The Rising Fastball

The Newsletter of SABR's Science and Baseball Research Committee

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Greetings from the Chair

It was a great convention, highlighted by the Baseball at Altitude Panel. Our committee meeting was enjoyable, and I think a few basic themes can be summarized:

1. There is a diversity of scientific interests in among our membership; Alan and I encourage and ask for feedback about the specific interests of group members so that (to the extent anyone can do so) we can try and satisfy the needs of everyone.

2. We remain without an official SABR project. A number of suggestions have been raised, but as it stands we are a collection of people with a shared interest providing feedback, information and support. This is fine, but as part of the larger organization, we will likely be called upon to make a larger contribution in the form of a permanent project. We should toss around some ideas on this.

3. There seems to be a lot of interest in the Kansas City Baseball Academy. In light of number 2, above, I'd suggest that a history of the Academy linking it to current practices would be a nice SABR book.

In this issue, Jeff Wood and Howard Nemerov discuss pitcher abuse and the prevention of pitching injuries, and I contribute a short note on decision research and its application to baseball. New submissions are strongly encouraged as we try to include original material in each issue.

KVH

Pitcher Abuse

Jeff Wood & Howard Nemerov

There has been much discussion these last few years about an alleged imbalance between hitting and pitching. Are batters gaining an unfair advantage by using illegal drugs to enhance performance? Do pitchers suffer some disadvantage through strike zone or other changes to the game? In spite of grandstanding by authors and baseball players looking to pump up book sales or extend their time in the spotlight, there has been no decisive conclusion reached on this matter.

There are specific topics involving science and technology which will shed some light on these concerns. It is our hope that in gaining deeper understanding of these factors, SABR members can continue the discussion of batter/pitcher relationships from a more scientific knowledge base.

In this article we will cover performance issues in which we have some professional expertise, discussing physiological issues which affect a pitcher's performance. We will cover the issue of Pitcher Abuse, a growing concern at all levels of amateur and professional baseball, in which young pitchers are being overused for short-term competitive advantage, leaving them more injury-prone. We will also discuss some basic muscle physiology and neurology, so that you will have a better understanding of what is happening "inside" the pitcher's body during training and competition. Finally, we will discuss some of the changes and enhancements to training over the last two decades, as this can also have an impact on injury potential.

Pitch Counts and Pitcher Abuse

Pitch counts and pitcher abuse is certainly a controversial subject. The head coach of the University of Tennessee is constantly questioning why it seems that there are more arm injuries now than ever before, and while there may be no concrete answers, the main answer is most likely pitcher abuse. However, it is not so much pitcher abuse at the professional level as it is the abuse that occurs beginning at the ages of 8 or 9, and progressing through the high school and collegiate levels. This early abuse leads to overuse injuries that manifest themselves as pitchers progress on to professional baseball.

The problem starts at the youth level where children are getting abused for the sake of winning. Most youth leagues have rules regarding number of innings pitched, but the key is the number of pitches thrown per outing and per year. Research out of the American Sports Medicine Institute in Birmingham Alabama shows that the injury rate in youth pitchers increases when they progress beyond 75 pitches and has led to the recommendation of a 75 pitch limit 2 times per week with a limit of 600 pitches total per year.

It is also commonly accepted among sports medicine professionals that children should not begin throwing curve balls until the age of 14–16. However, pitchers as young as 10 years of age try to throw curve balls and there are extreme cases like a 10 year old (who had been complaining of elbow pain for several weeks) throwing 126 pitches in a 6 inning game. This was only outdone by the 10 year old opposing pitcher who threw 136 pitches in the same game. Another incident involved a 13 year old throwing so much, with inappropriate pitches and poor mechanics who suffered a serious elbow injury.

You may remember the "heroic" act of the Louisville Little League pitcher in the 2002 Little League World Series who, in a 5 day span, threw 199 pitches in one game followed by 129 pitches a few days later. You could see him in the dugout between innings with a hot pack on his shoulder, so he could go out and pitch the next inning. The TV announcers lauded him as a hero. Another problem is the prevalence of "traveling teams" where players as young as 8–10 years old play upwards of 80–90 games per season. This was not seen until recent years, and it plays a certain role in the increased number of arm injuries.

