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A SURVEY OF FOOTBALL KNEE INJURIES AND CAUSES
ON SYNTHETIC SURFACES AS COMPARED
TO REGULAR FOOTBALL SURFACES

by

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A professional paper submitted to the Graduate Faculty
in partial fulfillment of the requirement for the degree

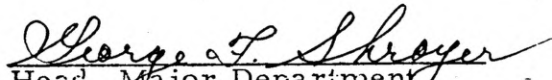
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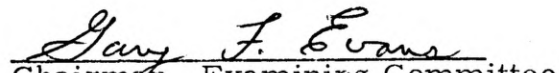
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ABSTRACT

The problem of this study was to conduct a survey of major football knee injuries and the causes of these injuries on synthetic football fields as compared to the knee injuries and causes on regular football fields.

A questionnaire developed by the investigator was used in this study to survey the following areas: (1) the types of playing surfaces and the conditions of these surfaces when the knee injury occurred; (2) knee injury as related to types of football shoes and cleats; (3) was severity of the knee injury increased or decreased by type of surface played on and the condition of that playing surface; and (4) personal data collected about the player preceding the knee injury and after the injury.

This study was delimited to the head football coach or trainer in fifty-four selected high schools and universities throughout the United States, who played on synthetic and regular surfaces during the football season of 1969.

The findings of the study showed there were more knee injuries on a grass surface than on any artificial surface that football is played upon and that dry playing surfaces of any type are the most dangerous condition as far as knee injuries are concerned. A large percentage of knee injuries are cleat in surface related and synthetic surfaced playing fields will reduce the severity of most types of knee injuries. Personal data collected showed better conditioned players, a cutting down on long practice scrimmages and long practices, and the resting of tired players during games will cut down on knee injuries.

It was concluded that synthetic surfaced football fields were safer than regular surfaced football fields, however the game of football with bigger, faster, and stronger players is going to result in a certain number of injuries regardless of the type of surfaces on which the game is played.

CHAPTER I

STATEMENT OF THE PROBLEM

The general problem of this study was to conduct a survey of major football knee injuries and the causes of these injuries on synthetic football fields. More specifically an attempt was made to determine the following:

1. The type of playing surfaces and the condition of these surfaces when the knee injury occurred.
2. Knee injury as related to types of football shoes and cleats.
3. Was severity of the knee injury increased or decreased by type of surface played on and the condition of that playing surface?
4. Personal data collected about the player preceding the knee injury and after the knee injury.

Definition of Terms

The following definitions are provided as a guide to better understanding in this study.

Major knee injury:

An injury to the knee that has caused the player to miss at least one full football game.

Those injuries which appear to be of a serious nature. The word serious was interpreted to indicate possible torn ligaments, cartilages, severe sprains, operative conditions, etc.¹

¹Mel Blickenstaff, Indiana State University Varsity Football Injury Report 1967-1968, p. 2.

Synthetic football fields:

Artificial football turf such as Tartan Turf or AstroTurf, basically made from nylon fibers placed on a shock absorbing rubberized pad.

Athletic Trainer:

A trainer is:

A qualified person working in close association with a physician to supervise the athletes' conditioning program, to fit carefully protective equipment, to render first aid in emergencies, and to carry out physical therapy.²

Delimitations of The Problem

This survey was delimited to thrity-five selected high schools and colleges in the United States playing on synthetic surfaces and the fourteen largest high schools in the state of Montana and twenty-one colleges throughout the United States who played on regular surfaces. (See Appendix A). The study was further delimited to major knee injuries and causes during the football season of 1969.

Justification of Study

The high schools and colleges of the United States have tried to cut down on the football knee injury rate. The many methods tried to

²Allan J. Ryan, Medical Care of The Athlete, New York: McGraw-Hill Company, 1962, p. 50.

protect football players from knee injuries have not been entirely successful. A new type of synthetic surface has been invented to play football on. The companies making these new synthetic playing fields claim it will cut down on knee injuries up to 80 percent. According to Rozelle:

The National Football League and the American Football League have subsidized a medical study on injuries and the feasibility of playing on synthetic surfaces as a means to cut injuries, but results are far from conclusive.³

This survey did try to determine something conclusive about synthetic surfaces and the causes of knee injuries.

Research Method

A questionnaire was designed to solicit the desired information for the following reasons (1) the questionnaire was constructed to easily obtain the desired information, (2) the questionnaire was a rapid and efficient method of gathering data.

The questionnaire did obtain information considered important. Questions were adopted from the NCAA Football Injury Questionnaire with the help of the Physical Education Staff and the Athletic Trainer at Montana State University.

Hypothesis

It was hypothesized that there were fewer and less severe

³Pete Rozelle, New York Times, November 15, 1968, p. 59.

football knee injuries on synthetic football fields, than on the grass and dirt fields played on by the selected schools in the United States.

Population Involved

The population playing on regular fields were the head football coach or trainer of the fourteen largest high schools by enrollment in the state of Montana and twenty-one colleges and universities throughout the United States. (See Appendix A)

The population on synthetic surfaces was the head football coach or trainer of the fourteen public high schools in the City of Seattle and twenty-one selected colleges and universities throughout the United States who played on synthetic surfaces. (See Appendix A)

The Questionnaire and Distribution

A questionnaire was developed by the investigator and pre-tested on four schools using regular and synthetic surface fields for football. The questions were very objective and involved only the marking of a number or short word answers on the part of the recipient. (See Appendix C) The questionnaire was directed to the head football coach or trainer of the selected high schools, colleges and universities. They were asked to fill out the questionnaires themselves or to forward them to a member of their staff who was best acquainted with the major knee injuries and their causes during the 1969 season.

Sent along with the questionnaire was a letter of explanation, and a stamped self-addressed envelope. A request was made to return

the questionnaire within three to five days after receiving it. (See Appendix B)

A follow-up letter was mailed in order to insure a larger amount of returns. An additional questionnaire was included with the follow-up letter. In some cases a second follow-up letter was sent. Of the seventy selected schools who had questionnaires sent to them, fifty-four answered and returned their questionnaires for a seventy-eight percent return. (See Appendix D)

Results of Questionnaire

The results of the questionnaire were tabulated on easily readable tables. After the results were tabulated they were analyzed and summarized into tables to compare major football knee injuries on synthetic fields and regular fields and their possible causes. In addition to the tables, the facts and data were fed into the Montana State University Computer Center Sigma Seven computer to find percentiles and relationships for questions one through twenty-five. Questions three and four were crossed over with questions 15, 16, 17, 19, 21, 22 and 25 to find a relationship between type of playing surface and knee injuries, and condition of playing surface and knee injuries. (See Appendix C)

CHAPTER II

REVIEW OF RELATED LITERATURE

In reviewing the literature, very few studies were found on football knee injuries and their causes on the new synthetic surfaces as compared to regular football surfaces. The synthetic surfaces are now in their fourth year as a playing surface for football. Much of the literature is promotional pamphlets from the companies themselves.

The first review of literature will cover the area of the first of the synthetic surfaces, AstroTurf, which was installed in the Astrodome in Houston, Texas, four years ago.

What is AstroTurf stadium surface made of? The surface is made of green grasslike blades of special husky nylon. Bonded to the surface is a shock-absorbing pad. The entire system is bonded to an asphalt base.

Does AstroTurf reduce injuries? Yes. Serious knee and ankle injuries, the most common football and soccer injuries, are reduced up to 80 percent on AstroTurf. Here are the figures for football:

	AstroTurf 1968	AstroTurf 1967	Total
Games	141	55	196
Practices	361	94	455
Knee Surgery	9	4	13

That's a big contrast with the average of 9.3 serious major knee and ankle injuries on natural turf per NCAA in 1967.

How are injuries reduced? Players get excellent traction because their cleats ride entirely on strong AstroTurf nylon. Cleats never penetrate AstroTurf, so feet don't lock. Knees and ankles don't twist when a player is hit.

