

The Rising Fastball

The Newsletter of SABR's Science and Baseball Research Committee



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Greetings from the Chair

The Science Committee meeting at SABR 34 is scheduled for Thursday at 4:30 PM. Vice-Chair Alan Nathan, Ph.D. will present new data from his lab on MLB baseballs from the 1970s and today, tested at 60 MPH and at higher speeds, and will also give a short talk summarizing the NCAA method of regulating the performance of non-wood bats and what it means to measure the performance of a bat. There should be a variety of research presentations of interest to our committee members at the convention, and I will plug the Special Session Beyond Moneyball (Saturday at 5:00 PM) in which myself and a colleague (David Faust, Ph.D.) will discuss the application of decades of research in decision-making and human judgment to baseball.

In this issue, Alexander Nussbaum, Ph.D. presents an article on the misperception of randomness as an evolved mechanism, and explains how this adaptation may contribute to the mis-appraisal of the value of baseball performances, with specific reference to the "Streak of Streaks." Also in this issue, Rick Swanson presents a new defensive statistic called "Reaction & Range." Ordinarily, I would refer a new statistic to the Statistics Committee's By the Numbers publication, but in this case, the statistic in question would require the implementation of camera systems in ballparks in order to be utilized, and so the technological

element seems to reasonably fall within our bounds.

See you in Cincinnati!

Ken Heard (ekenheard@yahoo.com).

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Gould, Probability, Baseball Statistics, and Idol Worship

By Alexander Nussbaum, Ph.D.

"Rarity by itself shouldn't necessarily be evidence of anything. When one is dealt a bridge hand of thirteen cards, the probability of being dealt that particular hand is less than one in 600 billion. Still, it would be absurd for someone to be dealt a hand, examine it carefully, calculate that the

probability of getting it is less than one in 600 billion, and then conclude that he must not have been dealt that very hand because it is so very improbable."
-John Allen Paulos

A Debate on Baseball Records

In 1941 Joe DiMaggio hits safely in 56 games in a row, and Ted Williams bats .406. Which was the greater feat? The argument has been regurgitated for the millionth time in a recent book on sports debates, and for a millionth time DiMaggio feat is pronounced greater. The logic is always that lots of guys batted .400 before Williams, and a few came close since, but 56 games batted safely in a row is untouched and untouchable (number two is a mere 44 games).

And that sounds correct. Batting .400 may be quite reachable at present (better living through chemistry!), but DiMaggio's streak does not seem breakable. (If for no other reason than that anyone getting even close to 40 games would not be able to go the bathroom without media microphones and cameras following.) At some point in history major league baseball will end, whether the result of slow cultural evolution, or a sudden cataclysm, quite possibly with DiMaggio's streak unbroken.

But all those judges of the worth of records have confused rarity with value, and engaged in the universal cognitive bias of placing a special and mystical significance on rarity. (And in evaluating the impact DiMaggio made using the term "mystical" is not inappropriate.) DiMaggio's statistics for 1941, while outstanding were not epoch-making. He had a great year, but not among the greatest in baseball history. If by value we mean contribution to team success, the value of a baseball player's record is subject to objective measures and probability of occurrence does not factor in. Triples are rarer than homeruns, but clearly less valuable. Reaching first base on catchers' interference is quite rare, but that does not make it more valuable than the relatively common single.

True, the chance of batting safely in 56 consecutive games was rather remote, even of a

hitter of DiMaggio's perfect attributes for the task, namely very high batting average & low walk total. These characteristics hold true of most players with 30+ game streaks. DiMaggio's long time rival, Ted Williams, for example, walked extremely often, resulting in too many games of only 1 or 2 official at bats to put a long batting streak together. Ironically Williams holds the less frequently talked about record of consecutive games reached safely -- 84 consecutive -- accomplished in 1949. Ironic, but not that surprising, considering that Williams' career on-base percentage of .483 is the all-time highest.

Rarity versus Significance

Let us say a batter puts together a modest streak of 20 games. That occurs every year -- not very unlikely to happen. But let us say in every one of those games our batter goes precisely 1 for 4, all singles. Furthermore, let us say in every game the hit occurs in the second time at bat. In addition let us say in every game he strikes out exactly once, always on the third time at bat. Oh, and on the first time at bat it's always a ground out to shortstop, and on the fourth time it's always a pop fly to center. What are the odds of this? Beyond computation. Yet in that 20 games our batter has hit .250, with exactly the same slugging percentage and on base average. Perhaps infinitely unlikely, but not exactly very good performance!

But say it did happen. What would it prove? What a great hitter our imagined batter is? Hardly. Would it demonstrate some deep meaning, some manifestation of "intelligent design" or any new age term you can insert here? In fact, it would prove absolutely nothing. It may have been extremely unlikely for *Homo sapiens* to evolve, but they did (to our satisfaction) and that proves no "cosmic significance." As Stephen Jay Gould was fond of writing, if you could rewind the tape of evolution, it would play out differently next time. Our imaginary hitter given those 20 games to play over, would have surely produced some other pattern of results, perhaps still batting about .250 during its course, and it has been pointed out that

if evolution was given a "do-over," the process of evolution might have been discovered by scaly intelligent descendants of the dinosaurs.

An Evolved Cognitive Fallacy

Unlikelihood by itself signifies nothing. Unlikely things not only happen, but in the passage of time *must* happen (Note Paulos' well known quote on this on this above). It is highly unlikely that any individual ticket wins the lottery (the lottery has been called a tax on the statistically challenged) but some ticket must win (to be labeled by its holder a "miracle from God"). No particular form of organized complexity is inherently destined, but evolution will inventively produce organisms of ever increasing complexity molded to their particular environments in a process constrained by laws of physics.

Our evolved cognitive mechanisms have already determined the "style of music" we are to play. We simply choose the particular culturally accepted tune in that genre, and believe we could have played anything. And the human "style of music" is the noticing of, and attaching significance to, rare events. It is easy to see the survival benefits of rare events standing out-- they may be important and necessitate immediate action. However, the resultant cognitive fallacy is the attributing of particular significance and meaning to coincidences.

This persistent fallacy, part and parcel of the human brain, perhaps explains why, while sophisticated mathematics is so ancient an activity, the field of statistics is so recent -- its genesis is in the late 19th century. Statistics could never have been born without the prior discovery of the process of evolution.

Statistics is the study of randomness, and the concept of randomness is alien to ancient thought, indeed to all but a strand of recent Western thought. Randomness is a difficult concept for humans, who evolved to perceive meaning and order in their environment through natural selection. On September 11, 2002, the first anniversary of the 9/11 terrorist attacks, the winning numbers in the New York State lottery were 911. Key components of a

statistics course should be teaching critical thinking, teaching the use of numbers as simply numbers, and teaching understanding randomness. Because of the publicity this coincidence was getting, I presented to my statistics class articles that debunked giving any meaning to this event, and that explained that some coincidences occurring are inevitable, given the infinite amount of coincidences that can potentially occur.

