TrackStat

COACHES' GUIDE



THE FUNDAMENTALS

THE COACHES' GUIDE TO SPEED

A practical guide for coaches bringing sprint analysis into everyday training.

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WHAT'S INSIDE

01 **What is sprint analysis?** PAGE 03
Speed, steps and positions, the phases of a sprint, and the two levers that make speed.

02 **How are sprints measured?** PAGE 07
Gates, GPS or video, and the setup that makes the numbers trustworthy.

03 **The practical applications** PAGE 09
Using the numbers in training: what to compare, what to look for in each number, and the return from injury.

04 **What does the research say?** PAGE 10
Top speed and race profiles from more than 2,000 races, where races are won, and the five positions of every step.

05 **What TrackStat captures and reports** PAGE 15
Every step from 240 fps video, every race from GPS, and how accurate it is.

06 **Key takeaways** PAGE 17
Six points worth carrying into your next session.

01 WHAT IS SPRINT ANALYSIS?

Sprint analysis measures how fast an athlete runs and how that speed is produced. It breaks down into three parts.

It all comes down to one equation: **speed = step length × step frequency**. Every change in speed comes from covering more ground with each step or taking steps more often, and step frequency comes from how long each step takes: the time on the ground plus the time in the air.

Speed

How quickly the athlete covers ground, and how that changes through the run.

- **Splits:** the time to cover a set distance, e.g. 0–10 m.
- **Split velocity:** the average speed across a split.
- **Acceleration:** how quickly speed builds from the start.
- **Top speed:** the highest speed reached, and where.

IN PRACTICE

Track acceleration and top speed across a season.

Steps

What each step is made of: how far, how often, and how long the foot is on the ground.

- **Step length:** the distance from one contact to the next.
- **Step frequency:** steps per second.
- **Contact time:** how long each foot is on the ground.
- **Flight time:** the time in the air between contacts.
- **Left and right:** each measure, compared by leg.

IN PRACTICE

See whether speed comes from longer steps or quicker ones.

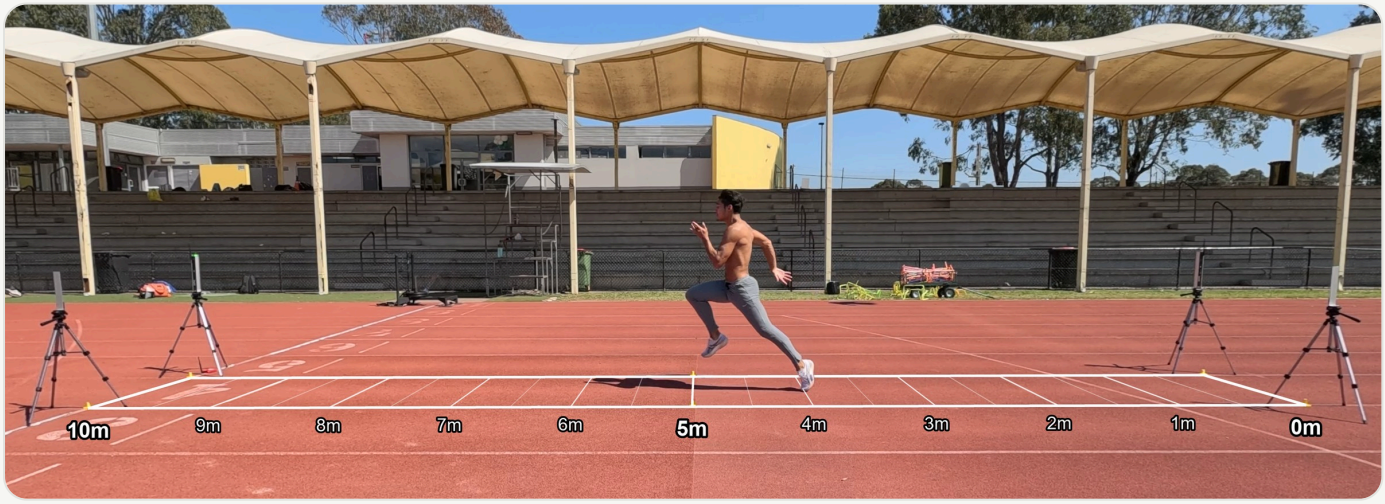
Positions

What the body looks like at the key moments of every step.

- **Touchdown:** where the foot lands relative to the body.
- **Toe-off:** the push-off position as the foot leaves the ground.
- **In between:** posture and limb positions through stance and flight.

IN PRACTICE

Review technique with the athlete, step by step.

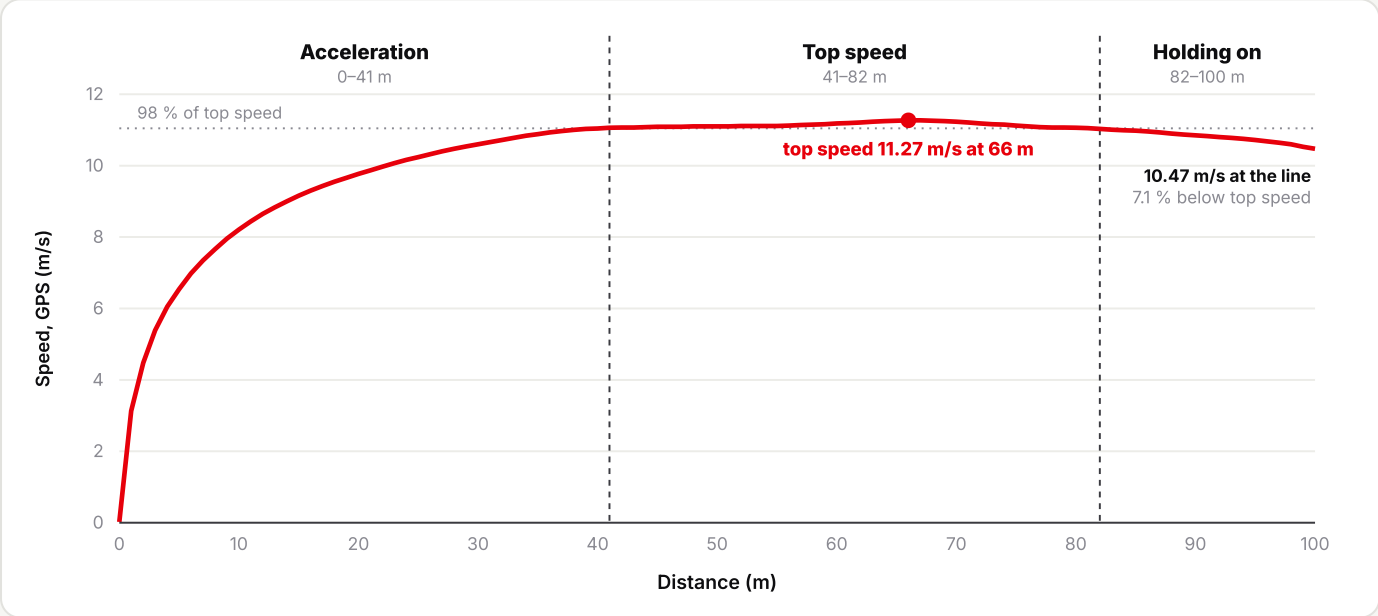


A flying 10 m through a zone marked out in metres. Speed, steps and positions all come from one 240 fps clip like this.