Is there good impact absorption on AstroTurf? Yes. AstroTurf and its shock-absorbing pad act much like an

automobile's shock absorber system. Hard falls don't bottom out--they're absorbed. This gives a softer fall than any other turf on earth.¹

A survey of ankle and knee injuries on AstroTurf was done by the Monsanto Company itself in 1967, the following is the result of their survey:

There were 3 AstroTurf football fields in use throughout the 1967 football season; one indoor field at the Astrodome in Houston, Texas, and two outdoor fields located at Seattle Municipal Stadium and Indiana State University. There were a total of 69 football games and 79 football practice sessions on these three fields during the year. In addition, there were several soccer games played on the fields as well as a full major league baseball schedule on the Astrodome surface. There was no discernible wear on any of the surfaces during this period and the surface relationship to performance remained consistent through wet or dry conditions and varying temperature conditions. This, in itself, is a remarkable performance. However, the most startling result was in the great reduction of serious injuries on this surface.

.....
There were no surface related knee and ankle injuries on AstroTurf in practice or games in 1967.²

The Monsanto Company also surveyed their product AstroTurf and injuries versus natural football turf in 1967:

Since the experience on AstroTurf is limited some caution is justified. However, the following comments on these comparisons should serve to make the data more meaningful:

If the games and practices that were held on AstroTurf had been held on natural turf, the expected total number of

¹"Bowl Record Guide, 1902-1969," AstroTurf, Recreational Surfaces by Monsanto, (Ray Franks Publishing Ranch, 1969) pp. 1B-9B.

²Survey of Football Knee and Ankle Injuries, 1967, Monsanto Company, April, 1968, pp. 2-3.

serious knee and ankle injuries would have been:³

Practices	79 x .066	=	5.2
Games	69 x .362	=	<u>25.0</u>
TOTAL Expected			30.2
ACTUAL Experience			<u>5.0</u>
Difference			25.2

The conclusions that the Monsanto Company came up with about their product AstroTurf were:

The relationship between the foot-surface and knee and ankle injuries is greater than those most directly associated with the game realize. The survey results indicate approximately 50 percent turf involvement while the experience of AstroTurf would warrant the deduction that 80 percent or more of the serious knee and ankle injuries are turf related. (There were approximately six natural turf injuries to each AstroTurf injury.)⁴

The types of footwear for playing on AstroTurf and some information on the subject of injuries and AstroTurf from a pamphlet on footwear by the Monsanto Company.

Football shoes with a molded composition sole and short flexible cleats on the posts perform well in both wet and dry play. Some players in the Astrodome -both lineman and backs- have come to prefer a soccer type shoe with flexible cleats, particularly the Adidas 131, Converse "Star", Puma 145 and Viking. The usual shoe with 3/4 inch hard nylon cleats and a stiff leather sole simply will not give proper traction on AstroTurf because they were designed to give traction through surface penetration. The immobility of the lower leg in this position is the cause of many knee, ankle and leg injuries. The University of Houston

³ Ibid., p. 4.

⁴ Ibid., p. 5.

reported no injuries due to AstroTurf for the entire season. In fact, the Athletic Director stated, "There is less slippage in a game on AstroTurf than there is in a game on regular grass turf with normal cleats."⁵

What about wet weather play on AstroTurf?

Even on soaking AstroTurf players with the proper footwear get superior traction. Athletic shoes with a substantial number of short, stubby, flexible cleats-are the best choice for wet weather play on AstroTurf. However, shoes with smooth, flat soles or hard nylon cleats are totally unfit for wet play.⁶

Doctor Kelly, Director of Monsanto Company's Medical

Department said:

For several seasons, Monsanto has been aware of the apparent lessening of injuries in games played on AstroTurf. The survey was initiated in an effort to quantify previous indications. The responses indicate that the total number of serious knee and ankle injuries per school on AstroTurf is about 1.6 per year as compared to the experience of 9.6 on natural turf by the reporting schools.⁷

Here is what AstroTurf is made up of:

The Company produces many variations of turf fabric, here's the makeup of its AstroTurf stadium surface S-20:

Pile height - 1/2 inch

Face ribbon (surface yarn) - 45 ounces per square yard

Backing (lay-in yarn)- 11-2/3 ounces per square yard.⁸

⁵"Footwear for Playing on AstroTurf," Technical Information on AstroTurf, Monsanto Recreational Surfaces, St. Louis, Missouri, May 1967, p. 2.

⁶Ibid., p. 3.

⁷Results of Knee and Ankle Injury Survey, "News For Release 1968, Monsanto Company, p. 1.

⁸Textile World, March, 1969, New York: McGraw-Hill, 2.

The University of Alabama's head football coach, Bryant, had the following to say after using AstroTurf on both practice and playing field.

AstroTurf has given me as many as two days of extra practice a week. We used to practice in the field house to protect the natural turf on wet days. The big thing for us though, is the reduction of knee and ankle injuries. According to statistics more football injuries actually occur in practices than during games. This fact led Alabama to be the first anywhere to have an AstroTurf practice field. Many potential injuries to knees and ankles just don't happen with AstroTurf. Unlike natural turf, it doesn't "lock" a player's cleats into position-while his legs may be twisting in another direction due to a block or tackle. I'm highly pleased with AstroTurf. In fact, I don't see how others can avoid going to it.⁹

Why is there an injury reduction on AstroTurf?

Cleats never penetrate through Monsanto's 500-denier nylon fiber, eliminating foot lock. The foot is free to move with the blow instead of catching in the ground. Superior traction, wet or dry, is achieved by the soccer-type cleats riding entirely on the nylon fiber. Although all types of football shoes may be used on AstroTurf, Monsanto recommends the soccer-type football shoe as the shoe that gives excellent traction in all weather on AstroTurf.¹⁰

Has AstroTurf changed since the original Astrodome installation?

AstroTurf, now established outdoors, has undergone considerable improvement since the 'Dome field was installed in 1966. The present AstroTurf football surface has a rugged 45 ounces of special nylon face fiber per square yard and a

⁹"The Astroturf Crowd," The Sporting News, September 10, 1969, Vol. 168, No. 10, 4.

¹⁰"The AstroTurf Story," Recreational Surface by Monsanto, p. 5.

5/8-inch shock-absorbing pad bonded to it. The AstroTurf in the Astrodome, going strong after years of use, has 32 ounces of nylon per square yard and originally had no pad.¹¹

A study made by a group of physicians in Seattle, Washington in 1969 on the AstroTurf in Seattle Memorial High School Stadium in part disagrees with the Monsanto Company's survey and studies on their AstroTurf:

We now come to the question of injuries. From the brochure on AstroTurf, we have the following statement: "Crippling knee and ankle injuries, the most common serious football and soccer injuries are reduced up to 80 percent on AstroTurf." In reading the full report from Monsanto, it is interesting to see how this 80 percent figure was obtained. A questionnaire was sent out to 542 colleges and universities, with 185 schools responding. In the survey it was stated: "Over 50 percent of the serious knee and ankle injuries were reported to be either turf related or possible turf related". This figure was assumed to be correct, and then with the low number of injuries reported on the AstroTurf, extrapolations were made to come up with the 80 percent reduction figure.¹²

A group of Seattle physicians is doing a five year study on the injuries on AstroTurf at Seattle Memorial Stadium:

During the 1968 football season, a study was made in the Seattle Metro League to determine the number of injuries that occurred on the AstroTurf, a grass field, and a dirt field-all of which are used for the high school games.

In the 1967 AstroTurf summaries (from Monsanto Company pamphlets), attention is drawn to the listing of knee and ankle injuries-the total being 4 knees and 1 ankle-on all

¹¹ Ibid., p. 2.

¹² Seattle Memorial Stadium, Study of AstroTurf, 1969.

three AstroTurf fields." In the Seattle study, a retrospective attempt was made to remember the number of knee and ankle injuries in 1967, as well as to list the reported injuries in the 1968 season.

Summary of Injuries at Memorial

	1967	1968	1969
Ankle	13	3	6
Knee	13	10	7

In the recently finished 1969 season, with 6 of the 14 schools reporting, there are already seven knee injuries on the AstroTurf (three requiring surgery), and six ankle injuries, of which three were fractures. Why there is the discrepancy in the Montsanto report and the Seattle study for 1967 I cannot explain. It is quite conceivable that a communication gap occurred. Since the schools used three different types of fields, a comparative study was possible for 1968.¹³

From the Seattle study, the relationship between the type of field and the kinds of injuries occurring is discussed:

The percentage of injuries for the knee was essentially the same for grass and AstroTurf, and less for dirt-or more accurately mud. The incidence of ankle injuries was about twice as high on the grass field as on the AstroTurf. It should be mentioned that this is a very soft field with numerous holes.

An attempt was also made to determine, if possible, whether the injury was field related or action related or both. The great majority of the injuries were felt to be action related, and only a few were field related.

