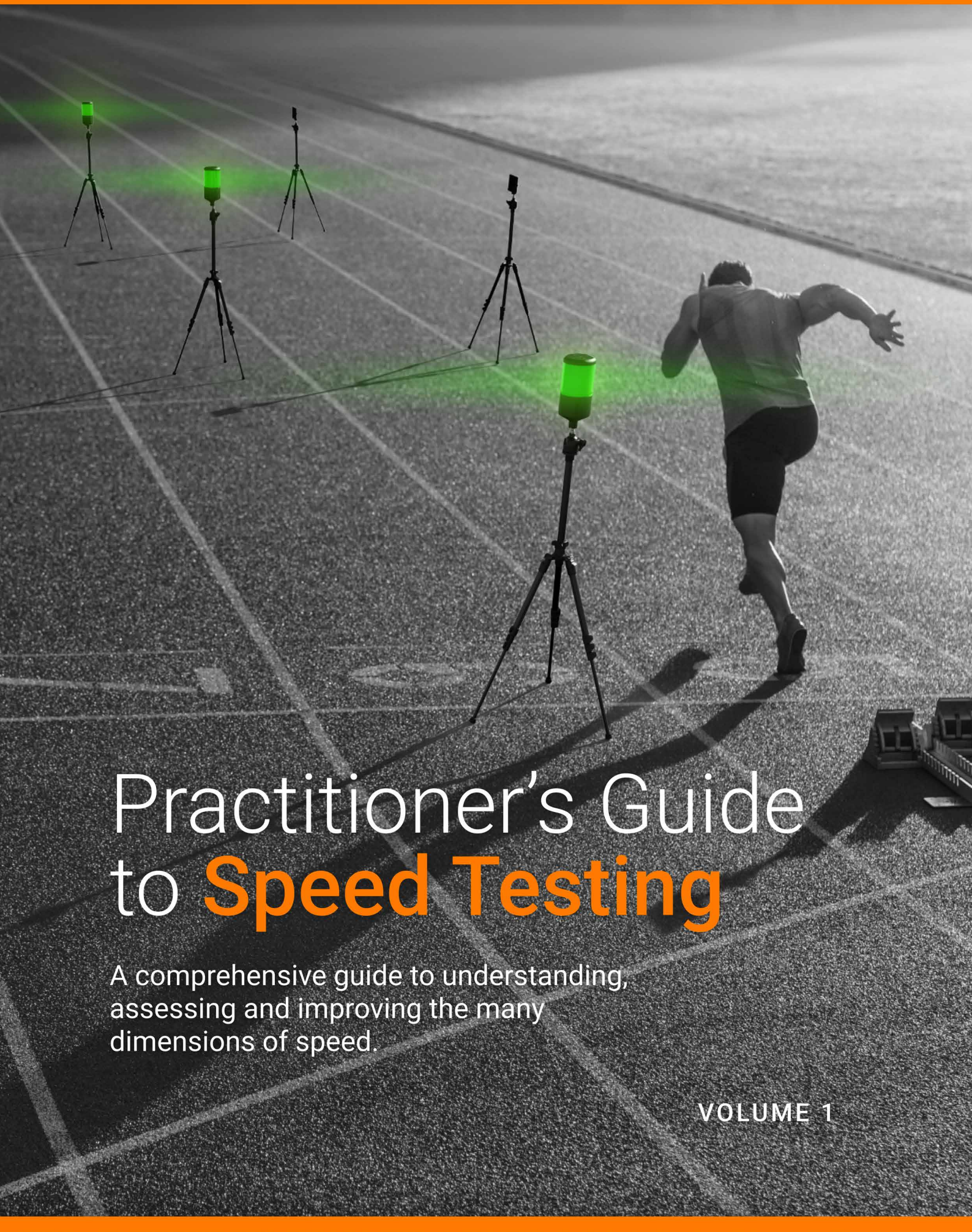
VALD



Practitioner's Guide to Speed Testing

A comprehensive guide to understanding, assessing and improving the many dimensions of speed.

VOLUME 1

Some Words from the **Speed Experts**

Derek Hansen

Sports Performance Consultant,
Runningmechanics.com

"Quality timing gates allow me to accurately track and document my own proprietary sprint testing and monitoring protocols in an efficient and effective manner.

The decision to use a timing solution (such as the SmartSpeed Plus system) goes back to my original frustrations with time being wasted fiddling with connectivity and reliability with any technology.

The value of technology has been proven over numerous trials and helped me validate my philosophy around speed development and return-to-play progressions."

Alex Natera

Performance Science Manager, NSW Institute of Sport
Creator of Run-Specific Isometric Strength Training (RSIST)

"In so many land-based sports, speed, in all of its manifestations, is often the holy grail in terms of the transfer of training many practitioners seek.

Although it is often difficult to completely attribute success on the sporting field to speed, we cannot deny the many scenarios where speed or the lack thereof has heavily influenced the different outcomes within competition.

The ability to quantify speed is, therefore, critical in running-based sports. Capturing split times, acceleration ability, maximal velocity and change of direction (COD) metrics can indicate the transfer of training and, ultimately, the success of the strength training, speed, COD training and overall training program.

Capturing and analyzing speed metrics is also critical in understanding and effectively managing the training dose of athletes."

Jo Clubb

Founder and Sports Science Consultant
Global Performance Insights

"Game-defining moments frequently hinge upon an athlete's speed, determining their ability to outpace an opponent to the ball or reach a critical position.

Although sprinting demands on the pitch are often chaotic, assessing an athlete's speed in a controlled environment is crucial for understanding their capacity and mechanics.

Timing gates are a versatile technology that facilitate a wide range of speed and change-of-direction testing methodologies. Quantifying these abilities provides practitioners with objective data to inform and enhance speed training programmes."

Robert Pacey

Founder and Director of
Sportsmith

"There is no topic in our industry right now bigger than speed training and testing.

One consistent message that the best coaches in the world are communicating is the value of robust, reliable and user-friendly technology to test their athletes.

Also, technology that fits seamlessly into the training environments and talks to the wider testing and monitoring ecosystem, as SmartSpeed does, is the holy grail."

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Testing the **Dimensions of Speed**

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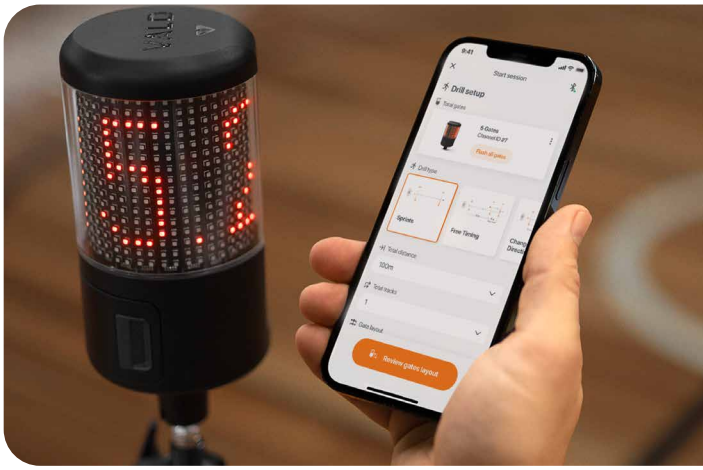
Speed:
Simple to Grasp, Difficult to Master

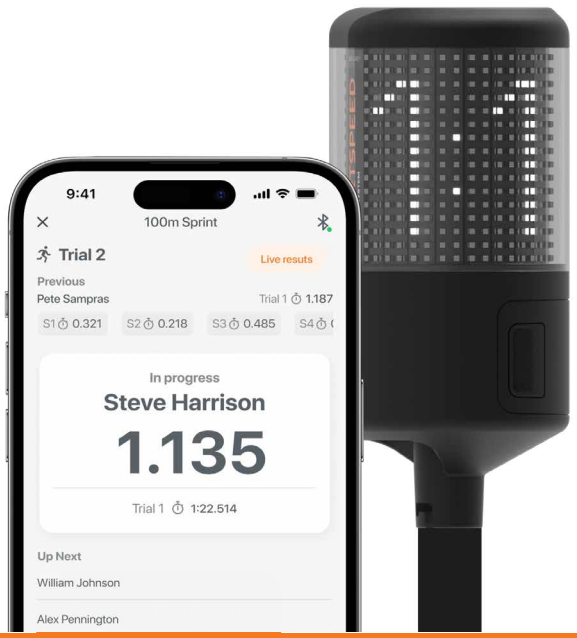


Speed as a concept is simple to understand: optimize stride frequency, stride length, foot strike pattern and ground contact times together from point A to B as quickly as possible. However, measuring, understanding and ultimately mastering the many factors that contribute to speed is something else entirely.

Speed as a concept is simple to understand...measuring, understanding and ultimately mastering the many factors that contribute to speed is **something else entirely.**

Unlike strength testing technology, which has only become commonplace in the past 5-10 years, speed testing technology has been used by coaches for decades. This technology has progressed significantly in that period and while speed technology could be considered relatively commonplace, not all technology is created equal.

It takes a knowledgeable professional to discern which technology to use, understand that technology's capabilities and apply them in their setting to derive the most value possible. For the purpose of this document, we will focus primarily on the use of timing gates in speed testing, but we will also touch on a range of other technologies that can be used to assess and improve speed.



...while speed technology could be considered relatively commonplace, **not all technology is created equal.**

Training prescriptions in the weight room are commonly based on strength, power, asymmetry and other variables measured by technology. Likewise, speed training requires accurate measurement of acceleration, agility, top-end speed and more to help with appropriate prescription.

This document outlines requirements, testing methods and applied examples to help you get the most out of your speed and agility testing. This document will use the term "speed" to encompass the entirety of an athlete's capabilities to move quickly, be that linear, curvilinear, change of direction (COD) or agility-based speed.

