

# Can a football really speed up in mid-air? (2)

Plus: Champions without awards; Relegations after winning the title (2); and Ole Gunnar Solskjaer: greatest ever supersub? Send your questions and answers to [knowledge@guardian.co.uk](mailto:knowledge@guardian.co.uk)



**John Ashdown**

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Cristiano Ronaldo scores against Manchester City while boffins the world over queue up in the background to break down the ball's movement. Photograph: Alex Livesey/Getty Images

Last week we asked three eminent physicists at Oxford University to discuss the veracity of Jens Lehmann's claim that footballs can speed up in the air. Suffice to say it has spurred a furious debate in the Knowledge email inbox. In last week's Knowledge we dealt with general outlines, this week we're looking at specifics. To that end, the most convincing argument, and, to give them due credit, one mentioned by our experts last

week, is that Lehmann's case is all about perception.

"It is noteworthy that the first conjecture comes from a player," writes Robin Marshall, Professor of Physics at the University of Manchester, who has had a long interest in the physics of football and free-kicks. "It reminds me of claims by footballers and football writers that centre forward "X" could defy gravity by hanging in the air while lesser mortals were pulled inexorably back to earth. The answer was that they jumped higher and/or their timing was better. Panic driven defenders jump too soon and thud back to Earth earlier. All the same, I was always convinced that my cat could hover at the top of her leap.

"Ronaldo hits the ball very hard and without spin, so the ball travels in a mode of turbulent flow for much more of its trajectory than a ball hit with less power or with spin. This means that it does not slow down as much, because it is travelling above the Reynolds number (Manchester's Reynolds) for much more of its trajectory. What Lehmann might be noticing subconsciously, is based on his years of experience, and is a consequence of him having become used to balls slowing down in a certain accustomed way. His perceived profile for typical shots would be: not much slowing down at the start and then much more slowing down as the ball nears the goalkeeper. So Lehmann has built up a professional 'speed profile' of a well-struck ball. Therefore he could quite easily form the opinion that when a ball that does not slow down like he expects, it appears to speed up when matched against his profile.

"The spin argument is dodgy and irrelevant because time and again, the slo-mo shows that Cristiano Ronaldo puts virtually no spin on the ball, and this is his special 'trick'."

Prof Marshall's view is one shared by many, with Martin Burke making the point that "if modern balls have less friction then they would slow down less, and hence would appear to have accelerated to the goalkeeper" somewhat offset by the fact that "modern balls are also lighter and have less kinetic energy to counter-act the drag and so should slow down more".

Dr João Fonseca, also of the University of Manchester, concurs with his colleague.

"Ronaldo's strike is tricky because it is hit with no spin," he writes. "Spin stabilises the ball (think about a gyroscope or a spinning ball in American football) and hitting the ball with no spin makes it unstable, susceptible to any variations in pressure and also likely to stall due to turbulent flow behind the ball. When the ball stalls or encounters

instabilities it dips and swerves, specially when the ball is lightweight.

"Now in fairness to Lehmann, a dipping ball is accelerating (speeding up) towards the ground and a swerving ball is accelerating left or right, even if it is slowing down in the direction of the goal. And I would have guessed that it's these accelerations that are difficult for a keeper and not the accelerations in the direction of the keeper."

Dr Matthew Harding has an alternative view: "Lehmann was comparing the new balls to the old," he writes. "What he was describing (though he didn't realise it) was merely a change in the deceleration of the new balls compared to the old. If the old balls slowed down to a greater extent as they travelled through the air, then to an observer used to this behaviour, the new balls may appear to accelerate."

And another theory comes following on from Richard Duff: "Could the Oxbridge boffins be missing two vital elements? Firstly, the ball is misshapen when first starting to travel having been squashed by the foot, upon returning to a spherical shape there could be a kinetic energy release that accelerates the ball. Secondly, the ball is not a completely even shape as it contains a valve. Often you see Ronaldo rotate the ball before taking a free kick so that his foot connects with the valve, could a correct connection with the valve cause it to act as a ball bearing does in a wheel and promote free movement through the air at greater speed?"