Of some interest was the type of activity during which the injuries occurred. The greatest number of knee injuries occurred when a player was being blocked, while other injuries were more frequent when tackling was being done.

.....
There was a higher incidence of knee injury on the dry

¹³Ibid., p. 4.

field.

.....
In summary, the following question may be contemplated. Is the nationwide epidemic of synthetic turf installations a reasonable and rational move?

I believe the answer is yes, but not for the reason of injury prevention. Certainly the elimination of holes and of cleats catching in the grass will reduce a certain number of knee and ankle injuries. But will this perhaps be offset by higher impact, hence more severe injuries?

The factors of consistency of surface, multiple use, lack of maintenance costs, and the apparent long life of the surface are sufficient selling points. It probably does not compare favorably with the ideal grass field. This requires a climate where the amount of water can be controlled, when expert maintenance can be obtained, and where a limited number of games are played. If these conditions cannot be fully met, then a synthetic surface is a practical and satisfactory substitute.¹⁴

Blickenstaff, Head Trainer at Indiana State University, made the following comments to summarize his findings after one season of practice and games on AstroTurf:

To help answer the many questions that have been asked, the following summary will be broken down into three categories—the playing field, equipment, and injuries.

Astroturf as a Playing Field

1. An excellent surface for many activities
2. Especially good for football and soccer.
3. Traction is good when either wet or dry.
4. Becomes slick when part of field is dry and low spots are wet.
5. Nylon turf holds water like a sponge.
6. Always playable regardless of the weather.
7. Extremely clean.
8. Gives appearance of a huge carpet.

¹⁴ Ibid., pp. 5-7.

9. Does not require the usual re-lining.
10. Holds heat and is probably 10° hotter than grass.
11. Extremely fast running surface.
12. Footballs takes the normal bounce.

Equipment

1. No unusual wear on footballs.
2. No unusual wear on practice uniforms that were made of nylon and cotton.
3. Two-way stretch nylon game pants and jerseys had many holes worn through them.
4. Soccer shoes were worn by most.
5. Most football players wore out two pairs of shoes and some three to four pairs.
6. The shoes with the soft gym type sole and cleats appeared to wear best.
7. To get a better soccer shoe for football, it appears the cleats need to be moved forward, and be made of a soft gum material.
8. Soccer cleats can be attached to regular football shoes, but it is apparent they must be made of soft material. Hard nylon wears out at the rate of one set per practice.
9. Arms, elbows and hands must be covered with pads. We used regular hand and forearm pads, but used a wrestlers knee pad for the elbows.

Summary of Injury Report (Based on 90 percent of practice time spent on AstroTurf).

1. There was a marked reduction in total injuries this year.
2. No serious injury could be attributed to AstroTurf.
3. Abrasions acquired on AstroTurf are clean and do not involve the dirt which is usually acquired on the usual practice field and game field.
4. Abrasions could be attributed to AstroTurf, but only when a player failed to wear his pads.
5. We had only two fractures. One was a navicular and the other a fibula.
6. We had six sprained ankles. Two on the old practice field and four on AstroTurf. None were serious and no boy missed more than three days of practice, ordinarily we would have had twice that many.
7. We had two knees, both medial co-lateral sprains and neither serious. Ordinarily we would have had 6-10 knee injuries and probably two to three knee operations.

After spending the greatest part of our season on AstroTurf, I am of the opinion that not only will the total number of injuries be reduced, but also the severity of the injury.¹⁵

After a second season on AstroTurf the Indiana State University trainer observed in 1968:

All indications of one year ago appear to be fairly accurate. We practiced several times this year in the snow, and I can assure you it is extremely slick.

I would recommend that AstroTurf be extended at least 30 feet beyond the out-of-bounds line. The second crop of AstroTurf is a great improvement, because the turf fibers are arranged in an irregular pattern. This heterogeneous arrangement should cut down on bursh burns. The new turf has an insulate pad under it instead of acrilon, so, it appears to be a little softer than ours. If you run very many wind sprints, it has a tendency to wrinkle and pile up around the goal posts. Our AstroTurf has been through one winter and is starting on the second. It has held up well and shows very little wear.

We still haven't found the right shoe. This year we used Spot Bilt Soccer Shoes and had to have over 50 pairs replaced. For next year Spot Bilt is making up a special shoe for us (EFB), with a Vibran sole-does very well on a wet field.¹⁶

Three seasons on AstroTurf brought forth the following comments by Blickenstaff:

After three years on artificial turf, I am thoroughly convinced the two most important advantages are:

1. The severity of most injuries has been reduced, however, we have about the same total number.

¹⁵"AstroTurf Indications 1967," Mel Blickenstaff, Athletic Trainer, Indiana State University.

¹⁶"Observations After Two Seasons on the AstroTurf," Mel Blickenstaff, Athletic Trainer, Indiana State Univ., 1968.

2. Playing surface is always clean, equipment men love it!

Chief Disadvantages

1. Surface becomes extremely tricky when the low spots retain water, and the rest of the field is dry.
2. Field becomes slick when wet unless special shoes are worn.
3. Field is like glass whenever snow falls on it.

In spite of disadvantages we still like it and would not want to go back to regular turf. ¹⁷

A-Seattle high school football coach had the following statement about football on AstroTurf in Seattle Memorial Stadium:

Both of the injuries we had to players on the AstroTurf happened on a day where it had rained early and then dried. The kids say that the turf becomes very sticky if these conditions exist. In this same type of day-I also had a couple of ankle turns. ... ¹⁸

Comments from a Montana high school coach whose team played only on grass and dirt playing surfaces were as follows:

I think we will have our entire squad in AstroTurf type shoes this year. We had that type of shoes on every athlete with a pre-existing knee problem and can report that none of these athletes had a reoccurrence. I must admit we covered them with protective wraps or tape depending upon the severity of previous injury. Also we made some position adjustments to try to help these people. ¹⁹

¹⁷Based on personal correspondence between Mr. Mel Blickenstaff, Athletic Trainer, Indiana State University, and the writer.

¹⁸Based on personal correspondence between John Boise, Head Football Coach, Shorecrest High School, Seattle, Washington, and the writer.

¹⁹Based on personal correspondence between Bob Lowry, Athletic Director and Football Coach, Central High School, Great Falls, Montana, and the writer.

The second artificial surface to come on the market is Tartan Turf, made by the 3M Company. The first football fields of Tartan Turf were put in at the University of Tennessee and the University of Wisconsin in 1968.

Tartan Turf is produced "on site". A one-half inch layer of special high resilient, shock-absorbing elastomeric material is poured on an asphalt base. To this is adhered a cut nylon pile in a knitted polyester backing. The end product is a unified construction thoroughly bonded from the ground up.

1. Turf related injuries to players are sharply reduced. Cleats do not catch in Tartan Turf.
2. Saves valuable space. A Tartan Turf field can be used for both practices and games.
3. Saves practice time. Tartan Turf provides excellent field surface conditions at all times--even when it's raining.
4. Tartan Turf is a completely unified construction, firmly adhered to the asphalt base, so no shifting of the surface can occur. No stretching or adjusting is necessary. No peripheral concrete anchors are required.
5. Any cleats may be used. However Tartan Turf is especially adapted to the use of the new soccer type football shoes which have great advantages for the players.
6. Shock absorption is much greater than natural turf or any synthetic product on the market.
7. Resilient, soft Tartan Turf surface reduces abrasions and equipment wear.
8. Natural appearance of Tartan Turf makes it look like lush natural grass at all times--no more brown spots, worn spots or torn turf.²⁰

Tartan Turf reduces injuries and gives maximum traction to football players:

Tartan Turf is specially designed to reduce knee and ankle injuries caused by cleats catching in natural sod. Cleats don't

²⁰"Recreational and Athletic Playing Surface," Tartan Brand Turf.

bury themselves in Tartan Turf ... and you can use any type of cleat on Tartan Turf, whether you prefer the new soccer-type, ripple soles or conventional football shoes. Bruises, shoulder, elbow, hip and head injuries are also greatly reduced because shock absorption is much greater on Tartan Turf.

Tartan Turf provides the perfect balance of cleat release to prevent injury and the maximum of traction of cutting and acceleration. Players are extremely pleased with Tartan Turf.²¹

The latest in artificial surfaces is made by the American Biltrite Rubber Company and is called Poly-Turf Synthetic Grass. Two new Poly-Turf fields will open up the 1970 football season at Wichita State University and Idaho State University.

