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MATH TREK

Winning the World Series with math

A nearly circular path could be the fastest way to home plate.

By Julie Rehmeyer

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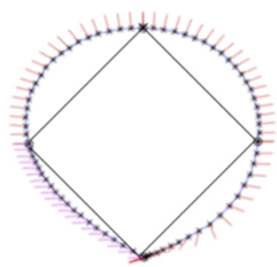
To run the bases faster, baseball players just need a bit of mathematics, according to research by an undergraduate math major and his professors. Their calculations show that the optimal path around the bases is one that perhaps no major-league ball player has ever run: It swings out a full 18.5 feet from the baseline.

The precise path the researchers calculated probably won't turn out to be the very fastest in the real world, they acknowledge, because of physiological and practical complexities they couldn't model. Still, the analysis suggests that runners might be able to improve their times by following much wider paths than they had ever considered.



RUNNING THE BASES Mathematicians computed that this path around the bases is, theoretically, the fastest. The red lines show the direction the runner is accelerating.

D. CAROZZA, S. JOHNSON, AND F. MORGAN

"I would definitely experiment with it," says former American Major League Baseball outfielder Doug Glanville, who last played with the Philadelphia Phillies. "There's no question in my mind that runners could be more efficient."

The issue is that turns slow runners down. The tighter the turn, the greater the slowdown, so while the straight-line path between the bases is the shortest, its sharp corners make it one of the slowest. Rounding the corner is faster, making the path a bit longer in favor of an efficient turn. And indeed, baseball players typically do this: They run straight along the baseline at the beginning and then, if they think they've hit a double or more, they bow out to make a "banana curve."

But this can't possibly be the quickest route, observes Davide Carozza, a math teacher at St. Albans School in Washington, D.C., who studied the problem while an undergraduate at Williams College in Williamstown, Mass. It'd be faster, he reasons, to veer right from the beginning, running directly from the batter's box to the widest portion of the curve. Of course, a runner is best off running straight toward first base until he's certain he's hit more than a single. But Carozza noticed that even when the ball heads straight for a pocket between fielders, making a double almost certain, runners almost never curve out right away.

To figure out just how critical the turns are, Carozza did a calculation comparing the straight-line path with a circle around the bases. A path that follows a circle turned out to be a whopping 25 percent faster.

When Carozza presented his calculation at a colloquium talk in the math department at Williams College, Stewart Johnson, one of the professors in the audience, got intrigued. The circular path is so long that it can hardly be the fastest, he figured. So what path *is* the fastest?

Johnson ran a simulation on his computer, tweaking the circular path in tiny ways to make it shorter and faster, until no more tweaks could improve it. The result was surprisingly close to a circle, both in its shape and its speed: It swung nearly as wide and was only 6 percent faster than Carozza's circle. On this path, a runner would start running 25 degrees to the right of the baseline — toward the dugout rather than toward first base — and then swing wide around second and third base before running nearly straight to home. Johnson also computed the best path for a double, and it swings nearly as wide, venturing 14 feet from the baseline.

Carozza says he checked the rules of major league baseball, and although these routes are highly unconventional, they're allowed**.** The only limits apply after a fielder has attempted to tag a runner with the ball. After that, the runner can veer no more than 3 feet from the straight line to the base.

"The math looks fine," says Wayne Winston, a specialist in the mathematics of sports at the Kelley School of Business at Indiana University Bloomington, "but is it a good description of reality?"

The researchers acknowledge that in some ways it's not. They assume that regardless of a runner's speed, he can speed up, slow down or turn at the same rate (more precisely, that his maximum acceleration vector is constant), which isn't strictly true. A particular concern is that a runner may not be able to speed up as quickly while running along a curved path as he can along a straight one. In that case, some form of a banana path might make sense, allowing a runner to go straight for the first few critical seconds.

"This cries out for an empirical test," Winston says. "It would be easy to do. If it holds up, God, that goes in the New York Times sports section."

Glanville points out another complication: Infielders might get in the way of such an unusual path. "They're supposed to be out of your way, but that's not usually what happens," he says, "and if someone's in your path, you're going to end up breaking your stride."

Still, the researchers say, baseball players should experiment with more exaggerated curves. "The fact of the matter is that based on what the optimal path looks like," Carozza says, "I don't think the way people do it now is the fastest path, no matter how you accelerate in real life."

The payoff for such experimentation could be huge, says Frank Morgan of Williams College, a collaborator on the project. "I'd feel pretty bad if I were a coach and I'd seen this and not told my team and then lost the World Series by a fraction of a second."

CITATIONS

Carozza, D., Johnson, S. and Morgan, F. 2010. Baserunner's Optimal Path. Mathematical Intelligencer 32 (1):10-15. [Go to].