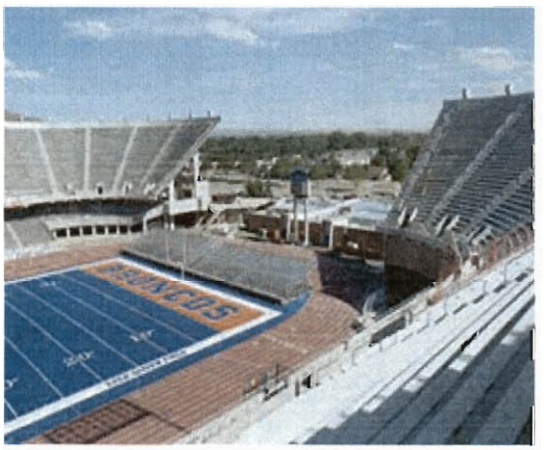


Figure 3.8 : Boise State's Bronco Stadium

Figure 3.9 : Nippert Stadium, University of Cincinnati

Conference USA

U.S. Military Academy at West Point

Tulane University

University of Cincinnati

Figure 3.10 : Franklin Field; Brown University

Ivy League

University of Pennsylvania

Cornell University

Columbia University

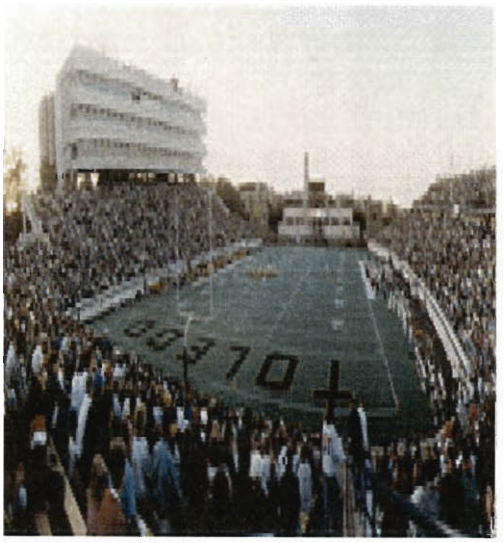


Figure 3.11 : University of Toledo's Glass Bowl

Mid-Atlantic Conference

Kent State

University of Toledo

Northern Illinois University

Central Michigan University

Marshall University

University of Akron, Eastern Michigan University

PAC 10

University of Oregon

University of Washington

Washington State

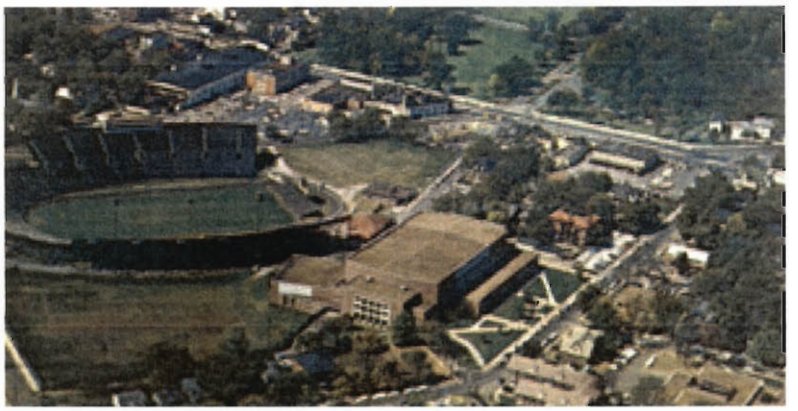
Oregon State

Figure 3.12 : Martin Stadium; University of Washington

South-Eastern Conference (SEC)

University of Alabama

Vanderbilt University



WAC

University of Hawaii

University of Texas El Paso

Rice University

University of Nevada Las Vegas

University of Tulsa

Figure 3.13 : Vanderbilt Stadium, Vanderbilt University

Part IV: Canadian Football League

In the CFL there are a total of eight teams, out of these eight, seven teams use artificial turf. Canada is known for its inclement weather, and this plays a factor in the type of surface you want for a field. In the rain and snow a grass field can get quite torn up, and needs time for recovery. A turf field is much more durable, and is quite low maintenance. This type of surface is a perfect match for the needs of the CFL. Below the teams in the CFL with artificial turf are listed.

CFL

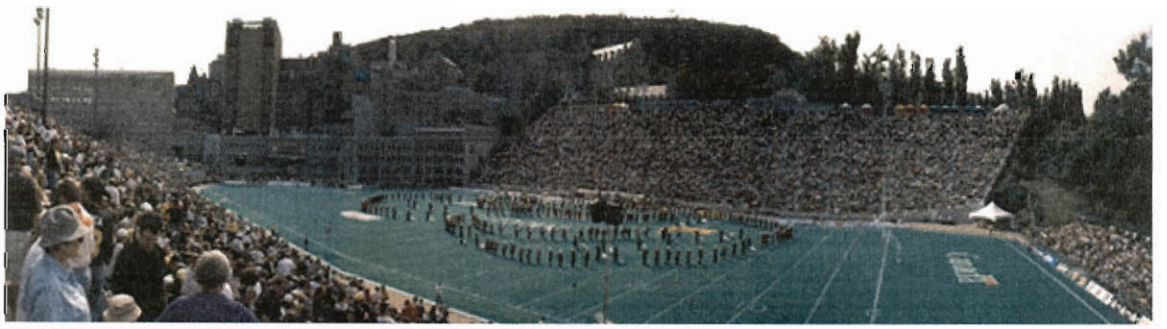


Figure 3.14 : Ivor Wynne Stadium, home of the Hamilton Tigercats

British Columbia Lions

Montreal Allouettes

Hamilton Tigercats

Toronto Argonauts

Winnipeg Blue Bombers

Calgary Stampeders

Saskatchewan Roughriders

Figure 3.15 : Molsen Stadium, home of the Montreal Allouettes

Chapter IV

Costs associated with the implementation on artificial turf versus grass

4.1 Installation

Installing an artificial athletic field can initially be quite expensive. Especially if the user elects to use a system that requires a shock-absorbing underpad. The installation of an artificial turf field is not just a matter of laying down a big green carpet; there are several important steps taken in order to produce a safe, long lasting, high performance facility. The first step is to level the surface to ensure that the field will be correctly placed for best play and drainage in particular. Once this is done the infill can be placed. Some systems such as those produced by Fieldturf are sand-based which means there is a layer of sand beneath the synthetic grass. Other systems like the Astroturf systems, use one or two layers of a shock pads rather than sand to help cushion the falls of athletes and control ball bounce. Once the infill is in place the turf can be laid. Some systems have painted on lines whereas others have sewn in lines. Sewn seems and lines are generally more expensive due to the labor involved, but have a much nicer appearance and never need to be repainted.

Naturally the installation of a grass field begins in the same way with leveling the soil. Quality, fresh soil may need to be purchased in order to get good grass growth. Without proper leveling the field will surely be bumpy and inconsistent. When the leveling is complete the grass can be planted, or the sod laid. For any field experiencing a significant amount of wear it is desirable to install an irrigation system. The irrigation

pipes can be laid before leveling or pulled through after. In order for the grass to grow in properly it is necessary to fertilize the field and water it regularly.

If a grass field is not installed properly it may have a very short life and will need to be done over. Installation can get very expensive if it needs to be done over one or more times. Even if the field is installed properly heavy use will mean a need for new sod every so often. If Worcester Polytechnic Institute had a grass field it would likely need new sod once or twice a year. Every time new sod is laid it needs extra special care to be sure it grows properly and performs at an optimal level.

4.2 Maintenance

Maintenance is an important issue in the turf versus grass war. Although installation is generally much more expensive for an artificial turf field maintenance is usually significantly less than grass. Artificial turf maintenance requires blowing and/or vacuuming four or five times a year, a thorough cleaning (scrubbing) once a year and occasional painting of lines. Some fields do not need to be painted because of their sewn in lines, some need to be completely painted, and some like Alumni field at WPI need just occasional touch up of some lines that were not sewn in (i.e. football hash marcs).

A grass field on the other hand needs far more maintenance. A properly maintained field should be mowed at least twice a week. This is especially important during August, September and early October when grass grows the quickest. If the grass grows too much between cuts the healthiest part of the grass will be cut off. A field with a lot play will also need to be painted more than once every two weeks. Grass fields

must be fertilized in the spring for best performance. It is also in the best interest of the field and the users for the field to be airified. Airifying is the process of removing small plugs of turf to allow for the grass to breathe better and its roots to grow. This will allow for the grass to flourish and help it to perform at a maximum. It also might be necessary to thatch the field in order to remove any dead grass and make room for the healthy grass to continue growing. An organization who is especially concerned about the quality of the grass, such as a professional sports team, might even spray the field with chemicals to be sure the field is disease free.

An outline of associated costs for installation and maintenance is shown below.

Installation – turf

* Leveling
  - surveying, crew and equip.
  - construction, crew and equip.

* Infill placement
  - material, equip. and crew

* Synthetic surface laid
  - material, equip. and crew

Installation - grass

* Leveling
  - surveying, crew and equip.
  - construction, crew and equip.

