The Epidemiology of Sports Injuries
or
Caveat Emptor!

by Ed M. Milner

Summary:

Studies of the nature and frequency of sports injuries tend to differ widely in content, character, and intended usage. This paper reviews the elements of well run injury studies as related to their purpose and usage, against the background of the sports world. It also discusses some of the misuses of such studies, and raises questions that should be answered as studies are evaluated and interpreted.

Introduction

When Monsanto Company accepted the challenge from the Ford Foundation to develop surfaces that might provide better places for kids to play, it invested several years of fundamental research and development before the introduction of synthetic turf in the Houston “AstroDome” in 1966. The new product, plus several imitators, gained rapid acceptance.

In 1967 Monsanto had its Medical Department circulate questionnaires to all the teams that had played on the new material. It also submitted the same data instrument to the several hundred colleges and universities who had teams playing American football. Response was quite good.

The same questionnaires were circulated in1968 and 1969. The year to year results were in very good agreement. They showed nearly eighty per cent reduction in knee and ankle injuries for players who played on synthetic turf.

We, at Monsanto, were gratified, but were also appalled at the accident rates for all those who participated in the game. Among players on traditional grass fields there was nearly a 50% frequency of players who either were hospitalized, or who missed a week or more of participation due to injury.

We did not publish the results, but did review them with fellow members of ASTM Committee F-8. To our surprise, one of our competitors included them in its response to the Moss Committee of the US House of Representatives. We, frankly, were surprised at the high incidence of injuries accepted as normal by the American football community, not unlike the dueling scars worn as badges of honor by German students of another age.

Later, we became wiser, the sporting press more aggressive, the players union organized and in need of negotiating issues, and the Committee on Competitive Safeguards and Medical Aspects of Sports more active and sophisticated in its study techniques. We gained a much better understanding of the nature and frequency of sports injuries. We learned a good deal more about the pitfalls of poorly planned and conducted studies. We learned that there are those who would misuse the data that resulted from them.

1) Why Study Sports Injuries

User Needs Vary-

- Sports Administrators

How do injury rates vary from team to team? Are there differences that result from coaching styles? Are our players well conditioned? Is their equipment functioning as desired? Are our playing facilities up to modern standards?

- Rules-Making Bodies

Do the rules encourage or limit dangerous play? Do the rules afford “loopholes” favoring improper or dangerous behavior? Do game officials need to change their strategies to insure a safe and fair contest?

- Equipment /Facility Suppliers

Is the use of my equipment associated with more injuries than expected? Do injury frequencies among players using my equipment vary with position or game activity? Am I doing the best job I can to supply players a good place to play?

- Purchasers of Equipment and Facilities

Am I choosing equipment or facilities wisely? Am I being “penny-wise and pound-foolish” to the detriment of player safety?

- Parents and Public

Is my son or daughter properly conditioned, coached, and equipped? Is there a good balance between costs and benefits, recognizing that sports participation always involves risk of injury?

2) Study Types

●Abstracts from Existing Records

It seems logical to just "look at the records". Unfortunately, the readily available records are seldom in a form that permits reliable statistical analysis. Even so, there are a number of sources that may be used to identify problems or suggest reasons for concern. Among the common places to look are:

Insurance Data

If an insurance program covers costs for treatment of player injuries there may be useful information with the insurer – whether private or governmental. One problem will lie with the confidentiality requirements of the records to be studied. Access to the data may be limited.

There is not a good case for "prior consent" of the patients involved, and no data about the players not injured. There will be later comments regarding the importance of information about the full "population at risk".

Sports Governing Bodies

In some instances the local, regional or national governing bodies for a sport (or sports) may keep records that can be helpful. Such records may, or may not, be in a form that allows rigid statistical analysis.

One example are the yearly reports of fatalities and catastrophic injuries in American Football These records are jointly compiled by the National Collegiate Athletic Association (NCAA) and the National Federation of State High School Associations (the "National Federation") in the United States. Their records are taken from a mixed group of sources – the media, reports from teams, reports from interested outside parties – and confirmed as well as possible. There are approximately 1.5 million young men who play American football, and there are seldom more than 3 or 4 fatalities each year. Some are the direct result of practice or play activities, others may be from completely unrelated causes, such as congenital heart problems or automobile accidents while traveling to or from a game. With the data problems, and small number of deaths reported from year to year, the report represents a commendable effort. Its precision is limited by the variety of data sources with no overall assurance of its completeness or accuracy.

