ARIONEO

HORSE DATA SCIENCE

HORSERACING SPEED ANALYSIS : WHAT CAN DATA BRING TO YOUR SPEED WORK?

TRACKING DATA FOR PERFORMANCE

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OVERVIEW

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Speed is a key parameter for winning a race. Monitoring this data regularly allows you to :

DETECT YOUR HORSES PREFERENCES

On which type of track does my horse perform best?
Which tracks offer the best performance?

ADOPT WINNING STRATEGIES

What strategy to adopt?
How to regulate the horse's speed during the race?
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Why analyse split times?

DETECT FUTURE PERFORMERS

What characterises a good horse?
What are the points of reference among the great champions?
What is the speed behaviour of my horses?

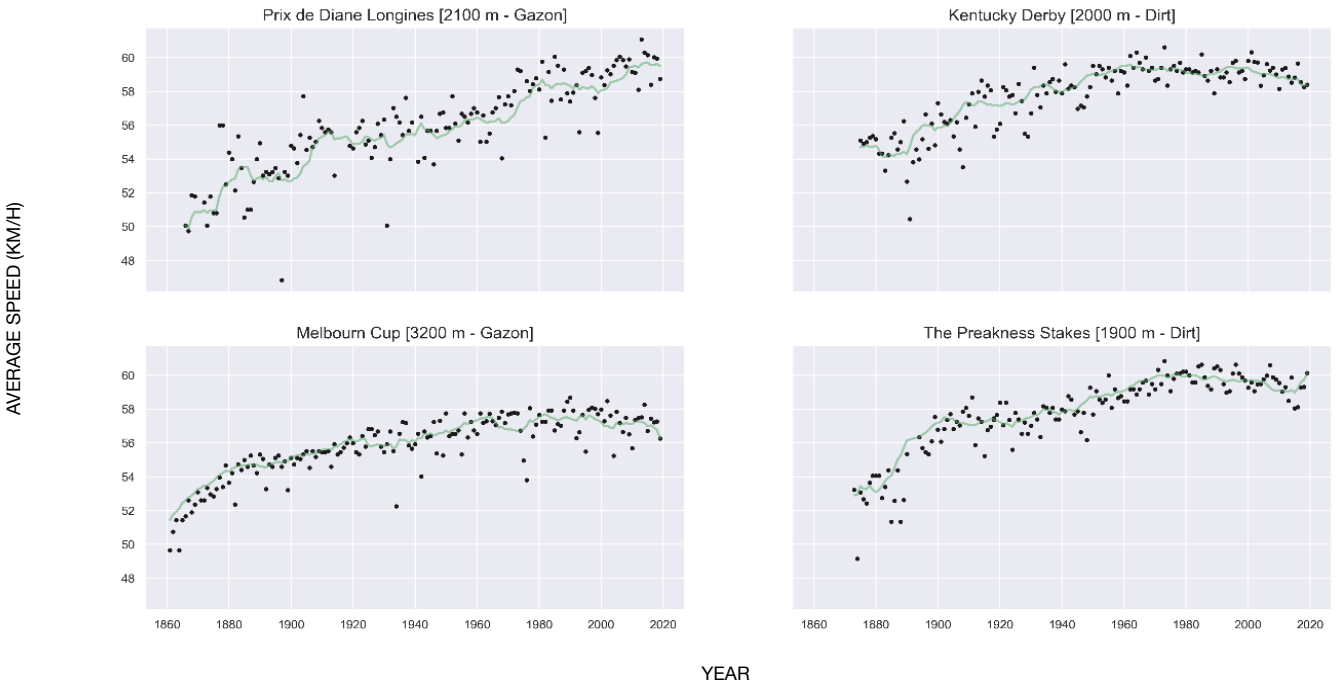
EVOLUTION OF RACING SPEED

Races have very much progressed during the second half of the 20th century, the industry got structured, the ecosystem in its whole gained coherence which lured more investors. Thanks to this, foals began to be better, so their price skyrocketed. However, it is interesting to notice that on the same period of time, the quality and speed of racing evolved in different ways.

For example, it is found that the times of big races like the Prix de Diane, the Kentucky Derby, the Melbourne Cup and the Preakness Stakes increased about 11% from the 1870s to the 1970s. Subsequently, there was a stabilsation of the running speeds except for the Prix de Diane. Breeding, training techniques, improving nutrition, or the improvement of the running surfaces are so many factors that contributed to the elevation of the level of the races.

Until the 1950s, the program of improvement of thoroughbred breeding has had a very important impact on the quality of the horses and therefore on their speed. Since the 1950s, the impact of livestock breeding on performance during races had a more limited effect.

Note also that the variation in running time on the dirt (here we can analyse the Kentucky Derby) is much lower than on grass. Indeed the quality of the turf tracks is variable each year. Maintenance techniques have been improved, which allows turf racing to see their running times improve more consequently.
As for the Melbourne Cup, it's a race where the horses are levelled in their adding weight, which may account for a certain balance of performance [Gardner, 2006].



Evolution of the average speeds of 4 major races since the 1880s

THE SCIENTIFIC LANDSCAPE IS STILL VERY IMMATURE

Nowadays, it remains difficult to find scientific documentation and studies which are precise and serious about speed during racing and training. The Arioneo team used every resource of which they could prove how serious it was and you can find them in the references at the end of this white paper.

The scientific landscape, still immature today, is growing thanks to the use of state-of-the-art technologies. Heart rate monitors, electrocardiograhs, more precise GPS, tracking systems in racetracks and sophisticated locomotor sensors contribute to research in the equine industry.

Thanks to our EQUIMETRE technology which combines electrocardiograph, GPS and locomotor sensors, Arioneo supports each year many research projects and is committed to extend the industry knowledge about it. This knowledge represent a benefit to the whole industry and contribute to a more respectful, safe and performant way of training racehorses.

CHAPTER 1 | HORSE RACING SPEED ANALYSIS

The question of speed is a central issue since the key factor to winning a race lies in managing speed throughout the race. All races are different and many events disrupt the evolution of speed during the race.

In order to understand how the parameters influence the race, it is interesting to get

What strategy do the winners adopt for their finish ?
Over long distances ?
How does the ground affect speed ?
To what extent do Group 1 winners run faster than handicap horses ?
From one country to another, how do racing and training strategies vary ?

1 AVERAGE SPEED AND FINISH LINE

The highlight of a race and the most beautiful impressions of speed often occur in the final straight line, at the finish during which the race ends. But these impressions of speed and acceleration are not always true in practice.

Is the finish line always run faster than the rest of the race ?
How do horses and jockeys optimise their speed to preserve their finish ?

To address the issue of speed in racing, split times – or intervals – are an ideal tool. They can shed valuable light on the way races are run, because they allow you to analyse the **different phases of the race**, **acceleration strategies** and **speed in the final line.**

Logically, we can expect to see slower rhythms, gradually increasing, then faster in the end of the race, and slower again at the end of the race when the horses peak in their speed at the finish and slow down in the last meters because they have exhausted their energy reserves. However, as speeds are affected by the curves and topographical undulations of the track, this remains a very general rule.

