The Rising Fastball

The Newsletter of SABR's Science and Baseball Research Committee

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GREETINGS FROM THE CHAIR

Science and Baseball continued to grow; As of this writing, we have 75 individuals subscribed to the e-group and 43 SABR members officially listed in the Directory on-line. I am hopeful that with good word of mouth and representation at SABR 33 we can continue to capture new expertise and interest following the Convention.

CONVENTION UPDATE

SABR 33 promises a lot for the Science enthusiast. Our meeting is scheduled for Friday at 9 AM, and I hope that we can use the time to discuss future directions and potential projects for the next year. The Baseball at Altitude Panel with Dr. Robert K. Adair, author of *The Physics of Baseball*, Rany Jazayerli of *Baseball Prospectus*, and Colorado Rockies General Manager Dan O'Dowd is scheduled for Thursday at 3 PM. In addition, among the many research presentations are Ron Selter, "Ballpark Dimensions and Batting"; Sheila Nguyen, "Psychological Skills and Player Position: A Qualitative Examination of Catchers"; Larry Hadley and Elizabeth Gustafson," Revenue, Population, and Competitive Balance in M.L. Baseball"; and Robert Schaeffer, "Baseball Bats."

SOME REMARKS ON CORKED BATS

Alan M. Nathan

What is a "corked" bat?

A corked bat is one in which a cavity has been drilled axially into the barrel of a wood bat. Typically, the diameter of the cavity is approximately 1 inch and it is drilled to a depth of about 10 inches. The cavity may or may not be filled with some substance, such as compressed cork, small superballs, etc.

What positive effect does this have on performance?

Because wood has been removed from the bat and (possibly) replaced by some substance with a smaller density than wood, the bat is lighter by 1-2 oz, depending on the dimensions of the cavity and the density of the filling substance. Not only is the bat lighter, but the center of gravity, or balance point, of the bat moves closer to the hands. This means that the "swing weight" of the bat is also reduced. In technical physics language, the moment of inertia (MOI) of the bat about the knob is reduced for a corked bat. You can think of the MOI as the "rotational inertia" of the bat. Just like the "inertia" or mass of an object measures the resistance of the object to a change in its translational motion, the rotational inertia

measures the resistance to a change in its rotational motion. The effect is easy to understand: It is much easier to swing something when the weight is concentrated closer to your hands (smaller MOI) than when it is concentrated far from your hands (larger MOI). You can try such an experiment yourself. Simply take a bat by the handle and swing try to rotate it rapidly. Then turn the bat around, holding the barrel, and try doing the same thing. You should find that it is easier to rotate it in the second case. Therefore, a batter can often get a higher bat speed with a corked bat than with a comparable bat that has not been corked. All other things being equal, a higher swing speed gives rise to a higher hit ball speed and greater distance on a long fly ball. Of course, all other things are not equal, and the reduced mass in the barrel produces a less effective collision, as we shall see in the next section.

An additional effect is that the lighter weight and smaller swing weight also lead to better bat control, which has a beneficial effect for a contact-type hitter, who is just trying to meet the ball squarely rather than get the highest batted ball speed. The batter can accelerate the bat to high speed more quickly with a corked bat, allowing the batter to react to the pitch more quickly, wait longer before committing on the swing, and more easily change in mid-swing. As has been pointed out by Bob Adair in his book, a batter can achieve the same effect legally by choking up on the bat or by using a lighter (and therefore probably shorter) bat. Of course, there are reasons one might not want to either choke up or use a shorter bat, especially in situations where you need to protect the outside part of the plate. In such a situation, a corked bat can provide a definite advantage. Many fast-pitch softball players take the issue of bat control to the extreme. The fast-pitch game heavily favors the pitcher, so a batter is often more interested in making good contact than in swinging for the fences. These batters use very light bats—25 oz or less-- to improve bat control and reaction time. Since they are using primarily aluminum bats, they can achieve low weight with no cost in length.

What negative effect does this have on performance?