* Irrigation system installed
  - pipes, equip. and crew

* Grass seed planted
  - seed, equip. and crew

Maintenance – turf

* Vacuuming (5x / year)
  - crew and equip.

* Cleaning
  - equip. and crew

* Painting (1x / year)
  - paint, equip. and crew

Maintenance – grass

* Mowing (2x / week)
  - crew and equip.

* Fertilizing
  - material, equip. crew

* Painting (1x / 2weeks)
  - paint, equip. and crew

* Airifying
  - equip. and crew

* Thatching
  - equip. and crew

* Spraying
  - chemicals, equip. crew

* Watering daily
  - water

Chapter V

Injuries

5.1 General Injuries

Since artificial turf came into existence, it has been widely believed that the new playing surface proposed a great risk to the players and there have even been motions to have it banned. These fears have been recognized by many athletic organizations such as, the NCAA, the NFL, the NFL Players Association and other numerous respected universities, who have conducted numerous tests and studies to insure the safety of their players over the years. These tests have consistently indicated that modern turf systems put athletes in no greater risk than natural grass surfaces do. In fact, on the most part athletes playing on a synthetic surface are at less risk than athletes playing on grass surfaces.

One of the main reasons that turf has been found less likely to cause injury, in general is its uniform condition. Natural grass becomes torn up late in the season producing more dips, soft spots and other abnormalities that can cause twists and sprains. Carl Blyth and Fred Mueller from the University of North Carolina conducted one of the first studies into this theory. In the late 60's and lasting for the next five years, many area high school football teams were surveyed as to the number and severity of injuries sustained by players during games and practices. All schools surveyed had natural playing surfaces. Nine of the schools' fields were re- sodded and carefully maintained in good shape during the course of the last two seasons of the study. It was found that

teams that played on well kept fields showed a much lower rate of injury than they had in previous years and than teams who played on fields that weren't resurfaced. But since keeping grass fields in pre- season condition all year long is beyond the means of many programs especially those who share playing fields with other sports, the fields wear down by late in the season.

Athletes, however still tend to distrust turf. In the past, athletes believed that turf posed such a threat to their safety that in the mid- 1970's, the NFL Players Association petitioned the league three times to have turf declared a "banned hazardous product". The first of these petitions was filed in 1973. The league, however, rejected the petition as it felt that the players did not present enough evidence to support their claim. The league rejected petitions again in 1975 and 1976.

Even today, with safer, more technologically advanced turf systems, an ominous opinion of turf still exists among players. In 1996 the NFL Players Association conducted a league- wide survey on players opinions of different fields across the league. The results showed that players in general definitely still feel as though turf can be a hazard.

Q: Which would you rather play on, turf or grass?
Grass: 86.7%
Turf: 6.3%
Doesn't matter: 7.0%

Q: Which surface is more likely to cause injury?
Grass: 0.9%
Turf: 93.4%
Neither: 5.7%

Q: Which surface causes more soreness to play on?
Grass: 1.3%
Turf: 94.8%
Neither: 4.0%

Q: Playing on which surface would be more likely to shorten your career?
Grass: 0.2%
Turf: 90.9%
Neither: 8.4%

Q: Playing on which surface is more likely to worsen your quality of life after football
Grass: 0.4%
Turf: 83.9%
Neither: 9.1%

Q: When your contract runs out, how important a factor will it be for you to select or stay with a team with a grass home field?
Very important: 33.0%
Somewhat important: 41.0%
Not important: 26.0%

Q: Do you believe that you have ever had an injury on turf that you would not have sustained on grass?
Yes: 52.5%
No: 39.7%
No response: 7.2%

The players were also asked to rate the five best and worst fields in the league. The five best were Tampa Stadium, Joe Robbie Stadium in Miami, Jacksonville Stadium, Sun Devil Stadium in Arizona, and Arrowhead Stadium in Kansas City, respectively. All of these stadiums have natural grass fields. Also, the rest of the top nineteen fields in the survey were natural grass as well. The Five worst fields, on the other hand were: Veterans Stadium in Philadelphia, Riverfront Stadium in Cincinnati, the Astrodome in Houston, Three Rivers Field in Pittsburgh, and Giants Stadium in New Jersey. All of these fields are artificial turf. Despite players' apparent dislike of artificial surfaces, all formal studies have found that there is no correlation between artificial turf and increased risk of injury.

In 1972 Joe Grippo, of the Stanford Research Institute, and Dr William McColl, a former standout with the Chicago Bears, sent a report to the NFL and the Players

Association. The report stated that, more minor injuries occurred on turf but with injuries causing athletes to miss at least one game, there was no difference. Injuries sustained on turf generally required less healing time than those sustained on grass. That year in the NFL, 53% of all games were played on turf. However, 60% of knee injuries, and 75% of ankle injuries, those which required the athlete to miss at least two games, occurred on grass.

In 1980, the NFL called upon Dr. John Powell from Penn State University and founder of the National Athletic Injury/Illness Reporting System (NAIRS) to analyze data on player injuries. In 1992 Dr. Powell released a publication based on over ten years of data. The publication stated that of the 1081 knee sprains experienced by players, artificial surfaces were responsible for only 36 or 6.2% of them. Turf was responsible for 26 or 6.6% of 737 sprains of the Medial Collateral Ligament (MCL), and 2 or 2.9% of 114 sprains of the Anterior Cruciate Ligament (ACL). That is not to say that these are the percentages of injuries that *occurred* on turf, but rather, these injuries can be *blamed* on of turf. Many of the injuries that occurred on artificial surfaces occurred from player to player contact. These injuries could have occurred on grass just as easily and are not included in these figures. These figures were generated during a time before newer turf systems came out. Today's artificial systems are safer and more durable than those used in the NFL through the 1970's and 80's.

These studies clearly indicate in general that there is no direct correlation between artificial turf and injuries. The main factors are player contact, position and the general aggressive nature of sports. Yet many athletes site turf as being harder to fall on, easier to catch an ankle and twist it, and more abrasive to the skin. Many separate tests have

been conducted in the three areas of traction, shock absorption, and abrasions. These studies will be discussed in the following three chapters.

5.2 Traction

One of the major factors that affects athletes through the course of the game is the traction provided between shoes and playing surface. Not only does it affect the athlete in terms of stopping and cutting, but it also has a significant impact on their personal safety. Excessive gripping action on the surface leaves the athlete susceptible to injury especially at the knee and ankle because these joints are most vulnerable to the twisting and rotational forces that occur during an athletic event. The athlete usually desires the greatest amount of traction that can be acquired so as to gain whatever competitive edge he can, while the trainer opts for the minimal amount of traction needed to make the game both exciting and safe. The advent of artificial turf has brought on a new option in choosing the most suitable playing surface in this aspect.

In the early 1970's Dr. Joseph Trog of the Temple University Medical School conducted one of the earliest formal studies on this topic. In this survey, Dr. Trog gave local high school football players multi-cleated soccer shoes to wear instead of the traditional seven- spiked football cleats. The study showed a significant drop in the number and severity of ankle/ knee related injuries. A study by Bostingl, Morehouse, and Neible of the Sports Research Institute at Penn State University backed these results. In this test a prosthetic mechanical leg was used to determine the rotational forces on

joints using several shoe- surface combinations. The results showed that the greatest rotational force was exerted on the knee occurred when wearing a seven- spiked football cleat on natural grass.

In 1990, the Nike Sport Research Laboratory conducted a study to determine a design that would produce the greatest amount of stopping, or translational, friction with least amount of rotational traction. Athletes performed regular stopping and cutting drills on an electronic plate covered with an artificial surface. The maximum friction necessary for the athletes to make either a cut or pivot without slipping was calculated to be .8. However, in non-controlled, game situations, the needed friction has been estimated to be as high as 1.5 with noticeable slipping occurring with a coefficient of 1.0. Nike finally concluded that once the coefficient exceeds 2.0, little impact on the quality of play takes place while the potential for twisting injuries continues to rise.

The type of artificial turf that is considered optimal for both the excitement of the game and player safety and is the most widely used today, was determined in a University of Arkansas study. The study used a triaxial elecrogoniometer, a tiny devise that is strapped to the knee and transmits the angular acceleration on the joint. Athletes in the test all wore shoes with a high coefficient of friction while performing basic crossover- running drills on different surfaces. It was found that running on an artificial surface made with textured nylon pile fibers produced less force on the knee than grass, and other forms of synthetic turf. These textured pile fibers are the basis for all current Astroturf playing surfaces.

The best step an athlete playing on artificial turf can take in preventing his own injury, aside from proper training is carefully selecting the shoe he will use. First, the

shoe should obviously fit well to prevent the foot from moving or twisting inside the shoe during a cutting action. The shoe should be cleated at the edge of the sole and toward the toe. This provides the athlete with balance while running on his toes and takes pressure off the ankle. Select a shoe that is well supported towards the front of the foot. This characteristic is to help prevent "turf toe".