SPEED

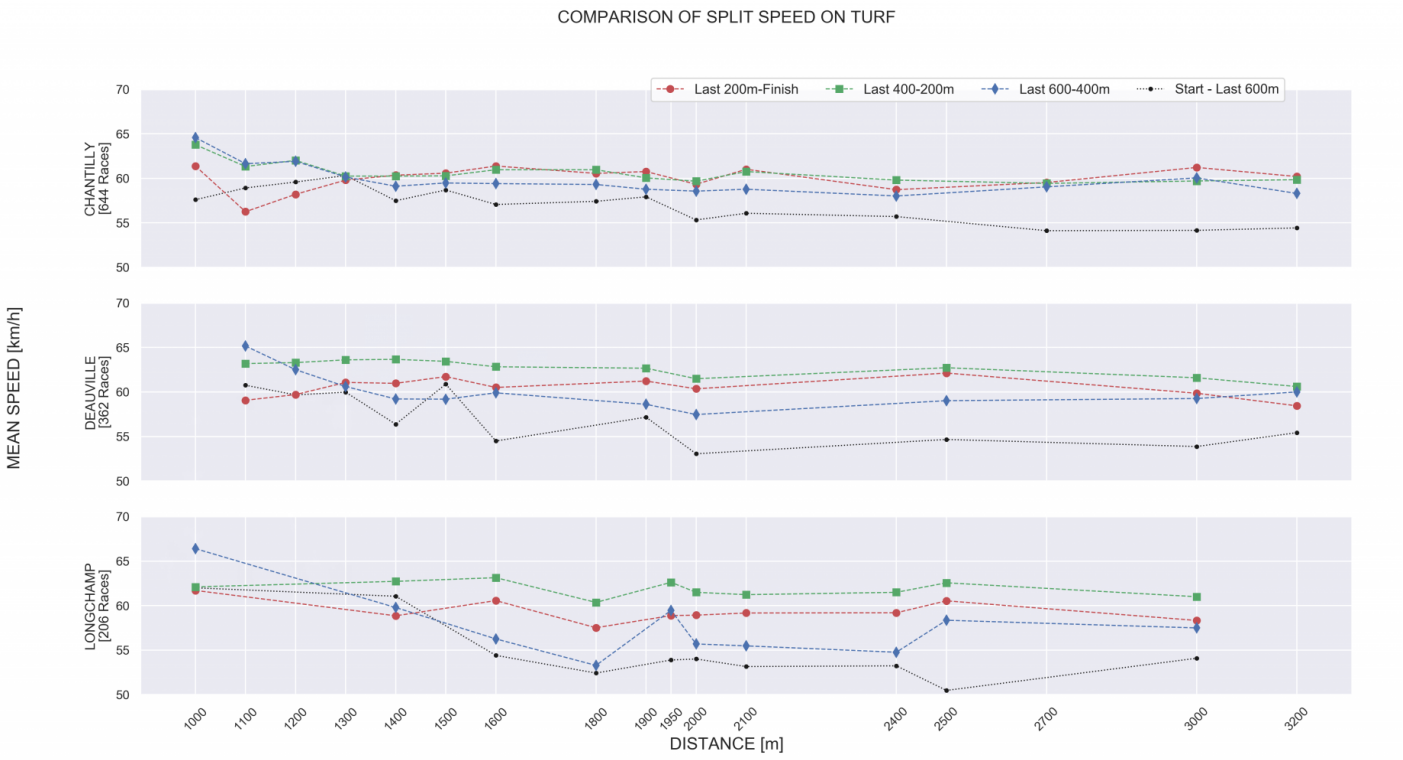
The speed of a horse is the ratio between the distance he's going to run and how long it's going to take him to travel that distance.

$$Speed = \frac{Distance}{Temps}$$

Speed can be expressed in several ways according to geographical areas, and by discipline.

In Europe, speeds are classically expressed in km/h, i.e. the number of kilometres travelled in an hour. More rarely is the speed expressed in metres per second (m/s). In English-speaking cultures, we'll talk more about "miles per hour" (mph, 1 Mile = 1.6 Km). When trotting, another way to analyse speed is preferred when studying mileage reductions. One then speaks of minutes per kilometre (min/km), or the number of minutes it takes to walk through a kilometer.

2 SPEED AND SPLIT TIMES ANALYSIS



Comparison of grass racing speeds over the different intervals in Chantilly, Deauville and Longchamp

The graph above compares race speeds and split times for grass races at the Chantilly, Deauville and Longchamp racecourses. First of all, it can be seen that the race pace is on average higher at Chantilly than at Deauville and Longchamp.

On the Chantilly and Deauville racecourses, it is interesting to note that in short distance races (1300m and less) the average speed of the last 200m is the lowest and that the last 600-400m are run faster than the last 400-200m. This clearly underlines the fact that the horses are thrown at a highspeed and that in the last 200m the horses slow down with a clear break in speed. The horses that will make the finish will be the ones capable of maintaining a high speed for as long as possible rather than those with the greatest acceleration capacity. This type of behaviour is also found in Longchamp races up to 1400m. Over 1300m, the horses at the finish will be those capable of maintaining a high speed for as long as possible rather than those with the greatest acceleration capacity.

The rhythm of the race is defined as the average speed at which horses run before accelerating to end the race. This notion is all the more true for races which are longer than 1400m. There, it will be defined as the average speed from the start until the last 600m.

Beyond 1400m, the race strategy differs.

The horses sprint a reasonable race pace of around 55 km/h and gradually accelerate over the last 600m.

At Chantilly, the speeds over the last 600 metres are quite similar to those of the race pace.

At Deauville, the speed of the last 200 meters is slightly lower than the last 400m-200m, which shows the difficulty of the track.

At Longchamp, the deceleration in the last 200m is even more pronounced due to the slope in the straight line that limits the horses ability to accelerate.

Depending on the distance, the racing strategies are different. Therefore the training strategies have to be adapted according to the targeted race. In short races, the horse must be able to maintain a high speed from start to finish. During longer races, the horse must be able to maintain a correct speed and then accelerate.

During training, the horse must learn to accelerate to reach his top speed.

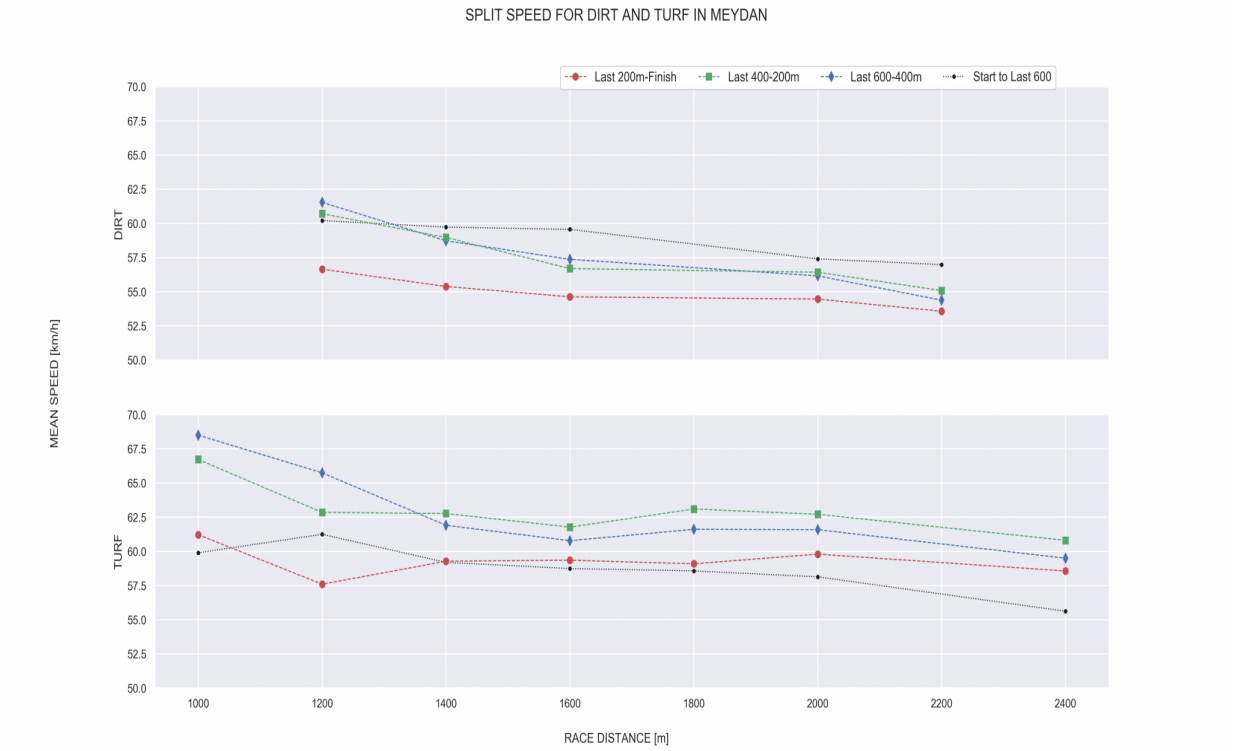
The strategy will then be based on the level of this top speed, the higher it is, the later the horse can be launched, surprise his opponents, and boost the horse's morale by letting him overtake his competitors.