We will help to demystify the essentials of speed assessment, providing answers to some of the most frequently asked questions and concerns on the topic, including:

- **How do I get started with speed testing?**
- **What are the different components of speed and agility and how can I test them?**
- **Which speed variables are the most relevant and how do I interpret them?**
- **How can speed data enhance my athletic programming?**

By providing insights that are easy to put into practice, conceptually sound and supported by case studies from leading experts in the field, this guide is designed to be an accelerant for your speed-testing knowledge. As a reader, you can expect to gain the confidence and clarity necessary to assess the many dimensions of speed using modern speed testing technology.

Speed Testing Fundamentals

While any coach would acknowledge speed as a fundamental skill, some may feel speed testing is futile due to haphazard, complex and unstructured testing processes. However, this guide will help demonstrate that from high-quality testing comes high-quality training.

As mentioned previously, speed's definition and conceptual basis are simple. At its core, speed training is about enhancing the ability to move fast. However, simple should not be confused with "easy."

Increasing an athlete's speed comes with an increased responsibility for practitioners to adequately dose key training thresholds, volumes and intensities.

Without a reliable process for testing speed, practitioners risk misidentifying when their athletes are fresh, fatigued or overtrained, potentially leading to ill-informed training modifications. (Soligard, 2016; Gabbett, 2016).

“What’s Wrong with My **Stopwatch?”**

There is no doubting the simplicity and power of a stopwatch for measuring speed. However, the average human reaction time for a visual stimulus can be between 180-200 milliseconds (ms) (Jain, 2015), leaving potential for human error in our data collection. For context, if an athlete sprints at 10m/s (22mph), a 200ms reaction gap can be the difference of two meters (six feet) of space.

...the average human reaction time for a visual stimulus can be between **180-200 milliseconds...**

That is not to say the stopwatch is a “bad” technology – ultimately, it is scientifically valid for speed testing (Mann, 2015) and is likely to remain a staple of coaches’ toolkits for the foreseeable future due to its convenience, affordability and practicality.

However, there can be inconsistencies between coaches as to when to start the stopwatch – when the first foot hits the track, when the back foot leaves the ground, when the body starts to roll forward or when the command is given to start. Each are valid, but yield different results.

In addition, when coaches are juggling the basic administration of a training session with running, communicating and recording stopwatch times, they often struggle to spend time where they can have the most significant impact: providing meaningful feedback and cues – ultimately coaching their athletes.

...when coaches are...running, communicating and recording stopwatch times, they often **struggle to spend time where they can have the most significant impact...** coaching their athletes.

Perhaps most impactful is the ability of speed testing technology to automatically record and track athletes’ testing results, eliminating the need for handwriting results or manually generating reports in spreadsheets.

Most modern speed testing technology includes centralized reporting, allowing coaches and athletes to access their data automatically in a format that is easily digestible and immediately shareable.

Implementing automated technology allows a practitioner to focus on the athlete in front of them rather than focusing on the skill of timing their athletes. More so, technology unlocks a range of new measurements and insights that are not possible to capture with a stopwatch.

...technology unlocks a range of new measurements and insights that are **not possible to capture with a stopwatch.**

Here are a few considerations for deciding when, how and which speed testing technology (or technologies) to incorporate into your program.

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Advantages of Modern **Speed Testing Technology**

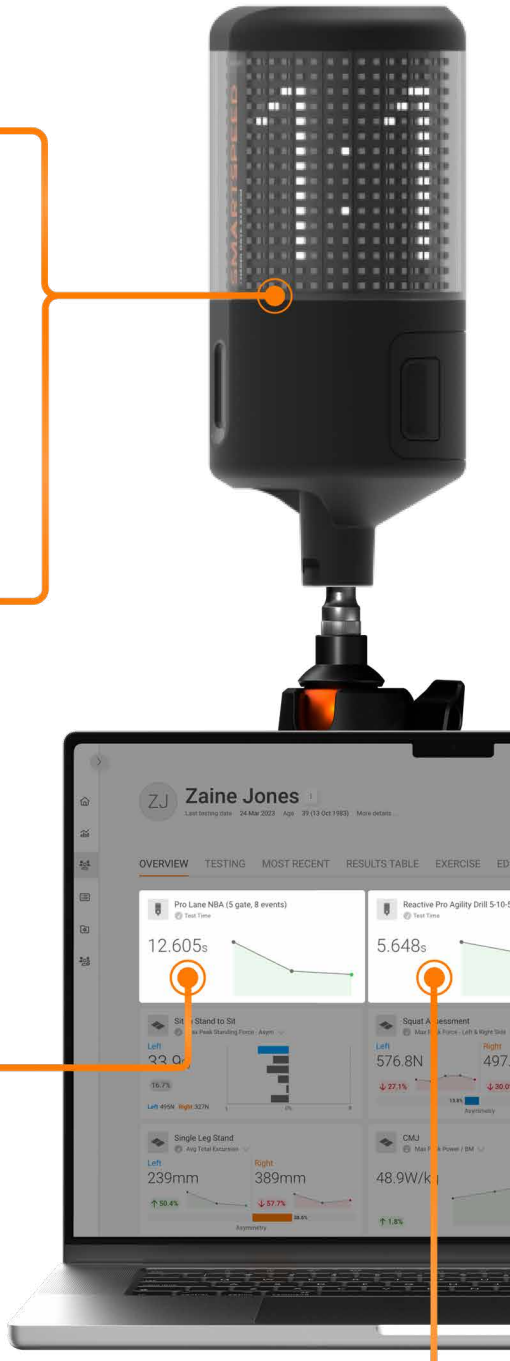
Immediate Athlete Buy-In

State-of-the-art technology lends credibility to training programs.

Immediate, accurate results foster a competitive and cooperative training environment, reinforcing accountability and commitment.

Accuracy

Advanced technologies like VALD's SmartSpeed Plus ensure precise, consistent results in speed testing, minimizing inter-rater reliability issues and missed timings.



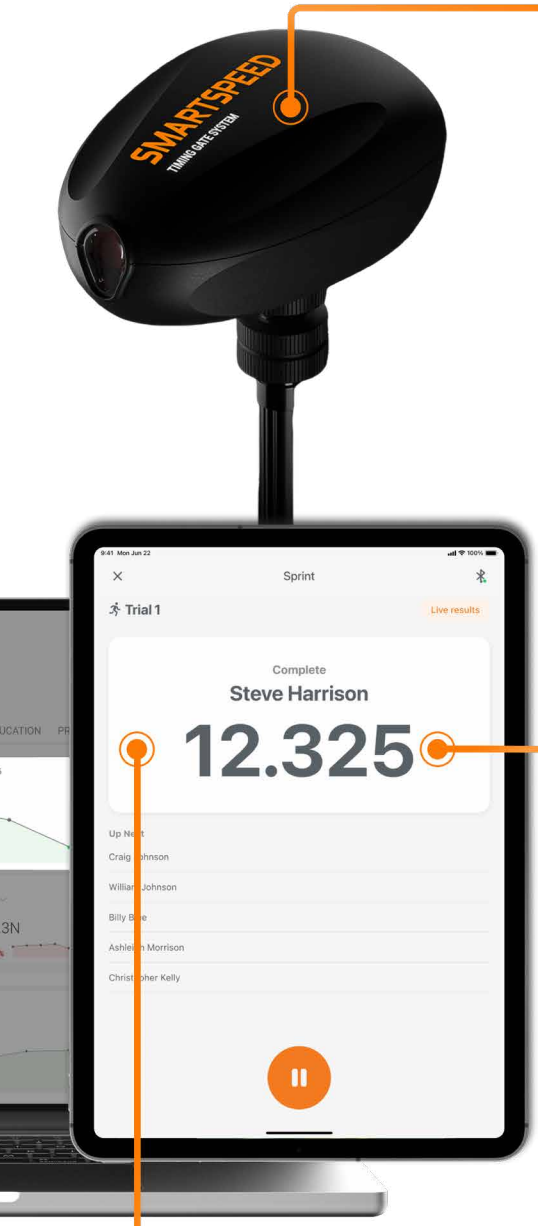
Monitoring

Modern dashboards allow practitioners to visualize team and individual data easily.

This allows for automatic flagging of changes and outliers, meaning quicker training changes to improve interventions and individualization, even in large teams.

Data Management

Platforms like VALD Hub centralize all athlete testing data, facilitating simple and effective training decisions through automatic logging of results and simple visualization of longitudinal performance metrics.



Auto-Collection

Automatic data collection allows for greater accuracy and efficiency.

This allows coaches to keep their focus on their athletes' performance, rather than spending hours, manually recording and uploading training data.

Specificity

Timing gates such as SmartSpeed provide detailed split times for customizable distances, intervals and tasks, providing detailed insights into each athlete's performance.

Enhanced specificity means more targeted training interventions.

Decision-Making

Accurate and insightful data enables more informed decisions about training adjustments and return-to-sport readiness.

This data-informed approach reduces reliance on subjective assessments and enhances training outcomes.