This abuse continues to the high school level. Recently, two pitchers came to the university of Tennessee who subsequently had "Tommy John" surgery, because injuries incurred during their high school careers manifested themselves when they began competing at the college level, and many collegiate athletic trainers are seeing similar problems.

Abuse occurs at the collegiate level as well. We only need to look at the 2003 College World Series where a pitcher threw 350 pitches in a span of only 10 days. Pitch counts and pitcher abuse play a key role in the prevalence of injuries that we are seeing at the professional level. As the Tennessee coach says: "There are only so many throws in a pitcher's arm." If we are using these throws up at a young age, those athletes who are able to progress to the professional level are at risk for early injury and prolonged disability. The pitchers of today are not weaker nor less tough than in the "old days." They are just getting abused so early on that the impact on their professional careers is more evident.

The Impact of Pitcher Abuse on the Pitcher's Ability to Throw

Now let us look at what is going on inside the body as the result of pitcher abuse. This will hopefully give you a better idea of how injuries progress over time. First, we will have a brief discussion of Motor Control Theory. Then we will use this conceptual framework to explain the injury process. Movement is governed by a part of the brain called the **Motor Control Center** (MCC).

The MCC has two primary neurological functions: learning and memory. During **Motor Learning**, the MCC compiles individual muscle functions into a specific sequence of contractions, in order to accomplish a desired outcome. A child learning to walk is an example of complex motor learning. Any new skill we learn involves this process, including throwing a small, round, white projectile at high speed.

Once the MCC has created a sequence that accomplishes the desired outcome to a satisfactory level, it creates a **Motor Program** and stores the program in **Motor Memory**. By doing so, whenever the action is required in the future, the MCC retrieves it from Memory and executes it, sending commands via neurological pathways to the muscles in the identical sequence as recorded in the program.

It is very similar to clicking on an icon on your computer's desktop. When activated, the program runs exactly as it was stored, and no intervention is required. Now notice we said "as it was stored" and not as you expect, because if the program has bugs in it, you will not get the results you want. This is the same for injuries, for damage to the physical structure of the body will result in dysfunction to motor programming, introducing "bugs" into motor memory. Erosion of refined motor control happens due to two primary conditions: traumatic events and repetitive stress. An example of a traumatic event would be an auto accident, where forces are introduced into the body that are beyond its ability to handle.

Repetitive stress consists of smaller amounts of force, none of which in themselves are capable of overloading muscles and joints, but which occur many times over an extended period of time. In either case, the muscles are unable to recover from the stress and "short circuit" in a manner similar to overloading an electrical circuit at home.

Pitching is a type of repetitive stress, as muscles fatigue over the course of the game. If one or more muscles fatigue beyond a certain point, they become unable to continued doing their part in the motor program. When this happens, the MCC initiates the Motor Learning process in order to recruit other muscles to assist the weakened ones. (Changes to a motor program stored in Motor Memory requires the activation of the Learning function first.)

The MCC takes stock of what muscle functions are still available and decides which other muscle fibers it can activate to best make up for the shortfall. Once the MCC has created a motor program that compensates as well can be expected, the MCC compiles this muscle sequence into a new motor program and stores it in Motor Memory. Once this is done, the original program is overwritten, effectively causing the MCC to "forget" how to perform the action in the most biomechanically natural and efficient manner.

What the pitcher usually notices first is persistent tension in certain muscles. These are the muscles being recruited by the MCC's new motor programming to continually assist the ones that became weak. Other early symptoms include feelings of weakness, reduced range of motion in the affected joints, and muscle and joint pain. As the injury progresses, tendonitis, damage to the joint capsule, and muscle tears may occur.

Even after the previously-fatigued muscles have recovered physically, the compensation pattern remains in Motor Memory, unless a specific intervention occurs to motivate the MCC to engage Motor Learning again to reintegrate the "lost" muscles and restore motor programming. Therefore, over the course of a season, pitching mechanics usually degrade, with one inefficient motor program causing more stress to the structure, which in turn causes more overloading, which results in more compensation, much like a fall of dominos. As these injuries add up and the structure becomes more unstable, the pitcher becomes more vulnerable to a season- or career-ending injury.