ORDER OF MAGNITUDE

To give a rough estimate, over the last 200 meters, 3 km/h of difference between two horses induces about 10 meters of difference, the slowest horse must therefore be thrown 10 meters earlier to have a chance to cross the line in the lead.

It is interesting to compare these French analysis with international strategies. What about Dubai, for instance?

Let's look at the split times of the races at the Meydan racecourse in Dubaï. On the Dirt, we notice that the race is run very differently. The race pace is very fast (up to 600m after the start), then the speed decreases on the last 600-400m, stays the same on the last 400-200m and drops drastically on the last 200m. We can see that the room left for acceleration is very limited. The horse that will win the race is the horse that will be able to maintain his speed and resist tiredness until the last moments. The level and this speed profile make one think of a typology of race on heavy ground. This means that it will probably be rather powerful horses who will carry the victory.



Comparison of racing speeds on grass and dirt at different intervals
MEYDAN Racecourse - Dubaï

On the grass at Meydan, the tracks are run in a slightly more similar way to French races. Above 1400m, the race pace is moderate then the horses gradually accelerate to reach their maximum in the last 400-200m, then the average speed drops sharply in the last 200m. In contrast to France, the horses are launched much earlier with an average speed in the race pace and in the last 600-400m about 5% higher. The average speed in the last 400m is slightly lower than in

It is therefore noticeable that racing strategies from one country to another, from one racecourse to another, or from one track to another can be very different. In what follows, we will attempt to quantify the impact that the different parameters can have on the way the race is run.

GRASS - CHANTILLY	1000	1100	1200	1300	1400	1500	1600	1800	1900	2000
Average speed [km/h]	61,2	60,1	60,4	60,3	58,6	59,5	58,3	58,2	58,6	56,5
Race pace [km/h]	57,6	58,9	59,6	60,3	57,5	58,7	57,1	57,4	57,9	55,3
Last 600m [s]	34,17	36,22	35,61	35,96	36,06	35,94	35,66	35,84	36,09	36,50
Best 200m [s]	11,15	11,68	11,61	11,95	11,93	11,89	11,73	11,81	11,85	12,07

GRASS - DEAUVILLE	1000	1100	1200	1300	1400	1500	1600	1800	1900	2000
Average speed [km/h]		61,6	60,5	60,6	58,5	61,0	56,8		58,1	55,2
Race pace [km/h]		57,6	58,9	59,6	60,3	57,5	58,7		57,1	57,4
Last 600m [s]		34,64	34,96	34,99	35,28	35,18	35,38		35,54	36,17
Best 200m [s]		11,05	11,38	11,32	11,31	11,35	11,46		11,49	11,71

GRASS - LONGCHAMP	1000	1100	1200	1300	1400	1500	1600	1800	1900	2000
Average speed [km/h]	62,9				60,9		56,4	54,6	55,5	55,2
Race pace [km/h]	57,6				58,9		59,6	60,3	57,5	58,7
Last 600m [s]	34,11				35,76		36,10	37,97	35,84	36,86
Best 200m [s]	10,85				11,48		11,41	11,93	11,50	11,71

GRASS - MEYDAN	1000	1100	1200	1300	1400	1500	1600	1800	1900	2000
Average speed	62,9		61,6		60,3		59,6	59,2	58,7	58,9
Race pace	59,9		61,3		59,2		58,7	58,6		58,1
Last 600m	33,06		35,01		35,27		35,65	35,37		35,16
Best 200m	10,94		11,46		11,78		12,14	12,34	12,66	12,38

DIRT - MEYDAN			1200		1400		1600		1900	2000
Average speed			59,7		58,9		58,1		57,1	57,1
Race pace			60,2		59,7		59,6			57,4
Last 600m			36,25		37,43		38,63			38,83
Best 200m			11,89		12,35		12,78		13,05	13,02

Detail of the racing speeds on the different intervals on Grass and Dirt Chantilly, Deauville, Longchamp (France) and Meydan (Dubai) racecourses

3 SPEED AND TOPOGRAPHY

The slope has a clear and intuitive impact on humans' body and therefore on speed. On uphill slopes, muscles are more strained and require greater energy expenditure at the same speed. On the opposite, on a downslope, the energy expenditure required is lower, and reaching a fast speed is easier. The acceleration caused by a downslope is explained by the energy gain resulting from the displacement of the body's centre of gravity with the drop in altitude. A slope even allows to reach over-maximum speeds, higher than the maximum speeds reached by the athlete during his training.

Training at over-maximum speed, achieved through a downhill slope for example, also allows the sprinter to better understand his pace and his body when he reaches his maximum speed. In addition, alternating uphill and downhill training allows the human athlete to increase his maximum speed. However, the loss of speed on climbs is twice as high as the gain in speed on downslopes.

However this rule is not true for horses

This is shown in particular by the study on the links between speed and slope of the terrain, conducted by the Structure and Motion Lab of the Royal Veterinary College of London.The aim of this study was to establish whether or not racing speeds could be explained by a power limit. Thus, if the speed was mainly explained by the power relatively to the physical effort required, the climbing speed should prove to be less important and the descending speed more important, the energy effort required being respectively more and less important.

The results of their study refuted these assumptions. Contrary to what was expected, the maximum speeds achieved during the race occurred when the slope of the terrain was neutral. In all other cases of slopes, whether ascending or descending, speeds decreased.

Uphill or a downhill, the horse reduces his speed.

Uphill slopes

Data collected on uphill slopes supports the hypothesis of a metabolic power limit of speed. The steeper the ascent, the greater the effort required of the horse. In an uphill race, this means that horses with a higher metabolism will stand out from others in their ability to compensate for the additional energy cost caused by the slope by better energy mobilization to maintain a constant speed.

Downslopes

On the other hand, in a downslope, a decrease in speed is noticed when the decrease in power requirement was expected to explain an increase in speed. The fact that the horses also slow down on downwards slope proves that factors other than metabolic factors are involved in explaining speed regarding topography. It is not only the efficiency of the heart and muscles, the sources of the general energy supply, that influences speed.

The following results are from the article by Self et al (2012). This is the only study to present the influence of elevation change on racing times in horses to the best of our knowledge. In addition, some readers have reported disagreeing with the data presented in this article. We, therefore, invite you to take a step back from the following results. If you know any articles that confirm or refute the following results, we would be happy to include them to illustrate our point.

When going downhill, the weight of the horse moves forward, on the animal's forehand. Thus, a greater energy consumption of the forelegs justifies a small part of the observed slowdown but this is considered negligible. **Two main hypotheses** are put forward by scientists.

The decrease in downhill speed could be explained by the different muscular and tendinous aptitudes of the forelegs in horses and humans. In horses, the fibres of the foreleg muscles are shorter than those of humans, and the structures of the extensor tendons of the equine knees are less effective in countering the gravity-induced compression of the limbs. Thus these factors would not allow the horse to face the downslope with as much efficiency as humans. If this hypothesis were to be verified, training work carried out downhill would enable the horse to adapt his muscles and tendons to this type of effort and his capacities on the slope would increase. Thus, when the horse faces a slope, uphill or downhill, the horse reduces his speed.

