

What If a Table Tennis Ball Had Dimples?

An AI-Assisted Theoretical Analysis of Speed, Spin, and Bounce

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Theoretical modeling, calculations, and draft prepared with OpenAI ChatGPT under the author's direction.

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Abstract

Golf balls use dimples to manipulate boundary-layer behavior, reduce pressure drag in appropriate flow regimes, and alter lift when the ball spins. A table tennis ball is also a light sphere moving through air, which raises an intriguing question: what would happen if its normally smooth surface were dimpled? This article develops a simple theoretical model for three consequences: loss of speed in flight, spin-induced curvature, and rebound from the table. The analysis predicts that dimples could produce a readily meaningful change in flight if they reduce the drag coefficient at table-tennis Reynolds numbers. They could also change the Magnus force and therefore the curvature of topspin, backspin, and sidespin shots. The effect on bounce is less predictable: dimples could change local contact friction, but the rebound also depends strongly on incoming speed, spin, shell deformation, and the coefficient of restitution. The central conclusion is therefore not that a dimpled ball would necessarily be 'faster' or 'spinnier,' but that the idea is physically plausible, quantitatively testable, and sufficiently sensitive to dimple geometry that an actual prototype or dedicated CFD study would be required for a definitive answer.

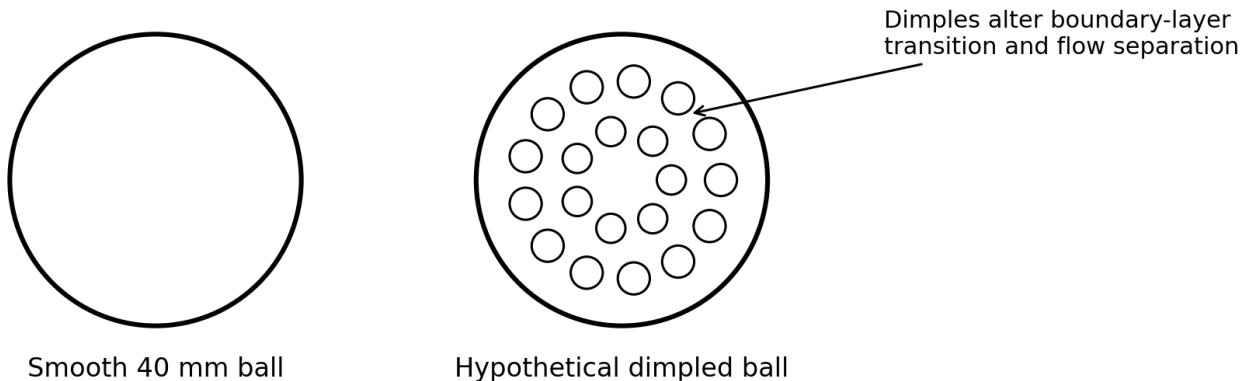


Figure 1. The proposed comparison. The dimple pattern shown is conceptual, not a manufacturing specification.

1. The question

A regulation table tennis ball is approximately 40 mm in diameter and 2.7 g in mass. Because it is exceptionally light for its frontal area, aerodynamic forces are important even over the short dimensions of a table. Recent CFD work on spinning table tennis balls has examined translational speeds from 2.5 to 20 m/s,

rotational speeds from 15 to 90 rps, and Reynolds numbers from 6.6×10^3 to 5.3×10^4 . Those values place ordinary play in a regime where surface texture could matter appreciably.

The thought experiment considered here changes only one feature: replace the smooth outer surface by a regular field of shallow dimples while keeping diameter, mass, material, and overall spherical shape approximately unchanged. Three questions follow naturally: (1) would the ball retain more or less speed? (2) would spin bend its flight more or less? and (3) would the ball leave the table at a different angle after a bounce?

2. Speed: drag is the first-order effect

For a ball moving at speed v through air, the conventional drag model is

$$F_D = \frac{1}{2} \rho C_D A v^2$$

where ρ is air density, C_D is the drag coefficient, and A is the frontal area. For a 40 mm sphere, $A = \pi D^2/4 \approx 1.257 \times 10^{-3} \text{ m}^2$. The Reynolds number is $Re = \rho v D / \mu$. At 15 m/s under ordinary room conditions, Re is about 39,779. This lies inside the range explicitly modeled in recent table-tennis CFD work.

