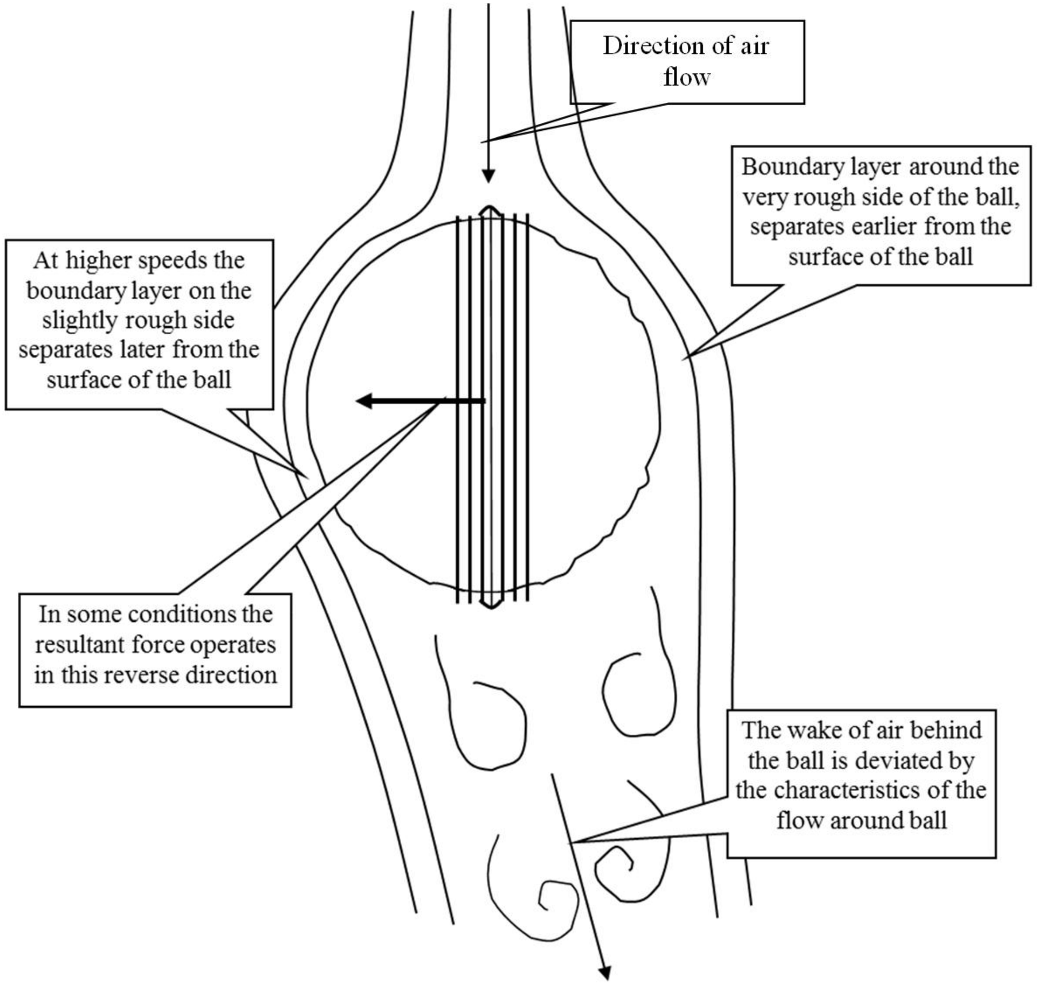
Old ball reverse swing

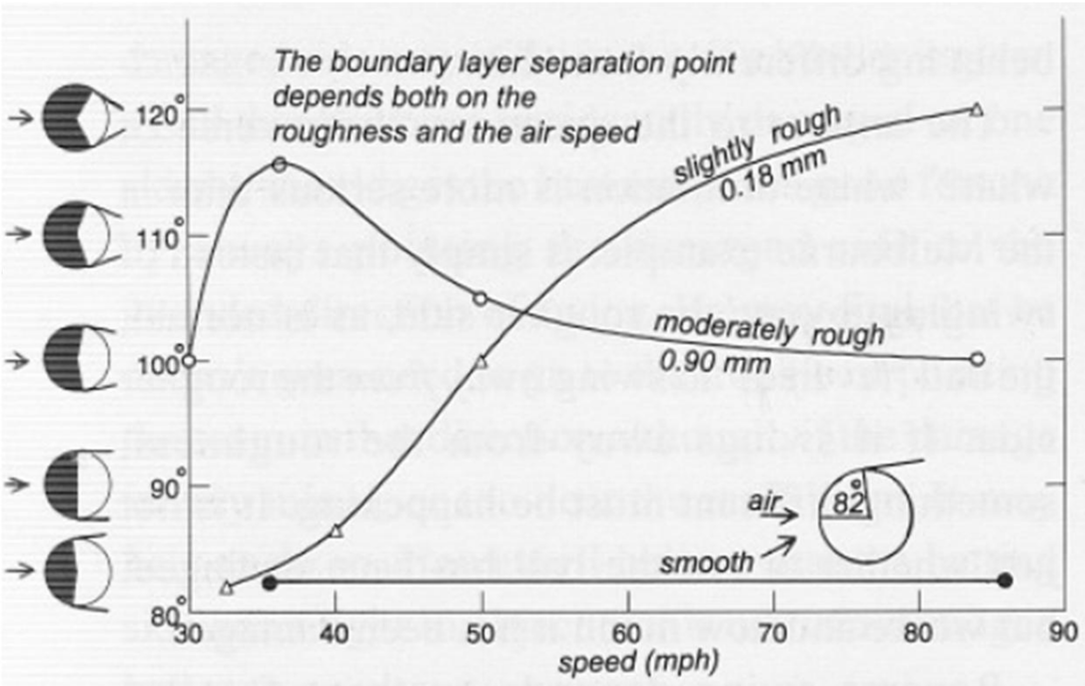
- Old ball swing due to a difference in roughness between the different sides of the ball
- The direction the ball moves is dependent on the relative roughness between the sides and the speed of the air flow
- The comparative roughness of the two sides of the ball have significant affect on the amount and speed at which reverse swing occurs
- Experimental results for the amount of swing of a roughened sphere at various angles of the seam and at different Reynolds numbers
- These experimental results for the sphere are in reasonable agreement with those from an actual cricket ball
- Best reverse swing occurs at a seam angle of 0^o, disappearing when the seam angle goes past 20^o and requires higher speeds or favourable atmospheric conditions

Old ball swing due to a difference in roughness between the different sides of the ball



- The flow of air around an old ball, can be affected by having one side rough and a less rough side
- For normal swing the rough side of the ball acts to cause the flow in the boundary layer around one side of the ball to separate later while the 'smooth' side separates earlier causing the normal swing force
- For 'reverse' swing both sides of the ball are rough, but one side is only slightly rough while the other is more rough.
- Under favourable conditions, the resultant force may act in the 'reverse' direction, typically:
  - the rougher the more rough side is, the greater the resulting force
  - reversing is more likely to happen at higher air flow velocities
  - the slightly rough side is usually not highly polished since if it is too smooth there will be no reverse swing, hence the advice to rub it dry on the trousers rather than polishing it with sweat

The direction the ball moves is dependent on the relative roughness between the sides and the speed of the air flow