A combination of two virtually indestructible materials, Poly-Turf provides a uniform, correctly cushioned playing surface that reduces injuries and abrasions. Poly-Turf affords a natural feel underfoot for superior playability. It also assures surefooted traction with cleated shoes without fear of damage to the playing surface.

With fast, complete drainage and no water retention, Poly-Turf stays playable in the worst weather ... retains its color for years. Vacuuming or hosing cleans it quickly.²²

Up to this time no football has been played on Poly-Turf, it should be very interesting for future studies to compare the injury rates on the different types of artificial playing surfaces.

²¹"The Grass is Great," Recreation and Athletic Products, 3 M Company.

²²"Poly-Turf Scores at Wichita State and Idaho State," Scholastic Coach, September, 1969, Vol. 39, p. 42.

In order to better understand prevention, examination, treatment, and rehabilitation of knee injuries, it is necessary to review the anatomical structure of the knee joint.

The knee is a hinge joint which permits flexion, extension, and rotation. Flexion takes place between the semilunar cartilages and the femur and rotation takes place between the semilunar cartilages and the tibia.

.....
Once a ligament has been stretched the only method of returning it to its normal length is through surgical procedures. Ligaments have no elasticity. Also, while this ligament is being injured, other structures about the knee, including the semilunar cartilages, become injured.

.....
The only definite sign indicating a torn cartilage is locking of the knee joint. If the knee remains in a locked position, refer the athlete to the team physician.

.....
The day following the knee injury, the athlete should start quadriceps setting exercises, since atrophy, or wasting away, of muscle begins almost immediately. In case surgery has been performed on the knee, the team physician will indicate the time to begin exercise. (Most team physicians start some form of exercise almost immediately after surgery.)²³

In summary, a review of related literature showed that there was a limited amount of information available on artificial surfaced football fields and knee injuries upon such fields. Most of the literature was found in promotional pamphlets from the companies themselves, and in magazine and newspaper articles about artificial surfaces. Only two other studies were found on the subject of injuries on artificial football

²³Gene A. Logan and Roland F. Logan, Techniques of Athletic Training (Los Angeles: Franklin-Adams Press, 1959) pp. 58-65.

fields. Much information for this study was obtained from personal correspondence with coaches and trainers who had experience with artificial playing surfaces.

CHAPTER III

ANALYSIS OF DATA

The purpose of this chapter is to present the results from the study. The data was tabulated and analyzed, with the help of a computer and interpreted with the help of Dr. Allan Suvak, Director of Testing, Scoring and Research, Montana State University, to find some of the causes of knee injuries in football.

Data was obtained by the use of a questionnaire. The questionnaire consisted of twenty-six questions taken in part from the NCAA Football Injury Questionnaire and covering injuries to the knee and possible causes of these injuries through studying regular surface and artificial surface related knee injuries. Also questioned was the possibility of knee injuries being caused by different conditions of the playing surface.

An analysis of the questionnaire returned by the schools indicated that the responses constitute a representative sample and a good cross section of high schools and colleges playing football across the United States.

The listing of the names and population of the schools selected for this survey are shown in Appendix A.

The questions asked in the survey are presented as tables for the sake of clarity. (See Appendix C)

Table 1, indicates the number of athletes on the squads of all schools surveyed and the total number of knee injuries.

Table 1. Number of Athletes on The Football Squad.

Total number of football players on squads in all schools surveyed	3,976
Total number of knee injuries	155

Table 2 reveals a higher number of upperclassmen were injured in football than underclassmen.

Table 2. The Year in High School or College of the 155 Injured Football Players.

Item	Injured	Percent
Freshman	20	12%
Sophomore	26	16%
Junior	58	37%
Senior	49	31%
Omitted	2	1%

The different types of playing surfaces upon which the 155 knee injuries took place are presented in Table 3. Regular surfaces had 68 percent of the knee injuries while only 20 percent of the total knee

injuries happened on synthetic surfaces.

Table 3. Type of Playing Surface on Which Knee Injuries Occurred.

Item	Injuries	Percent of Injuries
Grass	93	60%
Dirt	13	8%
AstroTurf	42	27%
Tartan Turf	5	3%
Other	2	2%
Regular Surface	106	68%
Synthetic Surface	47	30%
Other	2	2%

Table 4 indicates that 80 percent of the 155 knee injuries happened on dry surfaces, no matter if it was a synthetic or regular surface.

Table 4. Condition of Playing Surface as Related to Knee Injuries.

Item	Injuries	Percent of Injuries
Dry	125	80%
Wet	25	16%
Snow	1	0%
Mud	2	1%
Omitted	2	1%

The opinions of coaches and trainers on the relationship of the playing surface to the causes of knee injuries are presented in Table 5. Forty-one percent believed that the knee injuries were non-surface related, while 22 percent felt it was field surface related.

Table 5. Coaches' or Trainers' Statements on Surface Related Knee Injuries.

Item	Injuries	Percent of Injuries
Field Surface Related	35	22%
Non-surface Related	65	41%
Possible Surface Related . . .	53	34%
Omitted	2	1%

Table 6 reveals the most dangerous time of the football season when knee injuries occurred. Fifty-one percent of the knee injuries happened during games and 49 percent during practice.

Table 6. When Did the Knee Injury Occur.

	Number of Knee Injuries	Percent of Injuries
Game	79	51%
Practice	76	49%

In Table 7 we are able to determine how many of the knee injuries were new, or a reoccurrence of an old injury. Seventy-three percent of the injuries were new injuries and 25 percent were former knee injuries.

Table 7. New or Old Knee Injuries

	Number of Injuries	Percent
New Injury	114	73%
Old Injury	39	25%
Omitted	2	1%

Table 8 shows which day of the week the most injuries occurred. Saturday, which is a game day, had the most mishaps. Tuesday and Wednesday were the next leading days for injuries.

Table 8. Days of The Week Knee Injuries Occurred.

	Number of Injuries	Percent
Sunday	4	2%
Monday	11	7%
Tuesday	20	12%
Wednesday	24	15%
Thursday	15	9%
Friday	13	8%
Saturday	62	40%
Omitted	5	3%

The part of the football season in which the most knee injuries occurred on a weekly basis is presented in Table 9. The table shows the highest amount of knee injuries in the early weeks of the season.

Table 9. Week of Football Practice Knee Injuries Occurred.

	Number of Injuries	Percent
1st Week.	5	3%
2nd Week.	14	9%
3rd Week.	10	6%
4th Week.	17	10%
5th Week.	13	8%
6th Week.	13	8%
7th Week.	15	9%
8th Week.	18	11%
9th Week.	6	3%
10th Week.	9	5%
11th Week.	4	2%
12th Week.	4	2%
13th Week.	1	0%
14th Week.	4	2%
15th Week.	2	1%
16th Week.	1	0%
Omitted.	19	12%

Table 10 reveals the quarter of the game in which the knee injuries occurred. The most dangerous quarters, according to our survey were the second and the third.

Table 10. Time of Knee Injury During Game.

	Number of Injuries	Percent
1st Quarter	11	6%
2nd Quarter	31	20%
3rd Quarter	28	18%
4th Quarter	13	8%
Omitted	72	46%

Table 11 indicates the time of injury during a football practice, and shows that the third and 4th half-hours had the most injuries. Nineteen percent of the injuries occurred in the fourth half-hour of practice and 14-percent happened in the third half-hour of practice. Fifty-percent omitted this question.

Table 11. Time of Knee Injury, During Practice.

	Number of Injuries	Percent
1st Half-hour	12	7%
2nd Half-hour	13	8%
3rd Half-hour	22	14%
4th Half-hour	30	19%
Omitted	78	50%

In Table 12 the positions are shown which are the most dangerous to play in football as far as knee injuries are concerned.

Tackles had 19 percent of the knee injuries; ends, 17 percent; and linebackers, 13 percent of the total knee injuries.

Table 12. Football Position Played When Injury Occurred.

	Number of Injuries	Percent
End	27	17%
Tackle	30	19%
Guard	17	10%
Center	9	5%
Quarterback	8	5%
Halfback	20	12%
Fullback	4	2%
Linebackers	21	13%
Defensive Halfbacks	14	9%
Safety	1	0%
Omitted	3	1%

Table 13 shows the most dangerous unit to be playing on as far as football knee injuries. Forty-nine percent of all knee injuries happened to defensive players while the offensive players had 43 percent of the knee injuries.