Dimples do not reduce drag by simply making a ball 'slipperier.' They disturb the boundary layer and can move the main flow-separation point farther around the rear of the sphere. Experiments on dimpled spheres show that this can lower drag, but they also show an important complication: the result depends on Reynolds number, dimple depth, number, and geometry. At some conditions roughness can increase drag rather than decrease it.

Because no validated drag curve appears to exist for a 40 mm, 2.7 g table-tennis ball carrying golf-ball-like dimples, the safest calculation is a sensitivity analysis rather than a claim about a unique coefficient. Consider an illustrative launch speed of 15 m/s. A smooth-sphere case with $C_D=0.45$ is compared with a hypothetical dimpled case with $C_D=0.30$. If gravity and lift are temporarily ignored, integration of quadratic drag gives:

$$v(x) = v_0 \exp[-(\rho C_D A / 2m)x]$$

Over 2.74 m, this simple model predicts that both balls slow down because both experience aerodynamic drag. The smooth-ball case decreases from 15.0 m/s to 10.6 m/s for $C_D=0.45$, whereas the hypothetical dimpled case decreases from 15.0 m/s to 11.9 m/s for $C_D=0.30$. Thus, in this example, dimpling does not make the ball accelerate; it reduces the amount of deceleration. The dimpled ball reaches the far end about 1.3 m/s faster (about 12% faster relative to the smooth ball) solely because it has lost less of its initial speed. The exact numbers should not be mistaken for a prediction of a particular dimple design; they show how strongly this very light ball responds to a plausible change in drag coefficient.

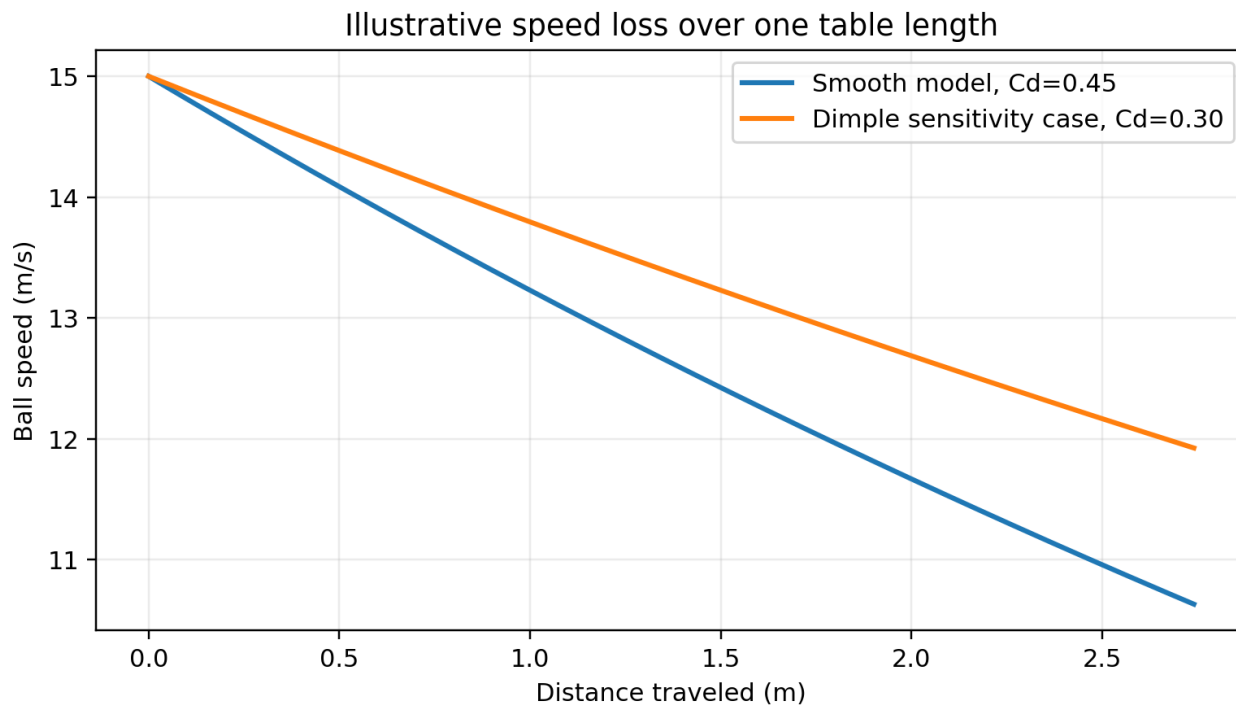


Figure 2. Sensitivity calculation for speed loss. The dimpled value of C_D is hypothetical and is used to show scale, not to claim a measured performance.