The exact definition of turf toe is somewhat obscure among athletes. Turf toe occurs when a large force is placed on the front of the foot. If the instep of the shoe is not stiff enough to support the big toe, the toe becomes hyper- extended at the joint with the foot. Players who suffer from turf- toe complain immediately of pain in the toe and walk on the outside edge of the foot so as to alleviate pressure on the toe. Swelling, depending on the severity of the injury occurs along with a great reduction in range of motion, both in flexion and extension. In the majority of cases, x- rays show no bone fractures but in

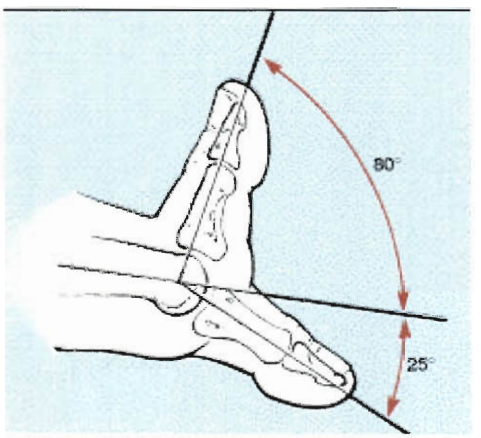


Figure 5.1 Normal range of motion for the big toe.

the more severely classed injuries. All turf toe injuries are classified as one of three different grades. The first grade is characterized by stretched tendons in the toe and is

accompanied by slight swelling soreness. Loss of playing time can be avoided in a class one injury by wearing a brace or shoe that restricts range of motion to 30 degrees. In a second grade injury the tendons become partially torn without injury to the joint; also slight bruising may occur with similar symptoms as in a grade one injury, only more pronounced. In the third and most severe grade of injury, not only are the tendons in the toe completely torn, but there is also a fracture to the joint and the toe itself can become dislocated. A third degree turf toe injury is very painful, with a great degree of swelling and bruising loss in range of motion. However, surgery is rarely required, even in the most severe cases, and if the injury is properly treated, a complete recovery is expected.

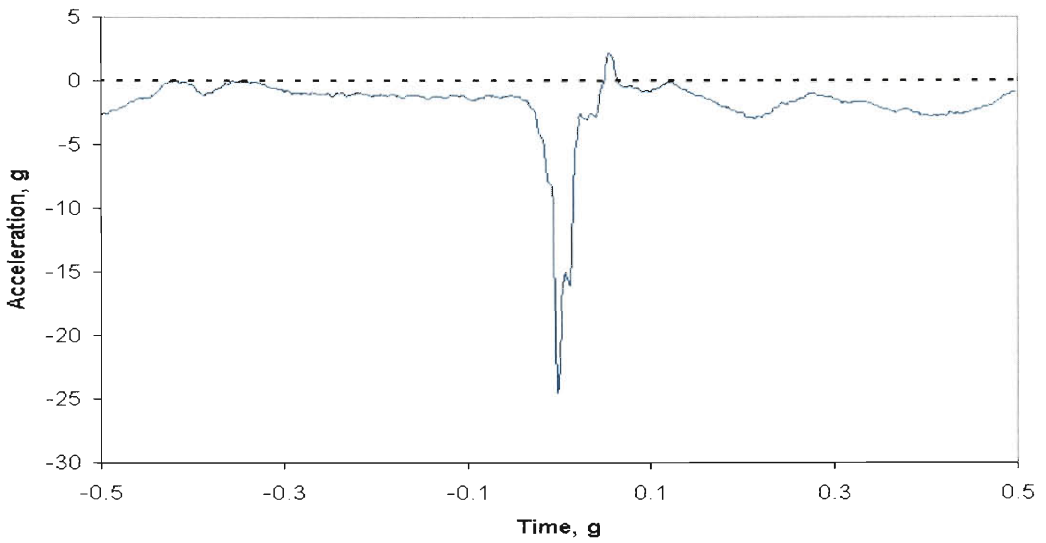
5.3 Shock Absorption

Another common concern about artificial turf is that it doesn't absorb shock very well and is dangerous when landing on it. Also that knees and legs are more easily worn down by running on it. This section will discuss a pair of studies dealing with a surface's ability to absorb shock in regards to both head, and foot contact.

One of these tests is outlined by the American Society of Testing Materials' (ASTM) F- 8 "Sports Facilities and Equipment" Committee. In this test a twenty-pound weight with a round, flat face, and twenty square inches in area, is dropped from a height of twenty four inches onto various surfaces producing a force of 40 ft.lbs. This figure is based on a Northwestern University study, in which it was found that, 85% of all head impacts for middle linebackers produce 40 ft.lbs. or less. The weight is equipped with a

devise that then measures the rate at which the weight decelerates and plots it against time. This curve is called the Wayne State Severity Curve.

Figure 5.2: an example of the Wayne State Curve



It was determined using this curve that 50 to 60 G can be tolerated for approximately 30 milliseconds. But as G levels increase, duration times must decrease.

Using this information the maximum G values for different playing surfaces under different conditions were calculated during the month of November, at the end of football season. While G values on grass depended largely on surface conditions, values for turf stayed relatively constant. On wet muddy grass, G values were determined to range between 65- 70 G. However, on a frozen field, with temperatures below twenty degrees Fahrenheit, G values were as high as 250 and up. On artificial turf, wet field condition G values stated at 75 but climbed only to 150 at sub- freezing temperatures. G values under normal circumstances were comparable between natural and synthetic surfaces. G values for grass surfaces with a sand base were shown to be even higher

under normal circumstances, ranging from 125- 150 G. Turf systems with sand bases also proved to have high G values as the sand gets wet, becomes tightly packed, and then freezes, making for an extremely hard base. By this token, another very hard athletic surface is the packed clay in baseball infields. In 1985 tests were conducted on fields around the major leagues. The infields' G values were found to range from 150 to 240 and up. These tests are the basis for the National Operating Committee on Standards for Athletic Equipment's (NOCSAE) standards in football helmet production.

Although these figures way seem high for both surfaces, these are extreme cases. It is also important to remember that in football helmets the pads provide extra shock absorbency in head collisions. These studies are in fact the basis for football helmet standards as mandated by the National Operating Committee on Standards for Athletic Equipment. (NOCSAE) Since these studies, efforts have been made to soften infield clay. In 1994 a new study showed infield G values to average from 100- 175. Also, although they still are available, sand based turf systems are beginning to be phased out by softer foam- pad bases.

Concern also exists that turf exerts additional shock on the knees and ankles than grass. It is thus believed that softer surfaces that better absorb shock will be less likely to cause injury. In 1998, the Biomechanica Research Group, in association with the Seattle Seahawks, who's home field is artificial turf, conducted a study on this topic.

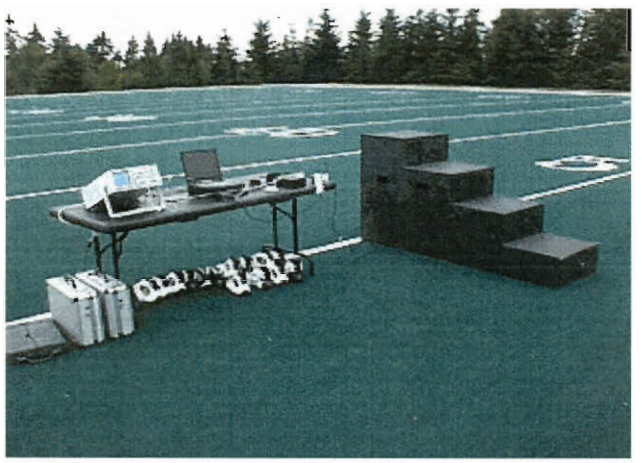
Fifteen men were selected to participate in the study. Four of these men were players for the Seahawks, the remaining nine were local volunteer firefighters and policemen. Each volunteer was equipped with the same make of sneaker and an Entran EGA accelometer, and jumped from a height of one meter. Each volunteer preformed

five jumps each on both grass and artificial turf. The accelometer measured the average shock forces on the knee for each surface. The accelometer and a picture of the test can be seen in figures 5.3, 5.4, and, 5.5.

Figure 5.3: subject wearing the Entran EGA accelometer

Figure 5.4: Subject performing test

Figure 5.5: Equipment used in test



The results of the test showed that the grass surface yielded a lower overall maximum shock value and that it better spread out the shock impulse over time. The average peak shock on turf was 31.8 g compared to 26.2 g on grass. A complete listing of individual shock values on each surface can be seen in table 5.1.