THE PHASES OF A SPRINT

Speed builds in phases, and the steps change with it.

PHASE	WHAT HAPPENS TO THE STEPS	WHAT DRIVES SPEED
Acceleration	Short steps with long contacts, the body leaning forward. Step frequency stops rising at about the 4th step; after that the foot lands in front of the body and posture keeps rising until about the 14th [10].	Pushing, then longer steps. Faster acceleration goes with more propulsive force [11], and speed keeps building as each step gets longer [12, 13].
Top speed	Steps at their longest and contacts at their shortest, about 0.09 s [10]. In a 100 m, top speed arrives between 30 and 70 m, later in faster athletes (pages 11–12).	Force in a short contact: faster runners push harder on the ground, not swing their legs faster [1].
Holding on	Everyone slows before the line. Speed drops with step frequency as contacts and flights get longer [14].	Holding step frequency. Athletes hold their top speed for only about 10–30 m [15].



One 100 m race on a 25 Hz GPS unit (the 10.28 race on page 13). Acceleration lasts until speed reaches 98 % of top speed, the top-speed phase lasts while it stays above 98 %, and holding on runs from there to the line.

Top speed sets the ceiling; how quickly an athlete reaches it, and how long they hold it, decide how much of it shows up in the 100 m time. A contact time only means something next to where in the run it was measured, so compare a 0–10 m rep with other 0–10 m reps, and a flying 10 m with other flying 10 m reps.

ONE STEP, MEASURED

One step at 10 m/s, measured frame by frame.

A sprinter's flying 10 m, filmed at 240 fps. From the touchdown of his right foot to the touchdown of his left, the step took 53 frames: 22 on the ground and 31 in the air.



2.25 m
step length, touchdown to touchdown

4.52
steps a second: one step every 0.221 s

10.2 m/s
speed: 2.25 m × 4.52 steps a second

Every step through the zone, same rep

	ON THE GROUND · IN THE AIR	STEP LENGTH	SPEED
Step 1 right to left	0.092 s · 0.129 s	2.25 m	10.17 m/s
Step 2 left to right	0.100 s · 0.129 s	2.34 m	10.20 m/s
Step 3 right to left	0.104 s · 0.125 s	2.33 m	10.14 m/s

Touchdowns and toe-offs read frame by frame from the 240 fps video, to within one frame (0.004 s); step lengths from the cones.

All of that speed was made in the 0.092 s on the ground; the flight only carries what the contact produced. That is where faster sprinters differ.

1.26 × the force

Runners with a top speed of 11.1 m/s pushed down on the ground 1.26 times as hard as runners at 6.2 m/s, while the time to swing the leg through was the same [1].

WEYAND ET AL., 2000

2.65 body weights

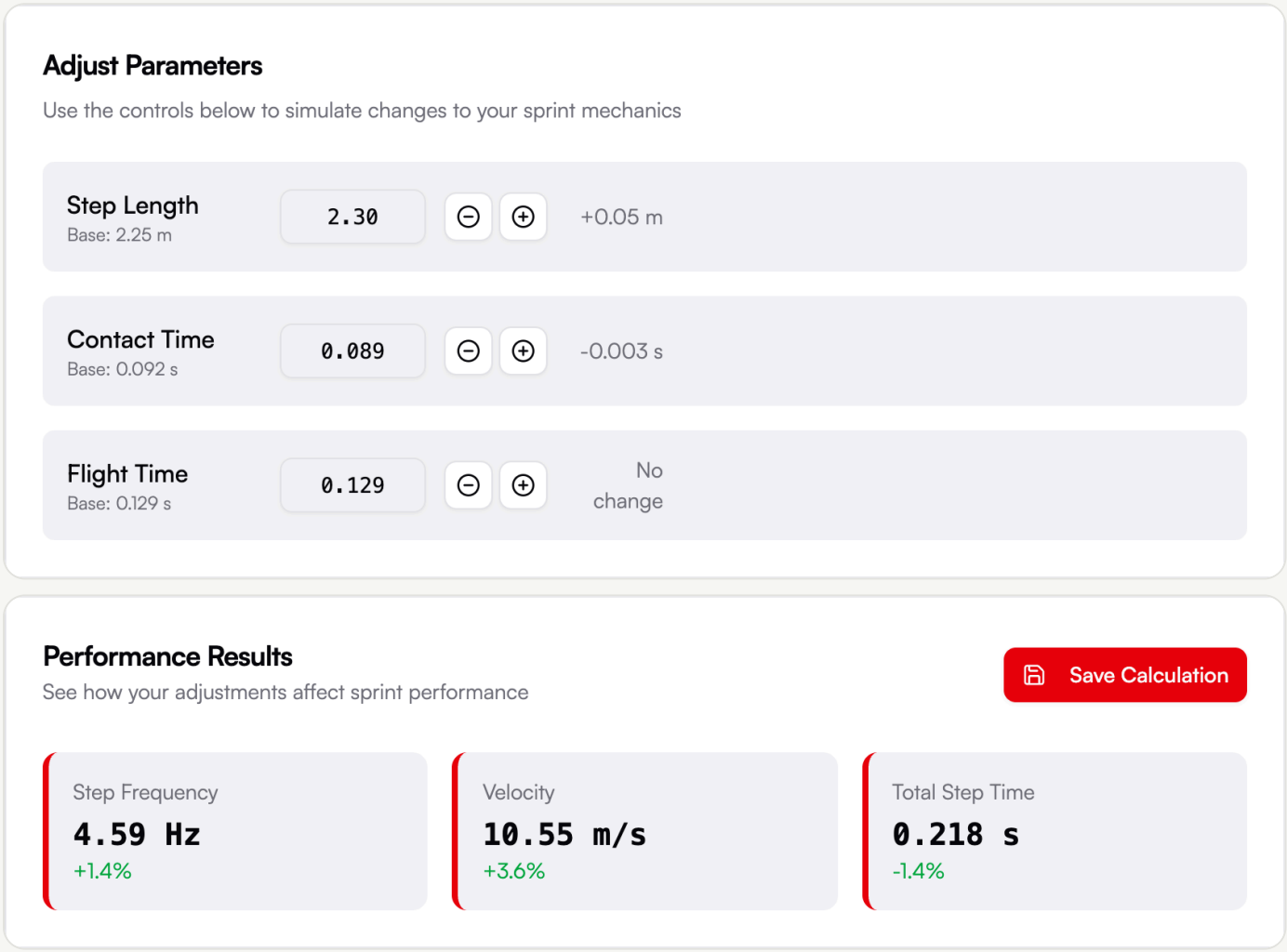
Sprinters reached 10.4 m/s, against 8.7 m/s for other athletes, by pushing harder in the first half of each contact: 2.65 against 2.21 times body weight [16].

CLARK & WEYAND, 2014

THE TWO LEVERS

Most programs time the sprint. Few measure the steps that make the time, so few know which lever to pull.

Speed has two levers: a longer step, or a shorter contact. The performance calculator shows what each is worth for the athlete in front of you. Here it is with the step from page 05.