Table 13. Players Injured On Offense and Defense.

	Number of Injuries	Percent
Offense.	68	43%
Defense	77	49%
Both.	7	4%
Omitted	3	1%

The total number of football games missed because of a knee injury by the football players in this survey are presented in Table 14. Forty-six percent of the players never played again, while 20 percent of the players missed only one game.

Table 14. Games Missed Because of Knee Injuries.

Games Missed	Number of Injuries	Percent
1	30	20%
2	15	9%
3	7	4%
4	5	3%
5	3	1%
6	3	1%
7	3	1%
8	4	2%
9	1	0%
10	1	0%
Did not play again after injury	72	46%
Omitted	10	5%

Table 15 presents the data pertaining to what happened to the player after the knee injury. Forty-five percent had a doctor's examination, and 45 percent had knee surgery.

Table 15. Type of Treatment Injury to Knee Necessitated.

Items	Number of Injuries	Percent
Doctor's Examination	71	45%
Hospitalization	5	3%
Surgery	71	45%
Doctor's Examination and Surgery	1	0%
All	5	3%
Omitted	2	1%

Table 16 shows the number of players who only had severely sprained knees and missed one or more games. Sixty-three percent of the total knee injuries were only severely sprained knees.

Table 16. Severely Sprained Knee Only

Items	Number	Percent
Yes	98	63%
No	25	16%
Omitted	32	21%

Table 17 indicates the number and percent of ruptured ligaments that occurred in the knees of the injured football players. Thirty-three percent of the ligaments injured were the medial ligaments (inside ligaments) of the knee.

Table 17. Ruptured Ligaments.

Items	Number of Injuries	Percent
Medial Ligaments	52	33%
Lateral Ligaments	21	13%
Cruciate Ligaments	8	5%
All	5	3%
Medial & Lateral Ligaments	2	1%
Medial & Cruciate Ligaments	13	8%
Lateral and Cruciate Ligaments	1	0%
Omitted	53	33%

The number and percent of cartilage injuries in the knee incurred, and if the knee was able to be played on again is presented in Table 18. Thirty-six percent of the injured knees were not playable again and needed surgery. Forty percent omitted this question.

Table 18. Cartilage Torn in Knee.

Items	Number	Percent
Playable	36	23%
Not Playable	57	36%
Omitted	62	40%

The type of cartilage torn in the injured knees is presented in Table 19. Thirty-six percent of the cartilages hurt were the medial meniscus (inside cartilages of the knee).

Table 19. Type of Cartilage Torn in Knee.

Items	Number	Percent
Medial Meniscus	56	36%
Lateral Meniscus	15	9%
Both cartilages	12	7%
Omitted	72	45%

Table 20 shows the types of support or braces used on the injured knees. The questionnaire found 76 percent of the injured knees had no support of any kind.

Table 20. Kinds of Support Used on Knee.

Item	Number of Injuries	Percent
Taped	12	7%
Braced	7	4%
Both taped and braced	8	5%
Elastic wrap support	6	3%
No support of any kind	119	76%
Omitted	3	1%

Table 21 indicates the opinion of the selected coaches and trainers as to the severity of knee injuries because of the playing surface. Forty-nine percent said that the knee injuries were non-surface related and 26 percent said injuries were increased because of playing surface.

Table 21. Severity of The Knee Injury Because of Playing Surface.

Items	Number	Percent
Reduced because of playing surface.	22	14%
Increased because of playing surface	41	26%
Non-surface related	76	49%
Omitted	16	10%

Table 22 shows the different types of football cleats worn by the injured football players: 50 percent of the players with injured knees had worn shoes with a regular football cleat on it; 18 percent had worn shoes with soccer type cleats; and, 14 percent had worn cleats for artificial surfaces.

Table 22. Type of Football Cleats.

Items	Number of Injuries	Percent
Short	10	6%
Regular	79	50%
Long	4	2%
Mud Cleat	0	0%
Soccer Type	28	18%
Disc or Bar	3	1%
Cleats for Artificial Surface	22	14%
Other	6	3%
Omitted	3	1%

The type of shoe worn by the injured athletes is presented in Table 23. The survey shows that 90 percent of the knee injuries happened in low cut football shoes.

Table 23. Type of Football Shoes

Items	Number of Injuries	Percent
Low Cut Shoes	141	90%
3/4 Cut Shoes	3	1%
High Top Shoes	7	4%
Omitted	4	2%

Table 24 shows the type of shoes worn by the injured players; 63 percent wore regular surface shoes, and 32 percent wore artificial turf surface shoes.

Table 24. Regular Surface and Artificial Surface Shoes.

Items	Number	Percent
Artificial turf surface shoes	51	32%
Regular surface shoes	99	63%
Omitted	5	3%

In Table 25 the coaches' and trainers' opinions are tabulated on cleat in field surface relationships as a possible cause of knee injuries. Thirty-four percent of the selected coaches and trainers thought that the knee injuries were non-cleat in field surface related, 25 percent judged the knee injuries to be cleat in field surface related and 32 percent thought they were possibly cleat in field surface related.

Table 25. Knee Injury Was Cleat In Field Surface Related.

Items	Number of Injuries	Percent
Cleats in field surface related	39	25%
Non-cleat in field related . . .	53	34%
Possible cleat in field surface related	51	32%
Omitted	11	7%

The brand names of the different types of football shoes worn by the injured football players are shown in Table 26. Thirty-two of the questionnaires did not include an answer to the question on the brand name of the injured player's shoes. The two brands named most often as being worn by the injured players were Riddell and Spot Built, with 39 and 37 respectively; most likely because of the wide-spread popularity of these two brands of shoes.

Table 26. Brand Names of Types of Football Shoes Worn.

Brand	Number of Players Wearing
Adidas	9
Brooks	1
Converse	3
Hyde Soccer	4
Magnus	2
Puma	7
Riddell	39
Spalding	2
Spot Built	37
Viking	7
Wilson	14
Didn't answer question	32

In Tables 27 through 33, with the help of the Sigma Seven Computer, we crossed over question No. 3, which dealt with types of playing surfaces, with questions No. 15, 16, 17, 19, 21, 22 and 25 (see Appendix C), which described the types of knee injuries and their severity. Using this method of crossing over of questions we were able to determine the most dangerous playing surface according to this survey.

In Table 27, ninety-three of the injuries were on grass surface, 49 of these needed surgery. Artificial surfaces combined accounted for 47 injuries of which 16 required knee surgery.

Table 27. Outcome of Knee Injuries on Different Types of Playing Surfaces.

Items	Number	Injury Necessitated		
		Doctor's Exam.	Hospitalization	Surgery
Grass	93	38	5	49
Dirt	13	7	0	6
AstroTurf	42	23	0	16
Tartan Turf . . .	5	0	0	0
Other	2	0	0	0
		Dr.'s Exam & Surgery		All
Grass	93	1		0
Dirt	13	0		0
AstroTurf	42	0		3
Tartan Turf . . .	5	0		2
Other	0	0		0

In Table 28 the crossover between questions on sprained knees and playing surfaces showed that the grass surface had 54 sprained knees, while the artificial surfaces had 36 combined sprained knees.

Table 28. Sprained Knees.

Items:	Number	Yes	No	Omitted
Grass.....	93	54	19	20
Dirt.....	13	8	1	4
AstroTurf.....	42	31	5	6
Tartan Turf.....	5	5	0	0
Other.....	2	0	0	0

Table 29 is on the crossover between the ruptured ligament of the injured knee and the type of playing surface. Grass was the most dangerous playing surface with 64 different types of ligament ruptures. The medial ligament (inside ligament) was ruptured the greatest number of times, 31 on the grass playing surface.

Table 29. Ruptured Ligaments

Items	Number	Medial Ligament	Lateral Ligament	Cruciate Ligament	All
Grass.	93	31	13	6	4
Dirt.	13	2	3	1	0
AstroTurf. . .	42	18	5	1	0
Tartan Turf. .	5	1	0	0	0
Other.	0	0	0	0	0

		Medial & Lateral	Medial & Cruciate	Lateral & Cruciate	Omitted
Grass.	93	2	7	1	29
Dirt.	13	0	1	0	6
AstroTurf. . .	42	0	0	0	12
Tartan Turf. .	5	0	0	0	4
Other.	0	0	0	0	0

In Table 30 the crossover of questions found 38 medial meniscus (inside cartilages) torn on a grass playing surface and only 16 medial meniscus torn on the combined artificial surfaces.

