

Football penalties: science is on the spot

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Chelsea's Frank Lampard (left) scores a penalty shot past Aston Villa's goalkeeper Brad Friedel during their English Premier League match at Stamford Bridge in London, on March 27. The perfect penalty, a mathematical study found, is a ball that is struck high, targeted precisely to the right or left of the goalie, and fast, travelling at 25-29 metres per second.

Few moments in football are as extraordinary as the penalty, the moment when a dream can crumble or glory is made - and a player is either cursed as a choker or enters the pantheon of legends.

In the nearly 119 years since the very first penalty kick, in a match between Wolverhampton Wanderers and Accrington Stanley, the 11-metre (12-yard) spot has determined more and more tournaments, including the 2006 World Cup final.

As the importance of the penalty has grown, so has research. Scientists see it as a duel between shooter and goalkeeper where [biomechanics](#) and

psychology can give either side a critical edge.

A mathematical study of penalties at Liverpool's John Moores University puts the death nail into the "blast-it-and-hope" approach.

The perfect penalty, it found, is a ball that is struck high, targeted precisely to the right or left of the goalie, and fast, travelling at 25-29 metres per second (90-104 kilometers or 56-65 miles per hour).

Anything faster than this boosts the chance of a miss because of inaccuracy, while anything slower helps the goalie to intercept it.

Moving swiftly to take the penalty (less than three seconds after the whistle is blown) gives the striker the element of surprise, while delaying the strike by more than 13 seconds makes the keeper unsettled, according to the researchers, who looked at decades of international matches involving England.

Waiting for the goalkeeper to move also boosted chances. However, waiting longer than 0.41 milliseconds caused a scoring chance to be halved. A runup of four to six steps was the most successful approach, while a long runup of 10 metres (yards) was the least.

Seen only through the prism of statistics, the balance in penalties is tilted massively in favour of the taker: between two-thirds and three-quarters of strikes result in a goal, according to various analyses in top-flight European club soccer.

But in a counter-intuitive way, these figures also give the psychological advantage to the keeper. If the penalty succeeds, people will pat him on the shoulder and say hard luck, because few expected him to save it. If he does save it, he will be praised to the rafters. In other words, all the onus lies with the penalty-taker.

This problem was explored last year by a team at the University of Exeter in southwest England, which asked members of the university [football](#) squad to wear special glasses, recording eye movements, while they took two series of penalties.

In the first series, the players were simply asked to do their best to score. In the second, they were told the results would be recorded and shared with the other players, with a bounty of 50 pounds (72 dollars, 57 euros) for the best penalty-taker.

The more anxious the penalty-taker was, the likelier he was to look at, and focus on, the centrally-positioned goalkeeper. And because gaze control and motor control are tightly coordinated, the player's shot also centralised, making it far easier for the shot to be saved.

"The optimum strategy for penalty takers to use is to pick a spot and shoot to it, ignoring the goalkeeper in the process," said lead researcher Greg Wood.

Practice is essential, he said. The Hungarian great Ferenc Puskas would train again and again, shooting at a 25-centimetre (one-foot) disc hung 80 centimetres (a yard) from the bar.

"The idea that you cannot recreate the anxiety a penalty-taker feels during a shootout is no excuse for not practising," said Wood.

"Do you think other elite performers don't practice basic aiming shots in darts, snooker or golf for the same reasons? The skills need to be ingrained so they are robust under pressure."

As for helping the goalie, experiments suggest looking at a players' hips during the end of the runup gives a tip as to where the ball will be struck. Researchers at the University of Hong Kong also suggest that if a keeper

moves just six to 10 centimetres (three to five inches) off centre, that is enough to tempt the taker into directing the kick to the side of the goal where there is more space.

There are also mind games, such as shuffling or taking time to prepare for the shot, to distract the penalty-taker.

Even clothing colour is thought to be a help: Petr Cech of Chelsea prefers a bright orange strip in the belief that it attracts opponents and make them likelier to shoot straight at him.

That belief is bolstered by sports psychologists at the University of Chichester, southern England, who asked 40 footballers to take dozens of penalties over a week against a single keeper who changed strip. When the keeper wore red, only 54 percent of the penalties scored; for yellow, it was 69 percent, for blue 72 percent and green 75 percent.

Why? Red is associated with danger, dominance or anger, and at times of stress we pay more attention to it in our environment, goes the theory.

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