“Speed Testing Takes **Too Much Time.**”

In years gone by, coaches would typically choose from two options for their speed assessments:

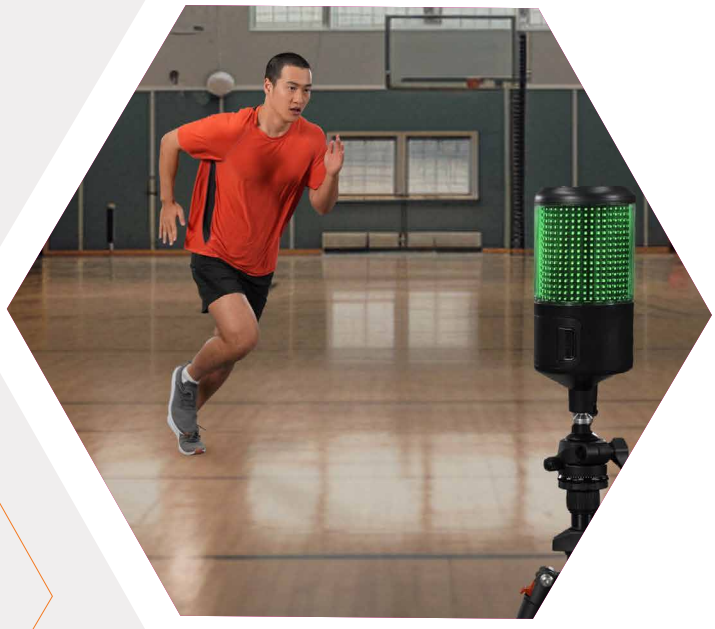
1. **Stopwatch:** Record athletes’ times painstakingly one-by-one with a stopwatch, pen and paper, followed by hours of transcription into Excel.
2. **Timing Gates:** Adopt early timing gate technologies, which were notoriously temperamental, cumbersome and frustrating to operate – commonly requiring 30+ minutes of setup time, hundreds of feet of wires and inconsistent connectivity.

Both options led to large time-investments for coaches on either the front or back end of the speed testing data collection process.

...early timing gate technologies were notoriously **temperamental, cumbersome and frustrating...**

As a result, many early adopters of timing gates subsequently abandoned them and reverted to their trusted stopwatch, or at the very least became skeptical of timing gate technology. This was not helped by the fact that – since their first appearance decades ago – timing gates had evolved very little, meaning many of their original shortcomings remained.

In many ways, this journey has mirrored the advent of smartphones, many of which first appeared as buggy, time-intensive explorations of new technology, putting off some early adopters in the process. Since then, smartphones have become ubiquitous, reliable and indispensable to most – regardless of their first impressions.



Modern speed technology is revolutionizing how today's practitioners **assess their athletes.**

Modern speed technology is revolutionizing how today's practitioners assess their athletes. Some of the contemporary solutions to optimize modern speed testing include:

- **Wireless Technology:** Modern timing gates utilize wireless connections, making speed testing and training a tangle-free process.
- **App Integration:** Smartphone and tablet app integration allows coaches to manage their entire setup from a single device. Enabling easy configuration, real-time data viewing and instant results analysis without the need for bulky hardware interfaces.
- **Portability and Flexibility:** Modern timing gates are travel-friendly, can withstand inclement weather patterns and, most importantly, are reliable wherever you go. Flexibility to set up anywhere opens more opportunities for sport-specific testing environments.
- **Automatic Data Synchronization:** With app-enabled systems, data collected during sessions is automatically analyzed and stored. This allows for seamless longitudinal performance tracking and easy collaboration between coaches and athletes.

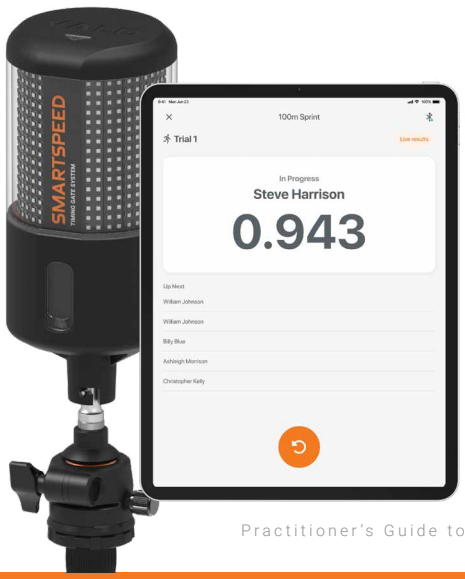
Modern timing solutions, such as the SmartSpeed range, continue to advance timing technology, offering easy athlete queuing, automated results recording, customizable speed drills and built-in scoreboard-style LED displays that make engaging, individualized testing easy to perform.

Seamless Athlete Testing and Data Management

*"**We use our SmartSpeed timing gates with our youth, college and professional athletes.** The automatic integration with our existing data hub saves us time with accurate data management. Importantly, we're able to test large groups of athletes frequently and effectively."*

Les Spellman

Operating these systems has become remarkably efficient. This not only saves time during individual sessions but also provides coaches with powerful data analytics tools over the long term, allowing for more informed decision-making and tailored training programs.



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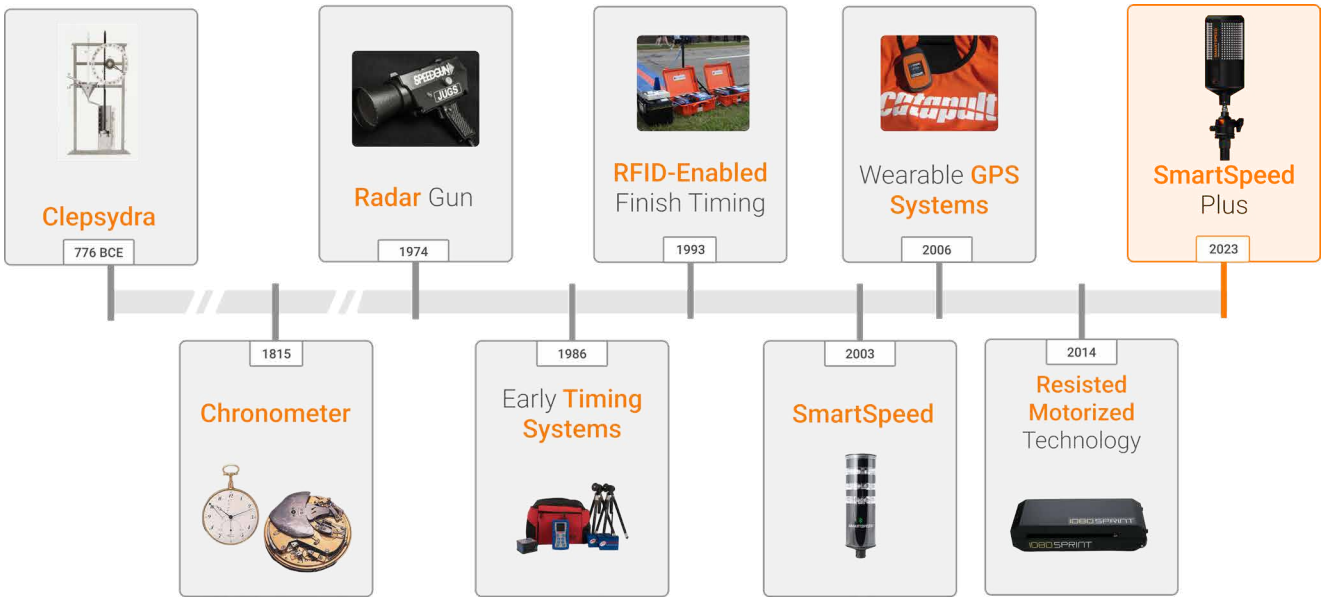
The Evolution of **Speed Measurement**

Before we explore the many dimensions and ways of testing speed, it is important for us to first understand the tools that have enabled it – from the earliest timing systems invented centuries ago to the bleeding-edge technologies of today.

Just as shoes have gotten lighter, tracks have become more efficient and clothing has become more aerodynamic, speed testing technology advancements have had their own contributions to the evolution of speed performance.

Surprisingly, the journey of speed testing technology began in the ancient world, where the Greeks first used clepsydra or water clocks, around 776 BCE during the early Olympic Games.

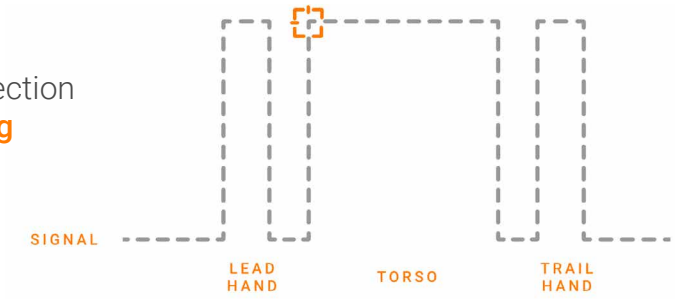
Speed Technology **Timeline**



Fast-forward nearly three thousand years, and the same principles of objective measurement continue to this day. With the invention of app-enabled electronic timing systems like SmartSpeed, coaches and athletes can accurately measure not only the time from one point to another but also a range of other variables.

The introduction of new timing technology has also produced features to improve the validity and reliability of speed measurement. For example, SmartSpeed's Error-Correction Processing (ECP) detects and eliminates erroneous beam breaks from arm swings or trail limbs, ensuring that only a beam break from an athlete's torso will contribute to their speed assessment and allows coaches to have confidence in the consistency of their results.

