BE A CHAMPION

FASCINATING FACTS YOU DIDN'T KNOW ABOUT SPORTS AND SCIENCE

an exhibition by **AMANDINE AFTALION**

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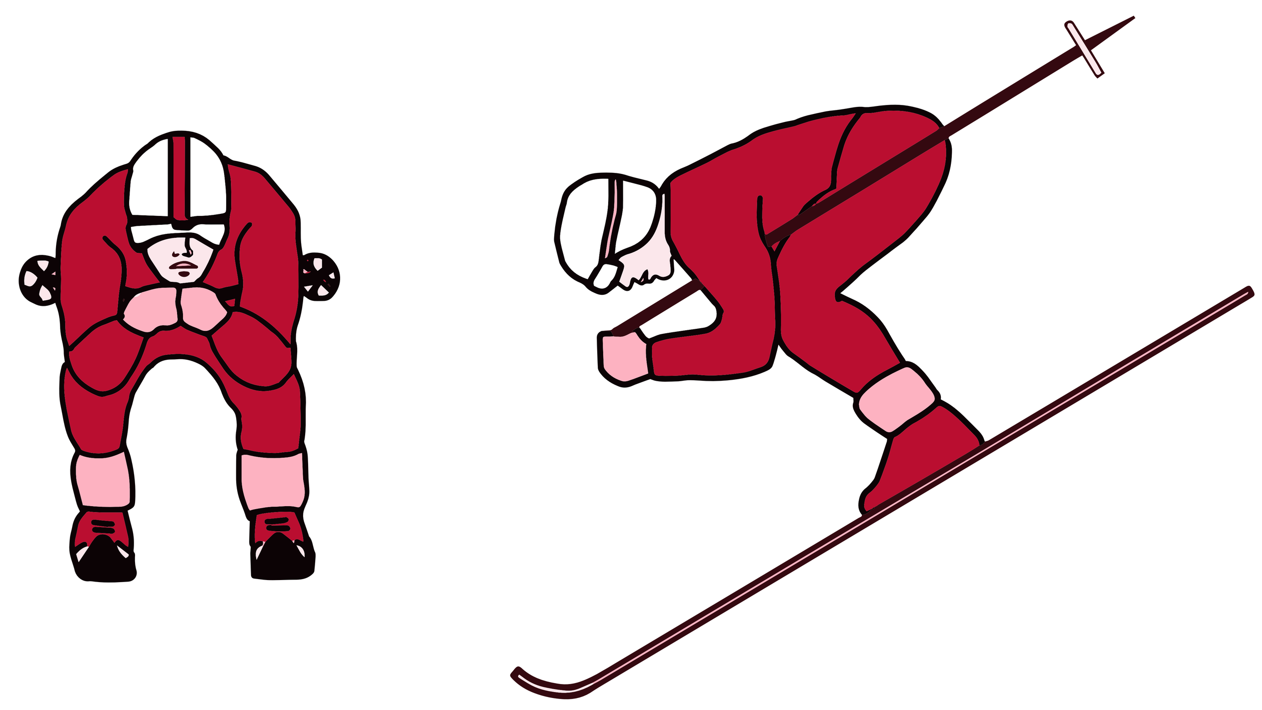
WHAT IS THE FASTEST SPORT?

The badminton shuttlecock holds the record at 351 mph, just above the golf ball at 241 mph, and the jai alai at 194 mph.

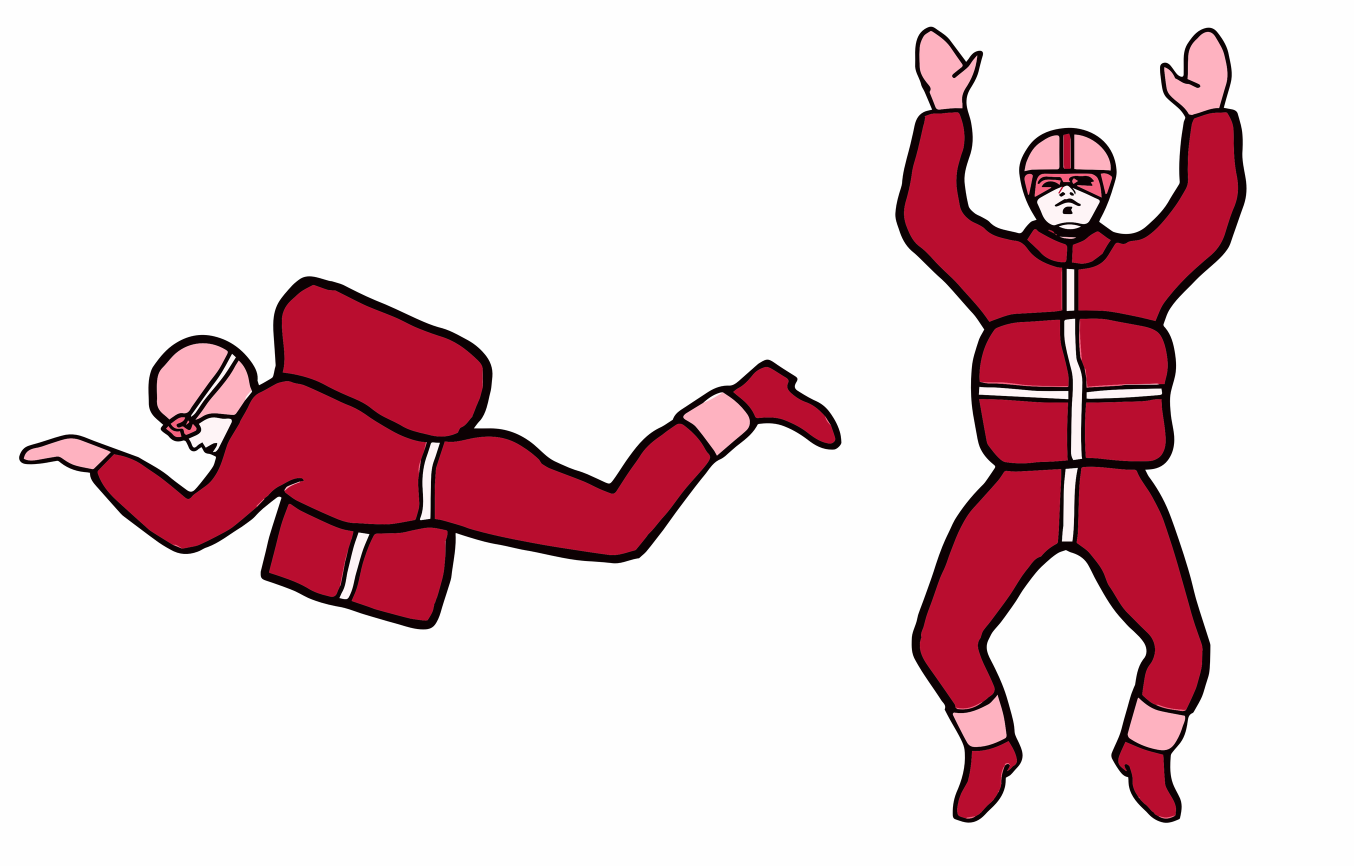
AND THE FASTEST ATHLETE?