More probably, this slowing down in the downslopes could also be explained by a mechanical functioning of the forelegs, inherent to the horse, which is not conducive to high speeds in downslopes. If this hypothesis prevailed, working on the slope would not help to improve the speed of the horse downhill, and would even cause risks of injury by pushing the skeleton and the musculature which, because of their constitution, do not allow to reach high speeds downhill. The difficulty for horses to maintain high downhill speeds may be due to the anatomical simplicity of their forelegs which limits weight resistance and stability.

A last hypothesis, less considered by scientists, is the influence of the psychology of the horse, or the influence of his free will. Difficult to assess, these parameters of fear, the reflex to preserve his integrity, his will to keep control of his gait, can vary according to the horse and explain in part why they tend to slow down in the downslopes.

The answer to this question requires further study. Arioneo's teams are putting their expertise in studies and the design of algorithms to work on a daily basis in order to be able to contribute to Research that will one day help to settle this debate.

4 SPEED AND TRACK DESIGN

Race track layouts are conventionally based on two straight lines connected by two circular curves. In the curves, the horse is subject to centrifugal force which tends to pull the horse out of the curve. The centrifugal force increases as the radius of the curve decreases or the speed increases. To compensate for the effect of this force, curves are mainly drawn with an increasing cant from the inside of the rail to the outside. This type of design can also be seen in curves of motorways or railways. When there is no curve canting, the horse is forced to reduce his speed and compensate by adapting his locomotion to stay on the inside of the curve and not give in to the centrifugal force. This compensation can induce a higher load on the joints. It has been shown that a poorly designed track can lead to asymmetric locomotion, resulting in locomotor disturbances and injuries.

Furthermore, it is also necessary to define the slow transition between the curve and the straight line, this will favor the horse's balance and natural stride and limit the mechanical stress on the limbs. It is therefore important to have a well-designed track to boost the horse's speed and natural stride.

Straight line training should be preferred to limit mechanical pressures.

However, training in bends should not be neglected in order to accustom the horse to the sensations. It is also important to train on left-handed or right-handed tracks to avoid creating muscular asymmetry and compensatory phenomena of locomotion linked to training in only one direction of rotation. As all horses have their preferred side, it is interesting to draw objective figures from the right-handed and left-handed trainings. In order to make informed racing choices, **knowing the time variations over a given interval**, on a left-handed track versus a right-handed track, **can be decisive**.

In order to evaluate the influence of the curve on race times, we can compare the 1600m races at Deauville in a straight line and in curves, for races with conditions and handicap races, on grass.

	Total	Start-1000m	1000m-1200m	1200m-1400m	1400m-Finish
RACE	Times [s]	Times [s]	Times [s]	Times [s]	Times [s]
RIGHT-HANDED TRACK	110,65	68,37	12,93	11,64	12,14
STRAIGHT LINE	98,37	62,21	11,58	11,64	11,72
	AVERAGE SPEED [km/h]	AVERAGE SPEED [km/h]	AVERAGE SPEED [km/h]	AVERAGE SPEED [km/h]	AVERAGE SPEED [km/h]
RIGHT-HANDED TRACK	52,1	52,7	55,7	61,8	59,3
STRAIGHT LINE	58,6	57,9	62,2	61,9	61,4

Comparison of average times and speeds for a straight line and a curved race including a right-hand track over 1600m, on grass, on the Deauville racecourse for a race with conditions and handicap

Non-straight races are on average 11% slower than straight races.

It's on the first 1200m that the difference is the biggest. Indeed it is where the turn happens. The speeds over the last 400m are almost identical. We notice a slightly lower speed of 2 km/h on the last 200m of the right-handed race. This can possibly be explained by the fact that despite the lower speed, racing with bends requires more energy to compensate for the effects of centrifugal force, energy that is no longer available to maintain the effort to the finish line. However, this hypothesis still has to be confirmed.

Every racetrack has specificities. Therefore, it's important to train horses in order for them to be fully performant facing all kind of tracks, despite their design specificities.

5 THE INFLUENCE OF TRACK TYPES AND CONDITIONS ON SPEED

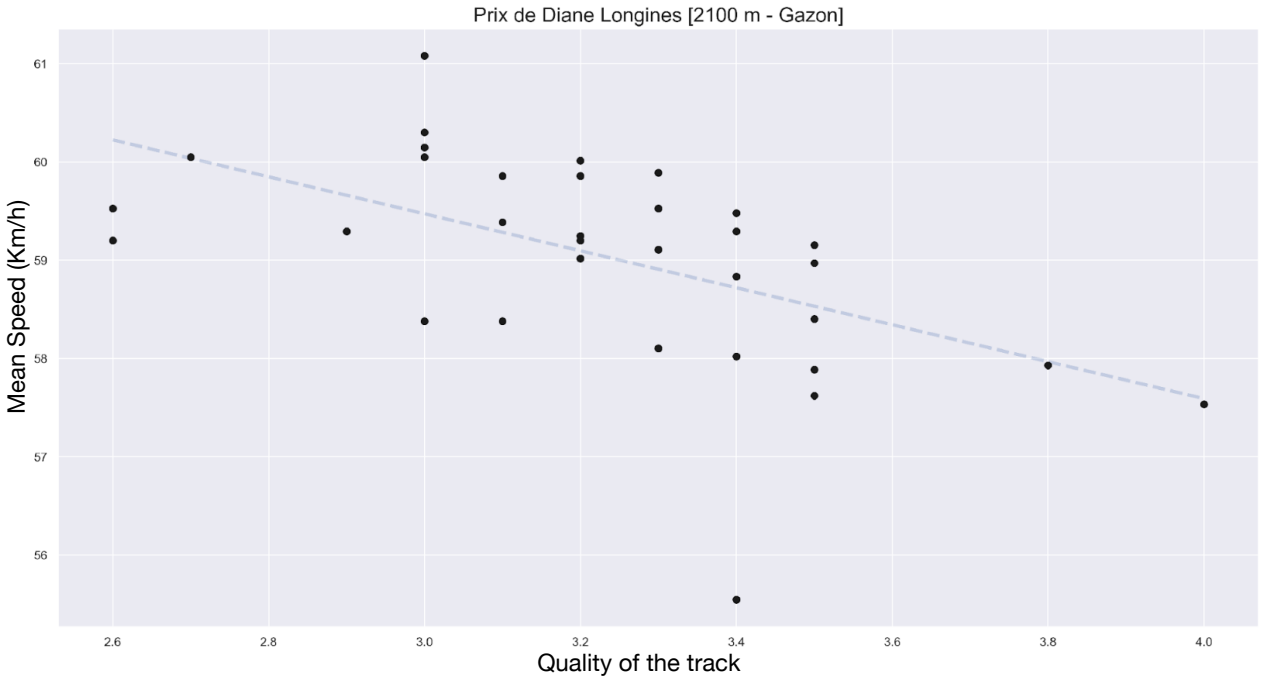
The type of track has a strong impact on the performance of the horses. They are all affected by the condition and nature of the track on which they run, but they won't be impacted in the same way. Each horse has one or more types of track on which he will perform at his best. Analysing regularly the speed performance of a horse on several types of tracks is interesting to better understand his physiological and athletic aptitudes.

How to analyse the training speeds of horses while taking into account the track type and its conditions ?

The track condition will mainly depend on its maintenance. For example, grass needs a very meticulous maintenance. Indeed, it is necessary to water it regularly while paying attention to the weather, fertilise the soil, remove weeds, aerate the sub soil, mow the track, etc.

The rain and humidity in the air soften the soil and therefore the weather plays a fundamental role. Horses with a fairly large mass find it more difficult to run on deep tracks.

The average speeds on the different Prix de Diane depending on the condition of the track is a good example. We can notice a very big influence of the track condition, with a loss of almost 2 km/h on the average speed between a good and a very soft ground.



