Physics of Sports: How Much Is Too Much?

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Sports have always been a part of humans' lives, with the most talked about event this summer being the Olympics, originally dating back roughly 3000 years ago. Physics on the other hand, has also been studied since the times of Aristotle. Both disciplines were rather disjoint and uncorrelated, however, fast forward to modern day physics and the increasingly competitive nature in sports, the two disciplines have found a way to merge into a new field of sports sciences. With current fast-paced development in science and technology, research within the field of sport sciences has mushroomed, which has led to some controversy due to beliefs that physics has overstayed its welcome in sports, causing athletes to overachieve unfairly. The main question in hand is to where the line should be drawn at the application of physics in sports to still be considered a "fair" game?

TRADITIONAL TECHNIQUES

In the past, instead of creating new techniques with the knowledge of physics, it was applied to explain certain phenomena that seem to occur naturally in sports. Considering free kicks in football (soccer), players have developed a popular technique to kick the ball in such a way that the ball spins with an axis of rotation perpendicular to the direction of travel. This causes the airflow on either side of the ball to have different speeds, in which the air travels faster around the ball where it is spinning in the same direction as the air flow. By Bernoulli's principle, the pressure is lower at that particular side of the ball and hence a lift force called the "Magnus Force" is generated which causes the ball to deflect in the direction of reduced pressure. With this knowledge in mind, footballers spend their career perfecting their freekick technique in the hope that physics will help them achieve victory in their game.

MALAYSIAN MISCHIEF?

As athletes start to understand the importance of the role physics plays in their respective sports, more effort is taken to develop increasingly innovative techniques to up their game. However, some of the most innovative ones have fallen under scrutiny by the sporting world, causing huge debates on their legitimacy which brings us to the question, at what point are they taking their use of physics too far?

In badminton, the distinct design of the shuttlecock allows it to be aerodynamically stable, where players will hit the cork base and the shuttlecock flips midair so that it always lands cork first to the opponent's racket. This is due to the non-homogeneous distribution of mass of the shuttlecock, in which the cork base is much denser than the feathers, causing it to travel faster throughout the projection as the feathers feel more air resistance.

However, in the late 1970s, a legendary Malaysian family of brothers within the badminton community applied their

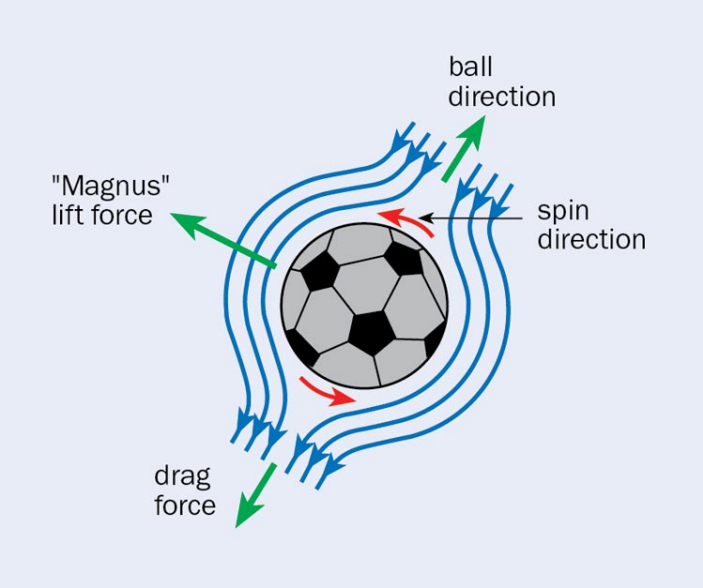

Figure 1. Forces acting on a spinning ball (Asal et al., 1998)