The evolved cognitive fallacy of inferring meaning onto blind chance is astonishingly powerful and pervasive. A clear demonstration of this is the existence of academics with modern Western degrees and training, who proudly proclaim this fallacy to be sacred belief (while, not surprisingly, also reviling evolution). An area of interest of mine, in studying how infra-critical thinking manifests itself, is the worldview of Orthodox Jewish mathematicians, statisticians and scientists, who, despite whatever conventional degrees and accomplishments they have, maintain that neither coincidence nor randomness exists.

Orthodox Jewish scientists still believe that Gematria (numerology) holds the secrets to the creation of the universe, that the minutest details of the universe were created to reveal God's lessons for mankind, and they proclaim numbers to be mystical entities. The "true" numbers are the numerical values of Hebrew letters, which existed before the creation of universe, mystically underlie the creation of the universe, and connect aspects of the universe through having the same numerical values. In that view there are of course no random events; every minute detail, every toss of the die, is the manifestation of divine will and the belief in coincidence is heresy.

According to Dr. Shimon Silman, Professor of Mathematics, Touro College and director of the RYAL Research Institute on Mosiach (messiah) and the Sciences, (for whom the calculations of relativity theory, allow us to "accept the idea that the earth is standing still in the center of the universe" (1992), "Mathematics, more so than science in general, has this quality of discovering the underlying unity in creation" as

"Mathematics discovers the secret analogies which unite" (1993).

Why is this so? According to Dr. Abraham Hasofer (1989), professor of statistics, it's because "both the human personality and the cosmos are built according to the same ground plan -- the Sefirotic Scheme. Since man's creative process mirrors the Divine creative process, the creations of the Divine mind can be grasped by using the creative ideas generated by the human mind", namely, "man's ability to use mathematical equations." The number 8, for example, according to Dr. Hasofer, represents the super-natural as it is seven, the number that represents nature, plus one (Katanga Archives, 2002). (Dr. Hasofer [L'Haim, 1990] also claims that according to his computations "there is absolutely no chance, within the time frame given by evolutionary theory, that even one level of species would develop, not to mention the development of the human species...from a statistical viewpoint the theory of evolution has no scientific validity.") The Sefirotic scheme is a tree-like mystical chain of being that encompasses creation.

Quoting an Orthodox Rabbi (Teitelbaum, no date) "While many believe that the winning of a lottery represents pure chance...the believing-Jew accepts the fact that all is Hashgacha Protis, which means that it is all Hashem's (God's) doing. The Torah (bible) warns us that those who believe that things happen through pure chance and coincidence will be treated accordingly... While atheists like Darwin and company would still contribute it to chance and coincidence...there are always the Darwins in our midst who will dispute all reason and logic."

A full measure of how hideous a sin accepting randomness is to this community can be seen in the Orthodox analysis of the biblical commandment to exterminate "Amalek" (Whomever they were, they are in orthodox lore the first to try to explain the world through natural processes, the worst possible sin). From one Orthodox Rabbi (www.jbuff.com) "Amalek believed in randomness...This is why they must be obliterated from the face of the earth."

These views echo through and affect all the members of that community. I read a review (Jewish Week, February 4, 2004) by a yeshiva high school student trying to make sense of an article by Lisa Belkin "Coincidence in an age of Conspiracy" (New York Times Magazine, August 11, 2002), which was about how humans attach meaning to meaningless coincidences. About chance and statistics, this reviewer concluded that she "rejected both ideas. After all I believe that every encounter, experience and challenge... is divinely ordained." and "The torah issues a caveat -- those who believe things happen through chance and coincidence will be treated accordingly...we believe in the concept of hashgacha pratis."

However, while ascribing meaning or value to chance might seem natural or even reasonable when viewed within the bounds of some cultural or religious belief systems, even those who endorse rational and probabilistic thought are not necessarily immune. The strength of this evolved cognitive bias to infer meaning to coincidence can be seen in the following anecdote from the autobiography of Isaac Asimov, one of the 20th century's foremost representatives of rational thought. While ill in the hospital, Asimov felt someone unseen poke him, and not realizing until later that it that he had actually poked himself, he called his wife to make sure she was all right because "rationalist that I am there was no way in which I could refrain from thinking some supernatural influence had interfered to tell me something had happened (to my wife). Nothing had of course happened to his wife, but thinking it over Asimov wondered what if by sheer coincidence something had befallen her right before he called "would I have been able to resist the thought of supernatural interference? I hope so, but I can not be sure" (1994).

Steven Jay Gould and "the Streak of Streaks"

Steven Jay Gould was best known among evolutionary theorists as an opponent of *adaptationism*, the idea that features of organisms are adaptations shaped by natural selection to answer survival problems thus

enabling the leaving of offspring and perpetuating genes, and should be analyzed as such. Evolutionary psychology, however, views psychological mechanisms as evolved adaptations. It may not be entirely unrelated that Gould, a lifelong baseball fan, who refused to see evolutionary products as adaptations, failed to see that the value of a baseball record lies solely in its utility to winning games. Thus he writes (1989) "Joe DiMaggio's fifty-six-game hitting streak is both the greatest factual achievement in the history of baseball and a principal icon of American mythology", but while "Statistics and mythology may seem the most unlikely bedfellows" when Gould wishes to quantify the great mark he does so in terms of the statistics of "runs," or in other words the probability or improbability of occurrence - improbability of occurrence is thus the measure of excellence. Gould seems to believe that DiMaggio's record was the only one in sports whose occurrence so unlikely "it should never have occurred at all" (1989).

Gould wrote "Among Sabermetricians -- a contentious lot not known for agreement about anything-- we find virtual consensus that DiMaggio's fifty-six-game hitting streak is the greatest accomplishment in the history of baseball, if not all modern sport. (1989)" This is a rather odd statement, for Sabermetricians are the most likely to point out that the value of a batter's performance is measured by production per out-going 1 for 5 with a single in each of two games is hardly as good as going 0 for 3 in one game and 3 for 4 with 3 homeruns in the second.