In other words, reduced drag means reduced deceleration, not acceleration. The comparison is between how much speed the two balls lose from the same starting speed.

3. Spin: dimples could change the Magnus force

A spinning ball experiences an aerodynamic force approximately perpendicular to its direction of travel. In coefficient form,

$$F_L = \frac{1}{2} \rho C_L A v^2$$

For topspin the Magnus force tends downward, making the ball dip; for backspin it tends upward; and for sidespin it bends the trajectory laterally. The lift coefficient C_L depends on Reynolds number and on a dimensionless spin parameter, often written $S = \omega R/v$. Recent table-tennis CFD work confirms that drag, lift/Magnus force, and aerodynamic torque all vary over realistic combinations of translation and rotation.

Dimples can alter both drag and lift because they alter the boundary layer over a rotating sphere. Golf-ball research has shown that dimple number, shape, and depth affect aerodynamic forces. It is therefore reasonable to expect a dimpled table tennis ball to have a different C_L from a smooth ball at the same speed and spin. What cannot presently be justified is the direction or magnitude for an unspecified dimple pattern.

Figure 3 illustrates the sensitivity rather than asserting a measured result. The smooth case uses $C_D=0.45$ and $C_L=0.10$; the dimple case uses $C_D=0.30$ and $C_L=0.15$. Both are launched at 15 m/s at a small upward angle. The dimple case retains speed better but, because a larger illustrative lift coefficient is also assigned, its topspin curvature changes as well. A real design could show a smaller, larger, or even differently speed-dependent effect.

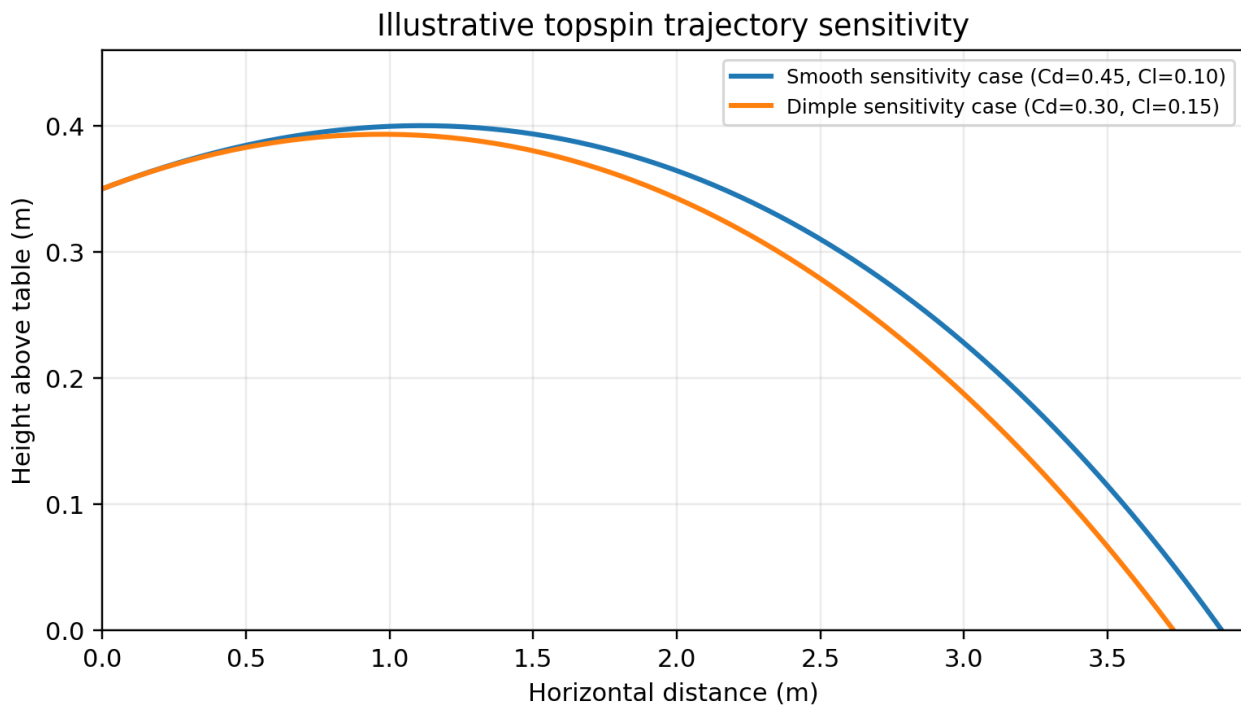


Figure 3. Illustrative trajectory sensitivity. These curves demonstrate how simultaneous changes in drag and Magnus coefficients can alter flight; they are not experimental predictions for a specified dimple geometry.