How Training Can Affect Injury Levels in Pitchers

Over the last 20–30 years, training and conditioning methods have improved considerably, but this can have a negative impact on the pitcher's joints. With weight training, muscle mass can increase far faster than bone, tendon, and ligament strength. Typical case study examples would be weight lifters. They increase their muscle mass quickly and do not stretch enough. As a result, the muscles tighten up, giving that pumped look they seek.

Unfortunately, connective tissue tends to get laid down along certain pathways and does not expand itself like muscle tissue. The larger, tighter muscles exert a larger, constant stress on the tendons, resulting in tendonitis or worse.

What is happening now in pitchers is that they are more conditioned muscularly, but their connective tissue likely has not increased by the same factor. The rotator cuff muscles were already at a disadvantage in the throwing motion, and now their tendons, plus the shoulder and elbow joint ligaments, are being stressed more than ever as the force of the throwing motion increases due to the greater force exerted by larger muscles.

Muscle mass can be easily gained by proper resistance training such as weight lifting, in conjunction with a high protein diet and legal nutritional supplementation.
For example, Creatine, the most popular supplement used for enhancing muscle development, enables the athlete to recover faster from heavy training. It does not help build muscle directly as much as steroids, but enhances natural metabolic activities in the muscle. Creatine is a naturally occurring substance that is produced in our liver. It

also can be found in naturally superior levels in salmon and red meat. This is why Creatine is legal even in the Olympics.
As mentioned previously, pitching is a highly stressful repetitive event that taxes the body's neuromuscular system. The body can cope with this stress until fatigue occurs. Then the circuit becomes overloaded, compensation occurs and injury results. Therefore, along with monitoring pitch counts (www.asmi.org), the pitcher needs to engage in some type of conditioning program to aid in injury prevention.

Pitching is an explosive, endurance activity, requiring balance and control. It is not a brute strength activity requiring large muscle mass, therefore we need to train the pitcher in that fashion utilizing low weight, high repetition, explosive activities; while also training core (pelvis, hips, low back, and abdominals) stability and balance. Strength/endurance training for pitchers starts in the lower extremities concentrating on the hamstrings and progressing up the kinetic chain into the hip extensors (gluteals), abdominal obliques and back extensors.

Once this core strength is established, training then continues to progress upward concentrating on the scapular (shoulder blade) stabilizing muscles such as the trapezius, rhomboids and seratus muscles. Current research is showing us that correct scapular control and function is critical to prevent overuse injuries to the pitching arm, since this is the site of the rotator cuff muscle attachments that control the shoulder joint and allow for a smooth transfer of energy from the ground, up through the trunk, into the shoulder and eventually into the hand to impart force upon the baseball.

Finally, exercises to improve the strength and endurance of the rotator cuff and forearm musculature are added. Pitchers should also engage in single leg strength/endurance activities such as single leg squats and multi-planar lunges to improve functional strength and balance. Medicine ball activities are also very useful for the pitcher since this promotes core stability and explosiveness.

For the high level pitcher to maintain success and minimize injury the importance of a pitching coach to monitor for mechanical flaws cannot be stressed enough and is critical to injury prevention. It is also important for the pitcher to throw everyday, but not off a mound. Research has shown that flat ground throwing is not stressful to the pitching shoulder, but add in a 10–12 inch mound and the stresses rise greatly. Therefore, the pitcher should throw 10 to 15 minutes everyday to work on activity-specific (throwing) training, while also working on proper mechanics to maintain the neuromuscular "health" of his Motor Control Center and the throwing Motor Programming. This flat ground throwing is not stressful and probably is as important to preventing injury as pitch counts and conditioning. In fact, many coaches feel that the baseball players of today do not do enough of this flat ground, technique type throwing. Remember: throwing off a mound tears the body down, while flat ground throwing builds and rebuilds.