Gould maintained "Only one record stands beyond reasonable probability, and should have not happened at all- Joe DiMaggio's fifty-six game hitting streak in 1941-- Thus validating the feeling of many fans that DiMaggio's splendid run is the greatest achievement in modern sports." (1996, p. 32). He bases this on "Several years ago I performed a fancy statistical analysis on the data of slumps and streaks, and found that only DiMaggio's should not have happened. All other streaks fall within the expectations for great events that should occur once as a consequence of

probabilities." (2000, p 242). Thus concluding (1989):

Nothing ever happened in baseball above and beyond the frequency predicted by coin-tossing models... There is one major exception, and absolutely only one—sequence so many standard deviations above the expected distribution that it should not have occurred at all. Joe DiMaggio's fifty-six-game hitting streak in 1941. The intuition of baseball aficionados has been vindicated... to make it likely (probability greater than 50 percent) that a run of even fifty games will occur once in the history of baseball up to now ...baseball's rosters would have to include either four lifetime .400 batters or fifty-two lifetime .350 batters over careers of one thousand games. In actuality, only three men have lifetime batting averages in excess of .350, and no one is anywhere near .400 DiMaggio's streak is the most extraordinary thing that ever happened in American sports. He sits on the shoulders of two bearers — mythology and science. For Joe DiMaggio accomplished what no other ballplayer has done. He beat the hardest taskmaster of all, a woman who makes Nolan Ryan's fastball look like a cantaloupe in slow motion — Lady Luck

What Gould makes unclear above is that a study published in *Chance* magazine found that four lifetime .400 hitters (assuming a 3000 game career) would have an about 50% chance that one of them would hit in fifty games in a row, likewise 52 .350 hitters would have an about 50% chance that one of them would hit in fifty games in a row- not that this is required for someone (any one) in history to have a 50% chance. (And why even talk about a 50% chance -- that is certainly not the standard in statistics.)

Gould, of course, was well aware of the error of attributing meaning to coincidence, writing "Our error lies not in the perception of

pattern but in automatically imbuing pattern with meaning, especially with meaning that can bring us comfort, or dispel confusion" (1989). Gould, in his voluminous writing, attempted to get a public fixated on the idea that humans were the pinnacle of creation to understand the randomness of creation, even to the point of overstating randomness from the point of view of his critics. Mutations are random, but their survival is not, and because mutations that improve genetic survival stay around (and so are "remembered") in evolution each generations of 'coin flips' builds on what is already there. Thus, contrary to Gould's position on the issue, many evolutionists feel that it is inevitable that evolution produce ever increased complexity, and in that sense "progress."

Gould articulated the mistake people make in believing streaks and slumps (and evolved life for that matter) must have a cause other than chance, made because "we have no feel for the frequency and length of sequences in random data" (1989). But for some unfathomable reason he felt "Thus, while we understand that DiMaggio's hitting streak was the longest ever, we don't appreciate its truly special character because we view all the others as equally patterned by cause, only a little shorter. We distinguish DiMaggio's feat merely by quantity along a continuum of courage; we should, instead, view his fifty-six-game hitting streak as a unique assault upon the otherwise unblemished record of Dame Probability." In other words, because the streak was so unlikely to happen, its occurrence uniquely is not due to chance but to ... what? Divine will of God, and/or near divine ability of a man.

In Innumeracy (1998) Paulos states he calculated "Given the differences in their respective batting averages, Rose's streak (44 games in a row in 1978) was a slightly more unlikely accomplishment (than DiMaggio's streak)." But even if DiMaggio's streak is the most unlikely thing to have ever happened in sports, was it the most valuable performance to the Goddess of victory? Hardly. Some have even pointed out that if done by a player of less stature than DiMaggio it would have been an

obscure record. Tommy Holmes who long held the modern National League record is no one's legend- and has received close to zero Hall of Fame votes. DiMaggio himself would always mention as his greatest achievement earning an amazing 9 World Series Championship rings in a 13 year career.

Helping Baseball's Dice

Gould was a staunch opponent of creationist doctrine. Creationists (including so-called "creation scientists", proponents of "Intelligent Design," or what ever other name purveyors of creationist religious doctrine go by) like to bring up the idea of evolution's extreme improbability as proof that it could not occur by chance. Astronomer Sir Fred Hoyle's quotes "The probability of life originating at random is so utterly miniscule as to make it absurd...The chance that higher life forms might have emerged in this way is comparable with the chance that a tornado sweeping through a junkyard might assemble a Boeing 747" (1981) have come to symbolize creationists' spectacular misunderstanding of evolution.

Evolution is cumulative & progressive, keeping the "best" of chance results for chance to improve on in the next round, as Richard Dawkins put it "non-random survival of randomly varying replicators." Intelligent Design proponents never deem it necessary to discuss how their intelligent designer got designed. But if intelligent design occurs to aid chance in a batting streak, the nature of those designers is clear- evolved *Homo Sapiens* known as "official scorers."

Batting and pitching streaks are accomplished by men who know that they are in the process, and scored by others who are also aware of what is occurring. A batted ball knocked down but not cleanly fielded by a third baseman is apt to be scored an error to keep a no-hitter going and a single to keep a hitting streak alive- especially by friendly home field scorers. Baseball writer John B. Holway (2001) for example claims "Joe DiMaggio's fame rests on a hitting streak that never happened. It is as full of

holes as an archery target—for example, two gift hits by friendly New York official scorers on easy bouncing balls in games 30 and 31.”

Regardless of whether baseball revisionists are correct that DiMaggio’s record was unfairly helped along by scoring decisions, their arguments demonstrate the difficulty of calculating the “probability” of baseball occurrences.

The Chances of a Batting Streak

Just what were the chances of DiMaggio batting in 56 consecutive games? Well, trying to estimate the chances of this or any other baseball record of consecutive successes necessitates choosing from a number of assumptions, none of them entirely satisfactory. Furthermore, different statisticians will make different assumptions, resulting in differing assessed probabilities. While the basic nature of the problem is if the probability of an individual event occurring on a given trial is P , then within a sequence of N trials what is the probability that at least X successes will occur in a row, there are wrinkles here.

First of all we need an estimate of the probability of success per one trial- in this case one game. DiMaggio’s lifetime average was .325, he averaged 3.93 official at bats per game, so his chances of getting a hit in a given game was $1 - (.675^{3.93})$ or .787. The chances of hitting in 56 consecutive games is $.787^{56} = .0000015$. While it’s tempting to leave it at that, that’s only an estimate of “given 56 games what were the chances that DiMaggio would get a hit in all of them,” not that a streak of that length would occur somewhere in his career. DiMaggio played in 1736 games, resulting in many opportunities of 56 game streaks. While a more precise answer to our original question requires a recursive procedure calculating the different ways in which one can hit safely in some string of 56 games in a row, we can obtain a (slightly too low) estimate using $[1 + (N-X)(q)] p^X$. In our case that is $360 \times .0000015$, or .00054. In other words DiMaggio had about a 5.4 per

10,000 chance of hitting in 56 consecutive games somewhere in his career.