Speed skiers,

at **158 mph**, are faster than sky divers thanks to their aerodynamic tuck position that offers little resistance to the wind.

Sky divers assume the spread eagle position, with arms and legs spread out and slightly bent. Air resistance slows them down a lot because of the large surface they present to the wind. They would need to jump from space to reach the skiers' velocity.



Wheelchair racers

outstrip the able-bodied over all distances of at least 800 metres. The wheelchair marathon record is 1 hr 17 min 47 sec, which is almost 40 minutes quicker than for able-bodied athletes. Moreover, wheelchair athletes manage a faster pace over the marathon than over 800 metres because a marathon is held on roads rather than on an athletics track, and the looser bends are easier for wheelchairs to negotiate.

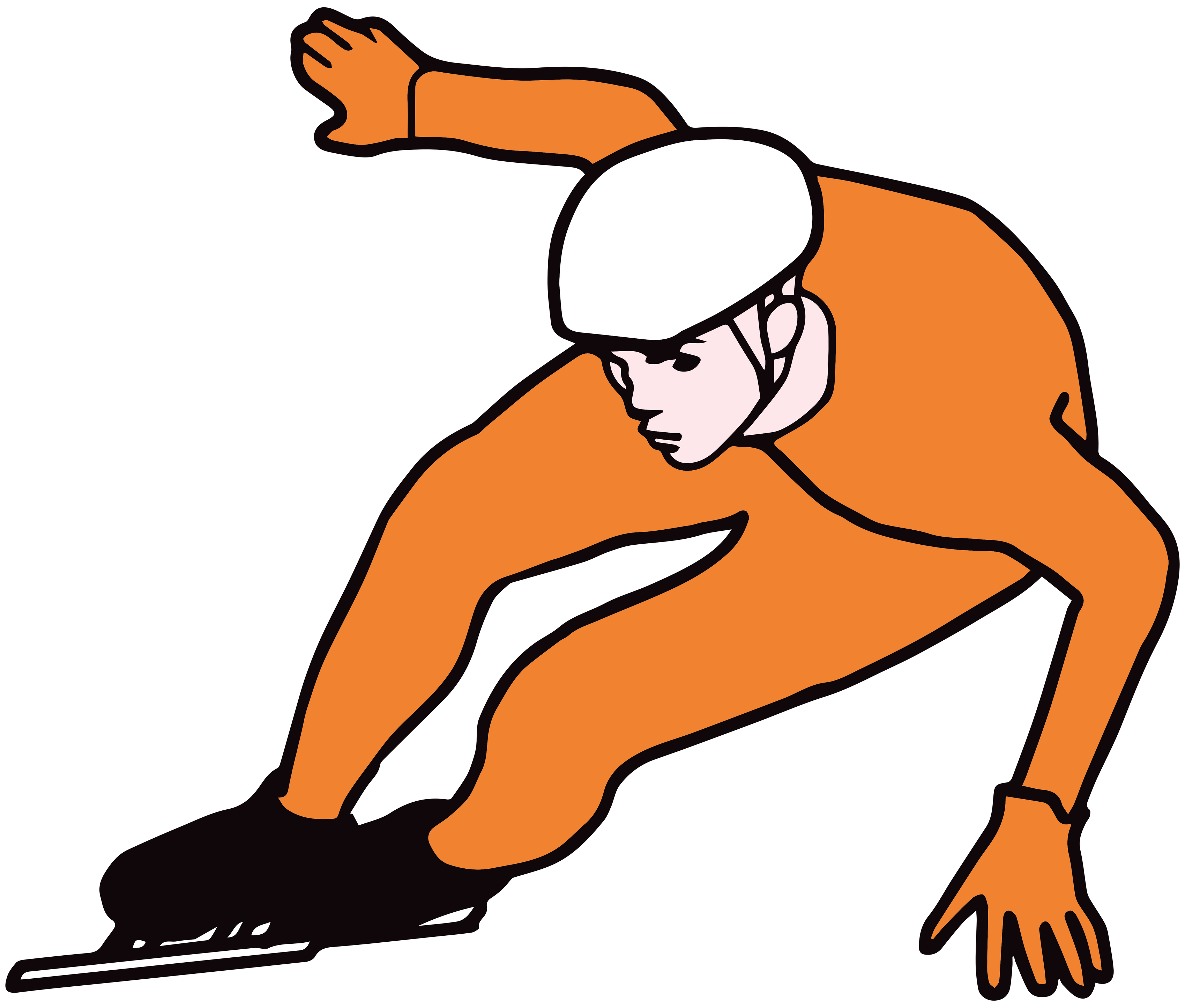
WHY DO YOU LEAN IN A BEND?