News Media

The most "creative writing" in the American press today is often on the sports pages. (I'm not sure where the London tabloids would fit into this analysis.) Unfortunately, sports writers and reporters are not statisticians or health researchers. What they have to say is addressed to their non-technical, sports fan, readers. While what a reporter says may be factual, he makes no effort to do the kind of complete data collection and precise statistical analysis demanded for drawing research-grade conclusions. Injuries to the stars are over-reported, and injuries to less glamorous players are given little attention. Statements regarding player availability for a given contest are often a part of team strategy. Sometimes, the writer is unduly influenced by preconceived opinions – either his own or those of a favorite player. There is no good way to audit the information from news stories for accuracy or thoroughness.

Hospital Emergency Room Data

The US Consumer Products Safety Commission has established its National Electronic Injury Surveillance System (NEISS), recording data from admissions to a select sample of hospital emergency rooms. Data regarding sports injuries obtained through NEISS are of limited value, since injuries from most organized team sports are generally moved directly to treatment rather than handled through the normal emergency room admissions process. Some injuries attributed to sports participation or sports equipment may have no relation to organized games or practices.

Existing Team Records

While this might seem to be a logical source for data, experience has shown that team to team record keeping procedures may vary widely. Definitions of Injury types, game situations, time lost due to injuries or player illness or to the malfunction of a piece of equipment may not be in agreement. This makes it difficult to draw valid conclusions from such mixed data sources.

"PARC" Analysis

This is an old statistician's acronym for "**P**ractical **A**vailable **R**ecord **C**orrelation". It sounds good, but gives a better measure of its common value when spelled backwards. Available records may sometimes be in a form and of sufficient reliability to be useful for analysis, but this is seldom the case. Read the newspapers to find out what people are saying. Perform well designed studies to measure what is really happening.

● Questionnaires

Design of Study Instruments

The use of survey questionnaires has become a major factor in analysis of political trends and public opinion. Polling data are collected on a daily basis by the news media and political organizations. They are highly subject to the quality of the questions themselves. Survey responses are not easy to audit for accuracy. Questionnaires taken long after the fact are subject to errors of memory. In the early Monsanto studies, company researchers who followed upon individual reports found a number of errors and omissions. The tendency is to under-report injuries when reporting is too long after the fact.

● *A Priori* Designed Studies

The best, most reliable studies of sports injuries involve a lot of planning before the fact, including trial runs to be sure that study protocols are complete, well defined, present minimal chances for error, and data are collected and organized for the analysis to follow. Some of the key factors to be considered are listed and discussed below.

3) **Definitions**

Clarity and precision of definition statements are vital to the quality of the final study and analysis. Writing good definitions is very hard work, and must not be done superficially. Among the many factors requiring precise definitions are:

● Population at Risk
- Those who were injured.
- Those who were not injured.
- How do they differ?

● Sports-Related:
- Nomenclature for Injuries must be precise, and agreed upon in advance.
- Levels of Severity
  - Days of practice missed.
  - Games missed.
  - Hospital treatment required.
- Environment where injury occurred.

- Sports or Game Situation/Activity

Consistent with game being played, player positions involved, subject to review and confirmation. This information is important to rules makers as well as sports administrators

- Sports Related Measures of Exposure

Player Hours
Team Games (one contest involves two teams)
Athlete Exposures (Number of players exposed to game or practiced situation for even a minute or two.)
Practice versus competition exposures

When one begins to evaluate a given study, the quality and precision of its definitions are key criteria that must be examined critically.

Data Collection Instrument and Provisions for Audit

Do the data fit sports situations?
Are data complete and accurate?
Are there provisions for field audit?
Ease of statistical processing

Study Length and Breadth

Cyclic nature of teams can be a major factor.

Sampling Design

Size of Population
Issues of Bias
    Geographical
    Style of play
Age/condition of facility or equipment.

4) Interpretation of Results

- Oriented to Groups rather than individuals

- Statistical Inferences

  What differences might occur due to chance alone?
  Errors of "Confounding" variables.
  The use of "Confidence Intervals"

Design determines analysis. Prior planning is essential to the collection, processing, and useful analysis of data regarding sports injuries.

5) A Few Examples of Well Conducted Studies

The tendency of Americans to seek relief in the courts for personal injury has tended to emphasize the need for reliable sports injury data, both in defense of those doing a responsible job and to identify those not so careful. Over the last 35 years or so, there have been a number of well-run, dependable study efforts, as well as some studies that were superficial, biased, or subject to the "conclusion-first, data-later" syndrome. One widely reported study mixed data from one year of play with that from 5 years of play to support the researcher's preconceptions.