That theory found some support with our academical correspondents. "The impact between the ball and foot is an 'elastic collison'," writes Dr Martyn Gadsdon, "and this leads us to consider the 'centre of mass of the ball' — something that James Richardson was close to hitting upon in a recent Football Weekly. Loosely speaking, the centre of mass of an object is the point (often within the body - but not exclusively so for, say, a very thin moon shape) at which the body could be described as behaving as if all its mass was concentrated. In an elastic collision with a foot, the ball clearly deforms and therefore, its centre of mass moves. When the ball returns to it's original shape, its centre of mass returns to its original location.

"Thus, while the Oxford professors are correct in stating that the ball will not accelerate, what they actually mean is that the ball's centre of mass will not accelerate. If, when the ball is kicked, the centre of mass (due to ball deformation) is moved forwards (nearer the front of the ball), such that, as the ball returns to its normal shape the centre of mass moves backwards (or put another way - the front of the ball moves forwards relative to

the the centre of mass), then if you were to define the front of the ball as the point at which the goalkeeper was focussing, this section of the ball would indeed appear to accelerate towards the keeper - purely by the deformation of the ball, even though the centre of mass does not accelerate.

"Footballs are continually being made more responsive and this is achieved by making them light and easily deformable, but crucially making them extremely efficient/quick at regaining their shape - unlike a beach ball - so it is expected that this effect is more prominent now than in the past. Although this may be a very small effect, plus it is likely to happen fairly quickly (otherwise the ball would be like a beach ball!) so may be minimal by the time the ball has passed the wall, and be undetectable to the keeper - but it is not impossible for the keeper to experience this in principle."

And finally, two links that may help to shed some light on the subject. Firstly, Dr Paul Coe, also of Oxford University's department of physics, directs us to [this article at Physics World](#) "which gives extensive scientific credentials to a phenomenon observed repeatedly by goalkeepers and football fans alike". Secondly, Nina Barneih suggests a neat optical illusion:

"Don't know if you watch much baseball, but a well-thrown pitch appears to accelerate (to me at least) as it bends in. Same with late (reverse) swung cricket deliveries ...

"There's a rather interesting [optical illusion that just won the '5th Annual Visual Illusion of the Year'](#) that demonstrates this principle rather compellingly. To my eyes at least, the ball appears to accelerate as it falls down the screen. The explanation is that this is due to the switch from 'foveal to peripheral vision', which I'm not totally sure I can rationalize for a batter or goalie who's tracking the ball directly, but if you're Jens Lehmann and attempting both to watch the ball and feverishly scan your penalty area for opponents to throw a stop on, it seems quite feasible that this effect might apply."

## **CHAMPIONS WITHOUT AWARDS**

**"Brentford were promoted to League One on Saturday but there's a debate going on about whether any team has been promoted as Champions without their manager winning a single manager-of-the-month award during the season?"** wrote Tony Cross [two weeks ago](#). **"Also we didn't apparently have a single player good enough for the PFA Team of the Season — is the**

## **combination unique?"**

It could well be, Tony. We can't find a title winner whose manager has failed to pick up the monthly gong. This season Alex McLeish has missed out on the award despite guiding his side to second place in the Championship, while Graham Turner also went award-free while guiding his Hereford side to third place in League Two in 2007-08.