You lean if you go fast! On a motorcycle, on a bike, skiing, or ice skating, you lean to keep your balance and counter the centrifugal force.

Centrifugal force pulls you out of the curve. It takes your body to where it would have been if you weren't turning. Just as when you judder on a braking train, you are thrown forward (because your body tends to stay where it would have been). When you turn, you are thrown outwards. This force is proportional to the square of your speed, i.e., your speed multiplied by itself, and inversely proportional to the radius of the curve.

$$m\frac{v^2}{R}$$

where v is the velocity, R the radius of the trajectory, m the mass.



The faster you go, the stronger the effect, the sharper the bend, the stronger the effect! For a runner at a speed of 10 m/s, this force represents a third of his weight and the angle of leaning is of the order of 15°.

An inclined surface in the turns can help you with the lean: when you go fast (on a bike for instance), or when the turn is sharp (in indoor athletics tracks), the banking helps athletes cope with the high centrifugal force so that they can maintain their speed on the turns.

A runner who has to take a sharp turn uphill will prefer to take it on the outside in order to reduce the centrifugal force he has to fight against, even if this means covering a slightly greater distance. Similarly, when coming out of a bend onto a straight path, you prefer to avoid a sudden change in centrifugal force and anticipate this by straightening up. Motorcyclists know this well. In anticipation of exiting the bend, they straighten the motorbike, which is hard on the arms.

WHY DO YOU RUN WITH FOLDED ARMS RATHER THAN STRAIGHT ARMS?

In any walking or running movement, you are stabilised by the movement of the arms which is opposite to that of the legs.

Every time a runner changes his **supporting leg, his hips rotate.** To balance the body and avoid falling down, especially when running fast, the runner **rotates his shoulders in the opposite direction**. There is a strong torsion between the hips and the shoulders, with the arms serving to **stabilise** the body.

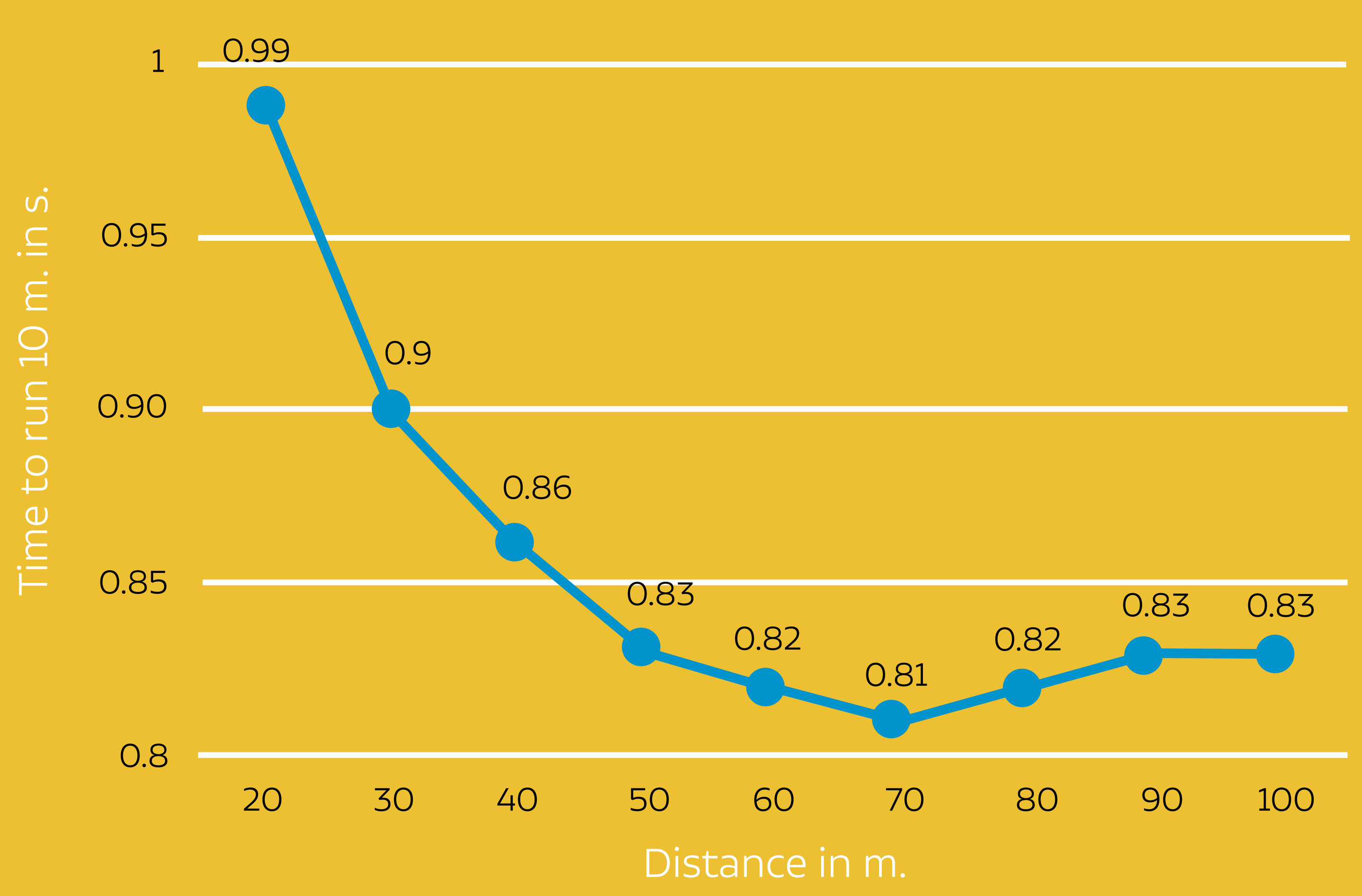
Keeping the arms bent rather than straight helps with the **swinging movement**. As with a swinging pendulum, the longer the wire, the harder it is to swing, and the shorter the wire, the easier it is to swing. By analogy, the arms **swing more easily** when they are bent, because they are then **shorter**.