Table 30. Cartilages Torn.

Item	Number	Medial Meniscus	Lateral Meniscus	Both Cartilages	Omitted
Grass.	93	38	10	10	35
Dirt.	13	2	1	1	9
Astroturf	42	14	2	2	24
Tartan Turf. . .	5	2	1	0	2
Other.	2	0	0	0	0

Table 31 shows that in the opinion of the football coaches and trainers, the grass surface increased the severity of the knee injuries, 33 to 6 over artificial surfaces.

Table 31. Severity of The Knee Injury.

Item	Number	Reduced due to Surface	Increased due to Surface	Non-surface Related	Omitted
Grass.	93	8	33	44	8
Dirt.	13	1	5	5	2
AstroTurf. . . .	42	10	6	23	4
Tartan Turf. . .	5	3	0	2	0
Other.	2	0	0	0	0

In Table 32 the Sigma Seven Computer related the type of football cleats to the type of playing surfaces, as to number of knee injuries. The regular cleat, on a grass surface, had 67 knee injuries to lead the statistics in Table 32.

Table 32. Type of Football Cleats Related to Surface and Knee Injuries.

Items	Number	Short	Regular	Long	Mud Cleat
Grass.	93	10	67	5	0
Dirt.	13	0	11	0	0
AstroTurf. . . .	42	0	0	0	0
Tartan Turf. . .	5	0	1	0	0
Other.	2	0	0	0	0

		Soccer	Disc or Bar	Artificial Cleat	Other
Grass.	93	6	3	1	1
Dirt.	13	2	0	0	0
AstroTurf. . . .	42	19	0	19	5
Tartan Turf. . .	5	1	0	3	0
Other.	2	0	0	0	0

The opinions of the selected coaches and trainers are given in Table 33 as to the possibility of cleat in field surface relationships as possible reasons for knee injuries. Grass was thought to be the most dangerous surface, as shown in the table.

Table 33. Knee Injury Was Possible Cleat in Field Surface Related.

Items	Number	Cleat Related	Non- Cleat Related	Possible Cleat Related	Omitted
Grass.....	93	27	26	33	7
Dirt.....	13	4	2	4	3
AstroTurf....	42	7	22	13	0
Tartan Turf. .	5	1	3	1	0
Other.....	2	0	0	0	0

In Tables 34 through 37 with the help of the computer we crossed over question four dealing with the conditions of playing surface as related to knee injuries with questions 15, 16, 17 and 19 (See Appendix C) which described the types of knee injuries and their severity.

In crossing over these questions we determined the most dangerous type of playing conditions on the surfaces of all playing fields, whether they were artificial or grass.

Table 34 shows what the knee injuries necessitated as far as doctor's examination, hospitalization, and surgery. Dry playing conditions proved to be the most dangerous of the playing conditions, 57 players had knee surgery after being injured on a dry surface, while only 14 players required surgery after being hurt on a wet surface.

Table 34. Condition of Playing Surface as Related To Knee Injuries, Treatment Necessitated.

Items:	Number	Doctor's Examination	Hospitalization	Surgery
Dry	125	58	5	57
Wet	25	10	0	14
Snow	1	1	0	0
Mud	2	2	0	0
Omitted	2	0	0	0

		Dr. 's Exam & Hospital	Dr. 's Exam & Surgery	Hospital & Surgery	All
Dry	125	0	1	0	4
Wet	25	0	0	0	1
Snow	1	0	0	0	0
Mud	2	0	0	0	0
Omitted	2	0	0	0	0

Table 35 shows that 82 of the sprained knees happened on a dry playing surface, while only 14 sprained knee injuries happened on a wet playing surface.

Table 35. Sprained Knees.

Items	Number	Yes	No	Omitted
Dry	125	82	20	23
Wet	25	14	3	8
Snow	1	1	0	0
Mud	2	1	0	1
Omitted	2	0	0	0

The type of ligaments injured in the knee while playing on different types of playing conditions are presented in Table 36. Dry conditions had the most injuries and the medial ligament (inside ligament) was ruptured 37 times to lead in ruptured ligaments of the injured knees.

Table 36. Ruptured Ligaments.

Item	Number	Medial Ligaments	Lateral Ligaments	Cruciate Ligaments	All
Dry	125	37	17	8	4
Wet	25	15	1	0	1
Snow	1	0	1	0	0
Mud	0	0	0	0	0
Omitted	2	0	0	0	0

		Medial & Lateral	Medial & Cruciate	Lateral & Cruciate	Omitted
Dry	125	2	10	1	46
Wet	25	0	3	0	5
Snow	1	0	0	0	0
Mud	0	0	0	0	0
Omitted	2	0	0	0	0

The different types of cartilage damage in the knees of the injured football players while playing under different surface conditions are indicated in Table 37. More cartilages were damaged while playing in dry conditions than on any other type of conditions. Sixty-nine total cartilage injuries happened on a dry playing surface.

Table 37. Cartilage Injuries.

Item	Number	Medial Meniscus	Lateral Meniscus	Both Cartilages	Omitted
Dry	125	44	13	12	56
Wet	25	11	2	0	12
Snow	1	0	0	0	1
Mud	2	1	0	0	1
Omitted	2	0	0	0	0

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem of this study was to conduct a survey of major football knee injuries and the causes of these injuries on synthetic football fields as compared to the knee injuries and causes on regular football fields. The major sub-problems of this study were to determine:

(1) the type of playing surfaces and the conditions of these surfaces when the knee injury occurred; (2) knee injury as related to types of football shoes and cleats; (3) was severity of the knee injury increased or decreased by type of surface played on and the condition of that playing surface; (4) personal data collected about the player preceding the knee injury and following the injury.

This study was delimited to: (1) the head football coach or trainer of the fourteen largest high schools by enrollment in the state of Montana and twenty-one selected colleges and university throughout the United States who played on regular surfaces; (2) the head football coach or trainer of the fourteen public high schools in the City of Seattle and twenty-one selected colleges and universities throughout the United States who played on synthetic surfaces; (3) the study was further delimited to major knee injuries and their causes during the football season of 1969.

A questionnaire was used in this study to collect the data. The questionnaire response, review of related literature and personal letters from coaches and trainers were the basis used in analyzing data for this

A summary of the findings follows:

A. The data collected in the survey for the types of playing surfaces and the conditions of these surfaces when the knee injury occurred showed:

1. The type of playing surface on which knee injuries occurred showed 68 percent happened on regular surfaces and 30 percent on synthetic surfaces.
2. The condition of playing surfaces indicated that 80 percent of all injuries happened on a dry surface. Wet, snowy and muddy surfaces were the type of surface on which 17 percent of the injuries occurred.
3. Ninety-three of the injuries were on grass surfaces; 49 of these injuries needed surgery. Artificial surfaces accounted for 47 injuries of which 16 required knee surgery.
4. The grass surfaces had 54 sprained knees, while the artificial surfaces had 36 sprained knees.
5. Grass was the most dangerous playing surface with 64 different types of ligament ruptures. The medial ligament (inside ligament) was ruptured the greatest number of times, 31 on the grass playing surface. Artificial surfaces had 47 ligament ruptures, 19 of these being the medial ligament (inside ligament of the knee).

6. Fifty-eight cartilages, total, were torn on grass surfaces as compared to 21 cartilages torn on artificial surfaces.

7. The conditions of playing surfaces related to knee injuries showed that 57 knee surgeries were required on injuries incurred during play on dry conditioned surfaces as compared to only 14 knee surgeries on wet conditioned surfaces and no surgery for snow and mud surfaces.

8. Ruptured ligaments in the knee totaled 79 on dry playing surfaces as compared to 25 ruptured ligaments on a wet playing surface.

9. Cartilage injuries to the knee were the highest on a dry surface with 69 cartilages injured, while only 13 cartilages were hurt on a wet playing surface.

B. Information collected as to knee injury as related to types of football shoes and cleats indicated:

1. Knee injuries as to type of football cleats worn showed 50 percent of the injuries happened to the players in regular cleats, 18 percent in soccer type cleats and 14 percent in cleats for artificial surfaces.