In TrackStat: that step in the performance calculator: 2.25 m, 0.092 s on the ground, 0.129 s in the air (10.18 m/s). Five centimetres more a step and 3 ms less on the ground: 10.55 m/s, or 0.034 s off his flying 10 m.

A longer step

More force put into the ground in each contact, directed forwards [1, 2, 3]. Strength, power and plyometrics build it; wickets, spaced by the wicket calculator, give the athlete a step to run into.

CHECK AT THE RE-TEST

Step length up, frequency held

A shorter contact

The same push in less time on the ground: short, stiff, reactive contacts, without losing the push that makes the step [1].

CHECK AT THE RE-TEST

Contact time down, step length held

A longer step that costs a tenth of a step a second is worth nothing, so both levers get measured, not just the time.

02 HOW ARE SPRINTS MEASURED?

There isn't one right tool. Each answers a different question, and most programs end up using more than one.

	Timing gates	GPS (25 Hz)	High-speed video
How fast?	**Yes** A time at each gate	**Yes** Speed from first movement to the line	**Yes** Splits through the filmed zone
Where is the race won?	**Partly** One split per gate	**Yes** The whole run, continuously	**Partly** Inside the filmed zone
How is the speed made?	No	No Speed, not steps	**Yes** Every step: length, frequency, contact and flight
Why does the step look like that?	No	No	**Yes** Every position, frame by frame
WATCH OUT FOR	Single-beam gates can trigger early off an arm or a thigh	Straight-line sprints outdoors; timing starts at first movement, not the gun	Needs a still camera and a calibrated zone
SETUP	A gate at every split	A unit worn between the shoulder blades	A tripod side-on and cones every 5 m

GPS shows where; video shows how and why. The two work best together: GPS for the whole race, and video for the steps and positions in the part of the race you are working on. 25 Hz GPS units are valid and reliable for straight-line sprints against laser and dual-beam timing [6].

Which test for which question?

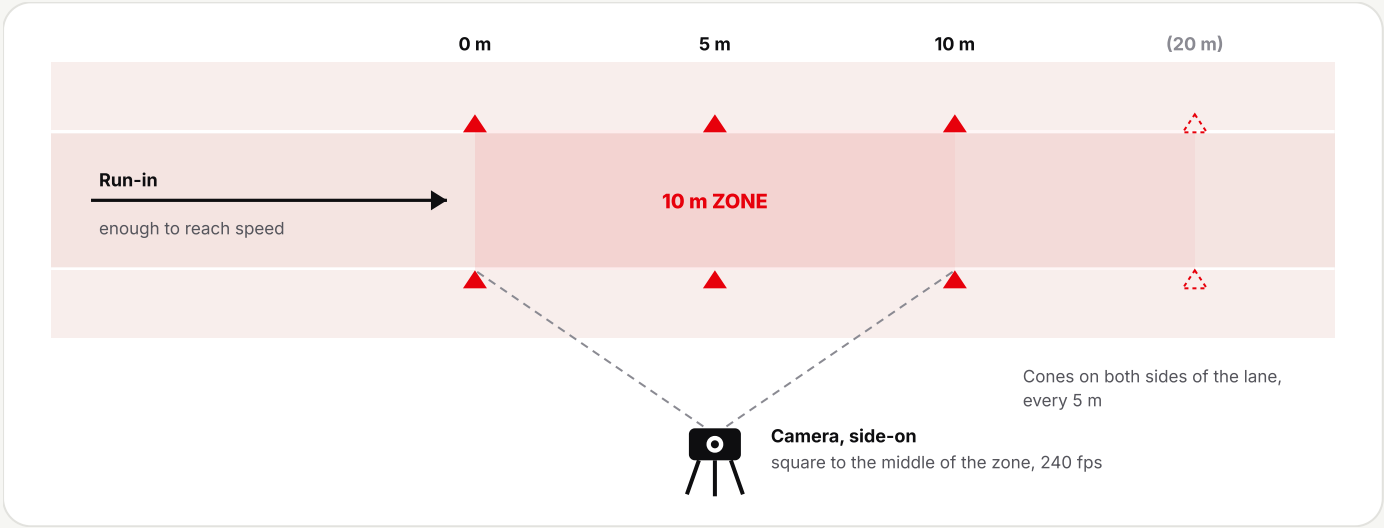
QUESTION	TEST
How fast is their top speed?	A flying 10 or 20 m on video, e.g. 50–60 m
How good are their first steps?	0–10 m from blocks or a standing start, on video
How quickly does speed build?	30 m with splits
Where is a race won or lost?	A 100 m on GPS
How long can they hold top speed?	A 150 m on GPS
Is a new step length holding at speed?	A wicket run on video

FILMING IT PROPERLY

Good numbers start with a good setup.



A flying 10 m filmed side-on at 240 fps, with cones every 5 m on both sides of the lane.



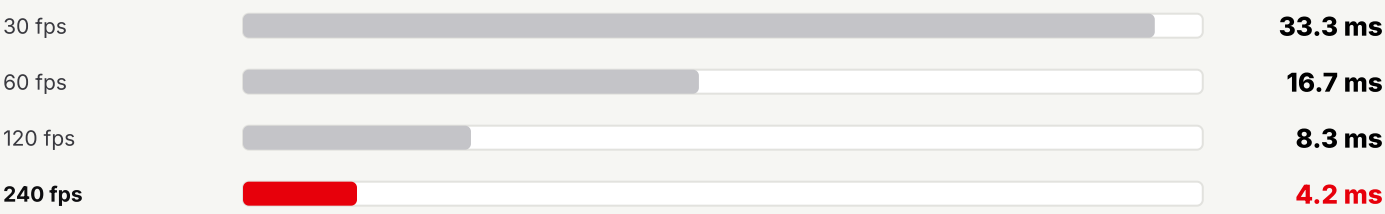
Top-down view of a flying 10 m setup. For a 20 m zone, add cones at 15 and 20 m and centre the camera on the new zone.

Setup

- 240 fps on a camera with a fixed frame rate, such as a GoPro.
- Tripod side-on, square to the middle of the zone, untouched all session.
- Cones every 5 m on both sides of the lane.
- Enough run-in to reach top speed, and the same zone and run-in every time.

Why it matters

- Single- and dual-beam gates differ by 0.05–0.06 s on the same sprint [4].
- Start and trigger procedures can change times by more than years of training [5].
- A change only counts if it is bigger than the typical error of the test; repeat trials reduce it [5, 9].



Time between frames. A contact at top speed lasts about a tenth of a second, so 240 fps gives more than 20 frames of every contact.

03 THE PRACTICAL APPLICATIONS

A number on its own means little: it needs context, something to compare against, and a change big enough to be real.

Context is the athlete's training age, the phase of the season, fatigue and what the rep was meant to be. A change is real when it is bigger than the smallest real change for the test (page 16).

Compare the athlete to themselves

Their own earlier reps, their other leg, or their best from earlier in the season. Usually the most useful comparison: same athlete, same build, same technique.

Compare across the squad

Useful when the question is where someone sits, rather than how they are changing. Most useful within one zone and one type of rep.

To trust a change, it has to come from the same setup: the same zone, the same camera position, the same surface and a similar run-in. Otherwise the change belongs to the setup, not the athlete.