Table 5.1: Mean Peak Leg Shock by Subject

	Natural Turf		Artificial Turf			
Subject	Mean	sd	mean	sd	Δ	*p*
1	-32.4	0.4	-28.4	2.3	4.0	0.044*
2	-21.7	3.0	-18.5	7.6	3.2	0.390
3	-28.6	0.8	-24.6	1.6	4.0	0.016*
4	-31.9	0.8	-30.6	0.0	1.3	0.052
5	-25.9	1.2	-26.1	3.0	-0.2	0.883
6	-32.6	0.7	-32.2	1.1	0.3	0.589
7	-27.0	3.7	-29.3	2.8	-2.3	0.226
8	-12.5	1.0	-22.6	3.7	-10.1	0.008*
9	-19.0	3.3	-21.0	3.4	-2.0	0.267
10	-28.9	3.4	-33.9	0.0	-5.0	0.059
11	-30.9	3.0	-52.8	8.9	-21.9	0.032*
12	-25.3	3.6	-39.7	6.5	-14.4	0.027*
13	-25.5	3.4	-40.5	5.5	-14.9	0.022*
14	-25.3	3.1	-40.1	6.1	-14.7	0.026*
15	-25.5	2.9	-37.5	6.1	-12.1	0.022*

Although in this case, grass did prove to be absorbent of shock on the lower extremities, the figures do not necessarily indicate a direct increase in the likely-hood of injury, as the peak shocks attained on turf do not necessarily exceed any standard deemed safe for shock on the legs. Also, these figures we're compiled in one day and are independent of a varying climate.

5.4 Abrasions

The one complaint against turf that is perhaps the most substantiated is that of skin abrasions or "turf burns". A turf burn is an abrasion on the skin, sometimes known as a "raspberry" that is cause when exposed skin rubs against the synthetic fibers of turf. Every athlete who plays on turf for his or her first time is sure to sustain a turf burn or two. In a survey of WPI athletes, mostly comprised of football players, almost every player asked listed turf burns as a major disadvantage to playing on turf. Although turf burns are a nuisance; they are hardly a cause of great alarm in the way of player safety and performance.

In 1974, the NFL released a study that included the previous two years. It stated that in games played on grass there was a mere .02 serious abrasion injuries per game. This average was predictably lower than that for games played on synthetic surfaces. The average for games played on turf, however, was also comparably low, averaging only .06 injuries per game. In 140 games played on turf during this period, only eight serious injuries occurred. A serious injury was defined as one that caused a player to have to leave the field of play and not return that day. Abrasions were found to be responsible for only 0.1% of all missed time injuries. In 1975 the NAIRS conducted a similar study in the college ranks. In a survey of forty different schools, it found that under game conditions there was only one serious turf burn for every one- thousand athletes. During practice only one in ten- thousand athletes ever sustains such an injury.

One thing that makes abrasions less of a hazard is that a player can easily learn to avoid them. Turf burns are much more common early in the year, and among young players. Over the course of a season, and their careers, athletes learn to roll during a fall

instead of sliding through it and across the turf, which is the habit of athletes who are accustomed to playing on natural grass surfaces. Wearing long socks, and keeping sleeves at three quarters length can help protect the skin from such injuries.

Abrasions do however occur on grass fields as well. This is where artificial turf's advantage is. Because turf is a synthetic substance, it is resistant to the development of bacteria. There is little organic matter to support its growth. If the surface is kept clean, then bacteria have no time to grow, while cleaning grass is not an option. Due to this fact when abrasions do happen, there is a much smaller chance of infection when scrapes happen on turf when they do on grass.

Turf burns are a problem that, although they reflect negatively on synthetic playing surfaces, they do not constitute enough of a threat to player's safety. The main danger that turf burns constitute in today's age is that of communicable diseases. The NCAA has passed rules in recent years prohibiting players to remain on the field while bleeding. This rule affects sports played on all surfaces and doesn't necessarily reflect on turf.

Chapter VI

Does artificial turf change the game, and if so, is it a hinder or a help?

Many different sports are being played on artificial turf, in particular, football, soccer, field hockey and baseball. There is a growing concern that the artificial surface alters the game, making it a different game than when it's played on natural grass. Does artificial turf change the game and if so, for the better or worse?

6.1 Major League Baseball batting averages

Artificial turf was born in the sport of baseball, in the Houston Astrodome, in 1966. Ever since then there has a great deal of concern as to whether or not the artificial surfaces changes "America's pastime."

Some people feel that the game is changed due to inflated batting averages. The argument revolves around the speed with which ground balls pass through the infield. People feel that because the baseball travels faster on an artificial surface than on a natural grass surface, more ground balls will get through the infield for base hits. The feeling is that many groundballs that become base hits on artificial turf would be merely groundball outs on grass (erols.com).

An analysis of batting performance between 1984 and 1994 was done, which included every major league game played in that 11-year period. The results of the study show that the surface is irrelevant and batting averages were in fact, unaffected by

League	Surface	Games	At Bats	Hits	Average
AL	Grass	8664	590960	154545	.262
	Turf	3466	237665	62888	.265
NL	Grass	5474	372243	95367	.256
	Turf	5202	352519	89421	.254
Both	Grass	14138	963203	249912	.259
	Turf	8668	590184	152309	.258

Table 6.1 Bating averages from 1984-1994 on both grass and turf (erols.com).

Table 5.1 shows that the batting averages over that 11-year span were not inflated by artificial turf at all. In fact the average of the batting averages was 1 point higher on the grass fields.

Since more major league teams have grass than turf, there were far more games played on grass. However, the National League has the majority of artificial surfaces and the number of games played on turf in the National League is close to the number played on grass. In the National League the batting averages were actually two points higher on grass.

It is not merely coincidental that the batting averages are unaffected by the surface on which the games are played. The reason is due to the fact that since the ground balls are traveling faster, the infielders adjust their positions by moving back toward the outfield accordingly. This allows them to have a seemingly equal range as

compared with grass when they play closer. Since the ball is moving faster the infielders are afforded the extra time necessary to throw the ball the extra distance (erols.com).

Since no two major league parks are the same, there are a number of other factors that may affect a batters performance, or batting average in this case. Some parks are domes and therefore wind is not a factor. Some parks are symmetrical whiles others, such as Fenway Park in Boston are extremely asymmetrical. Also, some parks have more foul territory than others do. David W. Smith, the gentleman conducting the batting performance study, attempted to reduce these factors that separate one park from the next. he did so by only counting the at bats where the ball was put into play on full swings and a fielder had an opportunity to make a play on the ball. This amounted to an adjusted value for at bats, which equaled at bats minus strikeouts, bunts and homeruns, plus sacrifice fly balls. The averages for the adjusted at bats are shown in table 5.2.

League	Surface	Games	Adjusted avg.
AL	Grass	8664	.290
	Turf	3466	.294
NL	Grass	5747	.290
	Turf	5202	.288
Both	Grass	14138	.290
	Turf	8668	.290

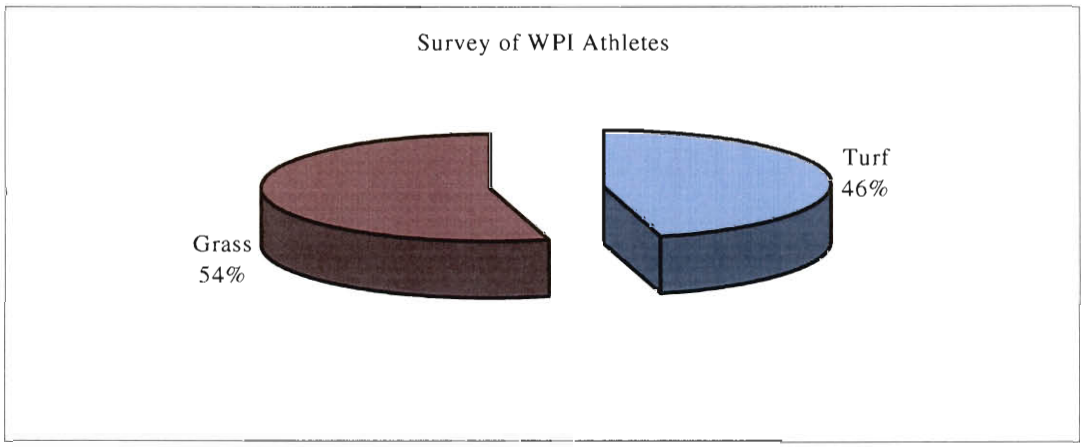
Table 6.2 Adjusted batting averages (erols.com).

Examining table **6.2** is clear that the batting averages in Major League Baseball are not affected by the surface that the game is played on. Using the adjusted at bats, the averages actually for both the National League and the American League were the same for grass and turf. So the conclusion drawn from this data is that batting performances are not affected by the surface and therefore the game of baseball has not significantly changed with the implementation of artificial turf.

6.2 Player surveys

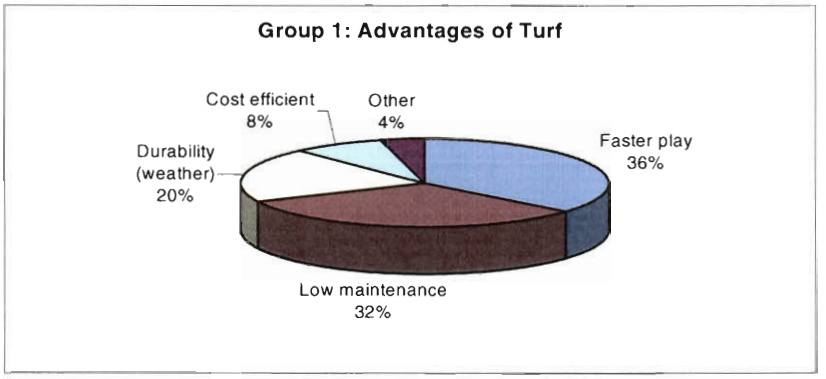
To get some hard results a survey was performed of athletes at WPI. 24 students responded to our 9-question survey, the results of which are contained in this section. Out of the students who responded, all have played on artificial turf as well as grass.