Error Correction **Processing**



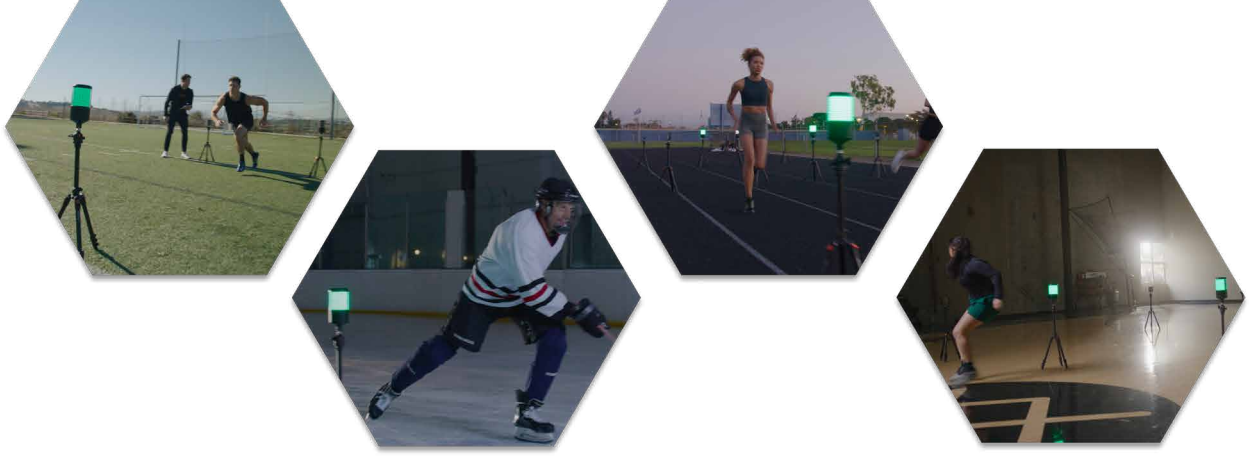
Largest beam break is registered and the start of this event is used as the time registration.

Types of Speed Testing Technology

Speed assessment comes in many forms and varieties. To successfully test and improve speed, you must first understand the tools at your disposal, their strengths, weaknesses and suitability for the specific needs of you and your athletes.

Below is a table of various forms of speed assessment with their respective benefits and drawbacks:

	Technology	Pros	Cons
	**Stopwatch** Manual timing of events by an operator starting and stopping the stopwatch at key time points.	Simple to use, very low cost.	Prone to tester error, may underestimate split times.
	**Timing Gates** Time splits measured as an athlete passes through infrared or laser beam.	Accurate & efficient; automatic timing reduces error. Some systems able to measure change of direction (COD) and agility.	Setup needs to be accurate & reliable. Measures time & calculates speed from splits.
	**Radar** Doppler radio waves measure speed as an object moves towards or away from device.	Measures speed from a distance. Highly accurate and can measure instantaneous speed.	Sensitive to object direction and positioning. Can't measure average speed and difficult to consolidate data.
	**GPS** Satellite signals calculate speed based on changes in position over time.	Useful for outdoor sports; can measure instantaneous speed. Cover large areas. Can measure game-like COD tasks.	Limited by satellite quality. Instantaneous data less reliable. Large number of metrics and data to sift through.
	**Inertial Measurment Unit** Accelerometers and gyroscopes measure speed and angular changes in sport.	Highly portable and reliable. Provides acceleration and speed data in all 3 planes.	Affected by collisions or external motion. Calibration needed. Requires a high-level knowledge for analysis.
	**Motor Technology** The cable is attached to the athlete and motor; speed and force are measured from motorized resistance.	Useful for strength & conditioning and assessing kinetic & kinematic demands of speed.	Equipment is expensive and bulky. Requires extensive knowledge for data interpretation.
	**Optical Tracking** Cameras capture and analyze movement through image processing.	Non-invasive, can track multiple athletes and implements (e.g., a ball) at once.	Requires multiple high-quality cameras, complex setup that is not portable; very expensive.



The **6 Dimensions** of Speed

Speed assessment is no longer constrained to straight-line acceleration and maximum velocity sprints. Thanks to accessible modern technology, speed assessment methods have expanded to include multidirectional assessments, reactive elements, and interval tests and more.

While many dimensions of speed exist, this guide aims to discuss **6 relevant applications** of speed testing:

Maximum Velocity Sprinting

The fastest possible speed an athlete can reach. It is the easiest-to-understand element of speed, yet difficult to reach in sports outside of track and field events such as the 100- and 200-meter (m) dash. Team sport athletes may only reach this threshold for 1-3% of match-play scenarios (Gualtieri, 2023).

Acceleration

The rate at which an athlete can increase their speed from a stationary position or slow velocity. Linear acceleration occurs most frequently in the first 20-30y of a maximal effort locomotive activity; however, world-class sprinters can continue accelerating into the 40 or 50y mark (Slawinski, 2017; Krzysztof, 2013).

Curvilinear Sprinting

While it appears as a relatively new training method in a team sport, running on a curve is a common sporting demand. In fact, 85% of maximum velocity maneuvers in Premier League Soccer are made in a curvilinear fashion.

COD & Agility

A particularly critical element of speed as well as a common mechanism of injury in unstructured sports, agility requires decision-making, deceleration, acceleration and finely-tuned coordination to execute effectively.

While some modern speed testing technology, such as timing gates, can be used to measure both COD & agility, these two qualities are not the same:

- **COD:** A pre-planned movement executed as quickly as possible. Commonly seen with American Football receivers "running routes" that are pre-planned to evade a defender.
- **Agility:** A movement in reaction to a stimulus in the external environment. Agility adds a layer of decision-making and cognitive demand to that of a standard COD test. These can most easily be seen in team sports by a defender who is reacting to their opponent's actions.

Speed Endurance and Repeated Sprint Ability

Speed endurance is the ability to maintain 95-100% efforts that typically last for 7-15 seconds and utilize full recovery periods (when done correctly, recovery periods can last up to half an hour).

This is different from repeated sprint ability (RSA), which refers to an athlete's capacity to perform shorter bouts of high-effort running (2.5-5 seconds) with shorter rest periods (typically between 10-60 seconds).

RSA is crucial for athletes competing in events requiring repeated sprints or high-speed running exposures, such as soccer or rugby, whereas speed endurance is often used for track sprinters to ensure each rep performed is at the highest quality possible.

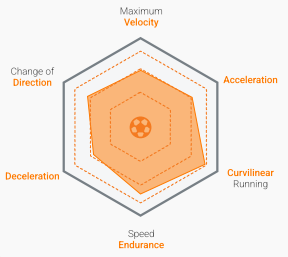
Deceleration

Deceleration is the ability to reduce speed as quickly as possible. Often accompanying a COD or agility task, proficient deceleration capacity is vital for sports performance and injury prevention.

High-speed deceleration is most often seen by an offensive player in team sports like soccer, football or basketball, where the athlete is trying to create distance or separation from their defender.

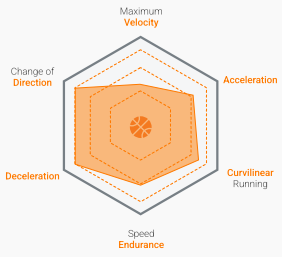
Each of these six components will have varying levels of relevance and carryover depending on the athlete's sport, development level, and previous training history. Examples of typical speed attributes for different sports are shown below to help visualize how an assessment process might differ based on task demands.

Speed Characteristics of **Different Sports**



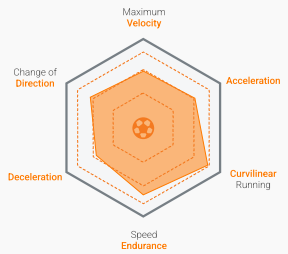
Soccer

Soccer is a highly reactive and dynamic sport with high volumes of curvilinear running, endurance and change of direction tasks with a large field that allows for maximum velocity breakaway plays.



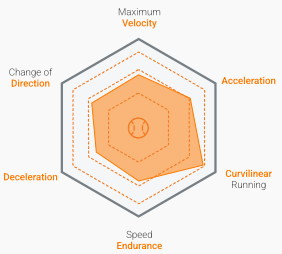
Basketball

Basketball is a reactive sport with moderate volumes of curvilinear running, high demands for acceleration, deceleration and change of direction tasks due to it's smaller court size compared to a soccer field.



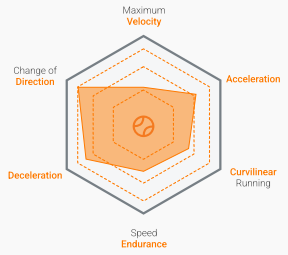
Track

Track sprinting is almost exclusively focused on velocity and acceleration, with very little need for change of direction or deceleration. Speed, endurance and the curvilinear running demands change by event.



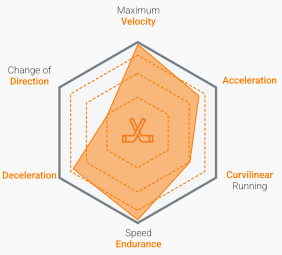
Baseball

Baseball is a slightly less reactive sport compared to soccer or basketball due to slower pace and general sport demands. It has a high demand for curvilinear running, acceleration and maximum velocity with occasional change of direction demands during fielding.



Tennis

Tennis is a fast-paced sport, constrained by a small court size. This requires athletes to have elite acceleration, deceleration and change of direction capabilities. Tennis has low speed endurance demands and it almost never requires maximum velocity.



Hockey

Due to the sporting environment (ice), hockey has unique demands that focus on skate acceleration, change of direction and deceleration requirements to optimize performance. Curvilinear running, maximum velocity and speed endurance often take a secondary role.

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Testing the Dimensions of Speed

The definition of "fast" is different depending on the sport and task at hand. In team sports settings, "high-speed running" and "sprinting" have a large variation and range of definitions depending on measurement methods and equipment.

In general, thresholds tend to hover around the 12-13+ miles per hour (mph) (19-20km/h) and 14-16+ mph (22-26km/h) marks, respectively. However, team sport athletes can regularly approach 18-19+ mph (29-30km/h) during breakaways. In elite sprinting, athletes like Usain Bolt have broken records with speeds exceeding 27mph.

In recent years, the term "game speed" has been popularized, as it better describes a multidimensional skillset of an athlete's physical speed and their ability to appropriately apply it in the context of their sport (Ian Jeffrey's Book).

Today, the question for an athlete has changed from "How fast are they?" to **"What speed attributes do they need to be successful?"**

Although the ability to "read the game" in real-time is a difficult attribute to quantify, the ability to sprint, change direction and react to a stimulus is not. Today, the question for an athlete has changed from "How fast are they?" to "What speed attributes do they need to be successful?"