The efficiency of the bat in transferring energy to the ball in part depends on the weight of the part of the bat near the impact point of the ball. For a given bat speed, a heavier bat will produce a higher hit ball speed than a lighter bat. By reducing the weight at the barrel end of the bat, the efficiency of the bat is reduced, giving rise to a reduced hit ball speed and less distance on a long fly ball. This is the downside of using a corked bat.

So what is the net effect?

We see that corking the bat leads to higher swing speed but to a less efficient ball-bat collision. These two effects roughly cancel each other out, leaving little or no effect on the hit ball speed or on the distance of a long fly ball. A specific example showing how this happens will be given below.

But is there a "trampoline" effect?

The trampoline effect is quite well known in hollow metal bats. The thin metal shell actually compresses during the collision with the ball and springs back, much like a trampoline, resulting in much less loss of energy (and therefore a higher batted ball speed) than would be the case if the ball hit a completely rigid surface. The loss of energy that I referred to comes mostly from

the ball. During the collision, the ball compresses much like a spring. The initial energy of motion (kinetic energy) gets coverted to compressional energy (potential energy) that is stored up in the spring. The spring then expands back out again, pushing against the bat, and converting the compressional energy back into kinetic energy. This is a very inefficient process in that only about 25% of the stored compressional energy is returned to the ball in the form of kinetic energy. The rest is lost due to frictional forces, deformation of the ball, etc. You can see the effect of this energy loss for yourself. Drop a baseball onto a hard rigid surface, such as a solid wood floor. The ball bounces back up to only a small fraction of its initial height because energy was lost in the collision of the ball with the floor. The loss mainly came from compressing and then expanding the ball. When a ball collides with a flexible surface, like the thin wall of an aluminum bat, the ball compresses less than it does when colliding with a rigid surface, since the thin wall does some of the compressing instead. Less energy is stored and ultimately lost in the ball, whereas the flexible surface is very efficient at returning its compressional energy back to the ball in the form of kinetic energy. The net effect is that the ball bounces off the flexible surface with higher speed than it does off the rigid surface. This is the essence of the trampoline effect. By the way, the trampoline effect is well known to tennis players, where the effect comes from the strings of the racket. All tennis players know that to hit the ball harder, you should decrease rather than increase the tension in the strings. Many people who do not play tennis find this counterintuitive, but it really is true. The lower tension makes the strings more flexible, just like a trampoline. You can even try the following experiment. Drop a baseball from the floor and measure the ratio of final height to initial height. Now drop a baseball from the strings of a tennis racket, making sure that the frame of the racket is clamped down so it does not vibrate. You should find that the ratio of final to initial height is higher than when the ball is dropped onto the floor. That is the trampoline effect in action.

With that long introduction, we come back to our question: Is there a trampoline effect from the hollowed-out wood bat or the cork filler? My own understanding of the physics of the ball-bat collision suggests that the answer is “no”. Why not? A 1”-diameter hole in a 2-1/2” diameter wood bat means the wall thickness is ¾”, which is at least 7 times thicker than that of a typical aluminum bat. It requires much greater force to compress such a bat than it does to compress an aluminum bat. In the technical parlance of physics, the spring constant of the hollow wood bat is much larger than that of a typical aluminum bat. Therefore, very little compressional energy is stored in the hollow wood bat during the collision, so that any trampoline effect is minimal at best.

In order to test this idea, I did an experiment several years ago with Professor Jim Sherwood at the Baseball Research Center (which Jim directs) at the University of Massachusetts/Lowell. We took two identical Louisville Slugger R161 wood bats, each with a length of 34” and a weight of 32.5 oz. Into one bat I drilled a 7/8" diameter hole, 9-1/4" deep into the barrel, removing a total of 2.0 oz of wood. We then measured the ball exit speed when a 70 mph ball impacted the bat at a point 6" from the end of the bat. The speed of the bat at that point was set at 66 mph. Using the measured exit speed, the known inertial properties of the bats, and appropriate kinematic formulas, we extracted the ball-bat coefficient of restitution (COR), which is

a measure of the liveliness of the ball-bat combination. We found the COR to be *identical* for the two bats, at least within the overall precision of the experiment. Had there been a trampoline effect, one would have found a larger COR for the hollowed bat. Armed with this information, I then did a calculation of hit ball speed that one would expect in the field, assuming a pitch speed of 90 mph and a bat speed that was slightly higher for the hollowed bat, based on a model for the relationship between bat swing speed and the swing weight of the bat. The model is based on the (unpublished) experimental study of Crisco and Greenwald, which gives a definite relationship between the MOI of the bat and the swing speed. The calculation shows that the unmodified bat actually performs slightly better than the hollowed bat (see figure below).