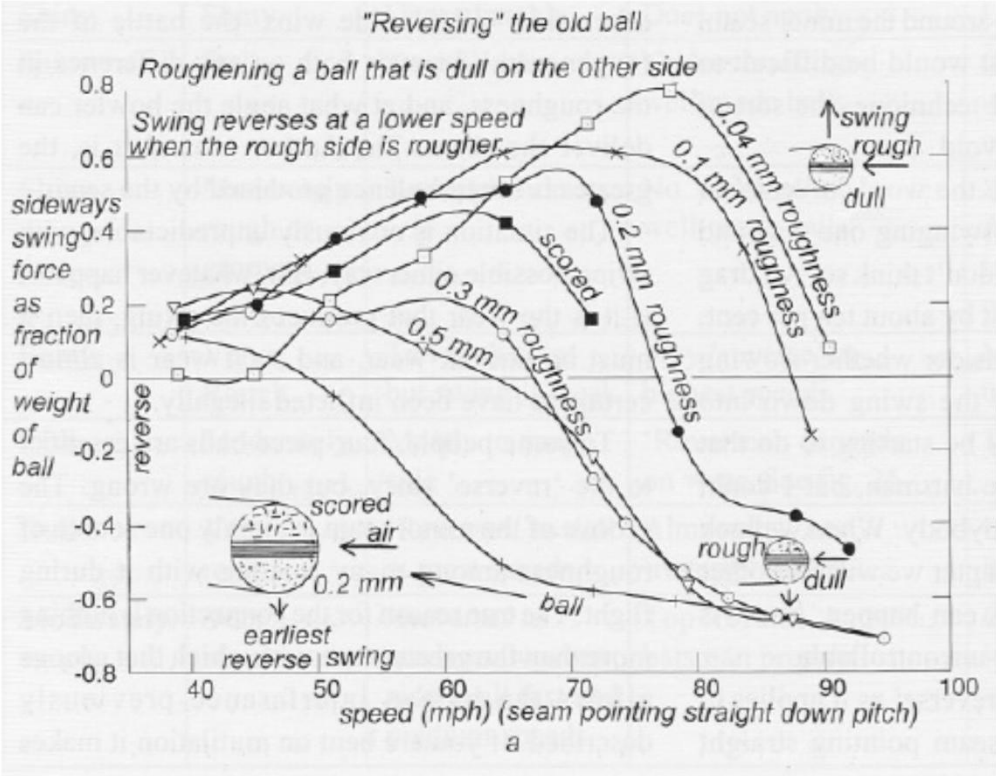


Source: Achenbach, E. (1974), 'The effect of surface roughness and tunnel blockage on the flow past spheres', J. Fluid Mech. Vol. 65:1, pp. 113-125 as quoted in Wilkins op cit

- For a moderately rough sphere, Achenbach found that the angle at which separation occurs decreases as the Reynolds number increases (quoted as speed of air flow by Wilkins e.g. exceeding ~40mph (65kph)).
- For a slightly rough sphere the angle of separation continues to increase as the air velocity increases.
- At velocities above about 55mph (~90kph) the moderately rough sphere starts to separate earlier than the slightly rough sphere.
- If a ball had a slightly rough side and a moderately rough side then this difference in the angle of separation above 55mph is likely to cause the resulting force to act in the 'reverse' direction.
- The difference between the angles of separation (and hence the size of this force) appears to continue to increase up to 87mph (~140kph)
- Note the air flow over a smooth sphere consistently separates at about 82°.

The comparative roughness of the two sides of the ball have significant affect on the amount and speed at which reverse swing occurs