Conclusion

Preventing injuries in pitchers is a controversial and complex problem with no easy answers or solutions. However, there are many factors which can be controlled by the pitcher and his coaches that will contribute to his health and longevity. With the proper training and gradually incremented stress to the young pitcher and his growing body (not 150+ pitches per

game at the age of 11 or 12) we think that many of the injuries that we are seeing at the collegiate and professional levels could be minimized.

About the Authors

Jeff Wood is a certified athletic trainer who spent 10 years in minor league baseball and is currently a Division 1 collegiate baseball athletic trainer. He is also the father of 3 boys (ages 9-14) who play youth league baseball.

Howard Nemerov is the developer of Applied Motor Control. He has taught AMC and maintained a clinical practice for 14 years, specializing in injury rehabilitation and athletic performance enhancement.

Bibliography

Information on youth pitch counts and when to start to throws certain pitches types can be found at the American Sports Medicine Institute web site.

For information on Creatine and other legal nutritional supplements, go to the United States Olympic Committee web site, enter "Creatine" in the search box in the upper right corner of the home page, and click on the Search button.

Further Reading

Pitcher Abuse Points

A couple of questions regarding Pitcher Abuse Points

Assessment of Shoulder Strength in Professional Baseball Pitchers
Journal of Orthopaedic & Sports Physical Therapy, 2000;30(9):544-551

Some Thoughts on Decision Research Applied to Baseball

Kenneth V. Heard

There is a 60-year tradition of research in expert versus statistical judgment (Grove & Meehl, 1996; Meehl, 1954; Sarbin, 1943), and the findings remain among the most robust and consistent in the behavioral sciences (Dawes, Faust, & Meehl, 1989; Grove & Meehl, 1996; Meehl, 1986). Across over 200 direct comparisons, with equivalent data (or an informational advantage in favor of the subjective judge), formal statistical methods nearly always equal or exceed the accuracy of subjective "in the head" methods of data combination (Grove & Meehl, 1996). This finding holds true across a wide variety of classification and predictive tasks in the behavioral sciences, medicine, personnel evaluation, auditing, economics and weather forecasting. An actuarial decision procedure may incorporate both qualitative and quantitative data, and such tools may be applied to virtually any decision process of interest.

In this case, the area of decision-making I would like to discuss is managerial strategy in the course of a baseball game. Following the conclusion of the American League Championship Series, there was been a great deal of criticism of Red Sox manager Grady Little's decision to send Pedro Martinez to the mound to start the eighth inning, and subsequent decisions to leave him in against each successive batter. While second-guessing after the fact and scapegoating are commonplace reactions of most human beings, the research suggests strongly that this criticism is well-grounded, and not only

the product of the frustration of Red Sox Nation (although there is surely much of that being voiced). Analysis of the probability of events after the fact is reasonable and appropriate. If one chose to walk through a minefield instead of staying on the safe(r) road, that person's judgment has been questionable whether or not he or she lives to hear the debate. Furthermore, future decisions about what responsibilities to assign that person (e.g., driving a school bus, walking the dog) can be fairly made.

An analysis of Pedro's performance after 7 innings or 100 pitches (information readily available to anyone with an internet connection, and certainly available to Little) shows a marked decline in performance. Compared to reasonably stable estimates of the available bullpen pitchers from the end of the season on, better options were clearly available. Little may have been utilizing a simple cognitive heuristic (rule of thumb) by sticking with his ace, may have decided based in part on interpersonal factors (his support of players and loyalty are surely positive personal characteristics by all reports), or may have evaluated Pedro's chances subjectively using some unknown variable or combination of variables. In doing so, he countervailed the statistical play, which is a very common error. In studies where individuals are given the statistical information and allowed to override it, they tend to countervail too frequently, and reduce the overall accuracy of their predictions. By playing his gut instead of the percentages, Little shifted the odds of a Red Sox win in the wrong direction (given his job description).

It is unusual for managers to be fired following 90+ game seasons, and many have questioned the move. However, listening to the public statements of Red Sox ownership and GM Theo Epstein, it is clear that the focus is not on what was won but how. A focus on game preparation and strategy based on evidence appears to be an important priority for this group, and while no reference has been made to the findings of decision research from the social sciences, the essential arguments are the same, and the existing research base almost certainly applies. This may be a new philosophy within baseball circles, but there is no need to reinvent the wheel.