What were the chances someone else would have done it? Let us take Napoleon Lajoie; using the above procedure, Lajoie had a 1.5 chance in a 1000 over his career. Our procedure shows George Sisler had a 3.4 in 1000 chance over his career. But what happens if we are concerned about chances of hitting in 56 in a row in a given year. What were the chances of DiMaggio having his streak just in 1941? The answer 2.4 in 10,000. How about Lajoie in 1901 or Sisler in 1922? The chances respectively are 2.4% and 2.0%. Wait a second- are we saying that these hitters had 6-10 times better chance in one given year than at some point in their career? Isn’t that a logical impossibility!? But it turns out the paradox is no paradox at all, just a product of our assumptions. Lajoie batted .426 in 1901, only .338 lifetime; that was more than enough to offset 2480 lifetime games versus just 131 games in 1901. Calculating probabilities based on a career as one long series of games with a particular average- which most people whom I’ve seen try calculate streaks do- will drastically underestimate chances if batting average had a high variability between years (in other words the batter batted much higher than his lifetime average some years, much lower other years- which is of course true for almost all players).

Batting Streaks’ Invisible Nemesis

To estimate to estimate probability of baseball events we translate the world of baseball into that of tossing coins or dice. We found that by doing this we could estimate that far from being an astronomically unlikely event, there were a few batters that had a better than 2% chance of doing it in a particular year. Assuming 4 at bats per game, any .400 year had a probability of 6 in 1000 and any .375 year (of which there have been many) had the probability of 2 in 1000 of producing a 56 games streak So why only one 50+ batting streak in all of major league history? The answer again lies in the

difference between dice and batters we hinted at above.

If a batter has a lifetime batting average of .333, he averaged 1 hit per 3 at bats. A die has a 1 in three chance of coming up 5 or 6. But for the die that 1 in 3 chance never changes. Our batter hit higher than .333 in his prime, much lower in his decline, and may have hit better than .400 in his best single year. Furthermore during a single season he had at bats with sprained fingers, in poor light, against pitchers he couldn't figure out, and also at bats against poor pitchers who were inadvertently tipping off everything they threw. In a given at bat our batter had a chance at a hit from not much above zero to not much below one.

We toss a die 5 times what are the chances getting anything but a "one" each time? Simple- its $.8333^5$ or about 40%. We calculate that a batter has a .8333 chance of getting a hit in a game. What are the chances he will hit in each of five games? Same math? Not exactly. Lets say in four of those games our outstanding batter who can pull any fastball has an .98 chance of getting a hit, in the fifth game he is facing a knuckleball pitcher and has only a .25 chance at a hit (it still averages out to .8333 per game) but using these exact probabilities our batters chances for this five game streak are not 40%, but only 23%. If a coin alternated between a 100% chance of falling heads and a 100% chance of falling tails on every flip, it would still come up heads 50% of the time, but the chances of two heads in a row would be zero.

It seems then that DiMaggio's batting streak is protected by an improbability not amenable to being statistically calculated. On the other hand, if one is interested in level of productivity, statistical procedures have been developed for the task. We can not precisely know the probability of a long batting streak. But we know its value is not greater than if the same statistics were compiled without the streak!

Improbability of Performance Hardly a Measure of Excellence

But the whole notion that the impressiveness of a baseball record lies in its improbability is a perverse reversal of the fact that great players are more likely to do great things. Roger Maris' 61 homeruns were criticized for being unlikely for him, thus just a "fluke" - he never hit as many as 40 in a year before or after. DiMaggio wasn't one in a million unlikely to hit in 56 games in a row because he had a number of years where he batted better than .350. George Sisler had a better chance because he topped .400 twice- turned out his best hitting streak was 41 games, the American League record until DiMaggio.

No-hitters are rare indeed. Since 1900 there have been about 200 no-hitters in about 155,000 major league games, or about 1 every 1550 starts (2 starts per game). Thus an average pitcher has about a .000645 chance at a no hitter in a given start. Dominant flame-throwers like Sandy Koufax, Nolan Ryan, and Bob Feller had much better chances, which is why they accounted for 14 no-hitters among themselves in just 1,571 starts between the three. A poor major league pitcher has much less chance, which did not stop Alva Lee "Bobo" Holloman (10 lifetime starts, 3 wins 7 losses, bloated 5.23 ERA) from beating the odds and pitching a no hitter- on his first major league start yet.

But the king of unlikely no-hit performances was Johnny Vander Meer (lifetime 119 wins and 121 losses) who is well known as the only man in major league history to pitch consecutive no hitters. How unlikely an occurrence was that taking? Taking .000645 as his chance of a no hitter in a start, Vander Meer, with 286 lifetime starts had a .83 chance of finishing with no no-hitters, a .15 chance of pitching one no-hitter and an .014 chance (or just a little over 1 in a hundred) of pitching two no-hitters. Not consecutive mind you, just two over his entire career. But what were the chances that his two no- hitters, the only ones he would ever pitch, would be consecutive? About 1 in 10 thousand. Note that major league base ball could hardly have produced 10,000 Vander Meer type careers. Much as Gould claimed for

DiMaggio's streak, it was unlikely that anyone would accomplish this. Unfortunately for Vander Meer, improbability of performance is not the measure of value. He never got to see a plaque in Cooperstown.

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Alexander Nussbaum holds a Ph.D. in experimental psychology, and is an adjunct assistant professor at St. John's University, Jamaica, NY- His teaching specialty is statistics and his dissertation area was evolutionary psychology. He has followed baseball since the early 60's. He can be reached at:

Department of Psychology
St. John's University
Marillac Hall
8150 Utopia Parkway
Jamaica NY, 11439
alex65@hotmail.com

Reaction and Range Defense Statistic :R/R

By Rick Swanson

The statistic called Reaction and Range is determined using the following formula: $T/D = R/R$, where reaction time T is defined as the time from the ball leaving the bat to the time (in seconds) when the ball is caught (or missed), and distance D is defined by linear feet traveled from the fielder's position when the ball is hit to the point where the catch is made. If you take the Reaction time, and divide it by the Range distance you will get a variable that will rate the value of each defensive play. The theory underlying this metric is that each play made by a fielder is determined by the fielder's ability to react to where the ball is going and then to move to that position to make the play. R/R creates a formal measure that would allow a more objective determination of when an exceptionally good (or exceptionally bad) play is made by a fielder. Outfielders will generally have more time but greater distances to cover for plays, whereas

infielders will generally need faster reaction times but cover less ground. For example, a third baseman that dives 10 feet to grab a ball in .5 seconds would score a R/R number .050. An outfielder may run 100 feet in 5 seconds, and end up with the same .050 number.

The R/R statistic can also be used to evaluate plays that are missed by fielders. If player A is positioned at shortstop, and is able to range 40 feet in 2 seconds to field a ground ball his R/R number would be .050+. If player B has the same play but doesn't catch the ball he would get a .050-, because he failed to make the play. The positive or negative notation does not imply that these plays should necessarily be summed or otherwise manipulated, but at the end of a season one would have two lists for the plays they made and missed over the year. The value of this statistic would be to determine which players are able to cover more ground than others over the course of a year, and also provide a more objective measure of errors, that is, plays that the player should reasonably be expected to make, given the difficulty of the play as measured by R/R.