Influence of the quality of the track on the average speed of the Prix de Diane

Measuring quality : The Penetrometer

One of the conditions impacting the performance of racehorses and therefore the pronostic is the quality of the track. To determine the condition of the track, the racetrack stewards use a specific instrument: a penetrometer. It is an iron rod with a one-kilogram point in the shape of a shell which is used by dropping it at a specific height and then measuring the depth at which it has penetrated the ground. Three consecutive shocks are made two or three metres from the lice at ten key points on the track. All the data collected gives an average numerical value ranging from 2.2 to 6 or more. The penetrometric index is usually measured in newtons (N).

The day before the races, the stewards measure the quality of the ground before noon and publish the index and the qualification on the website of France Galop. On the day of the races, they publish at 10am the qualification of the ground conditions. Two hours before the meeting, the stewards decide on a new schedule for measuring the terrain.

Finally, if during the meeting the stewards notice a noticeable change in the condition of the ground, they publish this news on the racecourse website.

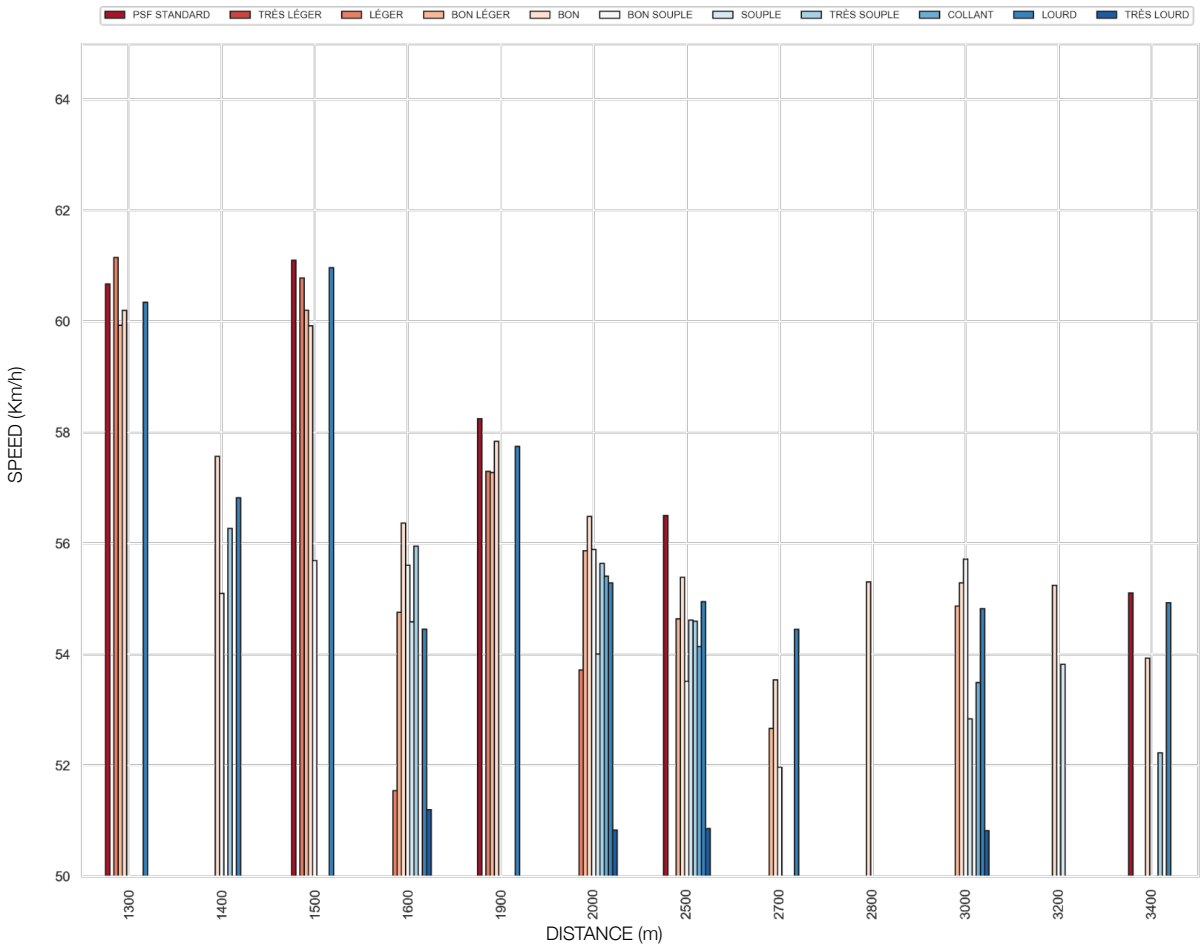
— Quantification of the influence of track on speed

We will use data collected at the Deauville racetrack to illustrate our point. The following graph shows the speed data. We can notice that the fiber-sandtrack is the fastest one. Fields rated good or close to good are generally the most conducive to the best speeds on grass. We also note that sticky, heavy and very heavy fields are generally the slowest. In Deauville, it is very interesting to train the horses on fiber-sand to give them the opportunity to experience full speed.

Training at over-maximum speed is very interesting and offering the opportunity to run at a high speed several times during the season is a great opportunity. It also allows to develop locomotor skills, coordination and balance at full speed. Working on heavier ground is also interesting to strengthen the muscles.

Ideally, heavy field work followed by trainings on fiber-sand track can allow the horse to do hard work and then easy movement, which from a perception of speed and morale point of view can be very good.

INFLUENCE OF TRACK TYPE ON SPEED DURING RACES IN DEAUVILLE



DISTANCE	PSF	VERY SOFT	SOFT	GOOF TO SOFT	GOOD	GOOD TO FIRM	FIRM	VERY FIRM	STICKY	HEAVY	VERY HEAVY
1300	0,8%		1,6%	-0,4%						0,2%	
1400						-4,3%		-2,3%		-1,3%	
1500	2,0%		1,4%	0,5%		-7,1%				1,7%	
1600			-8,6%	-2,9%		-1,4%	-3,2%	-0,7%		-3,4%	-9,2%
1900	0,7%		-0,9%	-1,0%						-0,2%	
2000			-4,9%	-1,1%	REFERENCE	-1,1%	-4,4%	-1,5%	-1,9%	-2,1%	-10,0%
2500	2,0%			-1,4%		-3,4%	-1,4%	-1,4%	-2,3%	-0,8%	-8,2%
2700				-1,6%		-2,9%				1,7%	
2800											
3000				-0,7%		0,8%	-4,4%		-3,2%	-0,8%	-8,1%
3200							-2,6%				
3400	2,2%							-3,2%		1,9%	
MEAN	1,53%		-2,27%	-1,08%		-2,76%	-3,19%	-1,82%	-2,47%	-0,31%	-8,85%

Variation of the average speed in percentage in relation to a field for condition and handicap races at the Deauville racecourse

Moreover, monitoring horses on a daily basis on the same track but in different conditions is very interesting. It makes it possible to find out which horses are the most suitable for which type of terrain. For example, a horse having a low speed on heavy track and a high heart rate is a horse who needs to train more to race, while another may be more confortable.

6 SPEED AND THE INFLUENCE OF SHOEING

At the races, when it comes to weight, everything counts. From the rider's equipment to the one of his horse, the horse's team tries to reduce the weight carried by the horse as much as possible in the hope of limiting his energy expenditure and therefore improving his speed.

What does science say about it ?
What is the impact of weight on the horse's speed ?

To study these questions we will make a distinction between harness racing and flat racing, for which different reasoning apply. When trotting, the question of weight is particularly relevant to the shoeing, which we'll be looking at. For thoroughbreds, as running without shoes is forbidden, this issue will be studied along with the handicaps and the impact of the weight added to the horse.