References:

Dawes, R. M., Faust, D., & Meehl, P. E. (1989). Clinical versus actuarial judgment. Science, 243, 1668 –1674

Grove, W. M. & Meehl, P. E. (1996). Comparative efficiency of informal (subjective, impressionistic) and formal (mechanical, algorithmic) prediction procedures: The clinical-statistical controversy. Psychology, Public Policy, and Law, 2(2), 293 – 323.

Meehl, P. E. (1954). Clinical versus statistical prediction. Minneapolis: University of Minnesota Press.

Sarbin, T. R. (1943). A contribution to the study of actuarial and individual prediction methods. American Journal of Sociology, 48, 593 – 602.

Note: Grove & Meehl (1996) provide a recent overview of the literature and answer common objections to the use of statistical prediction. This article is available in PDF format at:

http://www.tc.umn.edu/~pemeehl/167GroveMeehlClinstix.pdf

RESEARCH BRIEFS

From Earthquake Engineering Abstracts:

Disaster planning for major league baseball

Renteria, H. R.

Second U.S.-Japan Conference on Corporate Earthquake Programs, [Tokyo Metropolitan Univ.], [Tokyo], [1994], pages 192-212

The San Francisco Bay Area is home to two major league baseball franchises: the Oakland Athletics and the San Francisco Giants. In response to the 1989 Loma Prieta earthquake, the Oakland Athletics and the City of Oakland Office of Emergency Services developed a comprehensive emergency management plan which incorporates several different disaster scenarios including a major earthquake. This paper describes the process and efforts of the staff of both the Athletics baseball team and the City Office to develop and implement the emergency preparedness, response and recovery program. Overviews of the Emergency Plan and the drill and exercise program are also presented.

Stadium building in the "Minors"

Shald, S., & Gottlob, P.

Concrete International, 16, 6, June 1994, pages 55-57

The article examines the building of a stadium for a farm baseball team in Rancho Cucamonga, California. The authors describe the site characteristics and requirements, site preparation and construction, and the utilization of innovative materials such as drystrip plywood in vertical work.

From Energy Citations Database:

Baseball `79: the BTUs of Summer

Feder, B.J.

Energy User News ; 1979 Apr 09 Vol/Issue: 4:15

Energy consumption by major league baseball is reflected both in high utility bills and extensive travel costs, but there is little uniformity in how the teams plan for energy management. Stadiums having energy-management programs range from little effort to sophisticated computer control systems. East and West divisions of both the National League and the American League are compared on energy costs and efforts to develop efficient stadium lighting systems.

EPA-R-814903

Fleischman, M., Kirsch, F.W., & Maginn, J.C.

PB-94-119930/XAB 1993 Sep 01

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. Waste Minimization Assessment Center (WMAC) at the University of Louisville performed an assessment at a plant manufacturing baseball bats and golf clubs -- approximately 1,500,000 bats/yr and 550,000 golf clubs/yr. To make the bats, wood billets are oven-dried and machined to a standard dimension. After sanding they are branded and finished. The golf clubs are made by finishing and assembling purchased heads and shafts. The team's report detailing findings and recommendations, indicated that the most

waste, other than rinse water discharged to the publicly owned treatment works (POTW) and wood turnings which are sold, consists of scrap cardboard and paper from the shop and offices, and that the greatest savings, including new income, could be obtained by segregating the cardboard and paper wastes for sale to a local recycler.

From ASFA 1: Biological Sciences and Living Resources:

Disorientation of hawksbill turtle hatchlings, Eretmochelys imbricata, by stadium lights.

Philibosian, R

Copeia. no. 4, 824 p. 1976

The movement of hawksbill turtle hatchlings up a beach, away from the sea, towards powerful lights illuminating a baseball diamond Frederiksted, St. Croix, United States Virgin Islands is reported. If a geotaxis for reaching the sea is present in this sp it was counteracted by the lights since the turtles moved up an inclined plane. The possibility that brightness cues may be important in finding the sea is discussed. It is concluded that when beaches are designated for turtle nesting account must be taken of the environmental impact of artificial light inland.