The statistic could add to the history of the game, and let those in future years better understand how the outcomes of important games were affected by defensive plays. The example I give is the following: In game 7 of the 2003 ALCS Yankee short stop Derek Jeter hit a double in the eighth inning. The record books only show that he ended up on second base, but no indication is given that Red Sox right fielder Trot Nixon got a very poor read on the ball, and his initial move was not in the right direction. The time elapsed is 3.6 seconds on the play (that number is exact from the camera I used to film the play live at Yankee Stadium). The distance I estimate for Nixon was 20 linear feet; meaning he could have traveled more than 20 feet because he took an inaccurate direction to the ball, but a true R/R number would measure straight line from where he was positioned to where the ball ended up. Therefore his R/R number that would go into the record books would be 3.6/20 or .180 R/R. This

way future baseball historians could understand this was an easily catchable ball that was misplayed. Since the distance figure is only an estimate, the number is not completely accurate. In order for the statistic to be accurate, a camera system would be needed to record objectively where each player is positioned when every pitch is thrown. It is my belief that a program could be created, that would accurately determine the exact distance from where a player was positioned to where the play took place.

Perhaps the first person to try to use a clock with baseball was Hugh Fullerton, who in 1910 wrote "The Science of Baseball." <http://www.thediamondangle.com/archive/dec02/insidegame.html> Some of his early measuring tools were designed to see which fielders had more range than others. Fullerton was laughed by critics that said baseball does not need a clock to function, but is a timeless game. Now nearly a century late with new technology available baseball can find a statistic that will measure both the reaction and the range of all defensive players. It is my hope that Reaction and Range will be considered a new statistic for all of baseball.

Rick Swanson is a special education teacher who resides in Glastonbury, CT. He can be reached at rickswanson@cox.net.

Announcements

The 5th Conference of the Engineering of Sport will be sponsored by the International Sports Engineering Association (ISEA) and the Bioengineering Division of the American Society of Mechanical Engineers (ASME). It will serve as a forum for the discussion of technical issues related to research and development activities in sport. The inexorable advance and evolution of equipment and materials impose large, sometimes beneficial and sometimes adverse, effects on the many sports and games we experience and enjoy. We hope this conference, following on previous successful ones in

Sheffield, Sydney and Kyoto, will continue to be a useful meeting for exploring the interaction of technology and engineering in all aspects of sport. The organizers are making a special effort to include sessions with industrial applications in sports and hope to attract many participants with industrial affiliations. The program will include, among others, the following subject areas:

- Equipment design and development
- Sports strategy and technique
- Manufacturing processes and techniques
- Biomedical engineering and technology
- Computer and electronic technology
- Facilities development
- Performance optimization
- Biomechanics
- Materials engineering
- Dynamics and fluid dynamics
- Measurement techniques
- Robotics
- Other topics in sports engineering

The conference runs from September 13-16, 2004 and it will be held at UC Davis. There will be a total of 172 papers and 2 whole sessions on baseball. Complete information is available at: <http://conferences.ucdavis.edu/sporteng>

PhaseSpace motion tracking available.

If anyone is in or near the San Francisco Bay area, (Oakland side by the Oakland Airport) we will provide capture data at no charge in preparation for SIGGRAPH. The MoCap system is higher resolution and speed than most of the available technologies and we are interested in seeing the results of any studies done using our data.

Please contact info@phasespace.com to schedule any sessions. Please simply provide person capable of performing the desired motions, and we can provide the data in most of the standard formats.

www.phasespace.com
510-638-5035

Book Review Requested

The Science Committee has received a review copy of *Saving the Pitcher* by Will Carroll. Carroll, who writes the *Under the Knife* column for Baseball Prospectus presents research on how to prevent injury to baseball pitchers. A volunteer is requested to read and write a review of this book for publication in the Fastball. Please contact Ken Heard (ekenheard@yahoo.com) if interested, and provided a brief description of your qualifications for the job.

Research Briefs

The following are current scholarly publications from the year 2004 selected from PubMed. PubMed is a service of the National Library of Medicine, and includes over 14 million citations for biomedical articles back to the 1950's. It can be access by the public at: <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>

A simple rule for controlling overarm throws to different targets. *Exp Brain Res.* 2004 Jun

Watts S, Pessotto I, Hore J.

We investigated the central programming of overarm throws by determining whether throws to spatially separate targets in the vertical direction (sagittal plane) are produced by changes in hand (i.e., finger) path direction or by changes in the timing of ball release. Six skilled throwers made 30 throws at the same speed with a baseball, from a sitting position with the chest fixed, at targets at different heights and distances. Arm segment angular positions in 3D were recorded with the search-coil technique. Videotaping revealed that ball direction was not, as commonly assumed, the tangent to the finger path at ball release. Rather ball direction was the tangent to the finger path at a point about half way between initial uncoupling of the ball from the hand and final ball release. When viewed from the side,

finger paths were tilted upwards for the high and the far targets and downwards for the low and near targets. This was associated with changes in angular orientation of the upper arm in space. Throwing at spatially different targets was not associated with changes in the timing of ball release. We propose that there is a simple rule by which throws to targets in different directions and at different distances are controlled: throws of the same speed are produced by different finger path directions, but the same timing of ball release. Such a mechanism would simplify the neural control of throwing to different targets.

Optimal feedback control and the neural basis of volitional motor control. Nat Rev Neurosci. 2004 Jul;5(7):532-46.

Scott SH.

Skilled motor behaviour, from the graceful leap of a ballerina to a precise pitch by a baseball player, appears effortless but reflects an intimate interaction between the complex mechanical properties of the body and control by a highly distributed circuit in the CNS. An important challenge for understanding motor function is to connect these three levels of the motor system - motor behaviour, limb mechanics and neural control. Optimal feedback control theory might provide the important link across these levels of the motor system and help to unravel how the primary motor cortex and other regions of the brain plan and control movement.

How dogs navigate to catch Frisbees. Psychol Sci. 2004 Jul;15(7):437-41.

Shaffer DM, Krauchunas SM, Eddy M, McBeath MK.

Using micro-video cameras attached to the heads of 2 dogs, we examined their optical behavior while catching Frisbees. Our findings reveal that dogs use the same viewer-based navigational heuristics previously found with baseball players (i.e., maintaining the target along a linear optical trajectory, LOT, with optical

speed constancy). On trials in which the Frisbee dramatically changed direction, the dog maintained an LOT with speed constancy until it apparently could no longer do so and then simply established a new LOT and optical speed until interception. This work demonstrates the use of simple control mechanisms that utilize invariant geometric properties to accomplish interceptive tasks. It confirms a common interception strategy that extends both across species and to complex target trajectories.