The impact of shoeing on the trotter's speed

Unlike flat trainers in France, harness trainers can choose to have their horses run without shoes, or barefoot. For flat racing, it is forbidden in France to run barefoot for two-year-olds, then it is more a question of permanent unshoeing for horses that are not comfortably shod, rather than a strategy to gain speed. Regulations vary from country to country. Within trotters, this technique is a real strategy and consists in removing the horse's shoes just before the race after a meticulous preparation of the horse's foot. The schedule has to be carefully followed in order to find a good balance between speed optimisation and the fact that he has shoes or not. A trotter is considered to be shod when "at least half of his hoof is fitted with a rigid and visible protection which ensures this function throughout the race (with the exception of the resin)". On the contrary, a horse is said to be barefoot "when his hoof is unprotected or protected only by resin"

What are the factors that explain why unshoding implies an improvement in speed?

— Lightness

A horse who is barefoot logically carries less weight, which allows him to improve his speed. Admittedly, it is only about 800 grams gained (about 200 grams per shoe), which is derisory compared to the weight of the horse, but placed at the end of the limb, this weight makes the stride heavier and affects natural locomotion.

— More natural Gait

Without the addition of any artifice at the end of the horse's limb, the trotter's gaits are more natural, which makes it easier for the driver to cause fewer gait irregularities.

— Irrigation and oxygenation of the foot

The anatomy and physiology of the horse's foot is complex. When the foot carries the horse's body by touching the ground, the special anatomy of the hoof provides the horse with a vital cushion for the quality of the stride. The heels spread apart, the fork stretches, which helps to cushion but also compress the blood vessels, increasing the blood pressure in the hoof, which pushes the blood towards the heart. When the foot touches the ground, the foot fills itself again with blood. When the horse is shod, hoof spacing and fork crushing are less important since they are held by the shoe. Thus, the removal of shoes allows a blood pumping system that allows a good oxygenation of the blood and an optimal perfusion of the tissues.

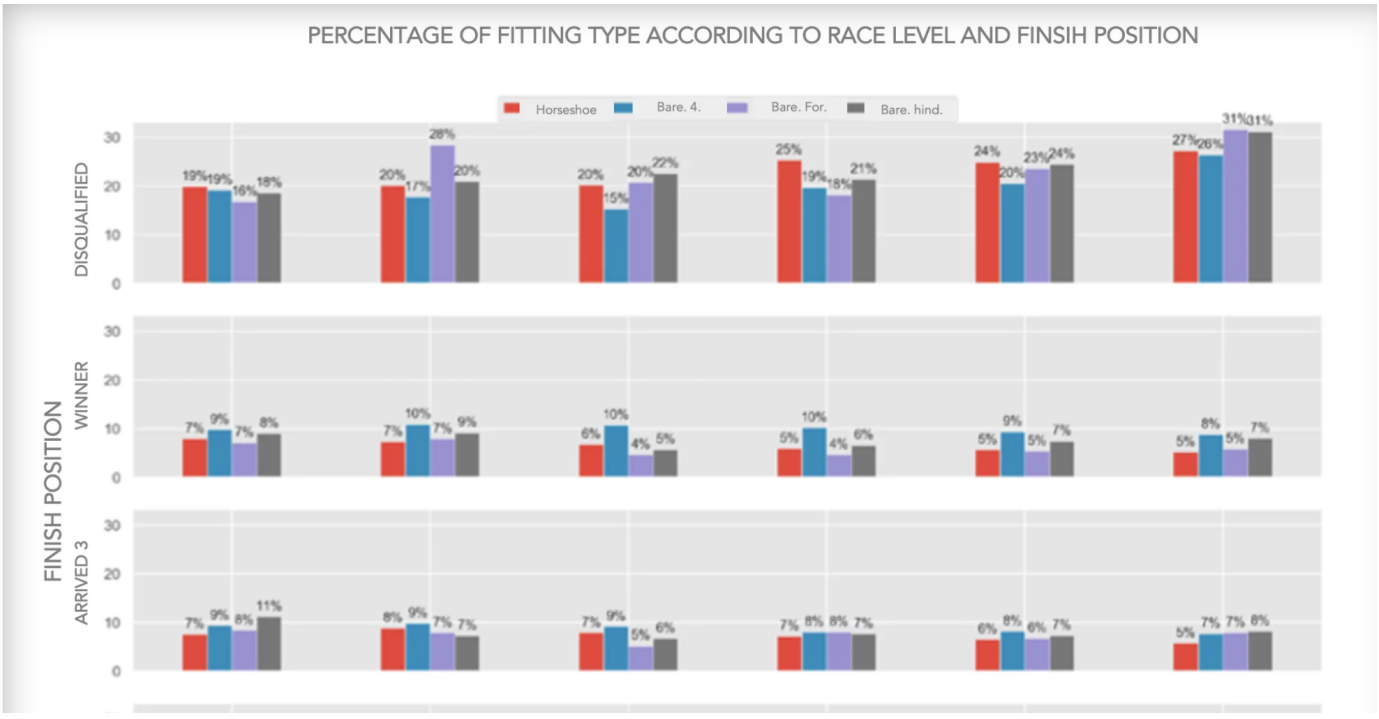
The efficiency of this "suction – delivery" pump depends on the horse (tolerance to the removal of the shoe, condition of the foot and horn), on his type of shoe (barefoot or not, as well as other types of protection such as resin), but also on the type of ground (hard or shock-absorbing) on which he is walking. However, the surface on which the horse runs can also have a detrimental effect on the foot in terms of

— Example: Influence of shoeing on the place at the finish and the level of races at Vincennes in harness trotting

Our data science experts were able to verify these theories. Here are the conclusions they came to. By a first check on numbers, shod horses are more likely to go off stride than horses shod at any level of racing. Furthermore, as the level of the race increases, the proportion of horses going off stride increases.

To win, the influence of shoeing is greater for class races than for group races. Horses that are barefoot have a better chance of winning in class races. This difference is thinner for the 3rd place, however, the horses arriving 3rd are most often barefoot. The difference is even less marked for the 5th place, where there are almost as many shod and barefoot horses. Of course, this statistic can also be explained by the fact that trainers choose to race their horses when they think that their starter have a good chance: the horse is ready to win so we unshoe the horse to put all the chances on his side. Thus, it makes sense that statistically the winners are most often barefoot.

It is interesting to note that hindquarters have better results than forelegs, and in most cases than shod horses. Thus, the issue of shoeing in trotting racehorses is relevant and important when developing the racing strategy because it can influence the horse's speed positively or negatively. Monitoring closely the training speed data for a specific type of training, with and without shoes, can be extremely useful to determine the horse's preferences. In the EQUIMETRE platform, each training can be edited to indicate the shoeing, the track, the track conditions, and the type of training, in order to compare smartly the trainings from one session to another.



Percentage of horses disqualified, winning, 3rd or 5th in relation to all horses shod, shod in all 4 shoes, shod in the front or shod in the back and of the same level of racing.

7 SPEED AND INFLUENCE OF THE LEVEL OF THE RACE

At first sight, it seems easy to say that Group 1 races are faster than condition races. However, figures allow us to nuance this and put an end to some clichés.