The need for reliable sports injury data became severe in the early 1950s, when the technology of helmet design for American football outran knowledge of the biomechanics for the player's head and neck, leading to a number of fatalities as well as even more catastrophic injuries

The following three studies are good examples of professional work at its best.

- North Carolina High School Study [1]

A stratified cluster sample of 45 high schools (from a total of 347) was selected to represent large and small student body populations, urban and rural school locations, all within a radius of 100 miles from the University of North Carolina campus. Every player involved was given a physical examination before the start of each season of play. A small group of professional investigators interviewed each player and coach prior to the season, and did follow-up visits to each school on a weekly basis throughout the study to insure accuracy and thoroughness of data.

[1] Blyth, Carl S., PhD, Mueller, Frederick O, PhD, "The Epidemiologic Study of High School Football Injuries in North Carolina, 1968-1972, funded by the US Public Health Service and the US Consumer Products Safety Commission

A pilot study was conducted during the 1968 season of play to evaluate study techniques, followed by 4 years of active study. During the last two years of the study certain test variables related to equipment models, coaching techniques and playing field conditions were added for sub-samples of the study population.

All playing fields in this study were natural turf. It represented a pioneering effort in sports injury analysis.

- The National Athletic Injury/Illness Reporting System (NAIRS)[2]

John Powell, at that time a doctoral student at Penn State University was a Certified Athletic Trainer. He depended on similarly qualified athletic trainers to collect the data for the NAIRS program. Again, there was extensive definition of the population at risk before beginning of play. All injuries were identified according to the American Medical Association's "Standard Nomenclature of Athletic Injuries"[3]. He introduced the concept of reporting injury frequencies per thousand athlete exposures, with each exposure defined as "one player in the practice or game" during one practice or game event. With the frequent substitution of players in American football this eliminated the need to track actual minutes or hours of exposure for each of the 50 to 90 players and substitutes on a given team.

An experienced Certified Athletic Trainer, Sayers "Bud" Miller was employed to review all injury reports for internal consistency, making sure that a given player might have been performing the reported game activity at the time of his injury. From 50 to 70 colleges and universities were included in the study.

During the three years of the original NAIRS work, there were over one million player exposures on natural turf and a similar number on synthetic turf. The brand of synthetic turf was identified as a study variable.

Upon receipt of his doctoral degree, John Powell was retained by the National Football League (Professional American football) to apply the NAIRS principles and software to analysis of all the NFL teams, and has done so for 15 years or more.

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[2] Clarke, Kenneth S., PhD, Alles, Wesley F, PhD, and Powell, John W., MS, ATC, "The National Athletic Injury/Illness Reporting System (NAIRS), An Epidemiological Examination of Association of Selected Products with Related Injuries in (American) Football, 1975-1977, The Pennsylvania State University

[3] Clarke, Kenneth S., PhD, "Standard Nomenclature of Athletic Injuries", The American Medical Association

● The National Collegiate Athletic Association (NCAA) Injury Surveillance System (ISS)[4]

Following preliminary work by others in the early 1980s, Randall W. Dick, another graduate of Penn State University, has managed the NCAA Injury Surveillance System. The ISS reports on injuries in 15 organized sports in American college and universities who are members of the NCAA. Sports for both men and women are covered, including, soccer, basketball, gymnastics and others. Since data for all sports involved are reported on the same basis, direct comparisons between injuries in men's and women's soccer and men's and women's basketball are possible. Stratified sampling includes schools from each geographic quadrant of the USA as well as all three major divisions of the NCAA.

The NCAA system has been in place for more than 15 years, permitting analysis of trends in injury patterns. While not quite as detailed as the original NAIRS program, it has been very useful in evaluating the effects of rules changes, practice frequency and seasons, the relationship between play at different levels (NCAA Divisions) of competition, and the effects of synthetic playing surfaces. It has not included identification of the brand or age of the playing surface where synthetic surfaces have been used.

All of the above studies define the population at risk, both injured and non-injured. They cover big enough samples to permit good statistical analysis. They have been continued long enough to establish and evaluate trends in injury patterns.

While there is nothing intrinsically wrong in reporting a study of "Indoor Football Injuries during the 19XX 72 Hour Indoor Soccer Tournament", or some other such imaginary event, it is important not to extend analysis of such work beyond its original scope. References to such injury studies should carefully state the limited nature of their scope, and use great care in extracting conclusions from them.

6) A Bit of Philosophy

● If there's No Risk, there's Not Much Fun!