The answer to this question allows a practitioner to determine and define the speed assessments and subsequent training that provide the best outcomes.

Athlete/Sport	Speed Attribute(s)	Test/Assessment(s)
Track & Field (400m)	• Straight-line sprinting	• 40 yard (y) dash
	• Curvilinear sprinting	• Curvilinear speed
	• Speed-endurance	• Accelerations • Fixed-recovery interval training
Basketball	• Acceleration	• 20-30y acceleration
	• COD	• 5-10-5
	• Agility	• Agility set up
Soccer	• Top speed	• Flying 10
	• COD	• 5-10-5
	• Speed-endurance	• Serpentine drill • Interval repeats
Distance Running	• Speed intervals	• Lap timing • Fixed duration sprint interval training
Baseball & Softball	• Acceleration	• 10, 20, 30 or 40-yard dash
	• Curvilinear sprinting	• Curvilinear speed

In the following sections, we will cover each of the dimensions of speed, which timing gate tests are available for assessing them and how to conduct these tests.

The **Golden Rules** of Speed Testing

When testing speed with timing gates, it is crucial to follow guidelines to ensure consistency and accuracy in your results. These "Golden Rules" help standardize the testing process, allowing for efficient assessments and reliable comparisons.

Environmental Conditions

- **Outdoors/Indoors:** Ensure that the location for testing, whether indoors or outdoors, remains consistent for all tests based on the population of interest. Variations in environmental conditions like heat, wind and humidity can significantly impact results.
- **Surface Type:** The type of surface – turf, grass, court or any other sports surface should be standardized. Different surfaces can affect traction and running mechanics, influencing the speed and performance of the athlete.
- **Footwear:** Athletes should wear the same type of footwear for each test. Different shoes can alter gait patterns and grip as well as task efficiency, leading to variability in results.

Cueing

- **Consistency:** Use the same verbal cues and demonstrations for every athlete in every session. Consistent cueing ensures that all athletes understand the start procedures and expectations, minimizing variability in their response times and efforts.

Task Setup

- **Gate Placement:** Accurately position each speed gate in the exact location for every test. Many timing gates, such as the SmartSpeed range, function optimally when the distance from the gate to the reflector is 2y or less. The beam should always be perpendicular to the reflector.
- **Gate Height:** Consistency in gate height is important to avoid different body parts breaking the beam during repeat tests. SmartSpeed's ECP feature can help correct for such inconsistencies, but a consistent setup is still recommended to limit variability.
- **Lead-In Distance:** Unless otherwise stated, 12in (30cm) lead-in times have shown to be the most reliable when executing a "break-beam start" (i.e., timing begins when an athlete breaks the first gate's beam).
- **Run-Off Distance:** Athletes without sufficient distance to decelerate after a speed test may not reach their maximum speed capabilities within the test. If possible, having run-off distances of 20-30m or greater will help to limit these effects.
- **In-Beam Starts:** Ensure that the beam is centered on the athlete's midline and that the athlete initiates the movement without taking a "false step" to accidentally trigger the start.
- **Warm-Up Procedures:** Standardizing warm-up sequencing, duration and intensity will help ensure that each athlete is prepared for the speed testing session. It is recommended that a trial run at 50% effort is executed before a maximum effort repetition to ensure beam height and placement are accurate.

By adhering to these Golden Rules, you can ensure that your speed testing using speed gates is reliable and valid. Consistency in environmental conditions, cueing and task setup is key to obtaining accurate and comparable results, allowing for better assessment and tracking of sprint and COD performance.

Maximum Velocity Sprinting

Maximum velocity sprinting focuses on an athlete reaching their highest possible speed over a short distance. This form of training and assessment is critical for sports that have high-speed demands, such as soccer, rugby, football and track sprinting.

While the immediate carry-over of max velocity sprinting may not translate to every sporting environment, the raw capacity of sprinting fast is desirable in many sporting disciplines.

Tests for Maximum Velocity Sprinting

Maximum velocity assessments with timing gates can be conducted in two ways.

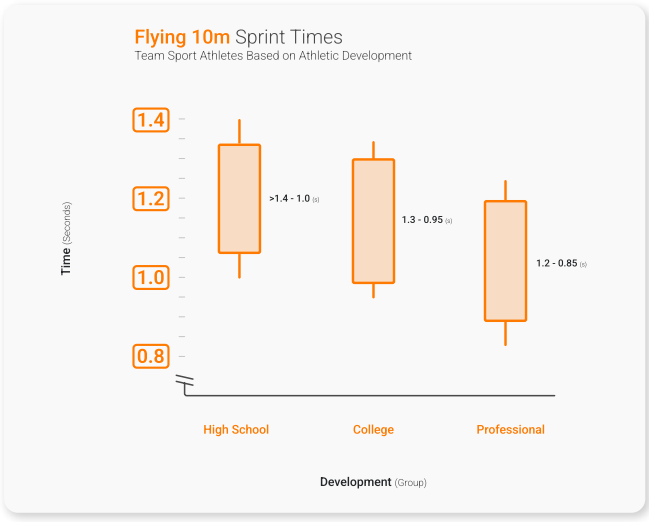
First, by running a 30-40m acceleration, practitioners can be confident that their athletes will hit top speed within this window; placing timing gates at 10, 20, 30 and 40m can provide 10m split times to find an athlete's maximum velocity.

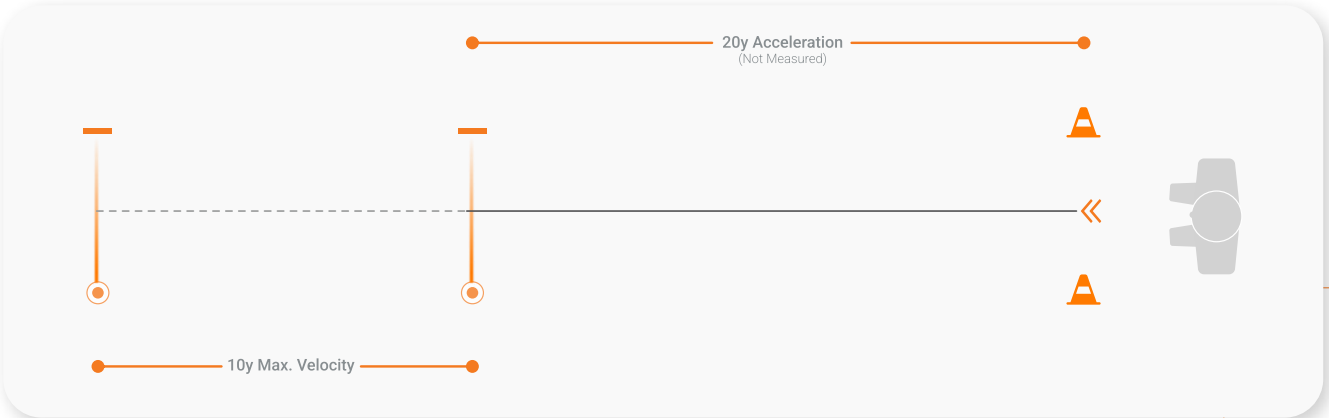
Second, knowing that most team sport athletes will reach maximum velocity between 20-30m (Young, 2008), practitioners can omit recording the acceleration and just perform a "flying 10 assessment" by having a run-up zone followed by a timed section where the athlete's peak speed is recorded.

Timing Gate Setup

The setup for flying sprints varies depending on the athlete's level and the specific training goals. It is common to have a 20-30y run-up zone where the athlete accelerates to their full speed but is not being timed.

This is immediately followed by a 10y maximum velocity zone where the athlete sprints through two timing gates that are 10y apart. Split times are automatically recorded and the athlete's maximum velocity is calculated.





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Acceleration

Acceleration may be the dimension of speed most applicable across all sports. With almost limitless upsides when it comes to athleticism and as a key quality of interest for many practitioners, acceleration assessment needs to be accurate and efficient.

The Demands of Acceleration

The maximal intent of accelerations and longer ground-contact times compared to top-speed running make this action very muscularly demanding.

The maximal intent of accelerations and longer ground-contact times compared to top-speed running make this action very muscularly demanding. During acceleration, force vectors have a greater horizontal component compared to maximalvelocity running, as the lower extremity forcefully propels the body forward.

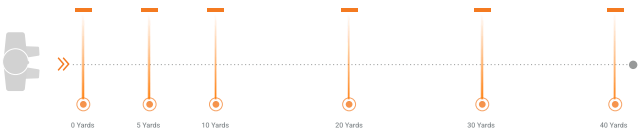
Commonly, athletes will reach their top speed within 20-30y of maximum effort acceleration from a stand-still; therefore, acceleration measurement strategies should focus primarily on tracking split times and speeds in distances of up to roughly 40y.

Tests for Acceleration

The most common test for acceleration with timing gates is a one-way timing drill. This test involves a defined start and finish point with the athlete moving in one direction only, ensuring they do not pass back through a previously broken beam.

For example, when using SmartSpeed, at least two timing gates are required to accurately perform a one-way timing drill, though more can be added to collect more split times.