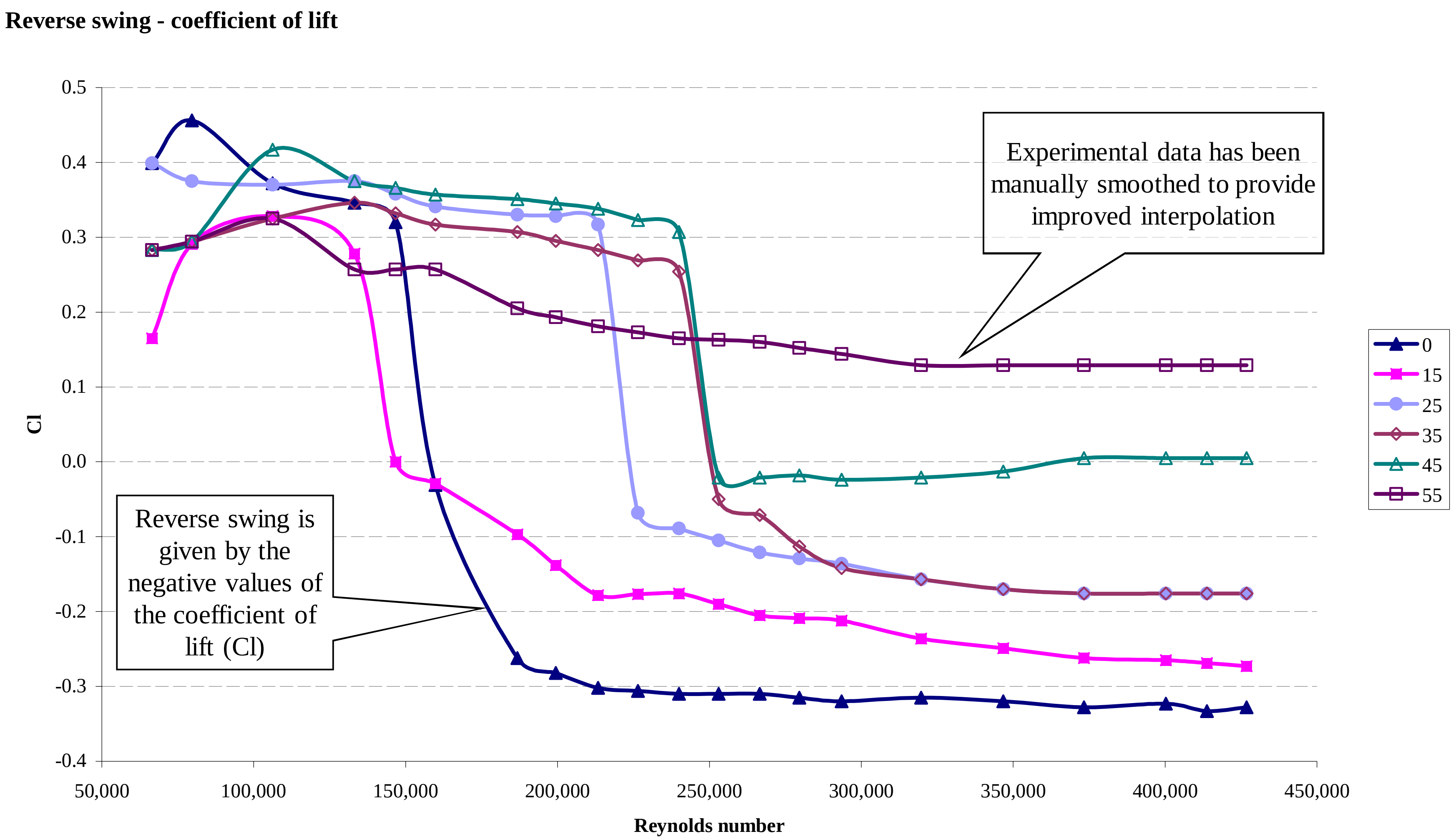
Effect of comparative roughness of sides of a ball[1]



- Brian Wilkins[1] has proposed that there are two types of reverse swing: 'seam imitating' and 'mutilation'.
  - 'seam imitation' reverse swing occurs on an old ball at high speeds as one side of the ball gets slightly rougher than the other through 'normal' wear, see the curves from about 0.2mm roughness in diagram
  - 'mutilation' reverse swing occurs when one side of the ball is heavily mutilated – as the difference in roughness between the sides is increased the ball starts to 'reverse' at lower and lower speeds, the bottom curve in diagram
- Note these curves are not normalised using Reynolds number, which makes it impossible to account for differences in atmospheric conditions in the data