WHY DOES A SPRINTER SLOW DOWN BEFORE THE FINISH LINE?

In the 100 metres, the 200 metres, the 400 metres, athletes do not cross the finish line accelerating but decelerating!

This is the best way to manage the energy and the effort, which cannot be maintained at a maximum throughout the race, even if this is the impression athletes give. So the maximum effort has to be produced at the start and then the deceleration has to be as small as possible. Calculations show that starting slower and accelerating throughout would be less profitable.

Over 400 metres, some athletes give the impression that they are outpacing their rivals at the end of the race, when in fact they are just decelerating less.

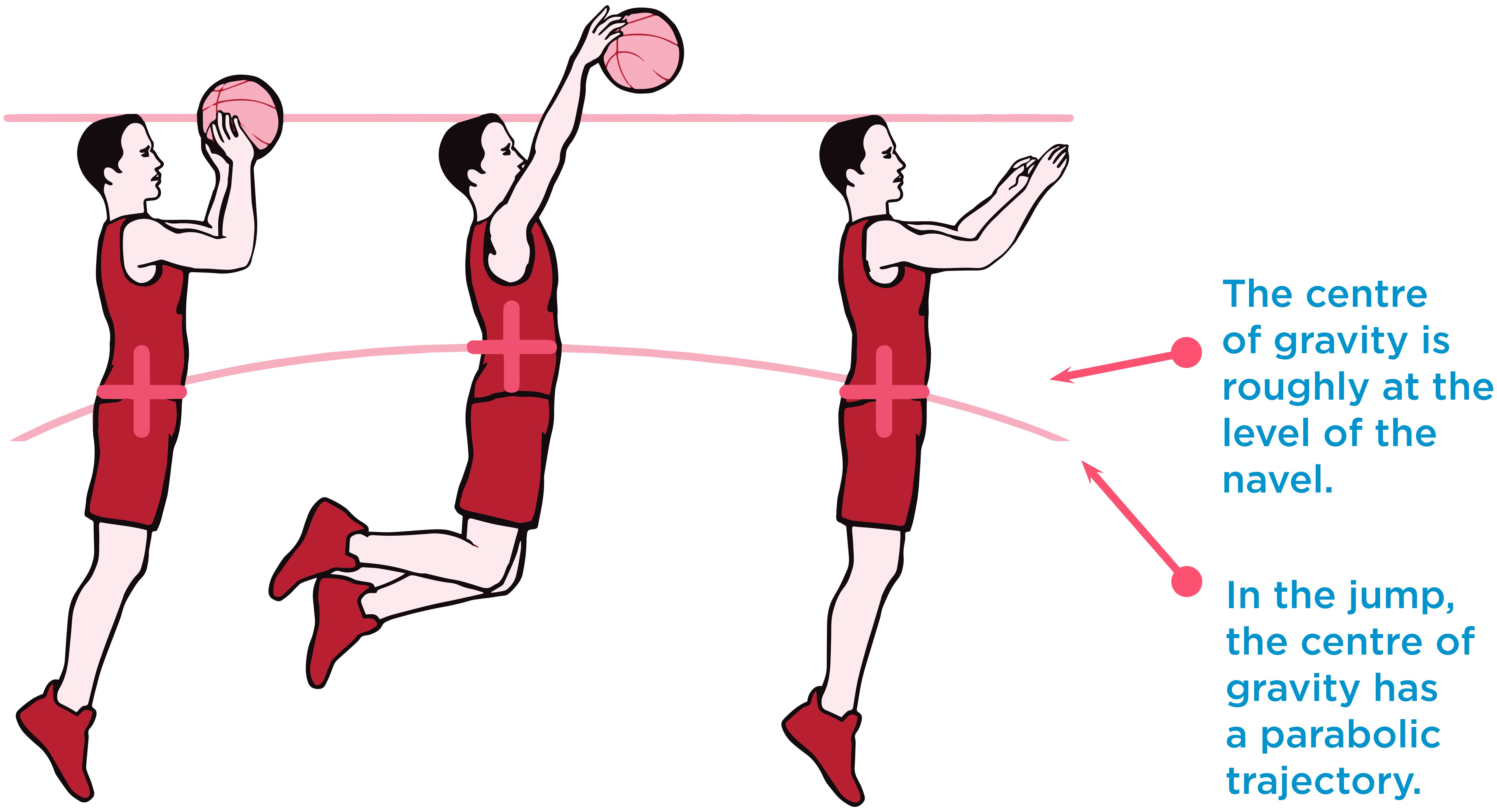


Time taken by Usain Bolt to cover 10 metres at the Berlin 100 metres in 2009 (his record).
This time increases in the last 30 metres, which means Usain Bolt slows down. On a 100 metres, all athletes slow down after 60 or 70 metres, that is after approximately 2/3 of the race.

It is only for distances above 1,500 metres that the best strategy is to accelerate at the end of the race!

WHY DO BASKETBALL PLAYERS SEEM TO HANG IN THE AIR?