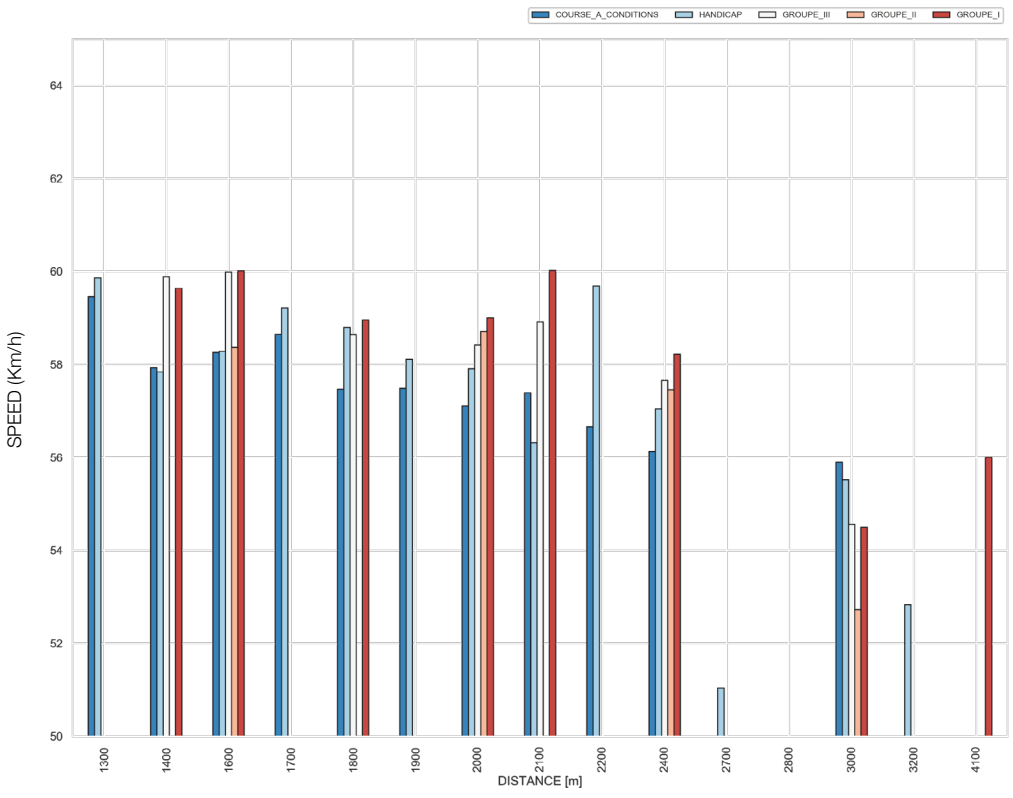
Here is a study about average speed at Chantilly according to the racing categories – and regardless of the quality of the ground.

Generally, this intuitive assertion gets confirmed. The more the quality of the race rises, the more speed rises. With that said, it's interesting to notice that difference of speed between races of Group 1, 2 and 3 are small. For 1400m, 1600m and 3000m races, Group 3 races are run faster than Group 1 races.

Eventually, for long distances – 3000m -, the speed report is reversed : condition races and handicap races are run faster than Group races. It is probably because Group races are more tactical.

It is important to nuance these results because a larger amount of data would be necessary to refine the analysis.

INFLUENCE OF RACE LEVEL ON SPEED DURING RACES IN DEAUVILLE



Influence of the level og the race on the average speed of the race at Chantilly (France)

CHAPTER 2 | TRAINING FOR SPEED

In order to follow the horse speed during training and to be able to compare the training times to race reference times, a good speed monitoring system is necessary for 5 reasons. By monitoring the training speed, the trainer can ensure that his instructions are being followed.

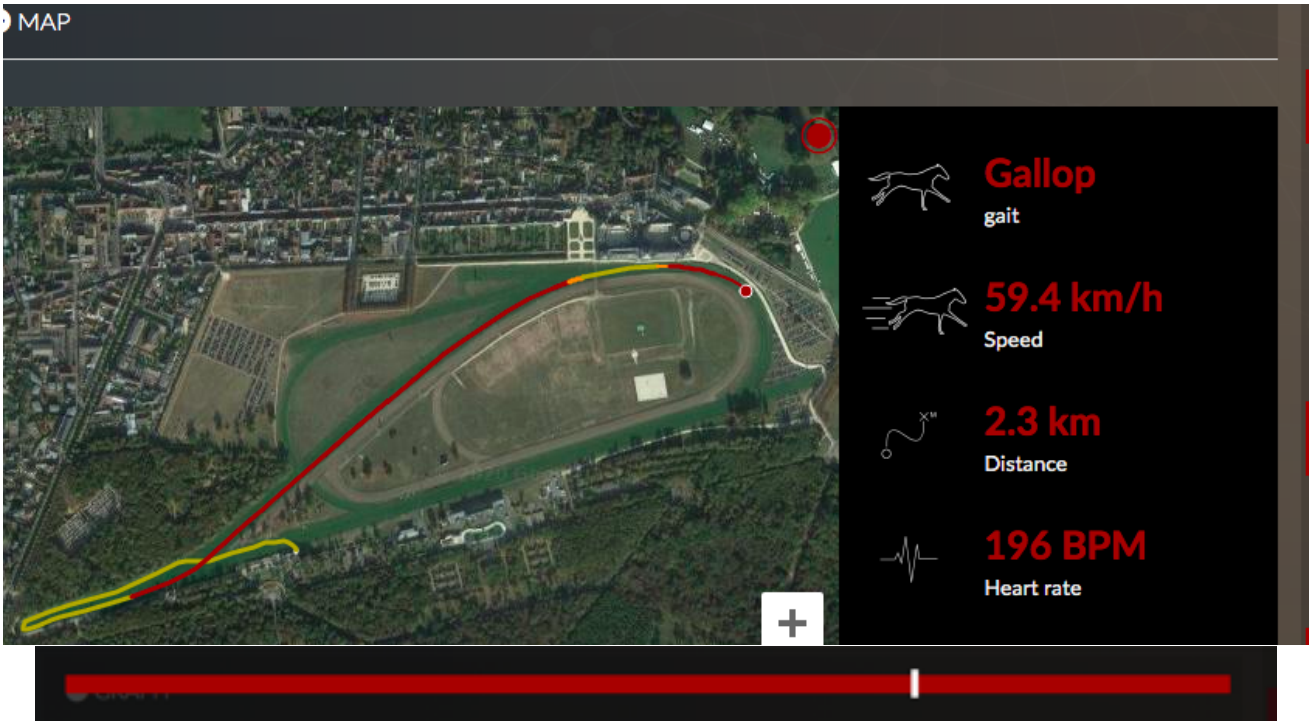
Then he can estimate the horse's response to the effort required and get an idea of the workload he has put on him.

This understanding of how the horse takes on the training allows the individual work of each horse to be adapted according to his response to the previous work. Once the horse is ready to race, the analysis of the split times allows the trainer to make informed decisions about his race choice.

1 RESPECT OF THE INSTRUCTIONS BY THE RIDER

On the one hand, with live GPS tracking, the trainer can follow the speed of his horses live during training, and not only when the horses pass in front of him. With the live speed of all the horses, the trainer can also intervene in the middle of the training if he has communication systems with his riders. In this way he can be assured that all horses are being trained according to his instructions.

In addition, the trainer has at his disposal an a posteriori training replay tool that allows him to analyse, thanks to a map and a scroll bar, how the speed has evolved during the training at specific points corresponding to his instructions. He can then play again the trainings, horse by horse, enriched with cardio and locomotor data.



Training map on the EQUIMETRE platform

2 RESPONSE OF THE HORSE TO THE REQUIRED EFFORT

Depending on the work, the conditions of the ground, the fitness of each horse, the same work will not be taken up in the same way by all the horses. Therefore, during speed training it is important to analyse the parameters of heart rate and recovery. The analysis of the recovery is carried out in two stages, first the **fast recovery after the effort**, then the **recovery at 15 minutes**.

A horse in good shape will show a good “elasticity” in the variation of his heart rate, i.e. the heart will be able to climb up quickly when the effort required is intense and to slow down just as quickly when the effort required is less intense. Depending on the quality of the recovery, the trainer can have a **precise idea of the difficulty of the day’s work** for the horse and then be able to anticipate possible over or under training, to understand that a certain exercise is not assimilated for a certain horse or, on the contrary, that a certain training was easy for another.

3 INDIVIDUALISE THE HORSES WORK

By analysing the response to the required effort, the trainer can make the horse progress faster by identifying points for improvement more effectively.From then on, a custom training for each horse becomes possible.

Analysing the impact of the different parameters which influence the speed of each horse is a matter of setting a variety in the nature and intensity of the effort required into the analysis. By varying the work, it will be possible to isolate the preferred parameters by the horses or, on the contrary, those representing the greatest difficulty for them. For example, the horses could alternate between long-distance canters, and high-speed gallops on the grass.