Humeral torque in professional baseball pitchers. Am J Sports Med. 2004 Jun;32(4):892-8.

Sabick MB, Torry MR, Kim YK, Hawkins RJ.

BACKGROUND: Spontaneous fracture of the humeral shaft in throwers is a rare but well-known phenomenon. Although it has been hypothesized that the biomechanics of the throw cause such fractures, it is not clear how or when the fractures occur in the pitching motion. **METHODS:** The torque acting about the long axis of the humerus was calculated in 25 professional baseball pitchers throwing in game situations. **RESULTS:** Peak humeral axial torque reached a mean value of 92 +/- 16 Nm near the time of maximum shoulder external rotation at the end of the cocking phase. This torque tended to externally rotate the distal end of the humerus relative to its proximal end. The direction of the torque was consistent with the external rotation spiral fractures of the humerus noted to occur in throwers. The magnitude of the peak humeral torque averaged 48% of the theoretical torsional strength of the humerus, suggesting that repetitive stress plays a role in humeral shaft fractures. **CONCLUSIONS:** Fractures are most likely to occur near the time of maximum shoulder external rotation when humeral torque peaks. Pitchers whose elbows were more extended at stride foot contact tended to have lower peak humeral torques.

Effect of grip strength and grip strengthening exercises on instantaneous bat velocity of collegiate baseball players. J Strength Cond Res. 2004 May;18(2):298-301.

Hughes SS, Lyons BC, Mayo JJ.

Bat velocity is considered to be an important factor for successful hitting. The relationship between grip strength and bat velocity has not been conclusively established. The purposes of this study were to determine the relationship of grip strength to bat velocity and to ascertain whether the performance of resistance training exercises designed to specifically target the forearms and grip would significantly alter bat velocity. The subjects for this study were 23 male members (mean +/- SD, age = 19.7 +/- 1.3 years, height = 182.5 +/- 5.9 cm, weight = 85.4 +/- 15.5 kg, experience = 14.4 +/- 1.7 years) of a varsity baseball team at a National Collegiate Athletic Association Division II school. The Jamar hand dynamometer was used to test grip strength, and the SETPRO Rookie was used to measure instantaneous bat velocity at the point of contact with the ball. Subjects were randomly divided into an experimental group and a control group. For 6 weeks, both groups participated in their usual baseball practice sessions, but the experimental group also performed extra forearm and grip strengthening exercises, whereas the control group did not. Pretest and posttest correlations between grip strength and bat velocity revealed no significant relationship between grip strength and bat velocity (pretest $r = 0.054$, $p = 0.807$; posttest $r = 0.315$, $p = 0.145$). A dependent t-test performed on all subjects revealed that a significant ($p = 0.001$) increase in bat velocity did occur over the course of the study. A covariate analysis, employing pretest bat velocity as the covariate, revealed no significant difference ($p = 0.795$) in posttest bat velocity scores between the experimental and control groups. Thus, increases in bat velocity occurred, but the differences were similar for both the experimental and control groups. The findings of this study suggest that grip strength and bat velocity are not significantly related, and

that the allocation of time and energy for added training of the forearms in order to improve grip strength for the purpose of increasing bat velocity may not be warranted.

Effect of different training programs on the velocity of overarm throwing: a brief review. J Strength Cond Res. 2004 May;18(2):388-96.

van den Tillaar R.

Throwing velocity in overarm throwing is of major importance in sports like baseball, team handball, javelin, and water polo. The purpose of this literature review was to give an overview of the effect of different training programs on the throwing velocity in overarm throwing, provide a theoretical framework that explains findings, and give some practical applications based on these findings. The training studies were divided into 4 categories: (a) specific resistance training with an overload of velocity, (b) specific resistance training with an overload of force, (c) specific resistance training with a combination of overload of force and velocity, and (d) general resistance training according to the overload of force. Each category is presented and discussed.

Looking for the evidence: a systematic review of prevention strategies addressing sport and recreational injury among children and youth. J Sci Med Sport. 2004 Mar;7(1):58-73.

MacKay M, Scanlan A, Olsen L, Reid D, Clark M, McKim K, Raina P.

OBJECTIVES: To examine evidence on the effectiveness of current injury prevention strategies in selected sport and recreational activities, determine the applicability of the evidence to children and youth and discuss the implications related to policy, programming and future research. **METHODS:** Research questions and relevance criteria were developed a priori. Potentially relevant studies were located through electronic and hand searches. Two independent assessors assessed articles for first relevance and then quality. Relevant articles were

abstracted and synthesised for activities that had three or more relevant articles. RESULTS: A total of 21,499 articles identified through database and manual searching yielding 117 that met inclusion criteria. The majority of the studies (93 or 89%) involved eight activities: baseball, basketball, cycling, football, ice hockey, rugby, alpine skiing and soccer. Children and youth were identified as the specific target group in 45% of the studies and another 12% included children in their sample. Studies addressed a range of intervention strategies and varied on quality of evidence. CONCLUSIONS: Surprisingly few well-designed and controlled studies investigating strategies to prevent injuries were found and an even smaller number evaluated strategies to reduce injury in children and youth. As governments in developed countries continue to focus on increasing physical activity among children and youth, thought must be given to the issue of risk of injury and the relative lack of evidence of effective preventive measures.

Sonography of injury of the ulnar collateral ligament of the elbow-initial experience.

Skeletal Radiol. 2004 Jul;33(7):386-91. Epub 2004 May 06.

Miller TT, Adler RS, Friedman L.

The purpose of this study is to describe the sonographic appearance of injuries of the ulnar collateral ligament (UCL) of the elbow.

Traumatic superficial temporal artery pseudoaneurysms in a minor league baseball player: a case report and review of the literature.

Am J Orthop. 2004 Apr;33(4):200-5. Romero AC, Fulkerson E, Rockman CB, Bosco J, Rosen J.

Traumatic STA aneurysm is a rare complication of facial trauma occurring typically in young men. We present the case of a minor league baseball player who developed 2 pseudoaneurysms after being struck by a baseball and review all cases associated with sports activities. Reports associated with sports activities are increasing

and may represent an increasing incidence. The team physician should suspect this condition when a player presents with a new temporal mass after facial trauma. Diagnosis is typically made on history and physical examination, but can be confirmed by duplex ultrasound. Definitive treatment is surgical resection of the aneurysm after proximal and distal ligation of the vessel.

Valgus torque in youth baseball pitchers: A biomechanical study.

J Shoulder Elbow Surg. 2004 May-Jun;13(3):349-55.

Sabick MB, Torry MR, Lawton RL, Hawkins RJ.