[1] Wilkins, Brian, (1997), 'Cricket: the bowler's art', 2nd ed, Kangaroo Press

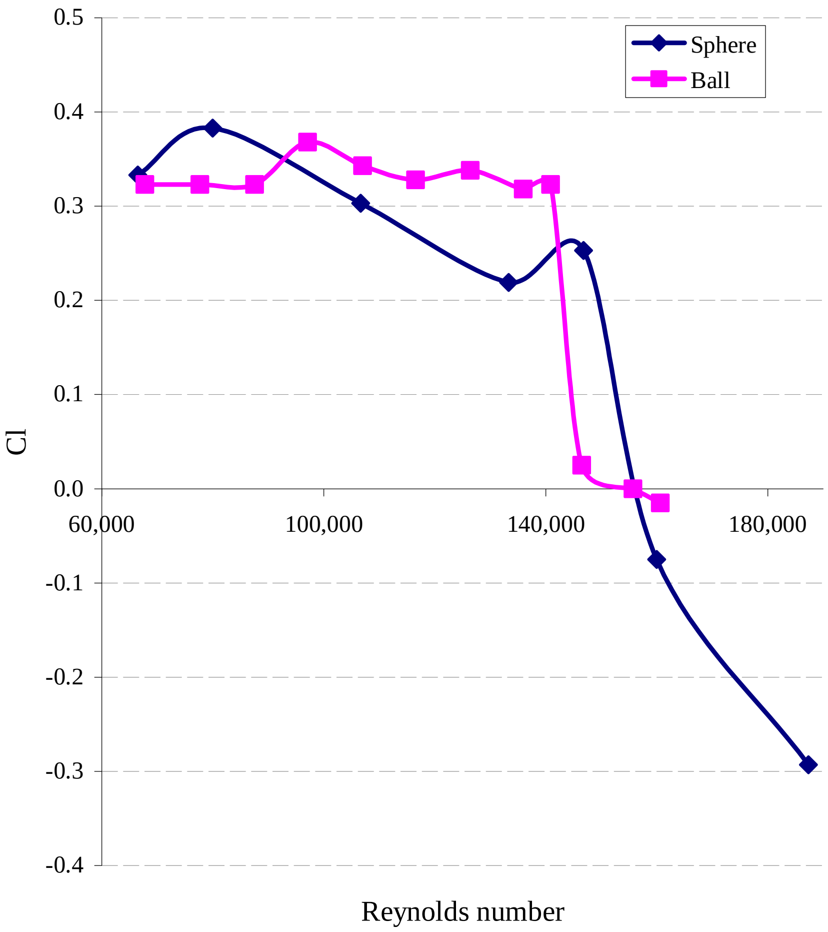
Experimental results for the amount of swing of a roughened sphere at various angles of the seam and at different Reynolds numbers



Source: Sayers, AT, (2000), 'On the reverse swing of a cricket ball – modelling and measurements', Proceedings of the Institution Mechanical Engineers, Vol 215, Part C

These experimental results for the sphere are in reasonable agreement with those from an actual cricket ball

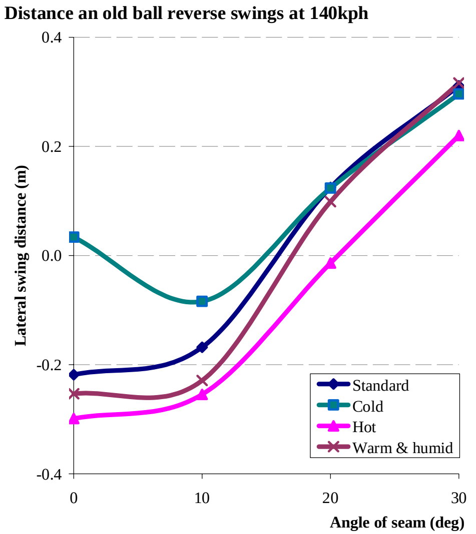
Comparison between roughened sphere and cricket ball