The pie charts below are the results of a campus small-scale survey done at WPI. The subjects studied in the survey participated in a number of different outdoor sports ranging from baseball to football to lacrosse.

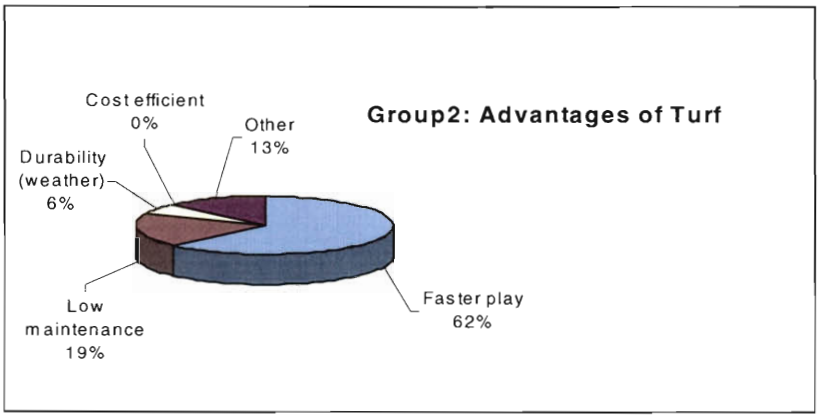


Graph 6.1 Turf versus grass preference among participants

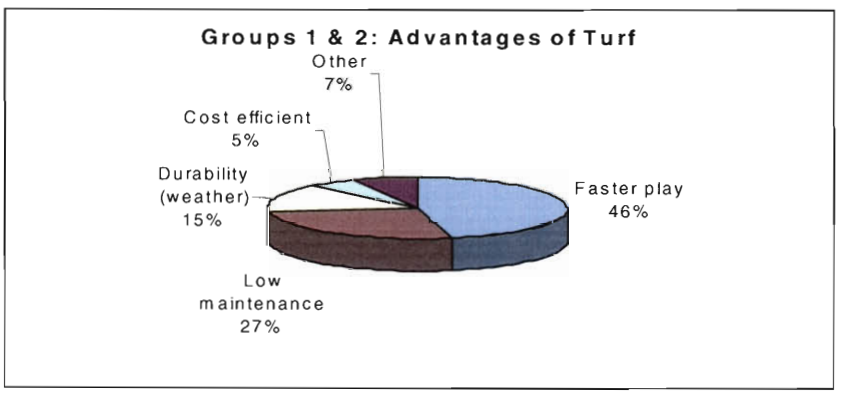
Graph 6.2

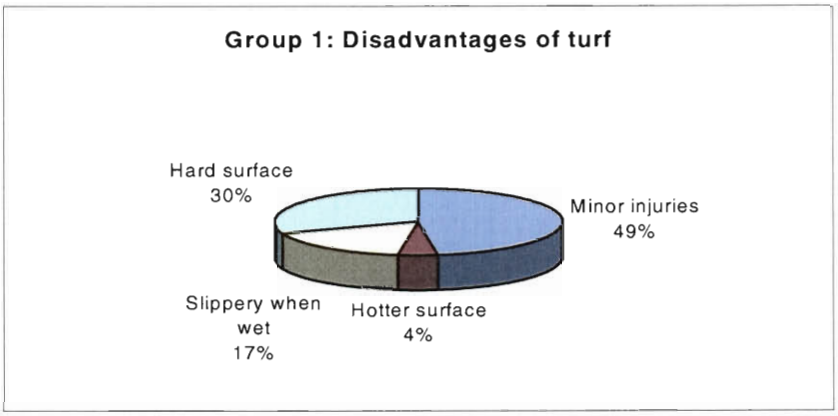


Graph 6.3

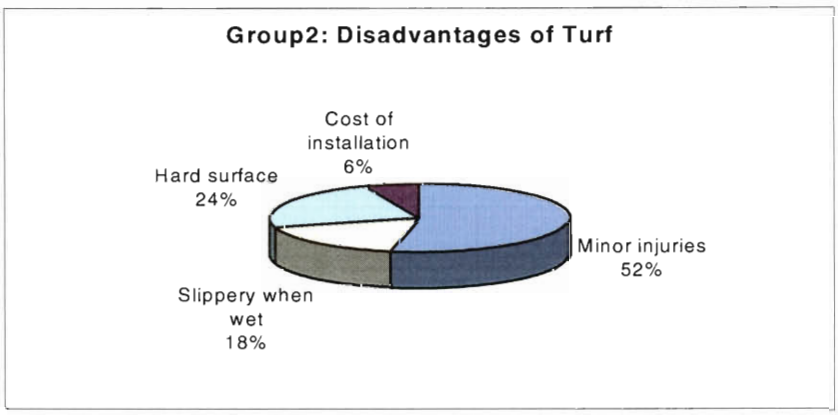


Graph 6.4

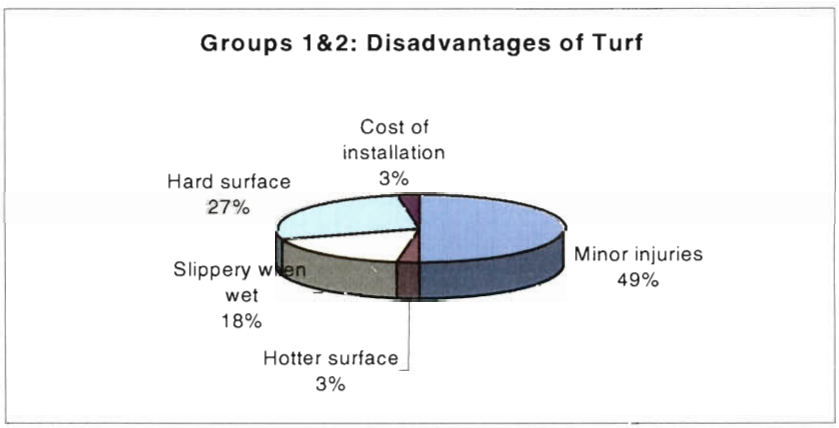




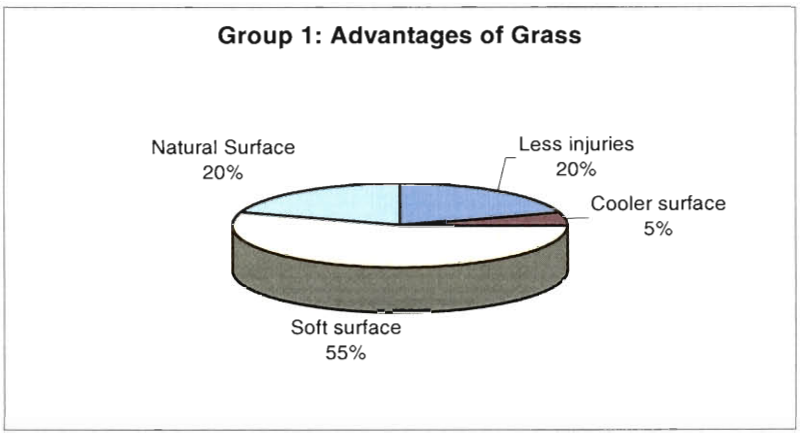
Graph 6.5



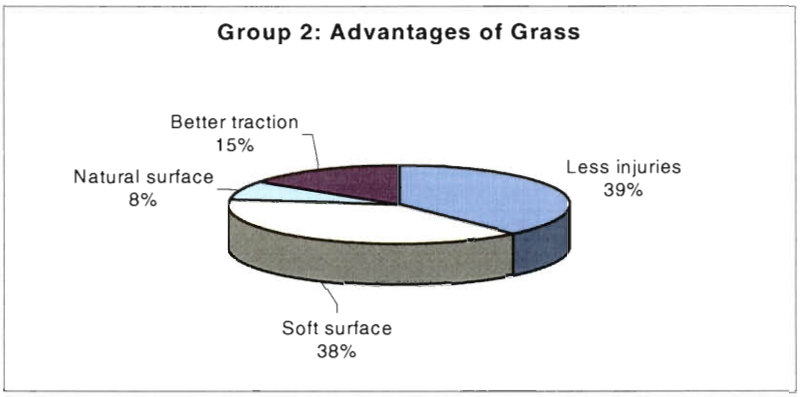
Graph 6.6



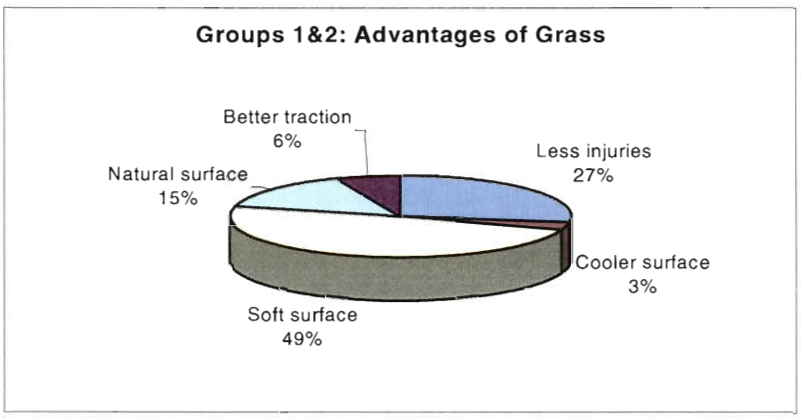
Graph 6.7



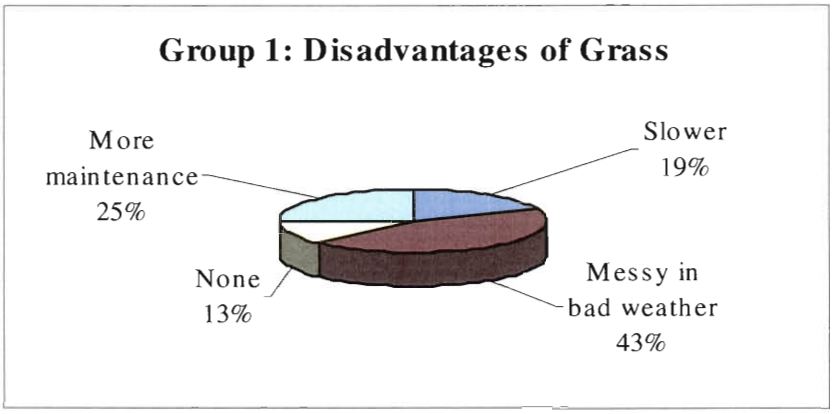
Graph 6.8



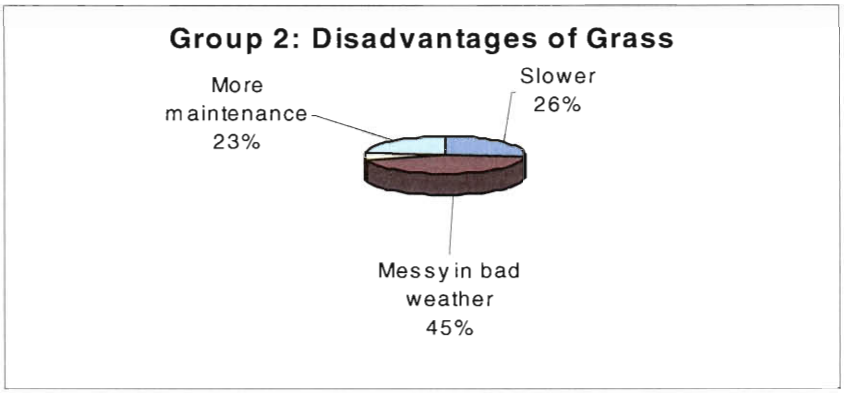
Graph 6.9



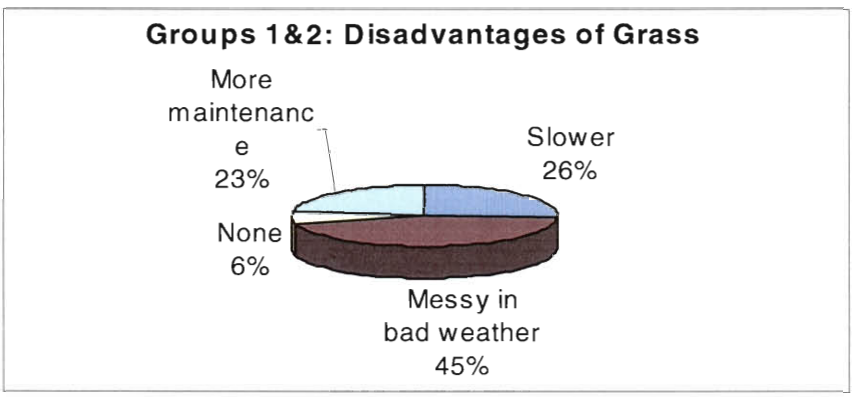
Graph 6.10



Graph 6.11



Graph 6.12



Graph 6.13

The intention of this survey was to get an idea of how student athletes generally feel about artificial turf, in hopes of helping to determine whether or not artificial surfaces changes the way the games are played. The pie charts are separated in two groups. Group 1 is made up of those that prefer to play their respective sport(s) on grass, and group 2 is therefore made up of those who prefer to play on turf (see graph 5.1).

The most common answers for the advantages of artificial turf are shown in graphs 6.2, 6.3 and 6.4. Those answers include cost efficiency, faster play, low maintenance and weather durability. These graphs and their results are directly correlated to graphs 6.11, 6.12 and 6.13, which are the disadvantages of grass. Of course many advantages for option can equate to disadvantages for the other. Since this chapter is devoted to determining if and how sports are changed by artificial turf, cost and maintenance can be disregarded. They are in fact useful for determining the practicality of turf as a grass alternative (see chapter IV). Without cost and maintenance only weather durability and speed of play are left. Weather can certainly change a game. If it rains or snows during a football game it becomes more difficult to establish a passing attack due to fact that the ball might be wet and therefore difficult to throw and catch. Strong winds can also make it very hard to successfully complete a pass. A soccer ball could also change path due to wind, making it somewhat difficult. Footing can change significantly as well under adverse weather conditions, for any sport. A football player carrying the football may fall to the ground untouched more often if the ground has become wet. A field hockey player on a brake away may slip just as she is about to shoot the ball. However, these weather possibilities are nothing new. Weather has played a factor in many contests for as long as these games have been in existence. The only significant difference between artificial turf and grass with respect to weather is mud.

Under heavy rain followed by heavy traffic, a grass field can become muddy. So now the question is, does the lack of mud on turf change the game? The answer is yes, somewhat. Mud only hampers player traction, so a lack of it on artificial turf means better footing. So, during a rainy game on turf one can expect a more consistent game in terms of traction. If the game is more consistent with normal, or positive conditions, turf has only *helped* the sports using it. Consistency is desirable in sports, mud is not. though some athletes find it fun to participate in a messy, muddy game, one would be hard pressed to find some who thinks mud helps any sport. Therefore turf has slightly affected the sports, but only in bad weather and in a positive manner.