When Michael Jordan throws the ball towards the basket from a jump, he gives the illusion of floating at the top of his jump, standing still, as if suspended in mid-air. This is an effect of the centre of gravity, which is the centre of mass of the body.



When you jump, your centre of gravity has a parabolic trajectory. If you raise your arms or bend your legs, your centre of gravity rises on your body. But as your centre of gravity moves through your body during the jump, your head can remain at a constant height. As the audience's attention is focused on the athlete's head, and the head remains at the same height for some time, this produces the effect of suspension in the air.

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It is the same for ballet dancers performing a grand jete. At the top of their trajectory, they raise their arms, which raises their centre of gravity and allows their head to remain at the same height for a few moments. They seem to fly!

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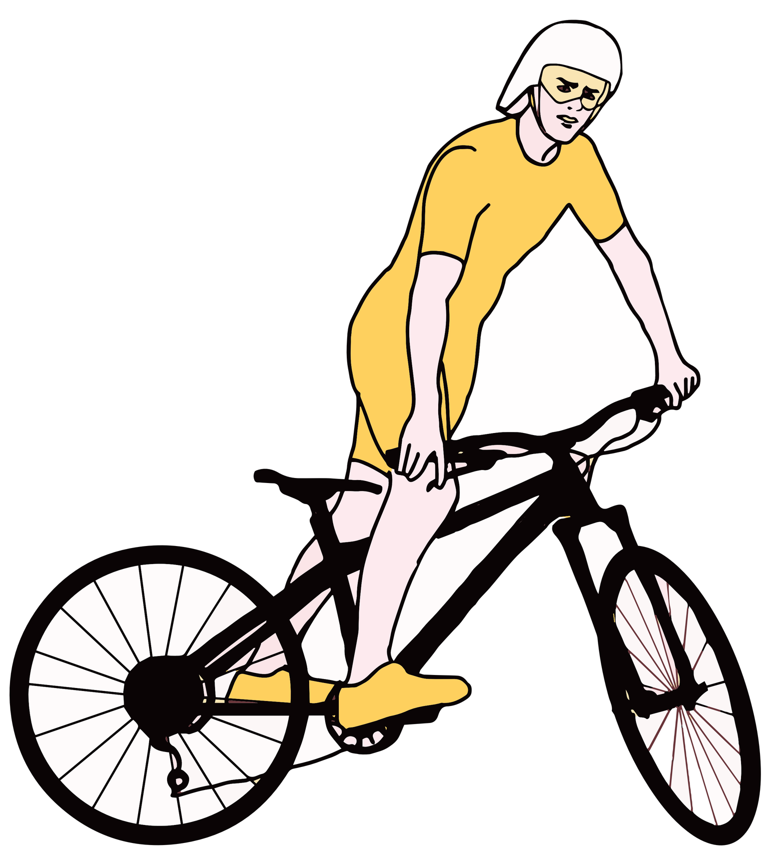
WHY, ON A BIKE, THE FASTER YOU GO, THE MORE STABLE YOU ARE?

Balancing your bike depends a lot on the handlebars. If you go very slowly, balance is very complicated and you keep twisting your handlebars not to fall down. Conversely, if you are able to speed up, balance seems easier, and handlebar movements to the left and right diminish.

The centre of gravity must remain above the area in contact with the ground (support base) for the bike to be balanced.



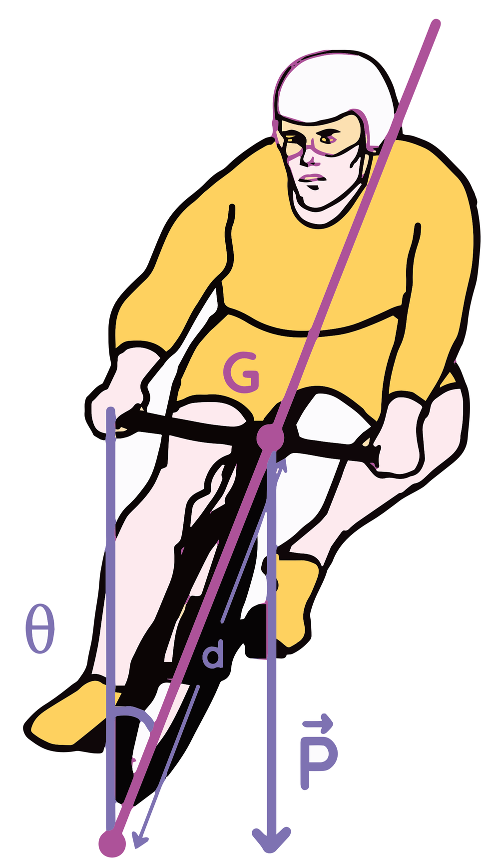
With the handlebars turned, you increase the surface area on the ground, which can guarantee balance even when stationary. And if you stand up, you make it even easier to balance!

The wider the tires, the wider the support base, making it easier to align with the centre of gravity and find your balance.

Following a slight imbalance, the weight creates a torque that tends to cause the system to fall down. Turning the wheel generates a rotation of the system that compensates that of the weight. Indeed, this rotation creates a centrifugal force giving rise to a torque in the opposite direction to that of the weight. Bicycle rebalancing is therefore linked to handlebar rotation by the formula:

$$\frac{v^2}{R}\tan\theta = g$$

where v is the velocity, R the radius of the trajectory due to the rotation of the handlebars, g the gravitational constant and θ the angle with respect to the vertical axis.



- **At low velocity**, the radius R must be **small**: in order to turn on a small circle, you have to give a big push with the handlebars.
- **At high velocity**, the radius R is **large**, you are almost straight, and the change in the trajectory is tiny.