The purpose of this study was to determine the biomechanical and anthropometric factors contributing to elbow valgus torque during pitching. Video data of 14 youth pitchers throwing fastballs were used to calculate shoulder and elbow kinematics and kinetics. Peak elbow valgus torque averaged 18 Nm and occurred just before maximal shoulder external rotation. The magnitude of valgus torque was most closely correlated with the thrower's weight. When subject weight and height were controlled for, maximum shoulder abduction torque and maximum shoulder internal rotation torque were most strongly associated with elbow valgus torque, accounting for 85% of its variance ($P < .001$). When only kinematic variables were considered, maximum shoulder external rotation accounted for 33% of the variance in valgus torque. Given that the biomechanical variables correlated with peak valgus torque are not easily modifiable, limiting the number of innings pitched is likely the best way to reduce elbow injury in youth pitchers.

Avulsion fracture of the lesser tuberosity in an adolescent baseball pitcher: a case report.

Am J Sports Med. 2004 Apr-May;32(3):793-6.

Sugalski MT, Hyman JE, Ahmad CS.

(No abstract available)

Influence of pelvis rotation styles on baseball pitching mechanics. Sports Biomech. 2004 Jan;3(1):67-83.

Wight J, Richards J, Hall S.

Efficient, sequential timing is essential for upper level pitching. Interestingly, pitchers vary considerably in timing related elements of pitching style including pelvis rotation, arm cocking, stride leg behaviour, and pitch delivery time. The purpose of this study was to determine whether relationships exist among these elements by examining the overall style of pitchers exhibiting different pelvis rotation patterns. Pitching styles were defined by pelvis orientation at the instant of stride foot contact. Pitchers demonstrating a pelvis orientation greater than 30 degrees were designated as 'early rotators', while pitchers demonstrating a pelvis orientation less than 30 degrees were designated as 'late rotators'. Kinematic and temporal differences were associated with the two styles. During the arm cocking phase, early rotators showed significantly greater shoulder external rotation at the instant of stride foot contact, earlier occurrence of maximum pelvis rotation angular velocity, and shorter time taken to complete the phase. However, by the instant of maximum shoulder external rotation, early and late rotators appeared remarkably similar as no significant difference occurred in pelvis and arm orientations. Therefore, it appears that early and late rotators used different methods to achieve similar results, including throwing velocity. Significant differences in throwing arm kinetics were also found for 10 of the 11 measures in the study. As the pelvis assumed a more open position at stride foot contact, maximum kinetic values were found to both decrease in magnitude and occur at an earlier time within the pitch.

Relation of handedness with season of birth of professional baseball players revisited. Percept Mot Skills. 2004 Feb;98(1):44-6.

Abel EL, Kruger ML.

We reexamined the relationship between month and season of birth and handedness in male professional baseball players listed in Lehman's Baseball Archive Vol. 4.5 database. The sample of 8,016 individuals (left-handed = 1,658; right-handed = 6,358) played major league baseball between 1900-2001. A slightly higher, but statistically significant, percentage of left-handed players were born in June compared to other months, and in the winter-spring months, but we were unable to corroborate Rogerson's spring and early summer categorization of handedness as related to birth season. The data did not support the hypothesis that the prevalence of left-handedness is related to season of birth.

Attending to the execution of a complex sensorimotor skill: expertise differences, choking, and slumps. J Exp Psychol Appl. 2004 Mar;10(1):42-54

Gray R.

A simulated baseball batting task was used to compare the relative effects of attending to extraneous information (tone frequency) and attending to skill execution (direction of bat movement) on performance and swing kinematics and to evaluate how these effects differ as a function of expertise. The extraneous dual task degraded batting performance in novices but had no significant effect on experts. The skill-focused dual task increased batting errors and movement variability for experts but had no significant effect on novices. For expert batters, accuracy in the skill-focused dual task was inversely related to the current level of performance. Expert batters were significantly more accurate in the skill-focused dual task when placed under pressure. These findings indicate that the attentional focus varies substantially across and within performers with different levels of expertise.

Little league shoulder: case report and literature review. Del Med J. 2004 Jan;76(1):11-4.

Ricci AR, Mason DE.

When compared with adults, children have unique injury patterns secondary to their anatomical differences. The susceptibility of the growth plate to injury is well-documented. "Little Leaguer's shoulder" is the term used for injury to the open proximal humeral epiphysis in the Little League pitcher. We present a case report and literary review. Discussed are the possible etiologies, patient presentation, physical exam, radiographic findings, and treatment recommendations.

The influence of the sensor type on the measured impact absorption of mouthguard material. Dent Traumatol. 2004 Feb;20(1):29-35.

Takeda T, Ishigami K, Jun H, Nakajima K, Shimada A, Ogawa T.

Mouthguards have been tested for impact energy absorption using drop-ball and/or pendulum devices. While all reports show efficiency of the mouthguard, the impact absorption abilities reported differ considerably. This difference has been attributed to differences of mouthguard material, design, and the impact force used. However, it is also possibly because of the difference in the sensors used in the experiments. The purpose of this study was to test three types of sensors and to assess which type was most appropriate for measurement of the impact absorption ability of mouthguards. A pendulum-type testing equipment and steel ball, wooden bat, baseball, field-hockey ball were used as the impact object. For all sensors or impact objects, the mouthguard decreased the impact forces. However, the absorption ability of the mouthguard varied according to the sensor or impact object. The absorbency values became smaller with the strain gauge, the accelerometer, and the load cell, respectively. With the steel ball

as the impact object, 80.3% of impact absorption was measured with the strain gauge and the accelerometer but, only 62.1% with the load cell sensor. With the wooden bat, impact absorption was 76.3% with the strain gauge and 38.8% for the load cell. For the baseball ball, the absorption measurement decreased from 46.3% with the strain gauge to 4.36 with the load cell and for the field-hockey ball, the decrease in measurement values were similar (23.6% with the strain gauge and 2.43% with the load cell). It is clear that the sensor plays an important role in the measurement values reported for absorbency of mouthguard materials and a standard sensor should be used for all experiments.

Perceived importance of weight training to selected NCAA Division III men and women student-athletes. J Strength Cond Res. 2004 Feb;18(1):108-14

Poiss CC, Sullivan PA, Paup DC, Westerman BJ.

The purpose of this study was to examine differences in perception of the importance of weight training as a part of general and sport-specific training for selected collegiate men and women student-athletes. Subjects included 139 men and 165 women varsity National Collegiate Athletic Association Division III student-athletes who participated in the following sports: baseball, basketball, field hockey, football, lacrosse, soccer, softball, swimming, tennis, track & field, or volleyball. Men student-athletes were significantly more likely to consider weight training essential to their general and sport-specific training than women student-athletes, as measured by the Training Information Survey. Additionally, men student-athletes were found to be significantly more competitive and win-oriented than women student-athletes ($p < 0.001$) as measured by the Sport Orientation Questionnaire, which is consistent with previous research. Results also showed that only highly goal-oriented student-athletes perceived weight training as: (a) important to both men and women and (b) having both feminine and masculine traits. It was concluded that significant gender

differences exist in the perceived importance of weight training and that the constructs of competitiveness, win and goal orientation, may influence a student-athlete's perception of the importance of weight training. Coaches of both men and women student-athletes must teach that weight training is important for female and male student-athletes.