What to look for in each number

MEASURE	WHAT IT IS	WHAT TO LOOK FOR
Split time and split velocity	The time over the zone, and the average speed through it.	Change across reps and sessions in the same zone.
Step length	The distance covered by each step.	Whether longer steps come without losing frequency.
Step frequency	Steps per second.	Whether it holds as step length improves.
Contact time	How long each foot is on the ground.	Shorter contacts at the same step length usually mean more force in less time [1].
Flight time	The time in the air between contacts.	How it moves with step length and contact time.
Left and right	Each measure, compared by leg.	Differences that repeat across several reps, not one-off readings.
Key positions	Touchdown, toe-off and the frames in between.	Where the foot lands relative to the hips at touchdown.

Coming back from injury. A pre-injury baseline of splits and steps is the reference for the return: the same test, in the same zone, compared rep for rep until the athlete is back to their own numbers. One rep is a snapshot; the trend across weeks is what to read.

04 WHAT DOES THE RESEARCH SAY?

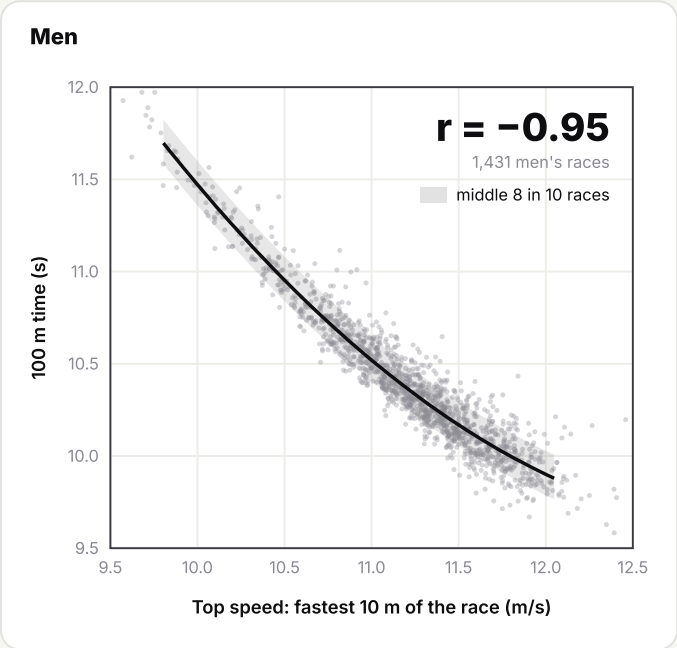
EVIDENCE: TOP SPEED

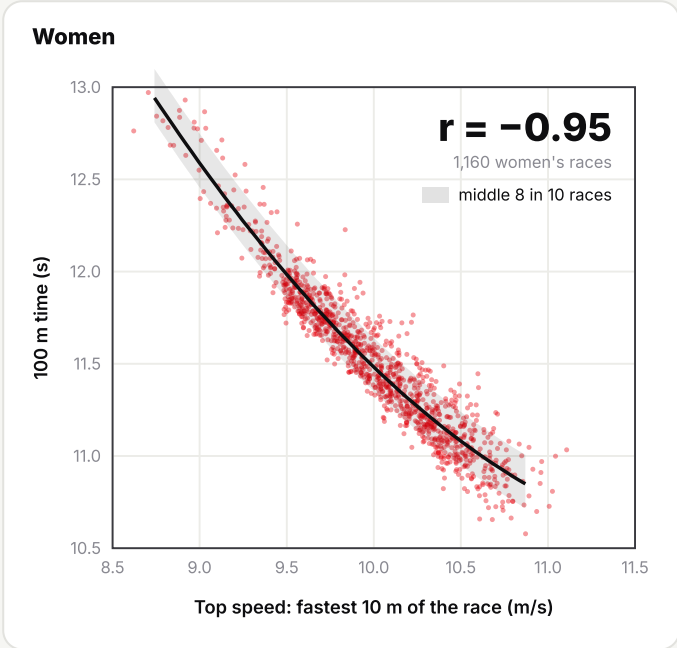
The faster the top speed, the faster the 100 m.

r = −0.95
between top speed and 100 m time, for men and for women

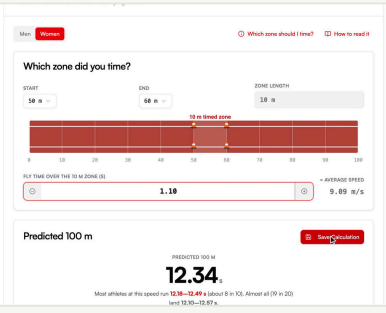
91 %
of the differences in 100 m time are accounted for by top speed alone

n > 2,000
100 m races with 10 m splits, 9.58 to 13.75 s





Each dot is a race; top speed is its fastest 10 m. Acceleration still matters, but across these races how fast an athlete got was the best single guide to how fast they finished. The band holds the middle 8 in 10 races: at the same top speed, 100 m times still spread 0.24–0.29 s.