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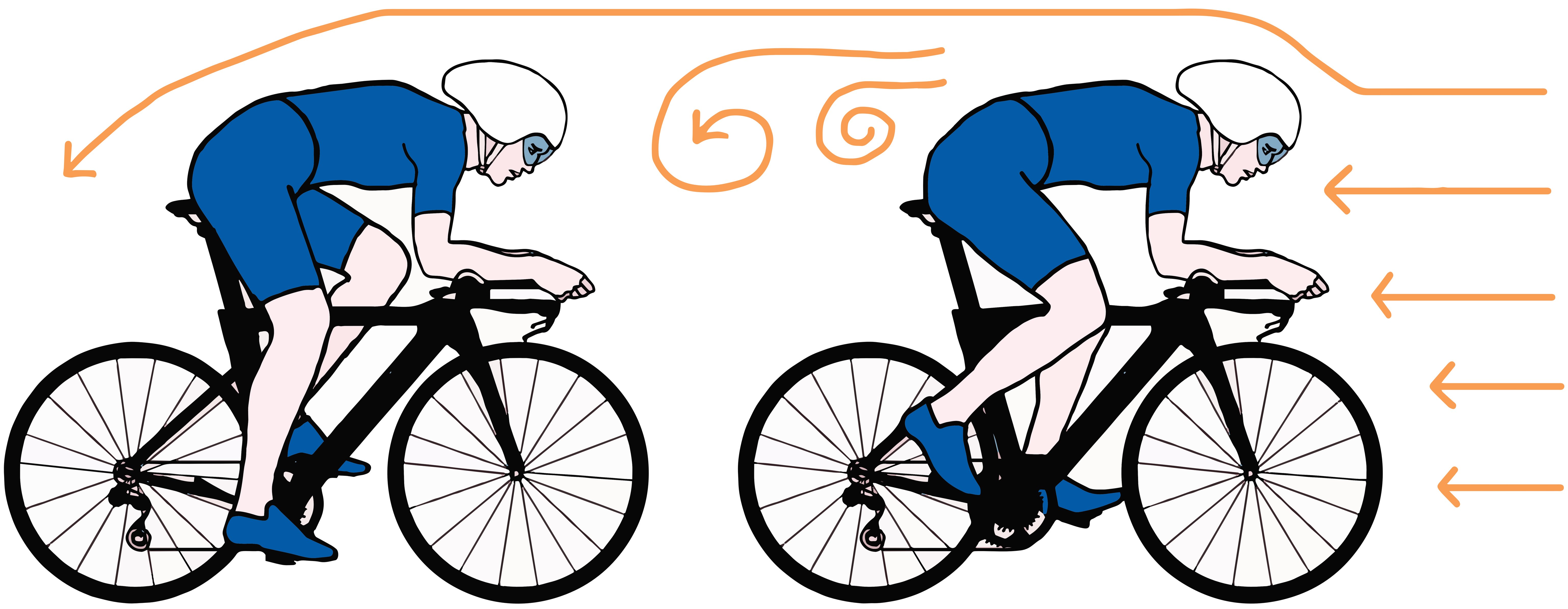
WHY DOES RUNNING BEHIND SOMEONE ALLOW YOU TO IMPROVE YOUR PERFORMANCE?

Running behind someone allows you to improve your performance. **The athlete does not have to think about his pace and saves energy to run.** An athlete running around a track (400 m) behind someone can gain up to one second compared with running solo in the race. This is not an aerodynamic effect but a psychological effect.

At higher velocity, for cyclists for instance, it is better to be behind for aerodynamic reasons. Inside a peloton, you can maintain your speed without too much effort, feeling as if you are being sucked along, whereas the leader at the front feels tired after a few minutes. This is because behind any object moving through the air, there is a wake in which the pressure is lower. So, if cyclist number 2 follows his leader closely enough, he finds himself in a low-pressure zone. Not only is there no air coming at him, but he also benefits from a suction effect.



Less well known is the fact that the leader also benefits from a suction effect, reducing his drag by around 5%. Indeed cyclist 2 occupies his wake, which reduces the vortices behind the leader, and thus reduces the drag that opposes movement. But this only works if cyclist 1 adopts an aerodynamic position. Therefore, if you are a leader, don't be alone!

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WHY DO YOU SWIM FASTER WHEN SLIGHTLY UNDERWATER?