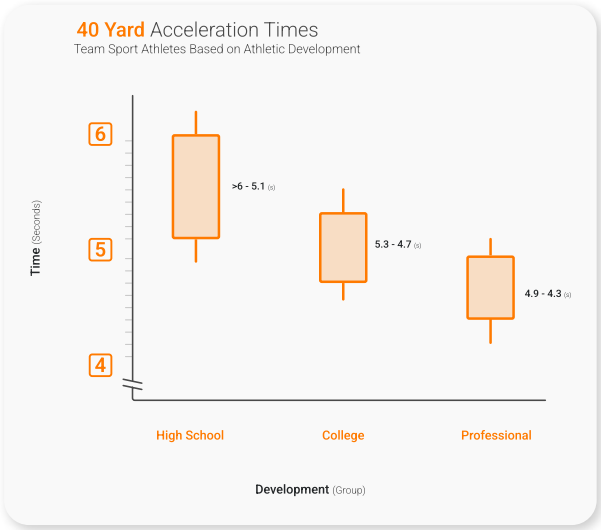
This setup is often referred to as a linear sprint drill, although the gates can be easily adapted to create curvilinear drills.



Setup for Testing Acceleration

When testing acceleration with timing gates, a common gate interval is 5, 10, 20, 30 and 40y.

This setup allows the practitioner to assess the entire acceleration process – and observe in higher fidelity in early distances where acceleration is highest – rather than simply timing the total distance.



Interpretation

By profiling an athlete's acceleration times and splits, practitioners can compare with benchmarks and other normative data to assess the athlete's acceleration abilities compared to their peers. This allows for training decisions for practitioners to focus on various methods of acceleration training.

Curvilinear Speed

An attribute commonly overlooked in many athletic assessments is the ability to run on a curve. Curvilinear running is an incredibly important action to master as an athlete, as some reports show more than 85% of max velocity maneuvers are curvilinear in nature.

Much like any trainable quality, the ability of a practitioner to change their athletes' capabilities is limited to their ability to test those capabilities. Therefore, understanding best practices and benchmarks associated with curvilinear running is imperative for the performance practitioner.

…some reports show **more than 85% of maximum velocity maneuvers** are curvilinear in nature.

The Demands of Curvilinear Running

Curvilinear running poses a unique demand on the body. With athletes able to hit speeds close to that of straight-line running whilst utilizing force vectors similar to those of shallow COD tasks, curvilinear running can be particularly taxing on athletes' bodies.

In straight-line running, each leg provides the same relative contribution to forward propulsion as a means of achieving the goal; this is not the case in curvilinear running. Research from Filter, 2020 shows that the inside and outside legs in curvilinear sprinting show significant differences in foot contact times and electromyography (EMG) data. Data from Filter and colleagues demonstrates that inside leg foot contact times can be 8-11% greater than speed-equated linear running, which places a greater muscular demand on the entire lower extremity.

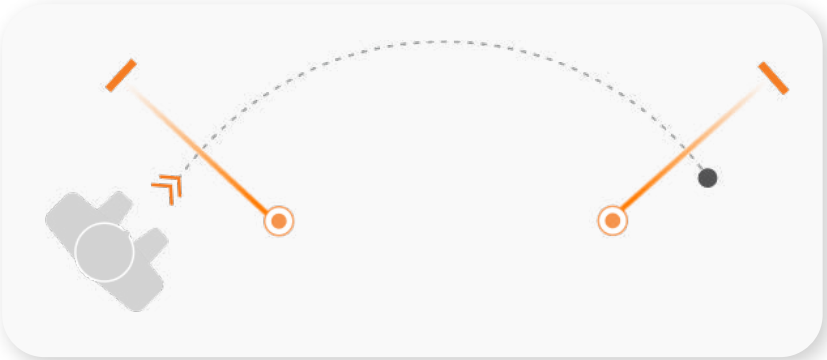
Interestingly, curvilinear running can also aid in detecting COD asymmetries but in the opposite direction. Approximately 70% of footballers who had a COD asymmetry presented with a curvilinear sprint test asymmetry in the opposite direction (Filter, 2021).

Methods of Assessment

Curvilinear tests using timing gates typically use a one-way timing drill, much like acceleration. Although some may refer to this setup as a linear sprint drill, the physical setup will not be linear for this assessment.

Setup for Testing Curvilinear Speed

Commonly, a curvilinear test would only require two timing gates, though more can be added to enable more split times. For example, two gates can be placed at the top of the penalty area on a soccer field in parallel with the penalty arc. This setup allows the athlete to run along the 18.5y (17m) arc with a 1y "run in" to best assess an athlete's curvilinear running ability.



Interpretation

Expert-reported benchmarks from Alberto Filter have been provided for high-level, senior players in soccer, which can be seen in the table below.

Population	Poor Curvilinear Time	Moderate Curvilinear Time	Good Curvilinear Time
Senior Soccer Athlete	≥ 2.9s	2.89 - 2.6s	< 2.6s

Change of **Direction (COD)**

COD training has seen a large increase in popularity in recent years due to its performance-enhancing and injury-reduction potential. In turn, this has drastically increased the demand for quality objective measurement solutions of COD for practitioners.

The Demands of COD

A key component that separates COD and agility from acceleration, load-velocity profiling or curvilinear running is the deceleration demands placed on the athlete.

While deceleration measurement can be a helpful tool for practitioners to assess, COD assessments like 5-10-5 or 5-0-5 require the same or similar demands as deceleration assessments while providing more information on the athlete's total COD ability.

Therefore, using COD drills like the 5-0-5 and measuring linear speed times of equal distance (i.e., 10m), practitioners can calculate the COD deficit (5-0-5 time (s) - 10m sprint time (s)) to indirectly assess an athlete's deceleration and COD capacity.

Agility, however, has equivalent physical demands with added cognitive loads. Agility measurement has become increasingly important during return-to-sport rehabilitation and performance training.

Timing Gate Setup

Multiple testing options exist for COD and agility training; however, this document will focus on the 5-10-5, Grid and Cut Drills to provide an indication of the breadth of options at your disposal.

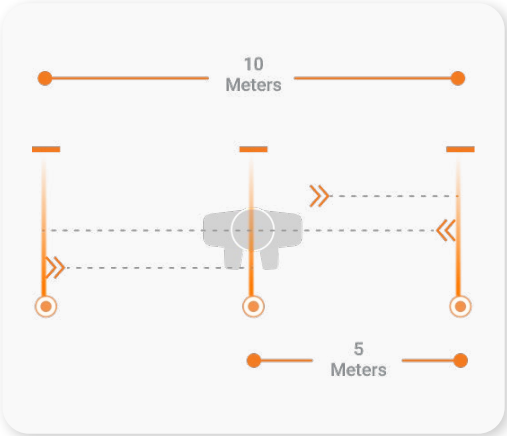
5-10-5 (COD)

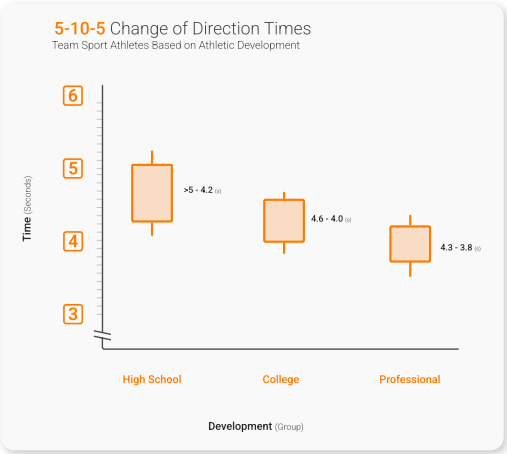
The 5-10-5 drill is designed to assess and train an athlete's ability to make rapid changes in direction. It is pre-configured and only requires one SmartSpeed timing gate, placed directly between two cones that are 10y apart.

This drill is different from others as the athlete begins in the beam; the athlete then runs to touch the cone to their right, 5y away, makes a 180° cut, runs 10y to the opposite cone (running through the beam), makes another 180° cut and runs through the beam a final time to complete the drill.

During the drill, athletes should be cued for their body to be facing the same direction during each cut; this ensures the athlete is alternating their plant leg during each COD rather than continually cutting on their preferred limb.

The athlete will repeat the drill going the opposite direction with the same directions as previously described.





Agility

While Agility and COD have colloquially been used interchangeably, they are indeed separate constructs. Agility encompasses the ability to acknowledge, interpret and react appropriately to a stimulus; the outcome of agility is often to change direction, which tends to be a confusing point for some practitioners.

To clarify, COD simply assesses the physical ability of an athlete to change direction, while agility adds a cognitive decision-making component.

Grid (Agility)

Modern technology allows an athlete to test and train their agility through various timing gate configurations. A common COD drill is the grid drill (or "X-drill"), which has been modernized to incorporate reactive components to test and train an athlete's agility.

Certain timing gate technologies, such as SmartSpeed Plus, have this agility drill pre-programmed in their software, allowing up to four athletes to be assessed at the same time.

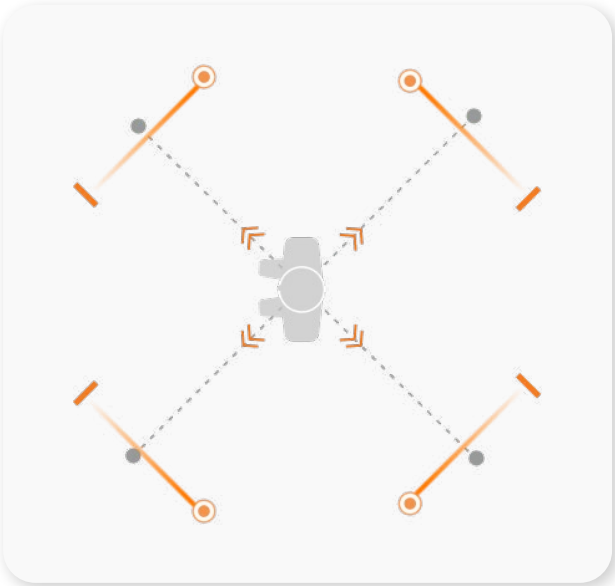
When using SmartSpeed Plus for a grid drill, a minimum of three timing gates are required, but the more gates you have, the more athletes you can test simultaneously.