Conservative treatment of isolated posterior cruciate ligament injury in professional baseball players: a report of two cases. Knee. 2004 Feb;11(1):41-4

Iwamoto J, Takeda T, Suda Y, Otani T, Matsumoto H.

Conservative treatment is currently recommended for most isolated posterior cruciate ligament (PCL) injuries in athletes. However, it is not known whether conservative treatment is applicable even in high performance athletes with isolated PCL injury. The results in two extremely high performance athletes, professional baseball players with isolated acute PCL injury treated conservatively are reported. A catcher and an out fielder, who were regular players, hurt their knees in baseball games. Magnetic resonance images of the knee detected complete PCL rupture. Following a carefully guided physical therapy program, a 3-week period of immobilization of the knee in full extension was achieved with a knee brace, while performing hard quadriceps muscle strengthening exercise, and then running exercise was started. Six to eight weeks after injury, they were able to return fully to their original sporting activity despite tibial posterior translation on posterior drawer test, and to sustain this activity over 2 years. Switching of weight-bearing to non-weight-bearing in a deep knee flexion is considered to contribute to subjective instability in athletes with PCL-deficiency. Probably because our cases, even though extremely high performance athletes were infrequently subjected to such a situation while playing baseball, they were able to return to their pre-injury level of athletic performance

without severe subjective instability through conservative treatment.

Prevalence of the Bennett lesion of the shoulder in major league pitchers. Am J Sports Med. 2004 Jan-Feb;32(1):121-4.

Wright RW, Paletta GA Jr.

BACKGROUND: The Bennett lesion is a mineralization of the posterior inferior glenoid noted in overhead throwing athletes. Although previous studies have debated appropriate treatment of the lesion, no studies have indicated the lesion prevalence in throwing athletes. **HYPOTHESIS:** The Bennett lesion is more common than previously believed and may represent an asymptomatic finding. **STUDY DESIGN:** Uncontrolled retrospective review. **METHODS:** Fifty-five asymptomatic major league pitchers underwent routine preseason radiographic screening. Radiographs were reviewed for the presence of a Bennett's lesion. Player demographics, pitching, and baseball records were reviewed to obtain the patient's dominant arm, age, years and innings pitched, and time on the disabled list or surgery. **RESULTS:** Twelve pitchers (22%) were noted to have a radiographic Bennett lesion. No statistically significant difference was noted in age, years pitched, or innings pitched between pitchers with and without a Bennett lesion. No player who demonstrated a Bennett lesion required surgical treatment for shoulder pain during his time with the club. Two players required time on the disabled list, but neither player had complaints of posterior shoulder pain. **CONCLUSIONS:** This lesion is a relatively common finding in major league pitchers. Concomitant pathology should be suspected when evaluating throwers with posterior shoulder pain and this lesion.

Infraspinatus muscle atrophy in professional baseball players. Am J Sports Med. 2004 Jan-Feb;32(1):116-20

Cummins CA, Messer TM, Schafer MF.

BACKGROUND: Infraspinus muscle atrophy has been observed in athletes who stress their upper extremities in an overhead fashion. The majority of such case reports have been in volleyball players, with far fewer cases reported in baseball players. **HYPOTHESIS:** Infraspinus muscle atrophy occurs to a notable degree in professional baseball players. **STUDY DESIGN:** Retrospective cohort study. **METHODS:** At the end of the 1999 baseball season, data were collected from all Major League Baseball teams in regards to players affected with infraspinus muscle atrophy. **RESULTS:** Twelve of the 1491 major league professional baseball players were identified as having appreciable infraspinus muscle atrophy. There was an increased prevalence of the muscle atrophy in professional pitchers (10 of 494, 4%) compared to position players (2 of 997, 0.2%) ($P < 0.001$). Among affected pitchers, the atrophy was identified more frequently in starting pitchers (8 of 10) compared to relief pitchers (2 of 10) ($P = 0.036$), pitchers who had played for more years at the major league level (8.7 +/- 4.9 versus 5.2 +/- 4.0) ($P = 0.017$), and pitchers who had thrown for more innings at the major league level (971.4 +/- 784.4 versus 485.0 +/- 594.6) ($P < 0.001$). **CONCLUSION:** Infraspinus atrophy was identified in 4.4% of major league starting pitchers and occurred in those pitchers who pitched for more years and innings during their major league career.

SUGGESTED WEBSITES:

Exploratorium Baseball Science Exhibit

Housed within the walls of San Francisco's Palace of Fine Arts, the Exploratorium is a collage of over 650 science, art, and human perception exhibits. Online since 1993, the Exploratorium was one of the first science museums to build a site on the World Wide Web. Various interactive baseball exercises are available at:

<http://www.exploratorium.edu/baseball/>

Finding the Sweet Spot: The Science of Baseball An article by Clifton B. Parker published in the online version of UC-Davis Magazine, which is a highly readable article discussing the Sports Biomechanics Laboratory at UC Davis. http://www-ucdmag.ucdavis.edu/current/feature_5.html

PBATS - Professional Baseball Athletic Trainers Society

The mission of the Professional Baseball Athletic Trainers Society (PBATS) is to serve as an educational resource for the Major League and Minor League Baseball athletic trainers. PBATS serves its members by providing for the continued education of the athletic trainer as it relates to the profession, helping improve his understanding of sports medicine so as to better promote the health of his constituency -- professional baseball players. PBATS also serves as a resource to educate those outside the professional baseball athletic trainer community about the profession and about the athletic trainer's integral position within the sports medicine team.

<http://www.pbats.com>

Baseball Research Center at UMASS Lowell

The mission of the UMass-Lowell Baseball Research Center is to be a Center of Excellence for the Science and Engineering of Baseball for both experimental and analytical methods. Currently, the Center is concentrating on baseball bat performance, and the Center is the official certification center for all NCAA baseball bats and Major League Baseball bats. The Center also has complete baseball testing services including, ASTM and MLB COR testing, pill drop testing, and baseball dissection.

<http://m-5.eng.uml.edu/umlbrc/>

The Art of Pitching in Baseball by Henry Chadwick from the *July 31, 1886* edition of Scientific American. Reprinted at The Diamond Angel Baseball Magazine website.

<http://www.thediamondangle.com/archive/july03/sciam.html>

http://groups.yahoo.com/group/SABR_Baseball_Science/