To vary the types of tracks, working on deep tracks forces the horse to use his muscles and thus develop them as well as his respiratory capacities. Then, by linking this work with faster tracks such as the fiber-sand tracks, the horse can loosen up and experience higher speeds, which will also have the benefit of having a positive influence on his morale.

Finally, varying the work also depends on the hand the horse is being worked on, and it will be wise to analyse for example the best 600m done on a right-handed track and on a left-handed track, with the same effort required. In this way, the trainer will have objective and precise data at his disposal to make his choice of enrolment.

In the same perspective, it is useful from time to time, in agreement with the veterinarian and taking all precautions to preserve the integrity of the horse, to experiment with top speeds in training, similar to racing speeds. These punctual maximum speed training sessions will allow the analysis of intermediate times in comparison with those observable during a race. This can also be useful in assessing the maximum heart rate for each horse. However, these maximum speed training sessions should be conducted with care to avoid any risk of injury.

4 ANALYSING SPLIT TIMES TRAININGS

The analysis of split times in the race, compared with the analysis of split times in training, is a main tool for decision support in race entries. The trainer is able to know whether a particular horse is ready for a particular race. By comparing race data with his training data, he will be able to decide more easily which race to enter, and which horse to choose.

Let's take a concrete example. The two-year-old horse Arion (anonymised, as well as all the data in the document), entered in St Cloud in a 2000m race with conditions (for 2 years never having won), whose intermediate times are shown below. The weather was rather bad on the day of the selected training (7.7 degrees under an overcast sky with light rain), so the ground was rather heavy.

		Gait	Distance meters	Time min	Pace km/h	Average HR bpm	Average tilt %	Stride Length meters	Stride Freq. stride/s
▶	1	Walk	1520	13:52.0	6.6	112	0.0	0.0	0.01
▶	2	Trot	285	01:05.0	15.8	166	0.1	2.6	1.65
▶	3	Gallop	1300	03:27.0	22.6	175	-0.0	3.5	1.84
▶	4	Walk	700	07:23.0	5.7	95	-0.1	0.0	0.06
▼	5	Gallop	1790	02:37.0	41.0	203	-0.1	6.2	2.16
			190	00:13.6	50.0	184	-0.5	6.25	2.23
			200	00:12.6	56.8	204	0.3	7.00	2.28
			200	00:11.6	61.7	207	0.2	7.35	2.31
			200	00:11.3	63.5	209	-0.2	7.62	2.34
			200	00:11.6	61.7	210	-0.1	7.39	2.33
			200	00:13.3	54.0	211	0.3	6.78	2.24

Intermediate times table on the EQUIMETRE platform

In the intervals framed in red, we see that the horse was doing a canter. Let's calculate the average of these intermediate times. We find 13.8 seconds.

Application to a race

On average, on the racecourse of St Cloud, in races with conditions of 2000m, on a ground from sticky to very heavy (predictable according to the weather), races are run in 146.21 seconds, with average intervals of 200m run in 14.2s. This calculation was carried out using a sample of 20 races meeting all these conditions, based on data found on PMU.com.

We can thus see that Arion, which was at his fastest at 12.0 and 12.3, and on average at 13.8 (average in the red square above), was therefore ready to run and win this race. The horse won the race by several dozen lengths.

SPEED ANALYSIS - WHAT YOU SHOULD KNOW

DETECT FUTURE PERFORMERS & INDIVIDUALISE WORK

Detect future performers

Once all the horses are ready to work on speed, a standardised test can be carried out. Performing the same exercise under the same conditions with all the horses of the stable allows comparisons to be made based on comparable data. This allows to detect future performers - horses with outstanding data.

Individualise training

With a standardised test, the speed ability and fitness of each horse are quantified. This is also a way to detect the future performers and the strenghts & weaknesses of the horses. You can then group your horses depending on what they should work on.

IDENTIFY TRACK PREFERENCES & MAXIMISE YOUR CHANCES

The indicators you should assess when identifying the track preferences are :

- **Stride changes over 60km/h** (in stride length & stride frequency) - if it varies a lot, the horse might have encountered difficulties in performing on this types of track.
- **Recovery** - If the recovery time is long, it means that the horse has made a heavy effort.

Factors influencing speed

Topography	Level of the race
Track design	Shoeing
Track quality	

DECIDE ON A RACE ENTRY THANKS TO SPEED ANALYSIS

Split times analysis

The trainer is able to know whether a particular horse is ready for a particular race. By comparing race data with his training data, he will be able to decide more easily which race to enter, and which horse to enter in which race.

Method

Calculate the average split times of the 200m of the targeted race & calculate the average speed time of heavy work in the same condition of the race (track types & quality if possible) and then compare them to assess wether the horse is ready or not.

THE EXPERT OPINION

Dr Emmanuelle van Erck

Veterinarian Doctor, European specialist in internal equine medicine Equine Sports Medicine Practice, Belgium

Sports performance is no coincidence. It is the result of optimal physical preparation and excellent health. The technological revolution over the last 20 years has changed our approach to sport, regardless of the athletic discipline. Connected objects allows athletes and their trainers to objectively measure the body's response to physical effort, whether the athlete was doing too much or too little and to what extent training could be optimized, both to improve performance and to avoid injuries.

Arioneo has developed EQUIMETRE, a new system for measuring and monitoring the horse's physical performance. Unlike other connected devices, EQUIMETRE allows integration of many sporting parameters, while offering a simple understanding of the exercise. The trainer has, at his disposal, the ability to re-run trainings, the speed of the horse, and also, furlong by furlong, locomotion and heart rate. The quality of the measurements is such that they can be used to establish a diagnosis of cardiac arrhythmia based on the recorded electrocardiogram.

«EQUIMETRE from Arioneo has established itself as a partner in the health and performance of horses.»

The training strategy depends on the level of fitness and recovery after work and competition. EQUIMETRE makes it possible to evaluate recovery in the short and medium term, giving information on the horse's state of fatigue and his ability to progress.The measured parameters can be compared from one training session to another, from week to week. The trainer therefore has the means to concretely evaluate a horse's progress during training, to compare the individual horse to himself as well as to other horses on the yard. Thousands of measurements acquired with horses of different profiles have made it possible to understand how each horse responds differently to his training. Therefore allowing the difficulty of the work of each athlete, to be adapted according to each individual's capabilities. Thus, when a horse responds easily and quickly to work, the trainer can safely choose to intensify the exercise and optimize the horse's state of fitness.

True to its origins, EQUIMETRE is intended not only to be a training monitoring tool but also a tool in sports medicine, useful for monitoring the athlete's health. The measurements make it possible to establish if the horse has worked within the limits of its physical abilities. If his capacities have been exceeded, is it the result of a lack of quality or a possible weakness related to a health problem that has evolved slowly ? The concept is to allow the trainer to react immediately and prevent problems and injuries before they occur. In a horse that has a proven injury or disease, EQUIMETRE is used to accompany the revalidation period, to determine if recovery times and recovery procedures are working. This avoids returning to work too early and to step up training at the horse's own pace.EQUIMETRE from Arioneo has established itself as a partner in the health and performance of horses.

ARIONEO

EQUIMETRE

Equine technology dedicated to the training of racehorses

Optimise horses performance

Detect future performers
Analyse speed aptitudes
Detect locomotor profiles and preferred distance

Follow-up of horses health

Prevent the risk of injury
Analyse underperformance
Communicate with your veterinary team

"We tried to extend the racing distance of one of my horses, Fast and Fearless. The aim was to get him to a stayer, on 1400m and 1600m races. However, looking at his data collected by EQUIMETRE (stride frequency and stride length), we jumped him back to 6 furlongs races and he's won his last few starts."

James Peters
Group 2 & 3 racehorses trainer in Singapore

EQUIMETRE IN 4 STEPS

- SET UP IN 30 SECONDES
- DATA COLLECTION
- DATA DOWNLAOD
- DATA ANALYSIS

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