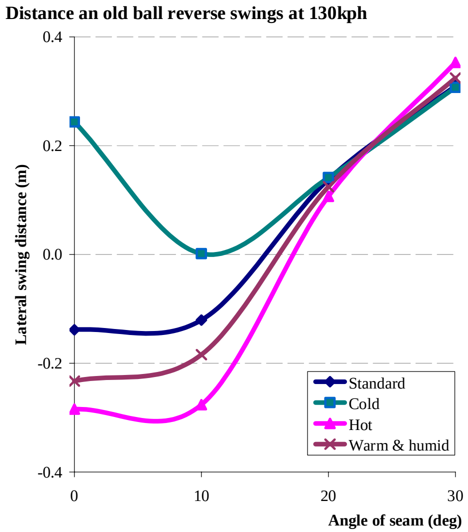


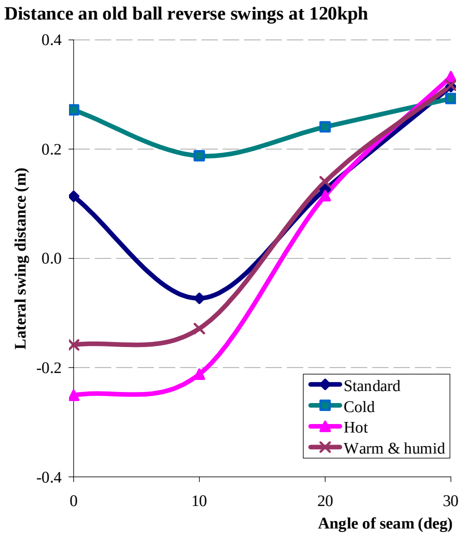
- This data was obtained by modelling a cricket ball as a sphere (diameter of 195mm – approximately three times a cricket ball) with three O-rings to mimic the seam. The sphere was roughened by gluing sand to one side
- The reason for doing this is to get equivalent data for higher wind flow velocities (three times higher) than is possible by using a cricket ball in this wind tunnel which would have been limited to about 120kph
- The equivalence was tested by comparing the lift on a cricket ball which had also been roughened by gluing the same size sand to one side of the ball
  - Note that the roughness on the ball is now equivalent to three times the roughness of the sphere

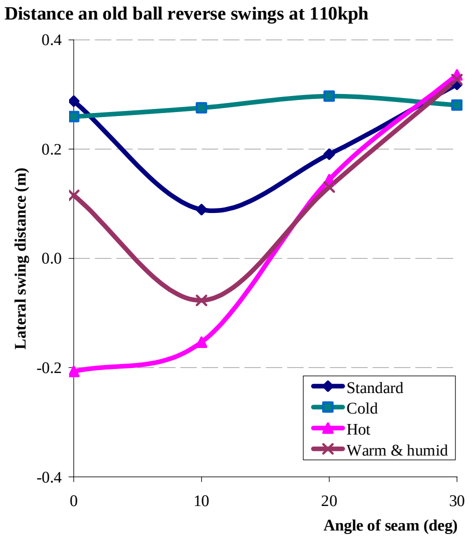
Source: Sayers, AT, (2000), 'On the reverse swing of a cricket ball – modelling and measurements', Proceedings of the Institution Mechanical Engineers, Vol 215, Part C

Best reverse swing occurs at a seam angle of 0º, disappearing when the seam angle goes past 20º and requires higher speeds or favourable atmospheric pressures









Source: Vaughan Roberts' bowling trajectory model

- It appears the ball swings more in hotter temperatures than colder ones, but this is related to the air pressure, not the temperature
  - the lateral swing forces are higher because of the greater air density associated with the higher air pressures used in the hot and warm scenarios
  - the density of air decreases as the temperature rises under constant pressure
- Greatest amount of reverse swing is achieved with an angle of seam of 0º
  - this result shows that the seam takes little part in the generation of reverse swing and as the seam angle gets back to about 20º, the normal swing returns
- Faster speeds seem to be required to get reverse swing, with it almost disappearing at 110kph, except when there is high pressure atmospheric conditions
- *Assumptions*: ball delivered to land 3m in front of batting crease, no air flow time delay, bi-cubic spline interpolation used to obtain coefficient of lift from smoothed experimental data