2. The survey showed that 90 percent of the knee injuries happened in low cut football shoes.

3. In comparing regular surface shoes to artificial surface shoes the findings were that 63 percent of the injuries

afflicted players wearing regular surface shoes, while 32 percent of the injured were wearing artificial surface shoes.

4. Was the knee injury cleat in field surface related?

Thrity-four percent said no; 25 percent said yes; and 32 percent said the injuries were possibly cleat in field surface related.

5. In determining the brand names and types of football shoes worn it was found that 76 of the injured players wore Riddell (39) or Spot Built (37) shoes. Thirty-two of those surveyed did not answer this question.

6. Also considered was the type of football cleat worn as to the type of playing surface in proportion to the number of knee injuries. The regular cleat, on a grass surface produced 67 knee injuries, while there were 47 total knee injuries on artificial surfaces, including all eight types of cleats listed in the questionnaire.

7. Knee injuries were possible cleat in field surface related or actually cleat in field surface related as shown by a total of 68 injuries or possible injuries on regular surfaces as compared to 22 injuries or possible injuries on artificial surfaces.

C. Data collected as to the severity of the injury and whether it

was increased or decreased by the type of surface played on and the condition of that playing surface showed:

1. Statements on surface related knee injuries showed that 41 percent were non-surface related, 34 percent were possibly surface related and 22 percent were field surface related.
2. As to the severity of the knee injuries because of the playing surface, the survey found 49 percent non-surface related, 26 percent increased because of playing surface and 14 percent were reduced because of playing surface.
3. Eighty-two of the severely sprained knees happened on a dry playing surface, while only 14 severely sprained knees happened on a wet playing surface.

D. Personal data collected about the players preceding the knee injury and after the knee injury showed:

1. The total number of football players on squads in all schools surveyed was 3,976 and out of this group 155 had major knee injuries.
2. The year in high school or college of the injured players were as follows: 37 percent, junior; 31 percent, senior; 16 percent, sophomore; and 12 percent, freshman.
3. Fifty-one percent of the injuries happened during a football game, while 49 percent of the injuries happened

during football practice.

4. Of the total of injured knees, 73 percent were new injuries and 25 percent were old injuries.

5. The days of the week on which the knee injuries occurred showed that the game days of Friday and Saturday had 48 percent of the injuries, while Tuesday and Wednesday led the rest of the practice days with 12 percent and 15 percent respectively.

6. The survey showed the highest amount of knee injuries took place in the early weeks of the season.

7. The highest number of knee injuries during a game happened in the second and third quarters.

8. In regard to the time of the knee injury during a practice, it found that the longer the practice the higher the percentage of knee injuries.

9. The most dangerous football position according to the knee injuries which occurred were in the following order; tackles, ends, linebackers, halfbacks, guards and defensive halfbacks. These position totaled 80 percent of all knee injuries.

10. Forty-nine percent of all knee injuries happened to defensive players and 43 percent of the knee injuries happened to offensive players.

11. In respect to total number of games missed because of knee injuries, the survey showed that 20 percent missed only one game, while 46 percent never played again after a knee injury.

12. Types of treatments to injured knees showed that 45 percent needed only a doctor's examination, while the other 45 percent needed knee surgery.

13. Sixty-three percent of the knee injuries were ruptured ligaments, 33 percent of the ligaments ruptured were Medial (inside) ligaments.

14. Of the injured knees with torn cartilages, 23 percent of the injured players were able to play again on a poor cartilage during the season without surgery. Of all the cartilage injuries in the knees, the survey found that most often, 36 percent of the time, the injured cartilage was the medial meniscus (inside cartilage) of the knee.

15. The kinds of support used on knees as to the number of injuries showed that 76 percent of the knees had no support of any kind, while 19 percent had on some type of support to help protect the knee.

Conclusions

In drawing conclusions from this study, it must be remembered that the findings of this study are based upon the representative samples obtained from this study only.

The findings of this study would seem to support the following conclusions:

1. There were more knee injuries, sprained knees, ruptured ligaments and torn cartilages on a grass surface than on any artificial surface that football is played upon.
2. Synthetic surfaced playing fields will reduce the severity of most injuries, however you will still have about the same total number of injuries as you had on regular surfaced playing fields.
3. Abrasions from synthetic grass burns are a problem. Players should wear additional protective pads in the form of knee and elbow pads when playing on a synthetic surface.
4. A dry playing surface of any type is the most dangerous surface to play on as far as knee injuries are concerned.
5. Synthetic surfaces reduced knee injuries about 50 percent.
6. A large percentage of knee injuries are cleat in surface related.
7. Better conditioned players, a cutting down on long practice scrimmages and long practices, and the resting of tired players during games will cut down on knee injuries.

8. A lessening of scrimmage in practice, or better controlled practice scrimmages will cut down on a large percentage of knee injuries during practice.

9. Some football positions are more susceptible to knee injuries than others. Coaches should be aware that tackles, ends and linebackers are more susceptible to knee injuries than other positions. A player with a knee problem in one of these positions should have some position adjustment to try to protect these people.

10. More upperclassmen were injured because more upperclassmen in general are participating in varsity football competition because their experience is greater than that of underclassmen.

11. During the week of football practice the survey showed that Tuesday and Wednesday were the leading practice days for knee injuries, probably because most teams have their heavy scrimmage on these practice days.

12. The high rate of injuries contributed to by regular football cleats and low cut football shoes must be looked at very carefully. More players wear regular cleats and low cut football shoes than any other types of cleats or shoes.

13. The reasons for the larger number of injuries in Riddell and Spot Built shoes is likely because of the widespread popularity of these two brands of shoes.

14. The survey showed that there were 155 knee injuries out of 3,976 total football players on all the squads that took part in this survey. According to these figures a coach should expect about four percent of his squad to have knee injuries in a normal year.

15. Regular playing surfaces are more dangerous (68%) than synthetic playing surfaces (30%) as far as knee injuries are concerned. This shows that synthetic surfaces are safer than regular surfaces at a ratio of almost 2 to 1 in the area of knee injuries.

16. The perfect shoe for synthetic surfaces is probably not yet manufactured.

17. On synthetic football fields the player runs on top of the surface, not in it as he does in grass. Because of this, he must keep his feet under him more and maintain better balance. Balance and agility became as important as strength when the player can't "dig-in" as he does on grass.

18. The footing on artificial surfaces is quite similar to wrestlers' footings on a rubberized wrestling mat, where balance is of great importance in controlling your opponent.

19. Defensive players are more susceptible to knee injuries than are offensive players.

20. Shoes with soft soles and cleats wear the best while hard composition cleats and hard nylon cleats wear out very quickly

on synthetic surfaces.

21. Synthetic surfaces are always clean, no mud or dirt, resulting in a saving on uniforms and equipment.

22. Once a synthetic football field is built it has very low maintenance costs, and tremendous multiple-use factors.

23. The nature of the game of football-with bigger, faster, and stronger players, a collision sport like football is going to result in a certain number of injuries. This is particularly true when the coaching philosophy of intimidation is prevalent and is stressed more than skill. As long as players are clipped, blind-sided, gang-tackled, etc., injuries will occur regardless of the type of surface on which the game is played.

Recommendations

1. Based on this study the recommendation that artificial playing surfaces are safer than regular playing surfaces, in so far as knee injuries are concerned, is a valid conclusion.
2. Close consideration should be given to the use of artificial surfaces when any new outdoor facilities are being contemplated.
3. It is recommended that synthetic surfaces be utilized as a satisfactory substitute whenever ideal climate and conditions cannot provide for the ideal grass field.
4. Recommend that a careful check of the facts and figures in the promotional pamphlets of the companies making artificial surfaces be done, to see if their claims and studies are valid.
5. Advise that coaches realize that there is no substitute for good conditioning and coaching techniques in injury prevention.
6. Because of abrasions (rug burns) from synthetic football fields, better design of protective equipment is needed to lessen this problem, particularly in the knee and elbow areas of the body.
7. Recommend that a preventive knee brace be required to be worn by all football players, or that the thoughtful football coach put knee braces on the players in the more dangerous football positions. Example: brace the knees of the tackles,

ends and linebackers.

8. Recommend that for safety purposes the artificial surfaces be extended at least ten yards beyond the out-of-bounds lines because synthetic surfaces are placed on asphalt or cement bases in building football fields.