IN TRACKSTAT

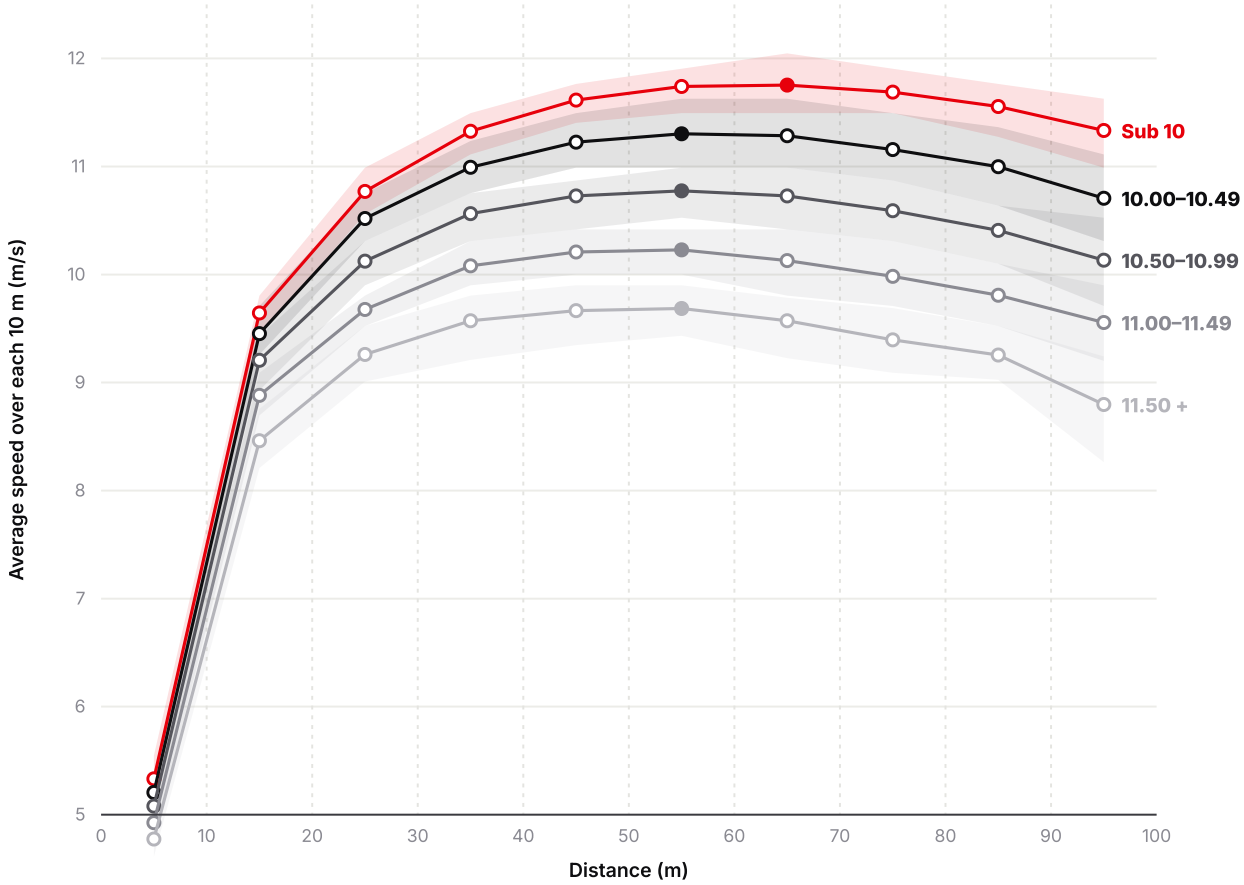
Flying 100 m calculator

Built on the same race data. Enter a flying 10 or 20 m and see the 100 m time it points to, and the range most athletes at that speed run.

EVIDENCE: RACE PROFILES, MEN

What it takes to run sub 10.

In 154 sub-10 races, men averaged a top speed of **11.84 m/s**: a fastest 10 m of 0.84 s. 8 in 10 were between 11.63 and 12.05 m/s.



Read the dots as 10 m segments. Each dot is the average speed over one 10 m segment, worked out from the race's 10 m split times; it is not instantaneous speed. GPS measures speed many times a second (page 13), so its top speed reads a little higher than the fastest 10 m average. Lines: the average of each band; shaded: the middle 8 in 10 races in it.

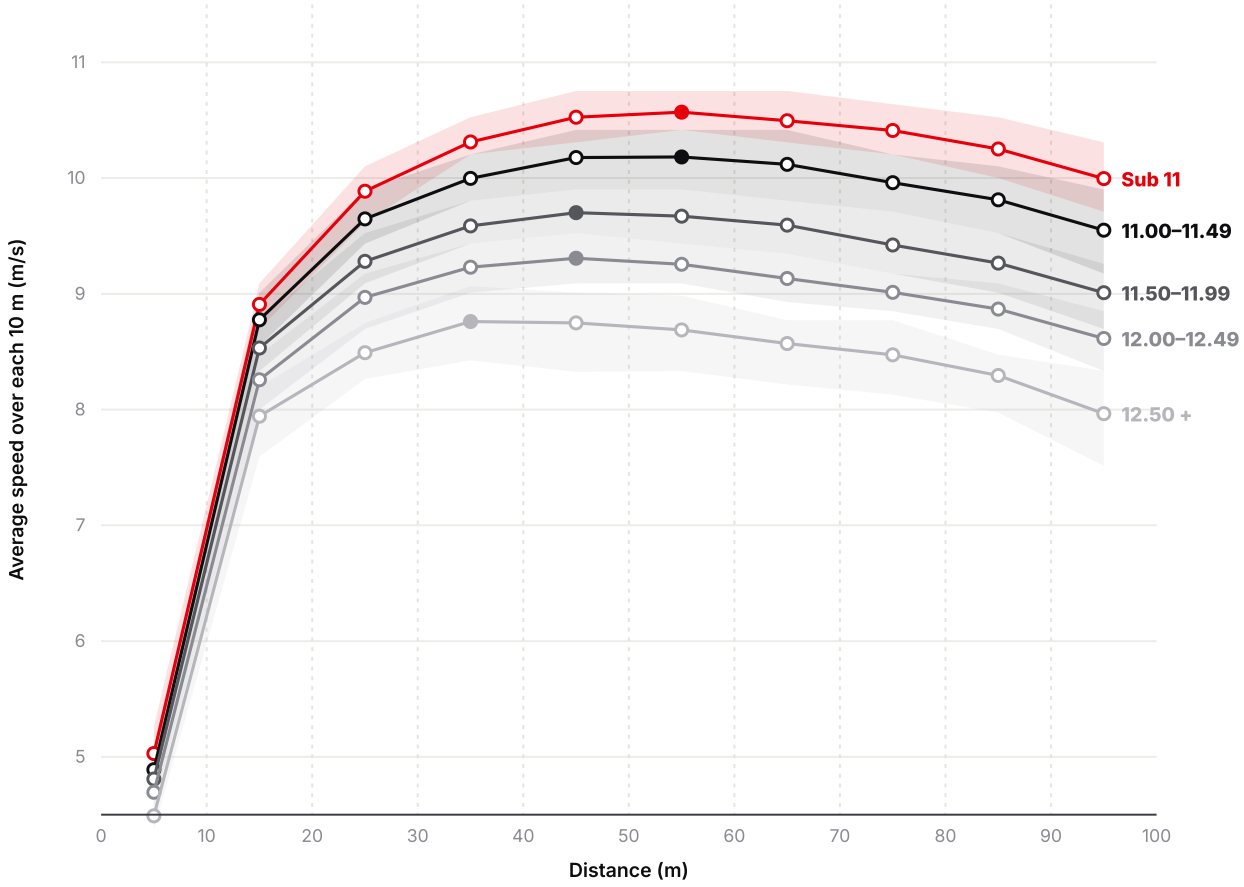
	Sub 10	10.00–10.49	10.50–10.99	11.00–11.49	11.50 +
RACES	154	809	351	94	23
TOP SPEED (M/S)	**11.84** 11.63–12.05	**11.39** 11.11–11.76	**10.85** 10.64–11.11	**10.29** 10.10–10.53	**9.73** 9.45–9.90
FASTEST 10 M (S)	**0.84** 0.83–0.86	**0.88** 0.85–0.90	**0.92** 0.90–0.94	**0.97** 0.95–0.99	**1.03** 1.01–1.06

Each band includes every race in that 100 m range (sub 10: under 10.00 s). Grey figures: the range of the middle 8 in 10 races. Top speed: the fastest 10 m segment of each race; fastest 10 m: the same segment as a time. Split times run from the gun, so the first 10 m segment includes reaction time. 32 races with an obvious split-timing error were left out.

EVIDENCE: RACE PROFILES, WOMEN

What it takes to run sub 11.

In 111 sub-11 races, women averaged a top speed of **10.64 m/s**: a fastest 10 m of 0.94 s. 8 in 10 were between 10.42 and 10.75 m/s.



Read the dots as 10 m segments. Each dot is the average speed over one 10 m segment, worked out from the race's 10 m split times; it is not instantaneous speed. GPS measures speed many times a second (page 13), so its top speed reads a little higher than the fastest 10 m average. Lines: the average of each band; shaded: the middle 8 in 10 races in it.