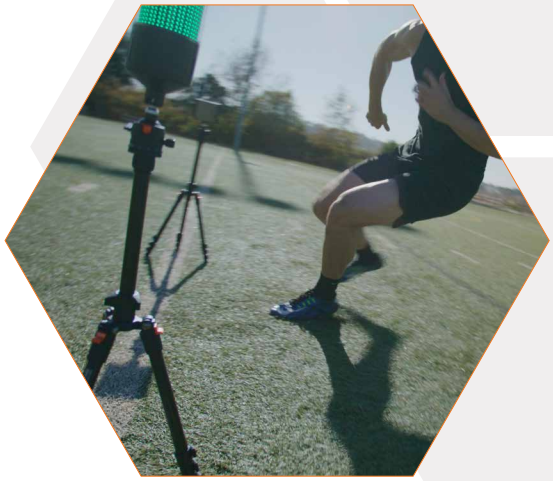
Athletes are surrounded by three or more timing gates, all equidistant from the starting point (typically 10-15y apart). Athletes are assigned a color and must react to the color that flashes. The drill can be either set for the duration or a specific number of beam breaks.

Rather than fixed criteria, two variables mark the completion of the drill:

- **Maximum number** of times the athletes can break the gates in a set time period or
- Athletes break the gates a **set amount of times** as quickly as possible.

With modern timing gate systems such as SmartSpeed Plus, each stimulus can be randomized, guaranteeing the athlete is reacting rather than predicting their next move.





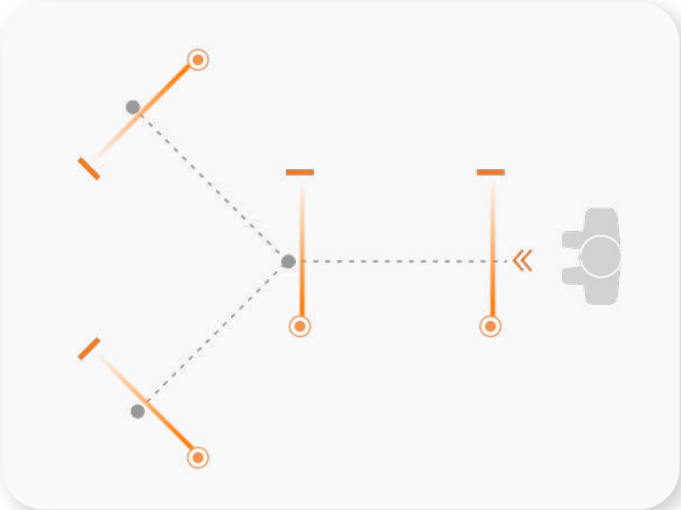
Cut (Agility)

Cut drills are used with the goal of testing the athlete's response to directional signals, random or otherwise selected, during their speed and agility training.

They often mimic a cutting or side-step maneuver, representing the visualization and exploitation of a gap from a defensive or offensive opponent.

These drills can be set up in many ways but require at least three timing gates. The cut drill begins with an athlete breaking a beam, triggering a visual stimulus from one of the gates for the athlete to then run through. Gates can be placed at nearly any distance or location from the original beam break to mimic whatever agility-dependent task the practitioner desires.

To add a further reactive element, practitioners can randomize the start times for each athlete, creating a "reactive start" feature. Some modern timing gate systems, such as SmartSpeed Plus, have reactive start features as preset options when selecting and creating an agility drill.



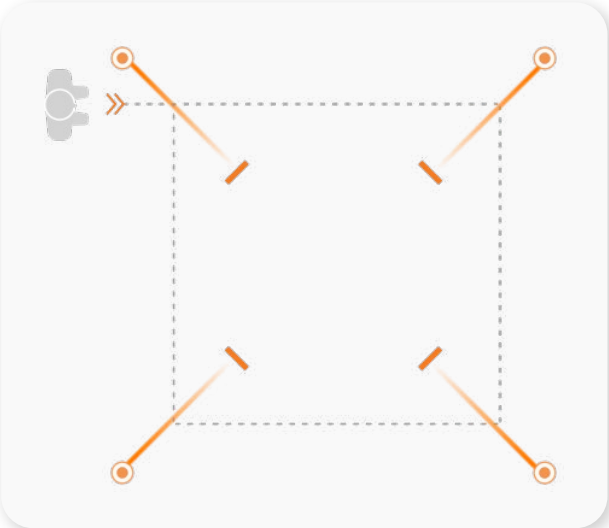
Interval Training and Conditioning Approaches

While this guide focuses primarily on high-speed applications, it would be remiss to neglect endurance, conditioning and metabolic performance while discussing all other aspects of speed.

However, traditional conditioning assessments are often either:

a. Inaccessibly complex and expensive for most coaches (such as VO2 Max assessment) or

b. Extremely rudimentary, leaving practitioners with minimal insights other than overall performance (such as the 12-minute run for time).



However, interval training and testing methods have been adopted by elite and sub-elite practitioners alike due to the ease of implementation and specificity of the stimulus to many team and endurance sports.

Characterized by alternating periods of high-intensity work followed by rest or low-intensity periods, interval training is a cornerstone of athletic training programs designed to boost endurance, speed and metabolic efficiency.

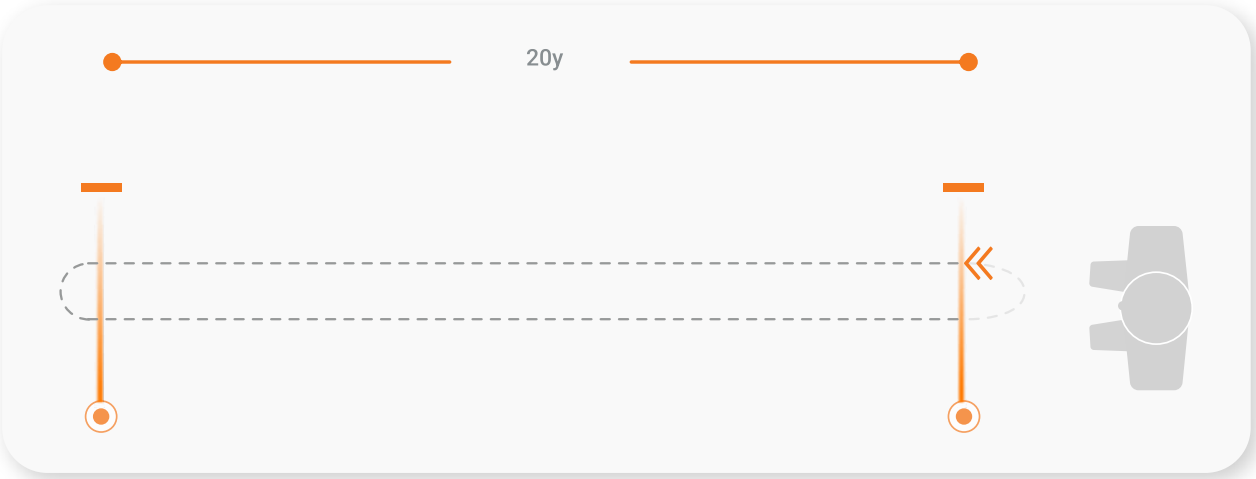
Timing gates offer a precise way to measure performance during these intervals, ensuring athletes train at the optimal intensities and rest adequately to maximize training improvement without overtraining.

Pace Conditioning

Pace conditioning is executed by one of two methods.

First, four timing gates are set up in a circle/square and the athlete must perform a given number of laps at a preset pace. Commonly used as a training modality, the number of laps and pace can be set to a certain limit to guarantee a set volume and intensity of running.

Similarly, the gates can be set for an athlete to complete as many timing gate breaks in the allotted time.



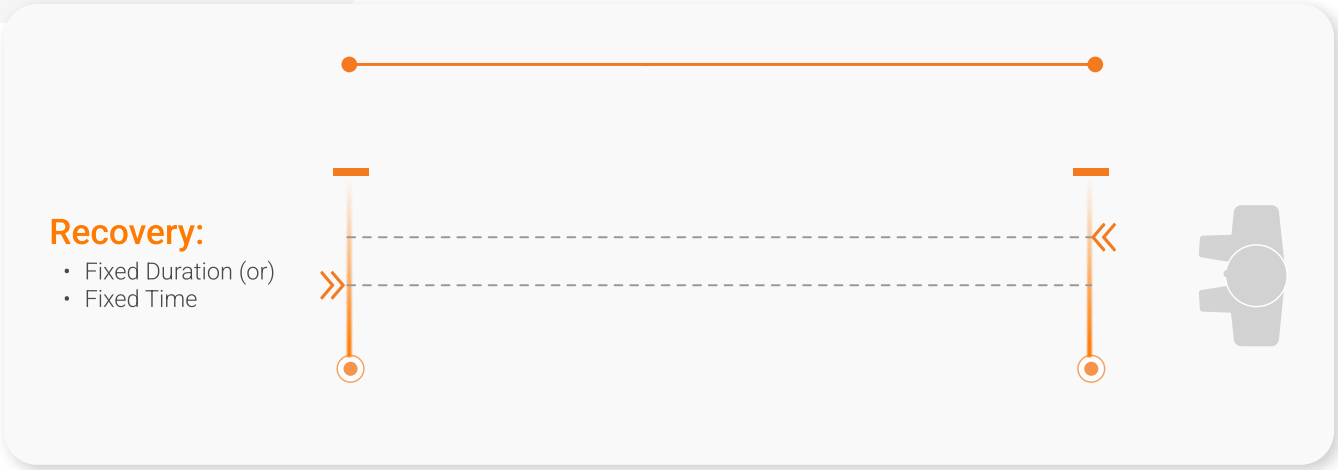
The second method is modeled after the well-known “Beep Test” (see previous page).