As for the PFA Team of the Season, we think champions have been overlooked 10 times before, though it's only happened once in the 18 seasons prior to this. The full list of sides are:

Bury (third tier) 1996-97

Bristol Rovers (third tier) 1989-90

Millwall (second tier) 1987-88

Swindon (fourth tier) 1985-86

Chesterfield (fourth tier) 1984-85

QPR (second tier) 1982-83 (second-placed Wolves, who finished 10 points behind, had four)

Wimbledon (fourth tier) 1982-83

Leicester (second tier) 1979-80

Shrewsbury (third tier) 1978-79

Mansfield (third tier) 1976-77

Conversely, eight is the record of players from one team filling the PFA side, set by Manchester United in 2006-07 (Edwin Van Der Sar, Gary Neville, Rio Ferdinand, Nemanja Vidic, Patrice Evra, Ryan Giggs, Paul Scholes, Cristiano Ronaldo) and West Ham in 1980-81 (Phil Parkes, Ray Stewart, Alvin Martin, Billy Bonds, Trevor Brooking, Alan Devonshire, Paul Goddard, David Cross).

## **RELEGATED AFTER WINNING THE TITLE (2)**

Last week we looked at sides relegated after winning their domestic championship.

What we could have done is linked through to the excellent rssf.com site, who have a full list from around the world. Thanks to Liam Curry for the link. As Roy Fauske points out, special praise goes to Brann, who won back to back titles in 1962 and 1963 only to be relegated in 1964.

One case not noted in that otherwise comprehensive list, is that of the Newcastle Jets in Australia. "Here in Australia we don't have relegation and promotion yet and that's lucky for the Jets," writes Davidde Corran. "They won the 2006/07 season (winning the title in the playoffs) and then came last the following 2007/08 season. They finished bottom of the standings with only four wins from 21 games."

## **KNOWLEDGE ARCHIVE**

**"In terms of goals scored, is Ole Gunnar Solskjaer the best substitute in English football history?"** asked Peter Brown way back in 2007.

He's certainly the best in Premiership history. Solskjaer has scored 17 league goals after coming off the bench, which puts him comfortably clear of Jermain Defoe, Kanu, Andy Cole and Tore Andre Flo, each of whom have 13. In all competitions, Solskjaer scored 29 of his 126 United goals from the bench. His first goal for United, in August 1996, came six minutes after he was introduced in a home match against Blackburn; spookily, his last goal for the club also came six minutes after he had come off the bench at home to Blackburn.

It is hard to say with absolute certainty that Solskjaer is the most prolific substitute in English football history, as records from the pre-Premiership era are less comprehensive. His most likely rival, Liverpool's David Fairclough, scored either 18 goals (according to the official Liverpool site) or 20 (various newspaper reports) as a substitute in his time at Anfield. Fairclough also played for Norwich, Oldham, Tranmere and Wigan but, in the absence of cold, hard data, we're presuming he wasn't a substitute too often. And he only scored three goals for them anyway.

For more sepia-tinged questions and answers take a stroll through the [Knowledge archive](#).

## **Can you help?**

"Whilst watching the Leeds v Millwall play-off semi, there was a coin (50p I think) thrown on to the pitch," notes John Stonestreet. "Eventually, the ref handed it to the fourth official. Given the harsh economic times, who gets to keep the coin? Is it given to the player it was aimed at, is it Sellotaped to the ref's match report, or is the answer something mundane like a charity donation?"

"Andy Booth retired this summer, having scored 150 league goals (lovely figure) and 183, if maths serves me, in all competitions for Huddersfield Town," writes Gareth Jackson. "Not one of these goals were penalties. Is there a player who has scored a higher figure of goals without a single penalty amongst them?"

"My team, Motherwell FC, appear to have had their badge stolen by a team in Iraq, called Al Sinaa," writes an outraged Gordon Blackstock. "It seems the Baghdad-based team has an exact replica of our badge, albeit with Arabic writing. Apart from the obvious parallels of life in the war-torn mean streets of Motherwell with Baghdad, why have this Iraqi powerhouse of a team picked our humble badge? And are there any other examples of teams blatantly ripping off another club's crest?"

"According to this excellent website there was an FA Cup third and fourth place play-off played in 1970-71 between Everton and Stoke," writes Tom Moore. "I never knew these games existed. Were they played every season and when were they introduced/scrapped?"

"Are Milan the first club to retire a number as a mark of respect for a player's retirement as they have done for Franco Baresi?" asks Karl Walsh.

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