Moreover, filling the cavity with cork, which is much more easily compressed than the wood itself, is not likely to help. The response time of the cork is much too slow to provide a trampoline effect. The typical ball-bat collision time is less than 1/1000 of a second, which is much faster than the natural vibrational period of the cork. During the short collision time, the cork barely has time to compress. In effect, energy gets transferred to the cork in the form of an impulse, which actually results in more energy dissipation than would be the case if the cavity were empty. Moreover, adding cork restores some of the weight that had been removed, thereby at least partially negating the increase in swing speed that had resulted. It would seem that leaving the cavity hollow would be better than filling it with cork.

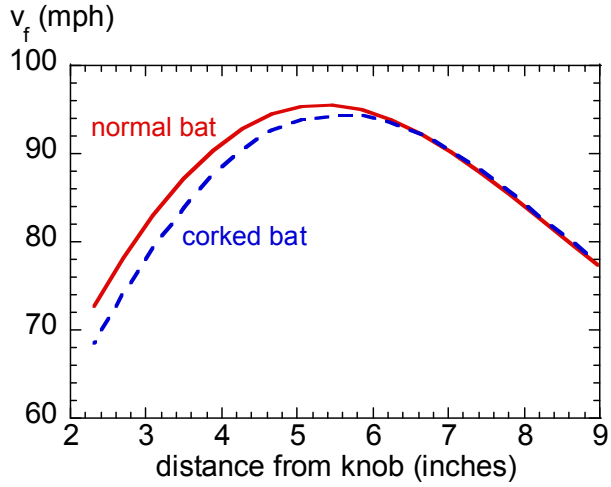

Figure 1. Calculation of hit ball speed from two otherwise identical wood bats. Relative to the normal bat, the corked bat had a cavity in the barrel of diameter 0.875" and depth 9.25", thereby removing a total mass of 2 oz from the barrel of the bat. The calculation assumes that the ball-bat COR is the same for each bat, as shown from experiment, and assumes a particular relationship between the bat swing speed and the moment of inertia of the bat. The calculation shows that the normal bat slightly outperforms the corked bat.

What about filling the cavity with superballs?

This is an interesting question. A more generic question is whether there is some substance that is compressible (so as to store energy) but not so compressible that it does not return the energy to the ball. This is a question that is worth thinking hard about and worth doing some experimental measurements to study the effect. Such experiments are currently in the planning stage.

(Alan Nathan is a Professor in the Department of Physics at the University of Illinois at Urbana-Champaign. His Physics of Baseball website can be found at http://www.npl.uiuc.edu/~a-nathan/)

RESEARCH BRIEFS

Baseball Caps

Civil Engineering—ASCE, Vol. 68, No. 12, December 1998, pp. 52-55

Bodamer, D.

Discusses the design and engineering of contemporary ballparks including those in Phoenix, Seattle, Houston and Milwaukee.

Fanfare

Civil Engineering—ASCE, Vol. 70, No. 12, December 2000, pp. A2-A4,A6-A7

Wells, C., Mann, S., and Roberts, J.

Discussion of the retractable roof design in Miller Park.

A League of Their Own

Civil Engineering—ASCE, Vol. 64, No. 5, May 1994, pp. 58-61

Tarricone, P.

Discussion of the design and engineering of new baseball stadiums in Cleveland and Arlington.

Building the Perfect Playpen

Tarricone, P.