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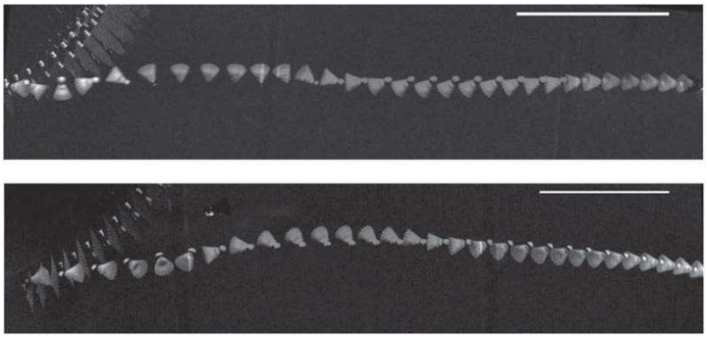

Figure 2. Chronophotographs of shuttlecocks changing in direction midair so that the cork base always leads the way after an impact with a racket (Zyga, 2015)

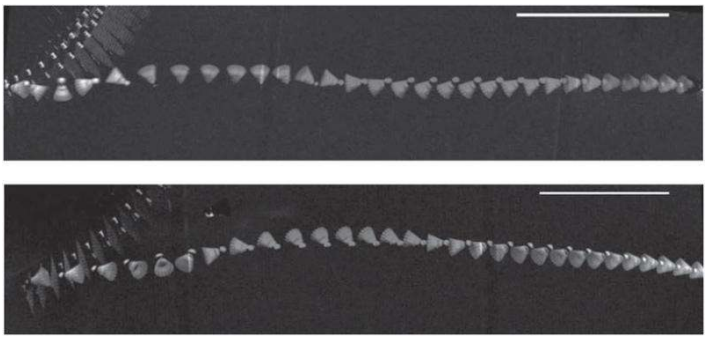

Figure 3.

understanding of this to invent the "Sidek serve", which defies the basic method of serving the shuttlecock. Instead of hitting the cork, the serve is basically executed by holding the shuttlecock in an inverted manner and slicing against the feathers which results in an irregular rotation of the shuttlecock, preventing it from falling cork-first into the opponent's racket and consequently making it near impossible for the opponent to return the shuttlecock well (Chowdhury, 2018). This cheeky technique caused dissatisfaction among certain groups of badminton professionals, and sparked a dispute on whether the technique goes against sportsmanship. Eventually, the technique was voted to be banned completely from all professional tournaments, with the new rule stating that players can serve only by hitting the base of the shuttlecock.

Now consider table tennis, where a famous technique of serving in such a way that spins the ball similar to the free kick example explained before, is mastered by the best players around the world and continuously used in professional games to this day. When serving, instead of just hitting the ball straight on, players brush their rackets against the ball at an angle less than 90°, which adds spin in the direction it was brushed against (Hughes, 2020). Similar to how a football behaves, adding sidespin to the much lighter table tennis ball will cause it to curve in midair due to the imbalance of forces, catching the opponent off guard.

Both the Sidek serve in badminton and the spinning serve in table tennis have the similar purpose of making it as difficult as possible for the opponent to return the serve. This begs the question, why is one deemed illegal whereas the other is allowed? Perhaps a perspective one can take is that the Sidek serve makes it nearly impossible for the opponent to return the serve but the spinning serve in table tennis can still be tackled well with sufficient speed, awareness and of course, enough practice. In fact, most professional players can often return the spinning serve as well as they can execute it.

BREAKING BOUNDARIES

With the advancement of physics, engineering and material science, sports companies have increased their commitment to research in the manufacture of sportswear and equipment to aid the performance of athletes.

For example, one of the main challenges in developing a high standard running shoe is to find the right balance between comfort and its ability to be energy-efficient. To ensure comfort, there should be enough cushioning to absorb some of the impact between the sole of the runners' foot and the ground. However, too much cushioning contributes to increasing the mass of the shoe and hence more energy will be required for the runner to lift the shoe off the ground for each stride. Furthermore, an optimal running shoe should also reduce energy loss and instead "return" as much of the energy it absorbs which was exerted by the runner on the ground, pushing the runner forward. Continuous research over the years has found that using foam as cushions and adding carbon fibres in the form of plates at the soles of running shoes were able to increase energy efficiency, while making the shoes as comfortable and lightweight as possible (Allen, 2019).