Since 40% of all individuals surveyed feel that an advantage of artificial turf is faster play it is desirable to examine whether or not it affects any sports. Since all 24 individuals in the survey play football and only a couple play other turf sports, a majority of the data and arguments should be directly related to football. Most individuals seemed to think their speed is increased on the artificial surface. However, this is only an indication of the pace at which the game moves. In football, a receiver may complete his pattern slightly quicker than on grass, or a defender might converge on a ball carrier slightly quicker. However, the game itself is not changed. A coach does not have to position players differently or plan an offensive attack differently. Everything is relative because all the players are playing on the same speed increased surface. A game on grass is still the same but at a slightly slower pace, which is unnoticeable from a fan standpoint.

The next step is to examine the responses to the disadvantages of turf, represented by graphs 6.5, 6.6 and 6.7, and therefore the advantages of grass, represented by graphs 6.8, 6.9 and 6.10. The most common answers given for turf disadvantages were, hard

surface, wet traction, injuries, cost and heat. The most common answers for grass advantages were, natural, soft, fewer injuries, cooler, and better traction.

Traction are thrown out because they have already been dealt with along with the weather issues. Cost is once again thrown out since it has no bearing on the play of game. The hotter turf versus the cooler grass can be disregarded since it is not significant enough to affect player performance and therefore game play. Grass being "natural" is not validated as an advantage over turf for the purpose of this discussion. The only item left is injuries. Though many people believe artificial turf causes more serious injuries there is no evidence to support that. Eric Barnum, the School District student-services director for the Northshore in Seattle, Washington, said, "there hasn't been any noticeable rise in injuries to high school athletes" (seattletimes.com). Another study done by Ekstrand and Nigg revealed the incidence of injury to be about the same (biomechanica.com). At this point all NFL studies have proved inconclusive (newstimes.com). Since studies show that turf causes no more injuries than grass, injuries can be ruled out as a factor affecting the play of the game in any way, shape or form.

For the last question of the survey the participants were asked to answer the question, do you feel the game is changed by turf, and if so, how and for better or worse. Mostly all the answers were directly related to the answers given for advantages and disadvantages, and as described above, none of them amounted to a true negative change of how the games are played.

Chapter VI

Growing need for field space

The Ford Foundation began researching the feasibility of an artificial athletic playing field in the 1950's in hopes of giving the youth of America's cities a better place to play. The goal of the Ford Foundation's research was to provide the cities with athletics fields that would not be turned to dirt in a short time due to overuse. Actually, many children in the cities do not even play on grass fields but rather on concrete lots. The idea was to provide a lasting surface that somewhat simulated grass, so that the children would have similar opportunities as the rural children to become athletic.