4. Bounce: the most interesting and least certain consequence

The bounce cannot be inferred from aerodynamics alone. During the brief collision with the table, the thin plastic shell deforms, the normal force determines the vertical rebound, and tangential friction exchanges linear and rotational momentum. Experiments and simulations on table-tennis balls show that rebound trajectory and post-impact spin depend on spin type, coefficient of restitution, coefficient of friction, incident velocity, and impact angle.

A useful first approximation separates normal and tangential motion. If v_z is the downward velocity immediately before impact and e is the normal coefficient of restitution, then $v_{z,\text{after}} \approx -e v_{z,\text{before}}$. Tangentially, the friction impulse J_t changes both horizontal velocity and spin:

$$m \Delta v_x = J_t \quad \text{and} \quad I \Delta \omega = R J_t$$

For a thin spherical shell, I is approximately $(2/3)mR^2$. The friction impulse is limited by the available normal impulse and depends on whether the contact patch slides or grips. A dimple that happens to lie in the contact region could alter local pressure, deformation, and effective friction. But a table-tennis ball also flattens during impact, so the interaction is not equivalent to a perfectly rigid, textured sphere touching the table at one mathematical point.

That leads to an important restraint on the theory: there is no defensible basis, without specifying dimple geometry and contact mechanics, for stating that dimples must make the rebound angle higher or lower. The most certain indirect effect is that any aerodynamic change in the incoming speed and spin will itself change the impact conditions. A direct surface-texture effect may then be superimposed on that.

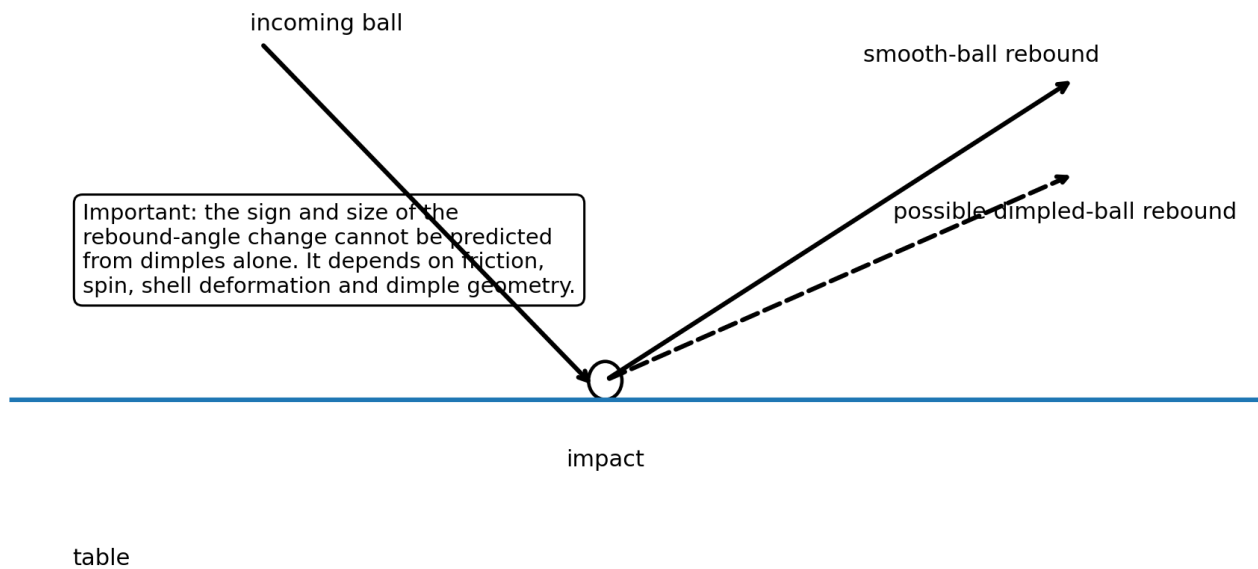


Figure 4. Rebound schematic. A change in rebound angle is physically possible, but its direction cannot be assigned reliably from surface dimpling alone.