Most active sports become, in some ways, analogs for combat, either against an opposing individual or team, or against one's own self image. We, as sports suppliers, sports administrators and sports players hope that the combat analog includes attention to safety concerns. Herein lies the problem – we want our risk taking to be limited and understood. Certainly safety

[4] Dick, Randall W, MS, FACSM, "The NCAA Injury Surveillance System" (Annual Reports), The National Collegiate Athletic Association, Indianapolis, IN, USA

is one of the responsibilities of referees and umpires. It must also be a concern for those of us in one or another part of the business of sports.

Similarly, if there's no risk, there is limited spectator appeal, partly explaining the popularity of sports like automobile racing, even "demolition Derbies", where the objective is to have the last vehicle standing and able to make a circuit of the track under its own power.

I have previously reported[5] conclusions from my analysis of winning speeds and fatalities in the Indianapolis 500 Mile Automobile Race. While there have been frequent, and repeated rules changes in the interest of driver and spectator safety, and while winning speeds have increased almost without exception, the frequency of fatalities has remained almost constant since the inception of this race more than 90 years ago. The drivers are willing to accept a certain level of risk in their competition in exchange for the chance of winning.

We in America saw the same phenomenon in the 1950s, when American football helmets were improved. The new helmets and face masks minimized the risk of skull fractures and concussion, but many coaches were quick to teach blocking techniques that put the neck at risk. Similar examples exist in other sports.

"Citius, Altius, Fortius", (Faster, Higher, Stronger), the motto of both ancient and modern Olympic Games participants reflects the desire of athletes to test themselves, whether against opponents or their own historic achievements. The development of more uniform, predictable playing surfaces, better "tuned" to the needs of particular sports activities will not necessarily lead to significant change in the attitudes of the participants, nor necessarily should it. Rather, the duty of suppliers and administrators is to help athletes understand the conditions under which they compete. Responsibility for their safety as well as their performance still lies in the same place – within themselves. We can reduce "surprises" – chuckholes, wet spots, rocks or broken glass, but we have not been able to effect much change in human nature.

Suppliers may quite properly advertise the performance attributes of their wares, even the pleasure or pride of users in their appearance. In my judgment, however, it is irresponsible, if not dishonest, to claim control of the level of risk that competitors are willing to assume.

7) A "Safe" Playing Surface

Sport requirements differ, and surface properties are subject to performance oriented measurement.

[5] Milner, Edward M., BChE, Societal Factors in the Management of Sports Injury Risks" Unpublished paper, delivered before the National Safety Council Congress and Exposition, Conference entitled ACTION PLAN FOR IMPROVING SAFETY IN SPORTS, Chicago, IL, 1989

Running and Traction relate not only to design of the playing surface, but to players' footwear. Both are also influenced by the moisture content of the surface, its cleanliness, and, in some cases, its age. With the new rubber-filled turf systems uniformity of infill as well as its nature can be affected by the quality control and care exerted during the installation process. Player traffic as well as the use of vehicles on the playing surface may also change the uniformity of surface conditions.

Falling varies in importance from one game to another, as well as with player function or position. A goalkeeper in soccer football dives to the ground more frequently than does a midfielder. Need for shock absorbency (cushioning) of the playing surface varies widely, from the hardness of a basketball floor or an ice rink to the deep, soft cushion of a gymnastics landing mat. A balance must be taken between the needs for player comfort, game skills, and player protection or cushioning in the choice and design of surface systems.

Ball Management is involved in most of the games we are concerned with. This includes the way the ball rolls and the way it bounces. Coefficients of friction and restitution between a given ball and a given surface are the physical properties to be determined, but they determine the player's ability to direct or predict the movements of the ball with both precision and accuracy.

Is there one surface that is ideal for all sports? No! The short-clipped, hard-packed natural grass of a putting green or a hockey pitch might be entirely too "fast" for soccer football. The degree of cushioning demanded for the frequent falls in American football tends to give ball bounce that is too lively for baseball or field hockey. A surface ideal for episodic sports like American football may not be ideal for the running flow of hockey, soccer, or Rugby. There is no "universal solvent" or single solution for all surface needs.

Predictability is the one factor that is central to almost all sports surfaces, with the possible exception of the rough of a golf course. (I hear rumors about the ground in front of the wickets on a cricket pitch.) Synthetic surfaces offer day to day uniformity for years of pitch life. The choice of pitch materials and surface design are fundamental factors in determining the life of a playing surface as well as its appearance and functionality.

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