Civil Engineering—ASCE, Vol. 59, No. 11, November 1989, pp. 55-58

Discussion of stadium design with special attention to skyboxes and the use of CADD.
Benchmark approach for baseball evaluation

European Journal of Operational Research, v 115, n 3, Jun, 1999, p 429-448

Sueyoshi, Toshiyuki; Ohnishi, Kenji; Kinase, Youichi

This research proposes a new analytical approach for baseball evaluation, referred to as 'A Benchmark Approach', by combining DEA (Data Envelopment Analysis) with OERA (Offensive Earned-Run Average). As a real application, this work applies the benchmark approach for the evaluation of offensive records of Japanese baseball players to obtain their ranking scores.

Performance assessment of wood, metal and composite baseball bats

Composite Structures, v 52, n 3-4, May/June, 2001, p 397-404

Shenoy, M.M.; Smith, L.V.; Axtell, J.T.

The purpose of this investigation was to develop and verify a predictive capability of determining baseball bat performance.

Deceleration distance estimation using a kinematic model and elapsed time measurements: An application to baseball

ASTM Special Technical Publication, v 1313, Jun, 1997, p 67-77

Koenig, Keith; Davis, Nan; Wilson, Tonya; Randle, Renae; Slavings, Rosalind

The results of this study suggest that baseball and softball players require on the order of 40 feet (12.2 meters) to stop after the home-to-first sprint and that this distance may be a useful value to first consider for safety

Indexing of baseball telecast for content-based video retrieval

IEEE International Conference on Image Processing, v 1, 1998, p 871-874

Kawashima, Toshio; Tateyama, Kouichi; Iijima, Toshimasa; Aoki, Yoshinao

The authors propose a method for indexing baseball telecast for content-based video retrieval.

Wood-composite baseball bats take the field

Mechanical Engineering, v 113, n 8, Aug, 1991, p 43-45

Ashley, Steven

Reports on a wood-composite baseball bat that delivers the look, feel, sound, and performance of traditional hardwood bats with the durability of metal bats, made of a high-strength inner core fabricated from resin impregnated synthetic fibers and yarns, integrated with an ashwood outer surface.

Physics of baseball: The standardization of balls and bats for recreational softball.

ASTM Special Technical Publication, v 1313, Jun, 1997, p 21-28

Adair, Robert K.

Abstract: An analysis of the effects on ball velocity and flight of the development of highly elastic softballs and bats suggests that it is necessary to constrain the elasticity of ball and bat to preserve the integrity of slow-pitch softball and to ensure the safety of the players.

Grease duct ensures baseball fans safe at home of minor-league team

HPAC Heating, Piping, AirConditioning Engineering, v 74, n 9, September, 2002, p 61

Describes mechanical design elements for a revitalization project on the fifth Third Field at the Ned Skelton Stadium.

Voting for the Baseball Hall of Fame: The effect of race on election date.

Industrial Relations: A Journal of Economy & Society. Vol 42(1), Jan 2003, pp. 87-99

Jewell, R Todd

This article examines whether a player's race affects his date of election to the National Baseball Hall of Fame. The results show no evidence of racial discrimination in the timing of election.

Baseball wives: Gender and the work of baseball

Journal of Contemporary Ethnography. Vol 30(3), Jun 2001, pp.335-356

Gmelch, George; San Antonio, Patricia Mary

Examined the effects of a husband's career in baseball on the lives of wives.

Performance-undermining effects of baseball free agent contracts

Journal of Sport & Exercise Psychology. Vol 23(1), Mar 2001, pp. 23-36

Sturman, Ted S; Thibodeau, Ryan

The results suggest that the new contracts received by Ss, particularly its substantial pay raise, caused a decrease in immediate post contract performance. However, further

results show evidence that performance output recovered to its precontract level in the 2nd season postcontract.

Holy cow! Wait 'til next year! A closer look at the brand loyalty of Chicago Cubs baseball fans

Journal of Consumer Marketing. Vol 18(3), 2001, pp. 256-275

Bristow, Dennis N; Sebastian, Richard J

This study examined several factors related to the brand loyalty exhibited by fans of the Chicago Cubs major league baseball team.