Today the same concerns about land development exist. The cities are not getting any smaller and even the rural areas are running out of land for new athletic fields. The only way to get land in the city is to tear down buildings. That just is not a feasible option for developing new fields. Corporate enterprises are the only ones tearing down buildings and they sure are not doing it so they can build athletic fields. The idea of using artificial turf becomes more and more appealing as there are little to no other options other than letting the children continue to play on overused fields and paved parking lots. In New York City over 30 fields have been converted to turf. The 42 fields that existed as of 1968 were just not sufficient enough to handle all the activity played on them, like high school sports, physical education and intramural activities. In 1968, five of the fields were converted to artificial turf and since then the number has ballooned to more than 30. One major project involving the installation of artificial turf was done on the roof of sewer treatment plant on the Hudson River in New York. Grass would not

have allowed this project to work, but thanks to the invention of artificial surfaces it was possible to build a wonderful facility for city kids to play (newyork.sidewalk.com).

Even smaller towns are now experiencing difficulty with field availability. The population is on the rise and will likely continue to do so. More and more youth organizations are starting up everywhere. America's youth are participating in baseball, tee-ball, flag football, tackle football, field hockey and soccer. The youth programs are expanding and it is becoming more difficult to keep the limited field space in good shape. Even the high schools are experiencing difficulty. Sometimes parents of the students push to get new sports implemented but the fields can only handle so much abuse. At Northbridge High School in central Massachusetts the parents of middle children tried desperately to get a middle school soccer program started. However, as it is, the fields are in poor condition at the high school and there is not enough space to accommodate all the sports that currently exist. The soccer teams at the varsity and junior varsity level have already been forced to use town fields away from the high school, which are also in poor condition. Many other towns are experiencing the same problems.

Part of the problem lies within the fact that the soccer population knows no limits. Every sport has its season except soccer. Football is played in the fall, field hockey in the fall, baseball in the spring, lacrosse in the spring, and so on. However soccer is played year round. There are fall leagues, summer leagues, spring leagues, and even leagues in the winter.

With the growing youth programs and soccer's need to play four seasons a year, it is becoming vitally important to come up with a solution. The towns do not seem to be rushing to build more fields, and in the cities that option does not really exist. The alternative is to start building artificial turf playing fields. Otherwise the fields will

continue to deteriorate until they are nothing but dirt. Most towns and cities do not have the financial means to keep the fields in proper working condition. The constant pounding that the fields take means that they would probably need new sod once or twice a year. The sod would get expensive enough never mind the labor. Probably most towns do not have enough money to install irrigation systems, which they would need if they were to have new sod laid down.

Most rural towns have not yet begun to install artificial turf athletic fields, though it is a practical alternative. As long as the youth programs continue to expand options and alternatives will run out. Turf fields provide smooth and consistent playing surfaces for many years and need far less maintenance than grass fields.

Although turf has yet to become a popular alternative for town youth programs outside the cities, it has become popular at the college and professional level all over. Many colleges like Worcester Polytechnic Institute have resorted to artificial turf due to the lack of available space. The campus here at WPI is small and has no room to expand its athletic facilities. With field hockey, women and men's soccer, lacrosse and football all sharing the same field for home games and practice, a grass field would get terribly worn down over the course of a year.

Many professional teams have opted for artificial turf as well. Some stadiums are domes like the Houston Astrodome and have no choice and others like the Meadowlands host an abundance of events and need a surface that can withstand the abuse. The Meadowlands, home to both the New York Jets and the New York Giants football teams, hosts all home games of both franchises, many college football games, high school championship games, and a host of concert events each year. A grass field simply could not handle all that traffic and stay in good condition.

Chapter VII

Conclusion

In analyzing whether or not artificial turf is a practical alternative to grass there are many things to examine. For example, it is desirable to look at costs associated with turf, versus those associated with grass. It should also be observed how turf changes athletics and most importantly, whether or not there are more injuries on artificial turf than grass.

The evidence in chapter 4 shows that it is more cost effective in the long run to use artificial turf, especially if the field in question experiences a large amount traffic. As Richard Leach, the Physical Education and Athletic Consultant for Atwood Stadium in Michigan tells us, one artificial field can provide what 17 grass fields can provide (astroturf.com). Since you can get so much use out of one field there is also the advantage of a joint ownership which can significantly minimize costs for each party involved. An organization is not afforded that luxury with a grass field since a grass field is only capable of handling so much use.

Chapter 5, dealing with injuries, demonstrates that injuries are not increased on artificial turf as so many people believe. Minor injuries like turf burn and turf toe are factors to consider, but are not significant enough to lesson the value of an artificial surface as an alternative to grass when so many organizations and schools simply do not have the luxury of using and properly maintaining grass fields.

Finally, chapter 6 shows that the sports played on turf are not significantly altered in the way that they are played, such that turf should be rendered impractical. The pace

of the games is quickened and weather is less of a concern. These factors do equal changes in the play of the games.

The conclusion is therefore that artificial turf is an extremely useful and practical alternative to grass, which does not put athletes at any more risk to injury than grass does.

Appendix A

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster
Cleaner
easier to maintain

3.Please list the advantages of grass.

no turf burns

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Broken ankle.

5.Please list the disadvantages of turf.

turf burns

6.Please list the disadvantages of grass

Dirty
slow

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf (✓) Grass ( )

9. Do you feel the game is changed by turf? How? Better or worse?

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(√) N( )

2.Please list the advantages of turf, in your opinion.

~~Better speed~~
Better speed
no cleats

3.Please list the advantages of grass.

Hurts less

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

rolled ankle on grass
deep scratches on turf.

5.Please list the disadvantages of turf.

The injury is more painful and There is more scrapes.

6.Please list the disadvantages of grass

Makes me more slower and it requires cleats which are more dangerous.

7.What sports do you participate in?

Football & Rugby

8.If you could make the choice which surface would you rather compete on?

Turf (√) Grass ( )

9. Do you feel the game is changed by turf?

How? Better or worse?
It's better to play on turf but the game is still the same.

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(X) N( )

2.Please list the advantages of turf, in your opinion.

Faster
no cutting
uniform surface
cut better

3.Please list the advantages of grass.

cheap

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

turf burns
ankle twist (grass)
turf toe

5.Please list the disadvantages of turf.

expensive
hard
slippery (wet)

6.Please list the disadvantages of grass

mud (wet)
cutting grass
non level

7.What sports do you participate in?

Football
Softball

8.If you could make the choice which surface would you rather compete on?

Turf (X) Grass ( )

9, Do you feel the game is changed by turf? How? better or worse? Faster

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster surface for running, easier to jump off of

3.Please list the advantages of grass.

Softer surface, better traction

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Turf - Turftoe, turfburn,

5.Please list the disadvantages of turf.

Not very good traction when raining

6.Please list the disadvantages of grass

Grass stains on uniform. That's it.

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf? How? better or worse? For the worse

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

- Sports are faster on turf. Less maintenance

3.Please list the advantages of grass.

More natural, less injuries, softer, You can get dirty on grass.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

None, None

5.Please list the disadvantages of turf.

Turf burn, hard, more injuries.

6.Please list the disadvantages of grass

Slower, more maintenance

7.What sports do you participate in?

Football, Lacrosse

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf? How? better or worse?

Football has not change. Lax the ball never stops. It sucks

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

(Y( ) N( )

2.Please list the advantages of turf, in your opinion.

BETTER WHEN IT RAINS THAN GRASS. NOT AS MESSY AS GRASS.

3.Please list the advantages of grass.

SOFT
SPIKES.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

5.Please list the disadvantages of turf.

NOT AS SOFT ON KNEES HURTS MORE WHEN FALLING DOWN. CAN'T USE SPIKES SO NOT AS MUCH TRACTION.

6.Please list the disadvantages of grass

MESSY WHEN WET

7.What sports do you participate in?

FOOTBALL
B-BALL

8.If you could make the choice which surface would you rather compete on?

Turf ( ) (Grass ( ))

9. Do you feel the game is changed by turf? How? better or worse? YES WORSE MORE injuries

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y( ) N(X)

2.Please list the advantages of turf, in your opinion.

Easier maintinence, faster for athaletes, more even surface, predictable bounces, lower overall cost.

3.Please list the advantages of grass.

Better all-around surface, easier on bodies, "nostaglia factor" where the game was meant to be played.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

None, but I have torn an acl, mcl, and cartilidge that required surgery.

5.Please list the disadvantages of turf.

More injuries, turf burn, knee problems, ankles, turf toe, harder surface, needs to be replaced

6.Please list the disadvantages of grass

More maintinence, worse in weather (rain, freezes), slower dirty (but that can be good)

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (X)

9. Do you feel the game is changed by turf? How? Better or worse? Made it worse, has taken games out of their intended natural settings, gives some people unfair advantages.

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

faster play
easy maintenance
always good playing condition
good traction

3.Please list the advantages of grass.

better on joints
softer
better feel when playing

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Turf Burns (Turf)
twisted ankel (grass)

5.Please list the disadvantages of turf.