From NASA Astrophysics Data System:

How Far Would a Home Run Really Have Gone?

Sherwin, W. G., Cheng, Y. C., Chunko, J. D., Eagan, T. P., & Brown, R. W.

American Physical Society, Ohio Spring Section Meeting: Photon Induced Processes, April 12-13, 2002, Youngstown, OH, Meeting ID: OSS02, abstract #B1.010

A controversial issue in professional baseball arises from attempts to estimate how far home run balls would have traveled if they had not hit some obstruction, such as a scoreboard or bleacher seating. A Runge-Kutta numerical simulation model is developed for baseball trajectories including the effects of velocity-dependent drag forces, velocity-dependent Magnus spin forces (including a model for the decrease of the spin rate over the trajectory), and the wind. The computational model is used to build a numerical catalog for the combination of initial ball speeds and angles that give rise to a set of trajectories that have the same final impact point (e.g., on the scoreboard). The data required by an observer to estimate the actual home run range are discussed. A homerun hit by Mark McGwire against the Cleveland Indians on 30 April 1997 that dented the Jacobs Field scoreboard is analyzed.

Knuckleball and Flying Disk: Boundary Layer Transitions, Separations and Vortex Wakes in Sports Aerodynamics

Higuchi, H., Kiura, T., Goto, Y, & Hiramoto, R.

American Physical Society, 54th Annual Meeting of the Division of Fluid Dynamics November 18 - 20, 2001 San Diego, California Meeting ID: DFD01, abstract #JL.005

In spite of their popularity, flow structures over common baseball and flying disks have not been studied in detail. A slowly rotating baseball is subject to erratic flight paths, and is known as a knuckleball. In the present experiment, the characteristic of force acting on a baseball was obtained and the velocity

vector field near the surface of the ball and the wake were measured with the DPIV technique. The seam triggered the boundary layer transition or caused the boundary layer separation itself. The laminar/turbulent boundary layer separations were identified with specific ball orientations. Corresponding three-dimensional wake pattern and the side force result in unpredictable trajectories. In the second part of the talk, flow physics regarding a spin-stabilized flying disk is addressed. The roll-up of trailing vortices was visualized in detail and their vorticity field was measured with the DPIV. The vortical flow over the disk produced flow reattachment at a very high angle of attack. The boundary layer at low angles of attack was affected by the surface motion with asymmetric boundary layer transitions as evidenced by the flow visualization and the hot wire survey. The flow separation and attachment on the underside cavity were also affected by the rotation.

Physics of Sports: Resonances

Browning, David

American Physical Society, New England Meeting, New England 14-April 15, 2000 Providence, RI, abstract #F1.01

When force is applied by an athlete to sports equipment resonances can occur. Just a few examples are: the ringing of a spiked volleyball, the strumming of a golf club shaft during a swing, and multiple modes induced in an aluminum baseball bat when striking a ball. Resonances produce acoustic waves which, if conditions are favorable, can be detected off the playing field. This can provide a means to evaluate athletic performance during game conditions. Results are given from the use of a simple hand-held acoustic detector - by a spectator sitting in the stands - to determine how hard volleyballs were spiked during college and high school games.

From Biological & Agricultural Index Plus:

The Art of Infields

Zwaska, P.

Grounds Maintenance 38 no2 44, 46-8 F 2003

Infields for Truest play

Landscape Management 41 no5 60, 62-5 My 2002

Note: No abstract is available from the latter two articles, but each deals with issues of the design and maintenance of ball fields, with attention to topics such as the composition of substrate, irrigation and drainage and so forth.

SUGGESTED WEBSITE

George Gmelch Homepage, Department of Anthropology, Union College.

Dr. Gmelch is a former MLB player and a current SABR member. He has written a number of articles on the anthropology of baseball, including the very famous Baseball Magic, describing the superstitions and rituals of MLB players. This paper has been anthologized and is a classic read in introductory anthropology classes in colleges and universities across America.

http://www.union.edu/PUBLIC/ANTDEPT/ggmelch.htm