Touching behavior in sport: Functional components, analysis of sex differences, and ethological considerations

Journal of Nonverbal Behavior. Vol 25(1), Spr 2001, pp. 43-62

Kneidinger, Linda M; Maple, Terry L; Tross, Stuart A

Examined touching behavior in collegiate varsity baseball and softball teams. Females performed more touching behaviors than males, almost half of the behavior types observed were performed more frequently by one sex than the other, males performed touching behaviors more frequently at away than home games, females performed touching behaviors more frequently at home than away games, and females performed more touching behaviors than males after negative game events

Manual laterality and hitting performance in major league baseball

Journal of Experimental Psychology: Human Perception & Performance. Vol 25(3), Jun 1999, pp. 747-754

Grondin, Simon; Guiard, Yves; Ivry, Richard B; Koren, Stan

AB: Abstract
Asymmetrical hand function was examined in the context of hitting in professional baseball. An archival study was conducted to examine the batting performance of all Major League Baseball players from 1871 to 1992, focusing on those who batted left (n = 1,059) to neutralize the game asymmetry. Among them, left-handers (n = 421) were more likely to hit with power and to strike out than right-handers (n = 638). One possible account, based on the idea of hand dominance, is that batting left involves a double-handed forehand for left-handers and a weaker and more reliable double-handed backhand for right-handers.

Repositioning the home plate umpire to provide enhanced perceptual cues and more accurate ball-strike judgments

Journal of Sport Behavior. Vol 22(1), Mar 1999, pp. 28-44

Ford, Gary G; Gallagher, Sheree H; Lacy, Barbara A; Bridwell, Angela M; Goodwin, Frankie

Examined the effect of alternative umpire positions on judgments of the strike zone.

Fans' judgments about the 1994-95 Major League Baseball players' strike

Multivariate Behavioral Research. Vol 34(1), 1999, pp. 59-87

Mellor, Steven; Paley, Michael J; Holzworth, R James

Examined fan reactions to different tactics employed in the labor dispute.

Women working in the management of professional baseball: Getting to first base?

Journal of Career Development. Vol 26(2), Win 1999, pp. 147-158

Hums, Mary A; Sutton, William A

Describes and examines the career paths of women working in the management of professional baseball.

"Superstition" in the collegiate baseball player

Sport Psychologist. Vol 11(3), Sep 1997, pp. 305-317

Ciborowski, Tom

Examined superstitious activity among 83 collegiate baseball players

Fandom in the 40's: The integrating functions of All-American Girls Professional Baseball League

Journal of Sport Behavior. Vol 20(2), Jun 1997, pp. 211-231

Weiller, Karen H; Higgs, Catriona T

Reports on a survey of committed fans of the All American Girls Professional Baseball League (AAGPBL).

A method for facilitating controversial social change in organizations: Branch Rickey and the Brooklyn Dodgers

Journal of Applied Behavioral Science. Vol 33(1), Mar 1997, pp.101-118

Austin, John R

Examines the racial integration of the Brooklyn Dodgers baseball team as an example of a successful social change that challenged organizational and societal norms. The 7-step method used by Dodgers general manager Branch Rickey was guided by an understanding of the social implications of integration.

Using the biopsychosocial model to predict athletic performance among baseball players

Journal of Human Movement Studies. Vol 33, 1997, pp. 31-45

Plante, Thomas G; Booth, J

Investigated the role of visual functioning (i.e., glare sensitivity, contrast sensitivity and binocular vision), selected personality and mood variables (i.e., anxiety, depression, interpersonal sensitivity and defensiveness), perceived stress and coping skills, and social variables (i.e., feeling comfortable with the coaches and the team) on athletic performance among 40 male NCAA varsity collegiate baseball team players.

SUGGESTED WEBSITES

ISEA The International Sports Engineering Association
The principal aim of the ISEA is to act as a forum to discuss technical issues relating to sport.
http://www.sports-engineering.co.uk/

QuesTec
The company providing the Umpire Information System for MLB.
http://www.questec.com