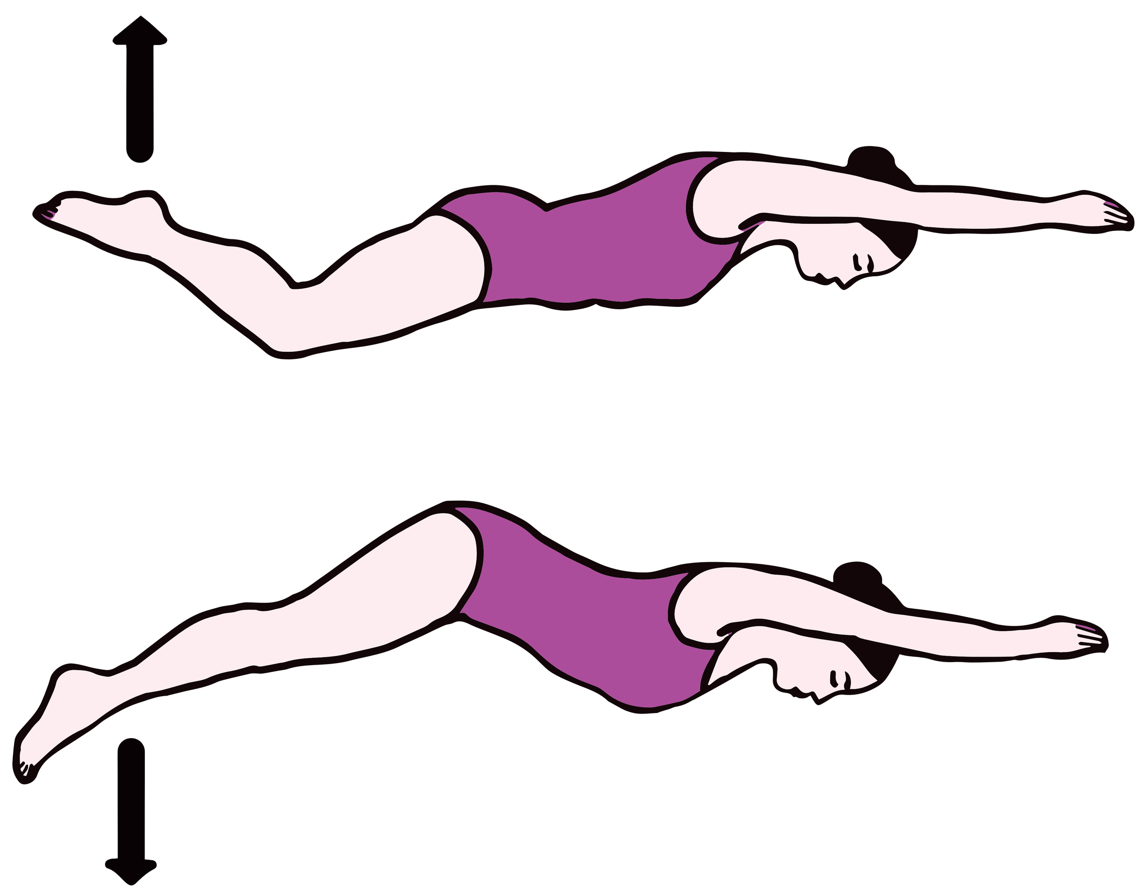
Submerged, **a swimmer's body moves** **faster**. **He encounters about** **two and a half times less resistance** **underwater than on the surface.** He is slowed down by a force, the drag force, opposing the swimmer's movement through the water, made up of three components :

Pressure drag: the swimmer pushes the water out of his way, creating a pressure difference between the water in front of him and behind him. This drag is reduced if the swimmer is as horizontal as possible and splits the water, and is reduced underwater

Skin friction, which is reduced with a swimming cap or a wetsuit that reproduces shark skin and glides through the water. Skin friction is lower underwater than on the surface.

Wave drag: this is caused by waves formed by arm and leg movements during swimming, which are reduced underwater.

But waves created by the swimmer exist underwater and they need to be used to propel undulating.



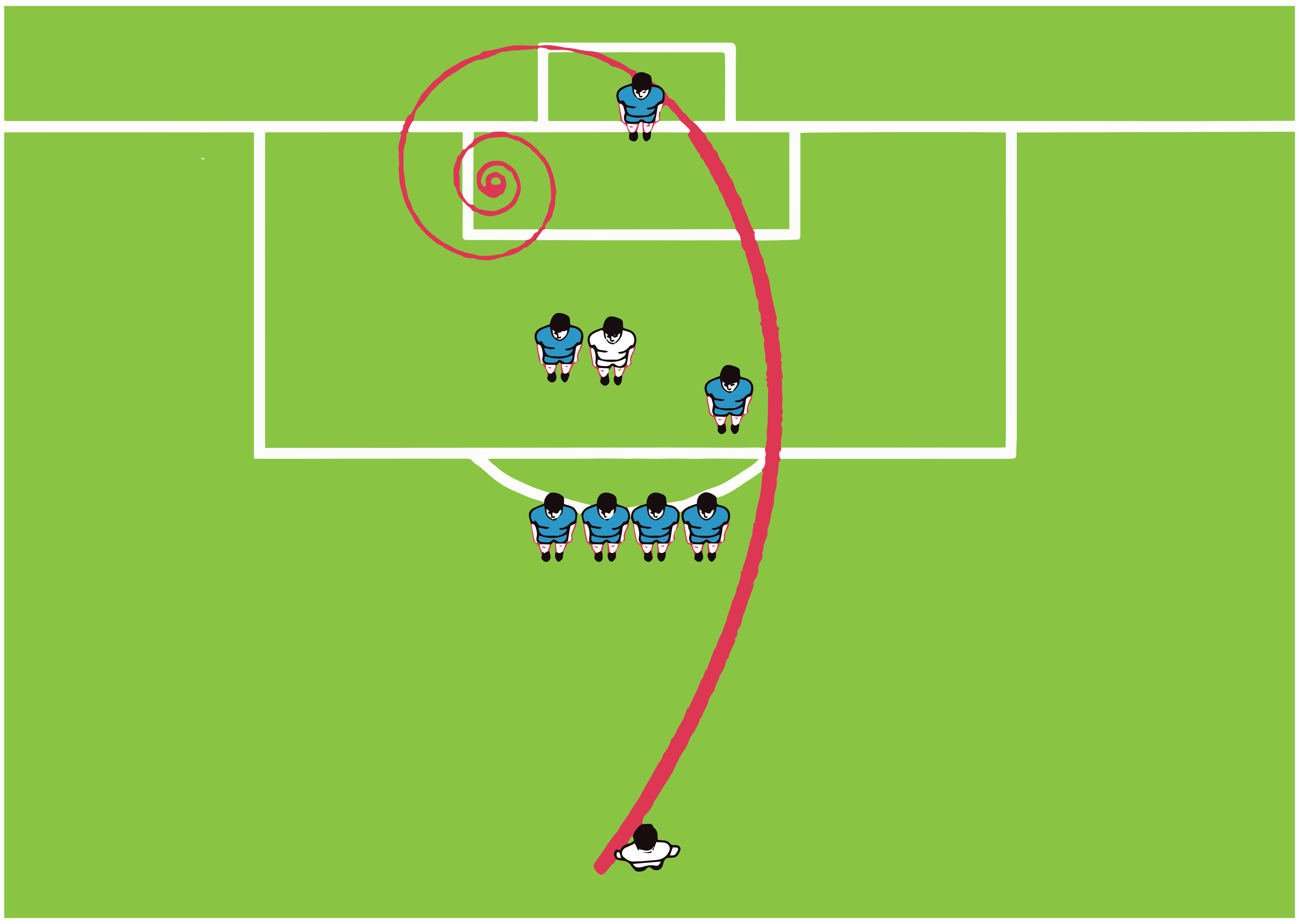
The swimmer pushes the water with an undulatory motion, and the water in turn pushes the swimmer, creating a thrust that propels her forward.
This is the **dolphin kick**.