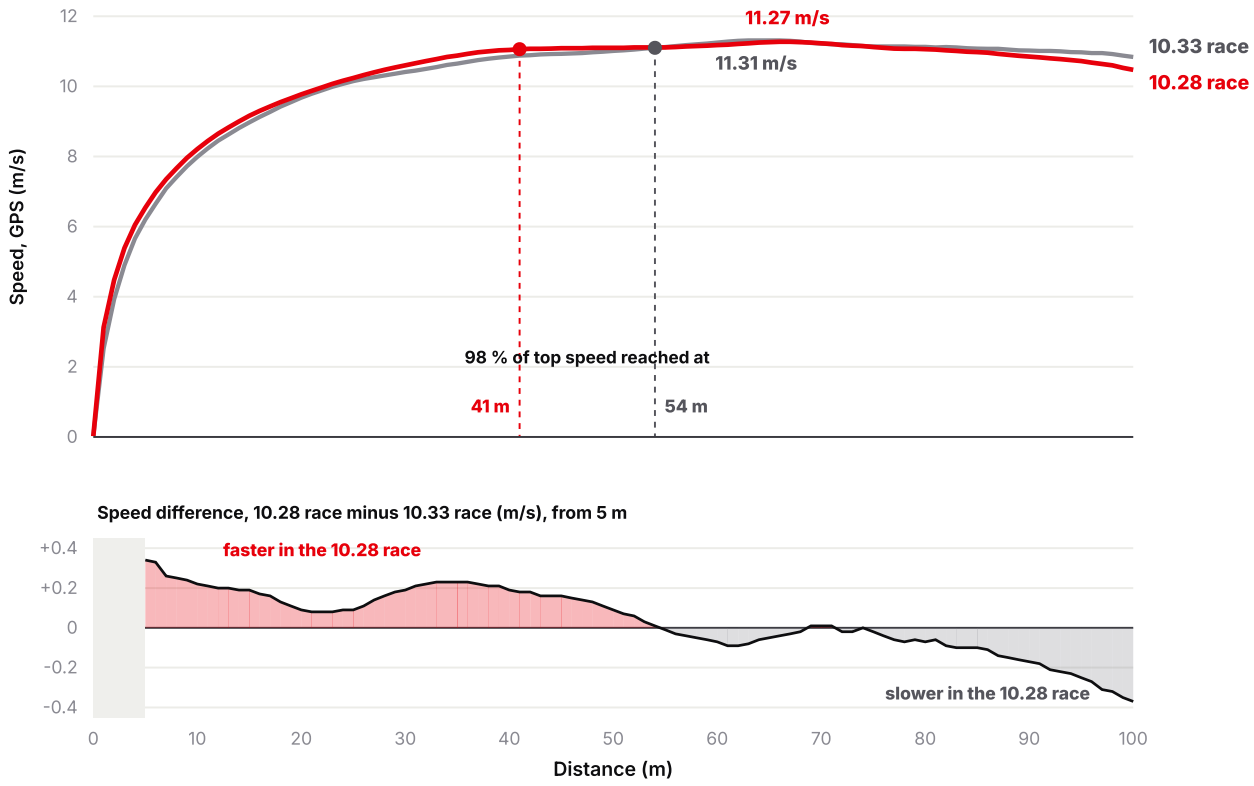
	Sub 11	11.00–11.49	11.50–11.99	12.00–12.49	12.50 +
RACES	111	476	458	81	34
TOP SPEED (M/S)	**10.64** 10.42–10.75	**10.28** 10.00–10.53	**9.76** 9.52–10.00	**9.35** 9.17–9.52	**8.81** 8.50–9.09
FASTEST 10 M (S)	**0.94** 0.93–0.96	**0.97** 0.95–1.00	**1.03** 1.00–1.05	**1.07** 1.05–1.09	**1.14** 1.10–1.18

Each band includes every race in that 100 m range (sub 11: under 11.00 s). Grey figures: the range of the middle 8 in 10 races. Top speed: the fastest 10 m segment of each race; fastest 10 m: the same segment as a time. Split times run from the gun, so the first 10 m segment includes reaction time. 32 races with an obvious split-timing error were left out.

EVIDENCE: WHERE THE RACE IS WON

10.33 and 10.28: almost the same time, so you would assume the same race. It wasn't.

Two of the same sprinter's races, six months apart, both on a 25 Hz GPS unit, with the same top speed: 11.31 and 11.27 m/s. In the 10.28 he reached 98 % of top speed by 41 m instead of 54 m and was 0.09 s up by 60 m, then slowed more, 7.1 % by the line instead of 4.2 %, and gave 0.04 s back. A time on its own can't show that; the speed curve can.



Time over each section, worked out from the GPS speed (s)

	5–30 M	30–60 M	60–80 M	80–100 M	5–100 M
10.33 race	2.81	2.75	1.78	1.81	9.16
10.28 race	2.75	2.72	1.79	1.85	9.11
Difference	**-0.06**	**-0.03**	**+0.01**	**+0.03**	**-0.05**

Won in the first 60 m

Across the race data (n > 2,000), top speed explains most of the difference between athletes (page 10). Within one athlete at the same top speed, getting there sooner was worth 0.09 s by 60 m.

TRAIN

Acceleration: reach top speed sooner

Given back in the last 40 m

The faster start came with a bigger fade: 0.04 s given back over the last 40 m. Reaching top speed sooner and holding it longer is where his next 100 m is.

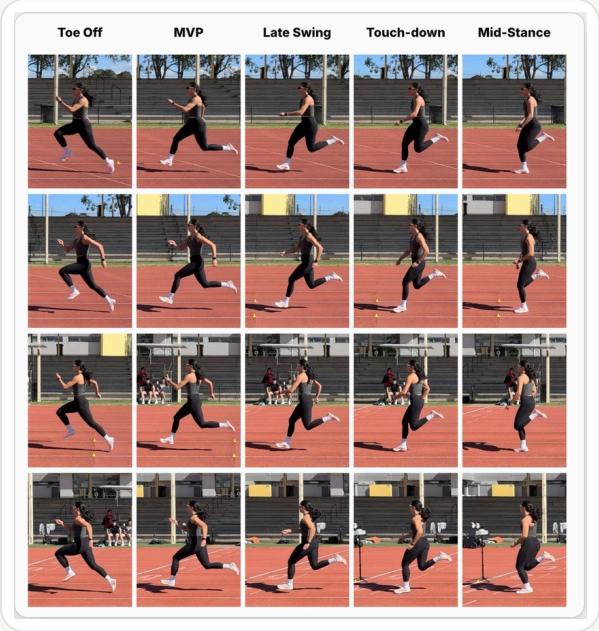
THEN

Speed maintenance over 60–100 m

Section times are worked out from the GPS speed from 5 m on; the first metres are left out because the moment a GPS unit picks up the start varies from race to race.

EVIDENCE: THE FIVE POSITIONS

Five positions, every step.



In TrackStat: Key Frames lines up the five positions of every step, ready to rate by eye.

The steps are the outcome of what the body does on the ground and in the air. A 12-item score built on these five positions, the Sprint Mechanics Assessment Score, can be rated reliably by eye from slow-motion video [7], and in 126 elite footballers each extra point came with a 33 % higher risk of a new sprint-related hamstring injury [8].