Turf Burns
bad on joints
very hard to fall on
very slippery when wet

6.Please list the disadvantages of grass

very sloppy in bad conditions
worse traction

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf? How? better or worse? Its much faster play. Play is better on grass because its better on athletes bodies

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Turf has more traction than grass does. Makes the participant faster and quicker than if on the grass.

3.Please list the advantages of grass.

Safer surface.
dirt is good.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Turf - turf toe, turf burns.

5.Please list the disadvantages of turf.

Turf burns.
Turf burns
Turf burns.
Turf toe.

6.Please list the disadvantages of grass

More slick than artificial turf.
unlevel playing field.

7.What sports do you participate in?

Football.

8.If you could make the choice which surface would you rather compete on?

Turf (✓) Grass ( )

9. Do you feel the game is changed by turf? How? better or worse? The game is much quicker and more exciting on turf than on grass.

Eddie D.

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Speed
Cutting
Maintenance

3.Please list the advantages of grass.

Softer
Easier on joints

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

5.Please list the disadvantages of turf.

burns
injuries

6.Please list the disadvantages of grass

Maintenance

7.What sports do you participate in?

Football
Hoops
Track

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf? Yes

How? better or worse? better - better speed, agility
Worse - burns, injuries

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

FASTER GAME
EASIER MAINENANCE

3.Please list the advantages of grass.

SOFTER SURFACE

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

TURF BURNS

5.Please list the disadvantages of turf.

TURF BURNS
HARDER SURFACE

6.Please list the disadvantages of grass

SLOWS GAME DOWN WHEN WET

7.What sports do you participate in?

FOOTBALL

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf?
How? better or worse? YES, MAKES IT FASTER, AND CHANGES THE INFLUENCE OF WEATHER

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster for Running
Very Even and Flat
Low Maintenence

3.Please list the advantages of grass.

Traditional
Soft-Squishy Landing

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Turf Burn
Turf Toe
Chronic Back Pain

5.Please list the disadvantages of turf.

Slippery when Wet
Too Hard, high impact through feet leads to chronic injuries

6.Please list the disadvantages of grass

Bumpy Uneven
Difficult to Maintain
Becomes Rocky and Dusty

7.What sports do you participate in?

F- BoM

8.If you could make the choice which surface would you rather compete on?

Turf (X) Grass ( )

9, Do you feel the game is changed by turf?

How? Better or worse?

Yes, it is played at higher speeds

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(X) N( )

2.Please list the advantages of turf, in your opinion.

Better grip (dry). Run faster, cut better.

3.Please list the advantages of grass.

Softer, less injuries, fun in the mud.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Turf: Broken Colar bone
Sore Knees
Shin Splints

5.Please list the disadvantages of turf.

When wet, slippery. Too good of a grip when dry; cause "turf toe" sprained ankles. Injuries!
Turf Burns

6.Please list the disadvantages of grass

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (X)

9. Do you feel the game is changed by turf?
How? better or worse? Worse. More Injuries.
Game is faster on Turf.

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(X) N( )

2.Please list the advantages of turf, in your opinion.

EASY TO MAINTAIN

3.Please list the advantages of grass.

MORE GIVING
NATURAL

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

NA

5.Please list the disadvantages of turf.

HARD - PRONE TO INJURIES
TURF BURNS

6.Please list the disadvantages of grass

DIFFICULT TO PLAY ON IN ADVERSE WEATHER CONDITIONS

7.What sports do you participate in?

FOOTBALL

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (X)

9. Do you feel the game is changed by turf? YES

How? better or worse? BOTH ADVANTAGES AND DISADVANTAGES

BETTER- SPEED WORSE - INJURIES

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(√) N( )

2.Please list the advantages of turf, in your opinion.

Game is faster, conditions are usually better and more predictable than grass

3.Please list the advantages of grass.

no turf burns and if field is in good condition it is easyier on body

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

turf burns groin

5.Please list the disadvantages of turf.

turf burns
seems like there are more knee injurys

6.Please list the disadvantages of grass

turned ankles if field is in poor cond.

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (√)

9. Do you feel the game is changed by turf?
How? better or worse? Yes faster game more hits and intensity

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓ N( )

2.Please list the advantages of turf, in your opinion.

More speed and ~~more~~ greater ability to cut.

3.Please list the advantages of grass.

No turf burn.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Turf burn on wrist and knees.

5.Please list the disadvantages of turf.

When you fall you get turf burn!!!

6.Please list the disadvantages of grass

You are slower on grass. When it rains the grass becomes really slippery.

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf (✓ Grass ( )

9. Do you feel the game is changed by turf? How? better or worse?

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster, quicker cuts

3.Please list the advantages of grass.

No turf burns

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Fractured thumb (2 places) - grass
Torn ligament - grass
turf burns - turf

5.Please list the disadvantages of turf.

turf burns

6.Please list the disadvantages of grass

slower, ditches, easier to twist ankle

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf (✓) Grass ( )

9. Do you feel the game is changed by turf? a little

If so, better or worse? I think better - feels more proffessional, and faster

ition

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster Running Speeds.
Game generally faster.
Referees make better calls.
Easier to run pass routes

3.Please list the advantages of grass.

Softer to land on.
No burn

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

- Turf burns
- Grass broken elbow
- Grass Sprained knee

5.Please list the disadvantages of turf.

More Knee injuries
turf burns.

6.Please list the disadvantages of grass

more ankle injuries.
Slower game.

7.What sports do you participate in?

Football, Wrestling

8.If you could make the choice which surface would you rather compete on?

Turf(✗) Grass ( )

9. Do you feel the game is changed by turf?

How? better or worse? Made the game more exciting and faster.

Pro Turf

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster, easy to maintain

3.Please list the advantages of grass.

Softer

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Torn Mcl
~~sp~~ Sprained ankles

5.Please list the disadvantages of turf.

Slippery when wet, turf burns

6.Please list the disadvantages of grass

Hard to maintain, when more than one sport uses it.

7.What sports do you participate in?

Football
Track

8.If you could make the choice which surface would you rather compete on?

Turf (✓) Grass ( )

9. Do you feel the game is changed by turf? how? better or worse? Much faster

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Turf is quicker, easier to run on.

3.Please list the advantages of grass.

Better footing, easier to push off on.

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Obviously, turf burns. Ive I broke my foot on turf but I don't know if it was from the turf

5.Please list the disadvantages of turf.

Hard to stop. Painful landings.

6.Please list the disadvantages of grass

When wet, can slide very easy.

7.What sports do you participate in?

Football

8.If you could make the choice which surface would you rather compete on?

Turf (✓) Grass ( )

9. Do you feel the game is changed by turf? Yes

How? better or worse? A lot quicker, faster, higher intensity.

DAN OBRIEN

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

speed, low maint., good looks, multi-sport participation good for field hockey

3.Please list the advantages of grass.

soft falls
natural feel

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

big burns
sore knees
frigging turf burns take forever to go away

5.Please list the disadvantages of turf.

injuries! esp. joints (knees)
turf burns
sucks for football

6.Please list the disadvantages of grass

upkeep

7.What sports do you participate in?

football

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf? yes
How? better or worse? obviously different speeds mean a diff game

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

consistent, all weather, flat (no holes or bumps)

3.Please list the advantages of grass.

less injuries than turf

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

ankle + knee sprains on grass

a. Do you feel the game is changed by turf?

How? (Better) or worse?

it is faster

5.Please list the disadvantages of turf.

higher percentage of injuries

6.Please list the disadvantages of grass

gets slick when wet

7.What sports do you participate in?

football

8.If you could make the choice which surface would you rather compete on?

Turf (✓) Grass ( )

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(X) N( )

2.Please list the advantages of turf, in your opinion.

LESS CHOCLATAS
DUE TO WEATHER

3.Please list the advantages of grass.

-NATURAL
-SOFT
-LESS INJURIES
-AWESOME

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

KNOCK ON WOOD

5.Please list the disadvantages of turf.

-INJURIES
-NOT SOFT
-NOT REALISTIC
-TURF BURNS

6.Please list the disadvantages of grass

NO DISADVANTAGES

7.What sports do you participate in?

FOOTBALL & BASEBALL

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (X)

9. Do you feel the game is ~~changed~~ changed by turf?

How? Better or worse?

YES — FASTER CUTS
- FASTER RUNNING TIMES

WORSE: - GRASS IS THE GREAT EQUALISER

Jared Lachapelle
Bill Ferrari
Matt Munzing

IQP Survey

1.Have you participated in athletics on grass as well as artificial turf?

Y(✓) N( )

2.Please list the advantages of turf, in your opinion.

Faster play, longer season possibility, lower maintenance

3.Please list the advantages of grass.

Less injuries, not as hot during FB season

4.Please list, if any, injuries suffered as a result of playing on either grass or turf.

Burns
ankle injuries
tendonitis

5.Please list the disadvantages of turf.

more injuries
hotter during season
turf burns

6.Please list the disadvantages of grass

slower
gets muddy in rain

7.What sports do you participate in?

FB

8.If you could make the choice which surface would you rather compete on?

Turf ( ) Grass (✓)

9. Do you feel the game is changed by turf? Yes, Indoor facilities
How? better or worse? somewhat better because you have year round play.

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