5. What does the model actually predict?

- **Speed:** potentially the clearest effect. Both a smooth ball and a dimpled ball will normally lose speed during flight because of aerodynamic drag. If an appropriate dimple pattern lowers the drag coefficient, however, the dimpled ball could lose less speed and therefore reach the opponent traveling faster than an otherwise identical smooth ball struck at the same initial speed. If the dimples are poorly matched to the relevant flow conditions, drag could instead increase and the dimpled ball could slow more rapidly.
- **Spin in flight:** likely to change, but not necessarily in one direction. Dimples can change the Magnus coefficient and aerodynamic torque, so topspin dip, backspin float, sidespin curvature, and spin decay could all differ from those of a smooth ball.
- **Bounce:** physically plausible but least predictable from first principles alone. The outgoing angle depends on the incoming velocity and spin plus restitution, friction, shell deformation, and the detailed geometry presented at the contact patch.

6. A practical next experiment

The theory suggests a surprisingly modest experimental program. One would manufacture smooth and dimpled balls with matched diameter and mass, launch them reproducibly over a range of speeds and spin rates, and use high-speed video to obtain position and ball rotation before and after the bounce. The minimum useful data set would estimate C_D from speed decay, C_L from flight curvature, aerodynamic spin decay from successive frames, and rebound angle and spin from the table impact. A wind-tunnel or CFD study could then isolate the aerodynamic contribution from the contact contribution.

7. Conclusion

The golf-ball analogy is tempting, but the correct conclusion is subtler than 'dimples make balls fly farther.' A table tennis ball operates at different size, mass, speed, Reynolds number, spin parameter, and impact conditions. Nevertheless, established sphere aerodynamics gives a sound reason to believe that dimples could materially alter its behavior. The speed effect can be estimated directly once C_D is known. The spin effect can be modeled once C_L and aerodynamic torque are known. The bounce effect requires contact information in addition to aerodynamics.

Thus the theoretical exercise produces a testable hypothesis: a deliberately designed dimple pattern could create a table tennis ball with a measurably different combination of speed retention, spin curvature, and rebound behavior. Whether that combination would make the game better is a question for players. Whether the physics would be interesting seems much less doubtful.

There is an intriguing historical precedent in golf. Golf balls were not always dimpled. Nineteenth-century golfers discovered that older gutta-percha balls, after becoming nicked and dented through use, often flew farther than smooth new ones. Surface markings subsequently became deliberate, eventually evolving into the engineered dimple patterns familiar today. What began as an accidental observation ultimately changed the aerodynamic behavior of one of sport's most familiar pieces of equipment.

Could something analogous happen in table tennis? Serious athletes often thrive on mastering new challenges, and a dimpled ball might alter speed retention, spin, trajectory, and rebound sufficiently to demand new techniques and strategies. Theory can suggest that such changes are physically plausible, but it cannot tell us whether players would find them challenging, interesting, or desirable. Only manufacturing a dimpled table tennis ball and putting it into the hands of skilled players could answer that question.

The comparison also contains an appealing reversal. In golf, players first discovered empirically that surface irregularities changed ball flight, and the aerodynamic explanation followed. Here the question is being approached from the opposite direction: can established physics predict an interesting change in performance before such a ball is actually made? That prediction can take the idea only so far; the final test must occur on the table.

Model assumptions and limitations

This is a deliberately low-order model. Air density is taken as 1.20 kg/m^3 ; the ball is treated as a 40 mm, 2.7 g sphere; the drag and lift coefficients in the example calculations are held constant even though real coefficients vary with Reynolds number and spin; seam orientation is ignored; and the dimpled coefficients are sensitivity assumptions rather than measurements. Accordingly, Figures 2 and 3 quantify the consequences of specified coefficient changes, not the coefficients that a real dimple pattern would necessarily produce.

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AI disclosure

The originating idea and questions were supplied by Ray D'Alonzo, Ph.D. The literature search, mathematical sensitivity calculations, figures, and initial prose draft were produced with OpenAI ChatGPT under his direction. The numerical examples are explicitly labeled as assumptions where no measured dimpled-table-tennis-ball data were available. While the submitting author has reviewed the analysis and calculations to the best of his ability, editors and reviewers are expressly invited to independently evaluate them, including through the use of other AI systems. Such independent AI review may itself provide an interesting test of the reproducibility and robustness of the present AI-assisted theoretical analysis.