9. Recommend placing radiant heating pipes under the asphalt base of synthetic outdoor football fields in the cold weather problem areas of the United States to eliminate the problem of slick fields when freezing weather exists or snow falls on the synthetic surface.

10. Prescribe the using of large rollers and vacuum cleaner types of equipment on the synthetic playing fields after it stops raining to squeeze out or suck up the excess water, thus drying up the playing surface for better footing.

11. Research should be done on the speed of the game and the impact forces in football games played on synthetic surfaces.

Nearly all coaches and players feel the game is faster on synthetic grass.

12. It is recommended that administrations, athletic directors and football coaches discuss the results of this study and make any changes in their football programs deemed necessary.

13. Suggest that a study be done on the different types of artificial surfaces to see what the differences are and which

is the least injury prone of these surfaces.

14. It is recommended that more studies be done on artificial surfaces and football injuries over the next five years, after considerably more experience is gained with these surfaces.

15. It is recommended that further study be done on types of shoes for artificial surfaces as presently no completely successful shoes has been developed.

APPENDICES

APPENDIX A

Regular Turf Surface

The following 28 schools returned their questionnaires out of the 35 schools selected which used regular surfaces.

High Schools (Montana)

1. Billings Central (3)*
2. Park Senior High (1)
3. Laurel High (2)
4. Havre High (1)
5. C.M. Russell High (2)
6. Flathead High (3)
7. Billings Senior (3)
8. Billings West (1)
9. Helena High (3)
10. Great Falls Central (3)
11. Great Falls Senior (3)
12. Butte High (2)
13. Hellgate High (2)

Universities

1. U. of California (6)
2. Weber State (3)
3. Adams State (2)
4. U. of Southern California (1)
5. U. of Nebraska (4)
6. New Mexico State (6)
7. Boise State College (4)
8. Northern Montana College (3)
9. Northern Arizona U. (1)
10. Western Montana College (2)
11. U. of Montana (3)
12. Central Washington State (3)
13. Eastern Montana College (2)
14. Montana Tech (1)
15. Carroll College (4)

Artificial Turf Surface

The following 26 schools returned their questionnaires out of the 35 schools selected which used artificial surfaces.

High Schools (Seattle, Wash.)

1. Franklin High (2)
2. Lincoln High (2)
3. Ballard High (2)
4. Shoreline High (0)
5. West Seattle High (3)
6. Ingraham High (0)
7. Rainier Beach (1)
8. Cleveland High (1)
9. Nathan Hale High (1)
10. Chief Sealth High (1)
11. Roosevelt High (3)
12. Queen Anne High (3)
13. Shorecrest High (3)
14. Garfield High (2)

Universities

1. Northern Illinois College (3)
2. University of Texas (8)
3. U. of Wisconsin (1)
4. Illinois State U. (7)
5. U. of Washington (11)
6. Oregon State U. (4)
7. Portland State U. (3)
8. U. of Alabama (4)
9. U.S. Air Force Academy (3)
10. Diablo Valley College (2)
11. U. of Arkansas (5)
12. U. of Oregon (4)

*The number behind each school indicates the number of knee injuries for that school.

APPENDIX B

—*Montana State University*—

Bozeman, Montana 59715

Tel. 406-587-3121

Department of Athletics

February 7, 1970

Dear Sir:

The enclosed questionnaire can be completed in a very short time by you, or the person on your staff best acquainted with football knee injuries in your school. The information gained in this survey will not in any way be used as an evaluation of the safety of your athletic program, but is intended merely to obtain a summary of the causes of knee injuries throughout the United States. Only the name of the school on the top of the questionnaire will be used, so it is not necessary to sign the questionnaire.

It would be appreciated if the questionnaire could be completed and returned within one week of the above date. Your cooperation will be greatly appreciated.

Sincerely,

Dick Watson

Dick Watson, Graduate Student
Freshman Football Coach
Montana State University

Gary Evans

Dr. Gary Evans, Coordinator of
Graduate Studies in Physical Education
Montana State University

Encl.

APPENDIX C

FOOTBALL MAJOR KNEE INJURY QUESTIONNAIRE*

School _____

Caused the football player to miss at least one full football game.Fill out one questionnaire per major knee injury.Directions: Enter the appropriate number in the space preceding the item number.Example: If in Item #6 the student injured his knee in practice, enter number 2 in the black space in front of item #6.

- _____ 1. Number of athletes on your football squad.
- _____ 2. Injured player was: (1) Fr. (2) So. (3) Jr. (4) Sr.
- _____ 3. Type of playing surface: (1) Grass (2) Dirt (3) AstroTurf
(4) Tartan Turf (5) Other _____
- _____ 4. Condition of playing surface: (1) Dry (2) Wet (3) Snow
(4) Mud.
- _____ 5. The knee injury was: (1) field surface related (2) non-
surface related (3) possible surface related.
- _____ 6. Injured knee in: (1) Game (2) Practice.
- _____ 7. New Injury: (1) Yes (2) No.
- _____ 8. Day of week injured: (1) S, (2) M, (3) T, (4) W, (5) TH,
(6) F, (7) Sat.
- _____ 9. Week of practice: 1 2 3 4 5 6 7 8 9 10 11 12 13
14 15 16
- _____ 10. Time of injury: Game - Quarter (1) 1st (2) 2nd (3) 3rd
(4) 4th
- _____ 11. Time of injury: Practice - (1) 1st half hour (2) 2nd half hr.
(3) 3rd half hour (4) 4th half hour.
- _____ 12. Position played: (1) E, (2) T, (3) G, (4) C, (5) QB, (6) HB,
(7) FB, (8) LB, (9) DHB, (10) S.
- _____ 13. Played on: (1) Offense (2) Defense.
- _____ 14. Games missed: 1 2 3 4 5 6 7 8 9 10 ____ 11 (Did not
play again after injury.)
- _____ 15. Injury necessitated: (1) doctor's examination (2) hospital-
ization (3) surgery.
- _____ 16. Severely sprained knee: (1) Yes (2) No.
- _____ 17. Ruptured the following ligaments: (1) Medial ligaments
(inside ligament) (2) Lateral ligaments (outside
ligament) (3) Cruciate ligaments (ligament within the
knee joint) (4) All.

*Note - A number of the above questions were taken from the
NCAA Football Injury Questionnaire.

- _____ 18. Cartilage torn: (1) but playable (2) not playable.
- _____ 19. Cartilage torn was: (1) Medial meniscus (inside cartilage)
(2) Lateral meniscus (outside cartilage) (3) Both
cartilages.
- _____ 20. The knee was: (1) Taped (2) Braced (3) Both taped and
braced.
- _____ 21. The severity of the knee injury was: (1) reduced because
of playing surface (2) increased because of playing
surface (3) non-surface related.
- _____ 22. Type of football cleats: (1) Short (2) Regular (3) Long
(4) Mud cleat (5) Soccer type (6) Disc or bar
(7) Cleats for artificial surface (8) Other (describe) _____
- _____ 23. Type of shoe: (1) Low (2) 3/4 (3) High.
- _____ 24. Shoe was for: (1) Artificial turf surface (2) regular surface
- _____ 25. The knee injury was: (1) Cleats in field surface related
(2) non-cleat in field related (3) Possible cleats in
field surface related.
- _____ 26. Kind of shoe: (Brand name of describe) _____
- _____ 27. Check here if you would like to have a copy of the results
of this survey.

APPENDIX D

February 21, 1970

Dear Football Coach or Trainer:

Recently you received a letter asking you to complete a short questionnaire concerning major football knee injuries in your school. Perhaps the questionnaire was misplaced or was not even included in the letter which you received from us. In any case, enclosed is another questionnaire which can be filled out by you or the person on your staff best acquainted with football knee injuries during the 1969 football season.

We would appreciate your completing this questionnaire and returning it as soon as possible. Your response is very important as we are trying to survey causes of major knee injuries in football in a selected number of schools throughout the United States and a large number of questionnaire returns is essential in order to draw any sound conclusions. This questionnaire will not be used in any way as an evaluation of your program. If you have already mailed the questionnaire, please disregard this letter.

Again we convey our thanks to you for helping make this study a success.

Sincerely,

Dick Watson

Dick Watson, Graduate Student
Freshman Football Coach
Montana State University

Gary Evans

Dr. Gary Evans, Coordinator of
Graduate Studies in Physical Education
Montana State University

Encl.

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