In October 2019, a Kenyan marathoner named Eliud Kipchoge became the first person to run a marathon under 2 hours, while wearing a special prototype of Nike's controversial "Vaporfly", first launched back in 2017. This achievement led to criticism of the shoes, with many raising the concern that the design overly enhances a runner's performance, achieving goals that do not accurately portray the runner's ability. Nike's Vaporfly is purported to improve running efficiency by 4%, supported by sufficient research, thus reducing the time of completing a run by a significant amount, especially for long distances (Gonzalez, 2019). This has caused official authorities to ban Nike's Vaporfly to be used in professional races, with the reason that the shoes are an unfair performance enhancer for athletes.

As revolutionary as it may be, this pair of shoes came under scrutiny due to its alleged over the top, dramatic performance enhancing properties. The significant improvement in performance for those wearing the shoes were too obvious such that it could not be ignored by

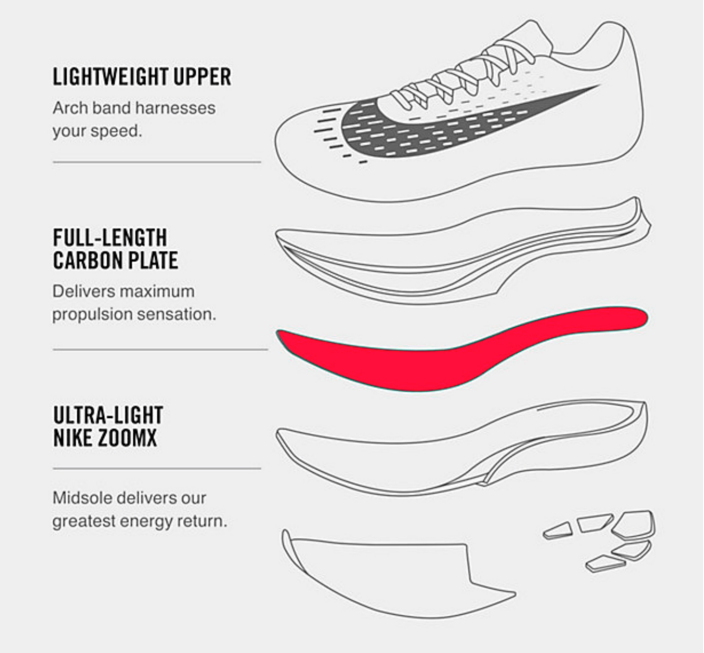

Figure 4. Composition of Nike'sVaporfly, with ultra-light Nike ZoomX foam as cushioning, and a full-length carbon fibre plate within the foam (Goldowitz, 2017)

spectators, hence it was inevitable that this raised the question of whether the shoes have sabotaged the idea of a level playing field in competitive sports.

One way to overcome this unfairness problem could be by allowing all competitors to have equal accessibility to wear these equipment, which is often not plausible due to professional sportspeople usually having sponsorships ranging from different companies, where the sudden technological breakthrough does not allow the market to adapt, hence leaving those athletes not sponsored by Nike in a huge disadvantage for a period of time. Furthermore, many have raised concerns that this kind of equipment is a form of technological doping, in which wearing the equipment overly enhances one's performance and their subsequent achievement does not reflect the athlete's true ability.

However, if there were to be a gradual increase in the development of sportswear leading up to the inventions of these revolutionary breakthroughs, there might not be a similar outcry as the sporting community would have enough time to adapt, increasing the level of performance at a steady and similar pace for everyone. Furthermore, would the sports community even take notice that these sportswear play a significant role in these improvements?

HOW MUCH IS TOO MUCH?

It is inevitable that physics will always have a hand in sports, as physics is literally set out to explain all natural phenomena. Although physics is sometimes an adversary, using it wisely can be an advantage to athletes with enough understanding of its inner workings. Of course, it is vital that lines are drawn to ensure that the essence of fair competition is maintained and that athletes do not obtain an overly superior advantage over others simply from equipment without extra hard work. However, any rules set by the governing bodies should still make room for the entry of new innovative equipment, as to not hinder their continuous development in conjunction with the technological revolution as these breakthroughs in science might not only benefit the sports community but the human population as a whole.

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