Compare the same position across steps and across sessions: a cue is working when the same frame changes.

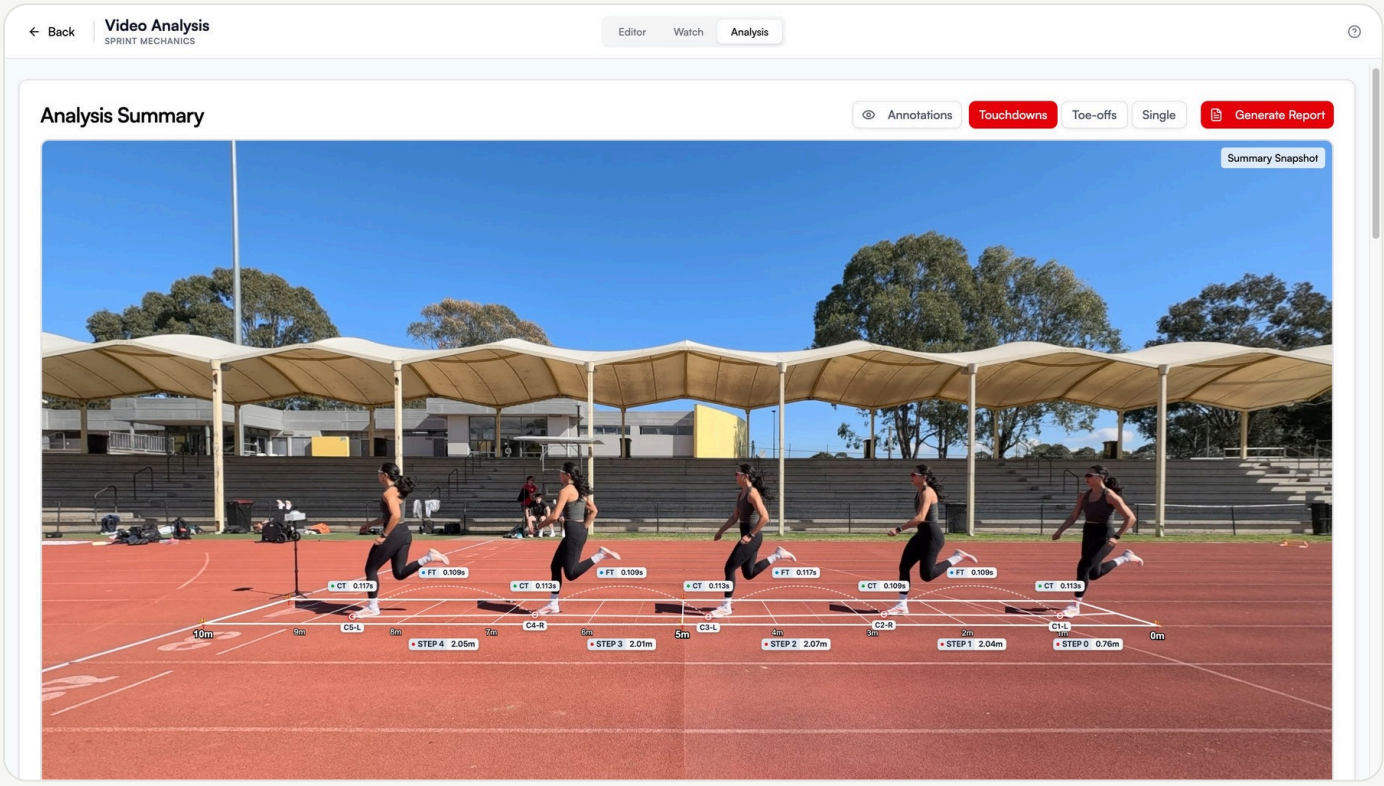
POSITION	WHAT GOOD LOOKS LIKE	FAULT TO SPOT
Toe-off	The push finishes with the trunk tall and the trailing leg extending behind the hip.	The trailing leg over-extended: the hip about 45° or more behind vertical with the knee locked straight [7].
Max vertical projection	The heel folds up under the hips; the trunk and pelvis stay quiet.	Back kick: the heel rises above the other calf. Or the trunk and pelvis twist, with big cross-body arm swings [7].
Late swing	The thighs are well apart, with the trailing knee already coming through.	The trailing knee still behind the hips, or the lower back arched with the pelvis tipped forward [7].
Touchdown	The foot lands close in front of the body, the shin near vertical, the trunk tall.	Overstriding: room for another foot in front of the centre of mass, or the ankle ahead of the knee [7]. Landing further ahead goes with more braking [11].
Mid-stance	The hips and knee hold their height.	Sinking: the knee bends and the ankle collapses, as if sitting down into the step [7].

05 WHAT TRACKSTAT CAPTURES AND REPORTS

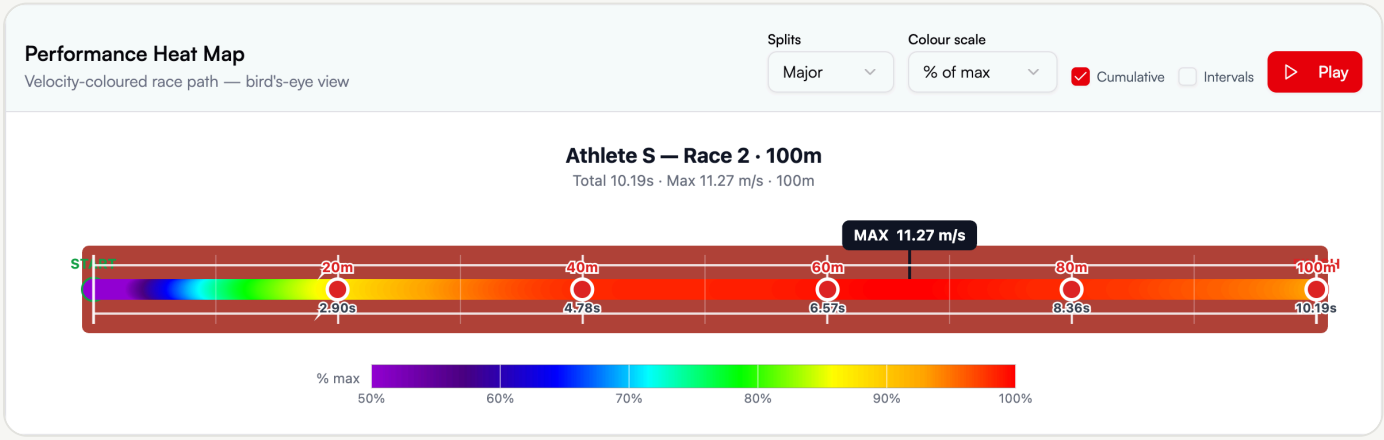
TrackStat turns a 240 fps video into every step, and a GPS file into every metre of a race.

From a clip of a calibrated zone, TrackStat gives the splits every 5 m and the length, frequency, contact and flight time of every step, left and right, with the five key positions of every step in Key Frames. From a 25 Hz GPS unit, it breaks a race into acceleration, top speed and deceleration, and maps the speed onto the track [6]. Every mark sits on the video, so every number can be checked.

4.2 ms between frames at 240 fps: more than 20 frames of every contact at top speed, where a contact lasts about a tenth of a second.