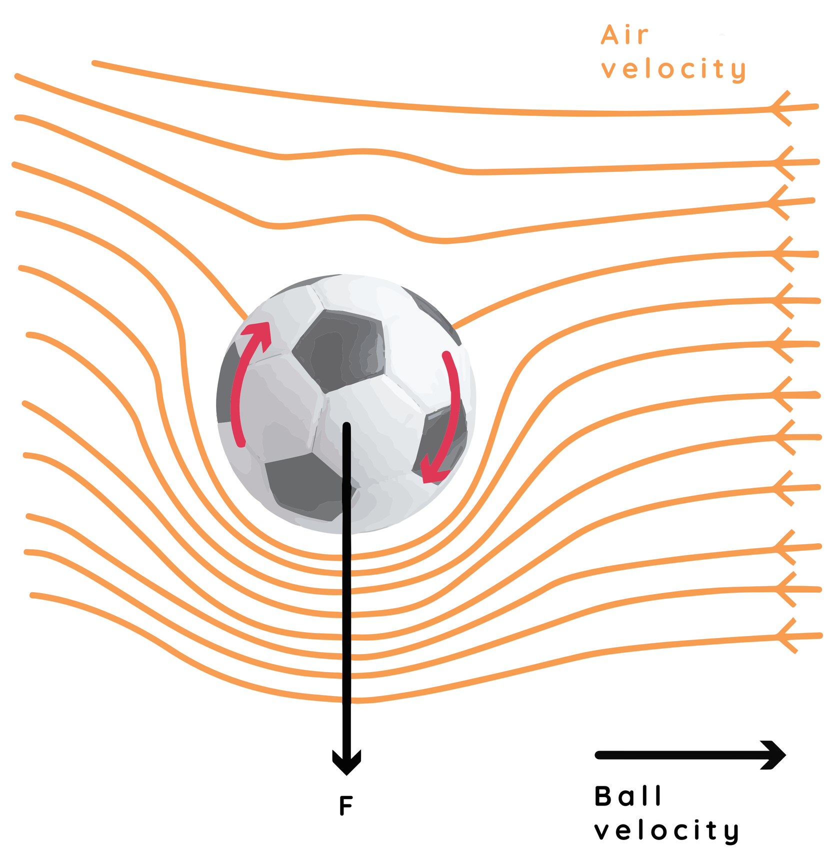
The effectiveness of the dolphin kick has forced the international swimming federation to restrict starts and turns to 15 m in competition at the risk of disqualification.

HOW DO SOCCER PLAYERS SCORE FREE KICKS?

Bend it like Beckham: if the ball is rotated when shot (this is called brushing the ball), the trajectory is curved.

Ball shot with a Magnus effect: the ball rotates on itself and follows a spiral trajectory. It bypasses the wall formed by the opponents, avoids the goal keeper and enters the goal. The thinner line is the end of the trajectory if there were no net.

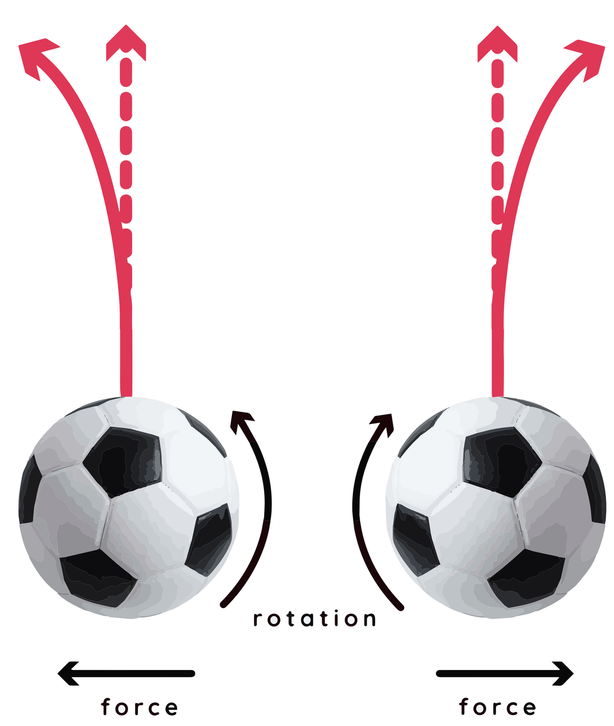




If the ball spins clockwise, the bottom of the ball has a greater velocity relative to the air than the top of the ball. By Bernoulli's principle, the top of the ball feels a higher pressure than the bottom, so a downward force is exerted, which deflects the trajectory.

On the left, rotation to the left and trajectory deflected to the left. On the right, rotation to the right and trajectory deflected to the right.

Similar effects take place in tennis or ping-pong, with bounces also affected.



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