Analysis summary: every touchdown of a flying 10 m on one frame, with each step's length, contact and flight time. Sample data.



GPS race analysis: speed along the track as a share of top speed, with the split every 20 m (the 10.28 race on page 13).

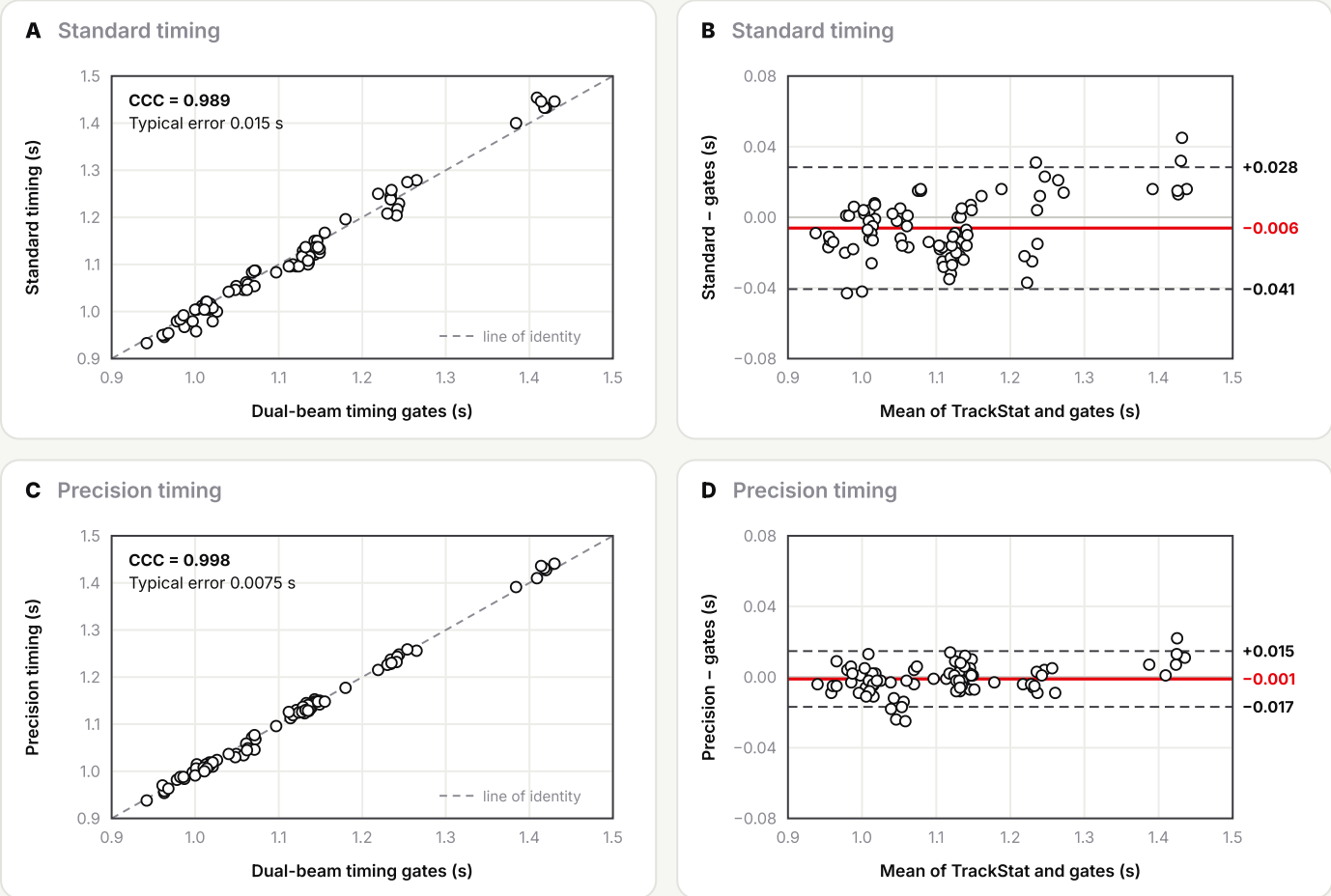
Video analysis, GPS races, testing, competition results, calculators and notes all sit on the athlete's profile, with a squad dashboard across all of it.

WHAT IS THE ACCURACY?

Video timing against dual-beam gates.

TrackStat was compared with dual-beam timing gates on **82 flying 10 m sprints by 16 athletes**, filmed at 240 fps on a GoPro, with the splits checked by the coach as in everyday use. Two timing modes were tested: **Standard timing**, which TrackStat uses today, and **Precision timing**, an upgrade coming to TrackStat that adds a further processing step.

	Standard timing	Precision timing
Average difference from the gates bias	**−0.006 s**	**−0.001 s**
95 % limits of agreement where 95 % of trials fall	**−0.041 to +0.028 s**	**−0.017 to +0.015 s**
Agreement with the gates concordance, 1.000 = perfect	**0.989**	**0.998**
Typical error of the estimate	**0.015 s (1.3 %)**	**0.0075 s (0.7 %)**
Smallest real change between reps MDC95; dual-beam gates 0.0215 s	**0.039 s**	**0.026 s**



A, C: TrackStat against the gates for every trial, with the line of identity. B, D: the difference from the gates for every trial, with the average difference (red) and the 95 % limits of agreement (dashed; mixed model, athlete as a random effect).

No two timing systems agree exactly: a laser and dual-beam gates differ by a few hundredths of a second [6], single- and dual-beam gates by 0.05–0.06 s [4]. The smallest real change includes the athlete's own rep-to-rep variation, so even the gates need 0.0215 s.

Flying 10 m, 26 September 2026, 240 fps. Smallest real change: each athlete's three fastest trials by the gates (15 athletes). Psarakis & Edwards, in preparation.

06 KEY TAKEAWAYS

- Every sprint has two levers: a longer step and a shorter contact. **Measure the steps, not only the time**, or you can't tell which one moved.
- **Top speed explains most of the difference between 100 m times**: r = −0.95 across more than 2,000 races.
- Two races with almost the same time can be run two different ways. **GPS shows where speed was gained, held and lost.**
- A contact time only means something next to where it was measured. **At top speed, faster runners push harder in shorter contacts.**
- **Film it the same way every time**, and compare the athlete with their own history first.
- A change only counts if it is **bigger than the smallest real change** for the test.

BEST PRACTICES

To get numbers you can act on, set the test up the same way every time.

- 240 fps on a camera with a fixed frame rate, such as a GoPro.
- Tripod side-on, square to the middle of the zone, untouched all session.
- Cones every 5 m on both sides of the lane.
- The same zone and the same run-in at every test.
- Repeat trials: they reduce the error of the test [5, 9].
- Compare the athlete with their own numbers before anyone else's.

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REFERENCES

[1] Weyand PG, Sternlight DB, Bellizzi MJ, Wright S. Faster top running speeds are achieved with greater ground forces not more rapid leg movements. *J Appl Physiol.* 2000;89(5):1991–1999.

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WHERE TO NEXT

Questions about filming, testing or your setup? Talk to us.

This guide covers the fundamentals, and every program is different. If something here raised a question about a test, the research, or how TrackStat would fit the way you coach, get in touch.

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