Here, short, moderate to high-intensity runs are repeated multiple times with brief recovery periods. A typical setup may include performing 2x20m sprints with increasing pacing standards for a fixed duration of time (i.e., 20 minutes) or until the athlete is unable to keep up with the selected pace. The athlete must maintain preset timing standards to complete the task.

Timing gates are placed at the start (0m), middle (10m) and end (20m) course to accurately measure the time each sprint takes and provide pacing options.

Interval Protocol Drills

Interval Protocol Drills are designed to test and improve an athlete’s speed endurance and intermittent performance capabilities. These drills use two timing gates per lane, allowing the athlete to run from Gate A to Gate B and back if required.



The intervals can be structured in two main formats: Fixed Recovery or Fixed Duration.

- **Fixed Recovery:** In this format, the athlete has a set rest period that begins as soon as they complete one interval repetition. For example, if the rest period is 20 seconds, it starts the moment the athlete passes through the timing gate at the end of a sprint.
- **Fixed Duration:** This format involves a fixed time frame within which each interval repetition, including the rest period, must be completed. For example, if the interval is set at 30 seconds and the sprint takes 10 seconds, the athlete has 20 seconds to rest before the next sprint starts.

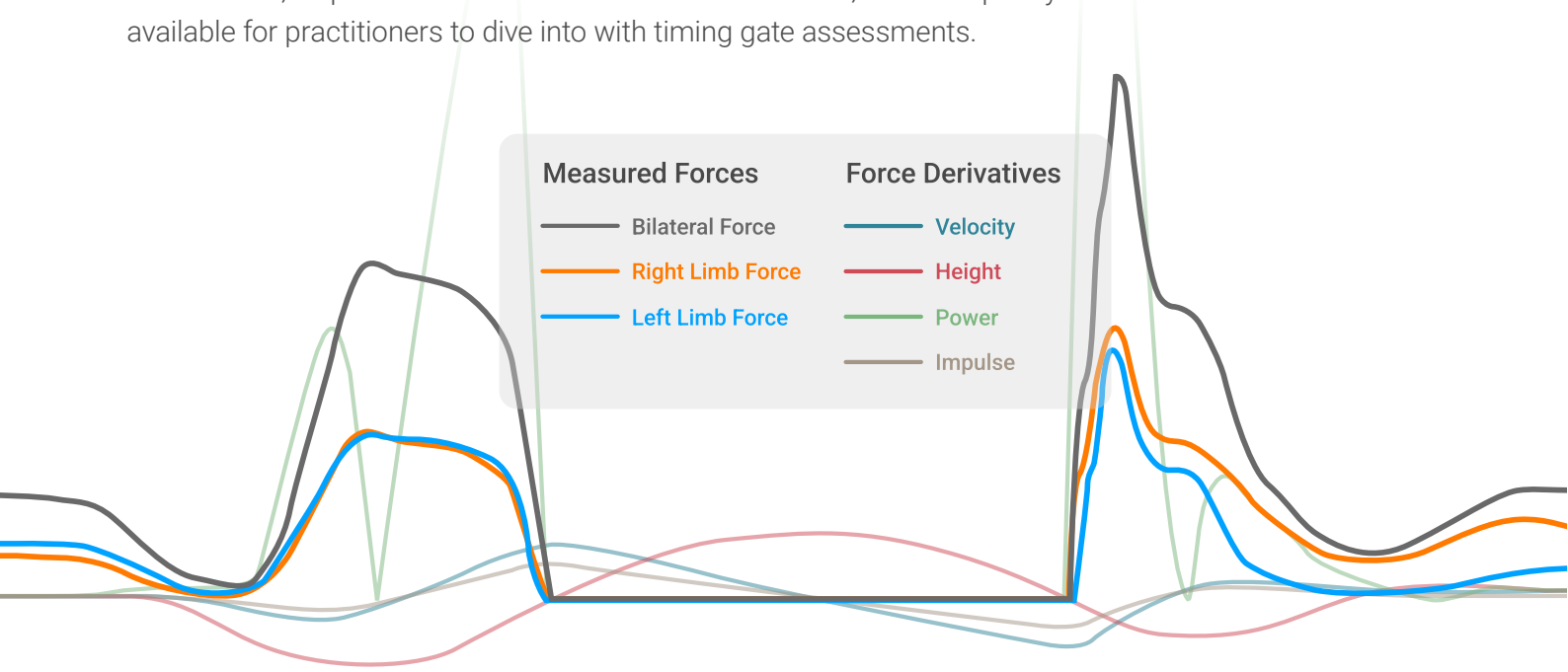
The customizability of each drill allows the practitioner to target the specific demands of their athlete’s sport, age group, position and countless other person-specific factors.

Understanding **the Results**

With data from human performance technology becoming increasingly voluminous and complex, practitioners can feel relieved and confident with the relative simplicity of most speed-testing data.

While outputs of peak velocity, mean velocity, splits and many other metrics are common in modern systems such as SmartSpeed, most speed testing involves simply measuring one variable: time.

Much like force plate assessments, where simple force-time data can be used to derive power, velocity, acceleration, displacement and hundreds of other metrics, there are plenty of time-derived metrics available for practitioners to dive into with timing gate assessments.



Force plates use force measurements to calculate a number of other metrics. **Similarly, timing gates use time to derive metrics such as speed and acceleration.**

To remove potential sources of error, such as those made when calculating speed based on split times and distances, practitioners are encouraged to use time as their primary metric for understanding speed.

This allows the results of a test to remain consistent and valid without the potential for calculation error or inaccurate prediction formulas.

Normative datasets for acceleration, COD and top speed lag behind age- and sport-related norms for other objective assessments, such as those from force plates or dynamometry.

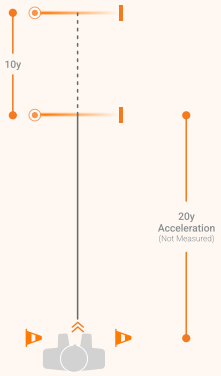
Due to limited data and highly variable athletic qualities, coaches may wish to use the following graphs as loose frameworks to conceptualize where an athlete may fit in amongst their peers in a particular test.

Summarizing the
6 Dimensions of Speed

Maximum Velocity Sprinting:

The fastest possible speed an athlete can reach.

Flying 10 Drills are executed as one-way timing drills. They involve a 20-30y acceleration that is untimed and a maximum velocity 10y sprint between 2 timing gates.



Acceleration

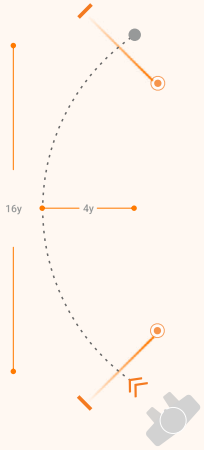
The rate at which an athlete can increase their speed from a stationary position or slow velocity.

30-40y accelerations are executed with multiple gates at relevant distance splits (5, 10, 20, 30y) to provide in-depth information on an athlete's acceleration.

Curvilinear Speed:

An athlete's ability to maximally accelerate and sprint along an arc.

Often executed as one-way timing drills. These drills simply measure the time between initial and final beam breaks (multiple gates can be added to provide split times as well.



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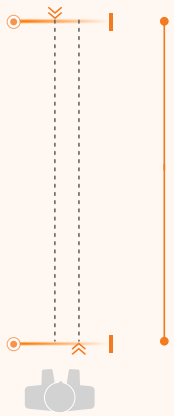
Speed Endurance and Repeated Sprint Ability:

Speed endurance is the ability to maintain 95-100% speed efforts. Compared to Speed Endurance, RSA requires much shorter efforts.

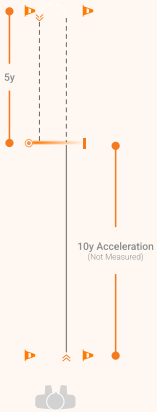
Interval Protocols test speed endurance and repeated sprint ability performance. The athlete moves between gates (in either direction) in a Fixed Recovery or Fixed Duration format for the set number of reps indicated.



Deceleration:

Deceleration is the ability to reduce speed as quickly as possible. Often accompanying a COD or agility task, proficient deceleration capacity is vital for sports performance and injury prevention.

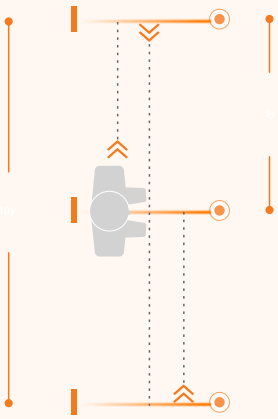
Deceleration is often measured in change of direction tasks like the 5-10-5.



Change of Direction & Agility:

Change of Direction involves a pre-planned movement executed as quickly as possible. Whereas agility is a movement in reaction to a stimulus in the external environment.

Both can be assessed with timing gate technology, depending on the set-up.



Example Applications for Speed Testing

Repeat Acceleration: The 10x10

Derek Hansen

Sprint Coach, Return-to-Play Specialist and Educator

After suffering multiple hamstring strains in his junior year, collegiate soccer athlete Brady Ruotolo knew he had a lot of work to do this off-season.

After multiple physical therapy sessions and completing a robust off-season weight training program, Brady was ready to return to the field.

However, he knew that his acceleration abilities and fitness weren't up to par for him to compete in his fourth and final season of college soccer.

During his on-field training, Brady's coach asked him to complete multiple sessions of the 10x10 protocol using SmartSpeed Plus timing gates. By doing so, Brady and his coach were able to assess key performance metrics, including acceleration times and potential acceleration fatigue.

Testing Approach

To capture the necessary data, Brady's coach used the 10x10 protocol to identify key acceleration and deceleration zones.

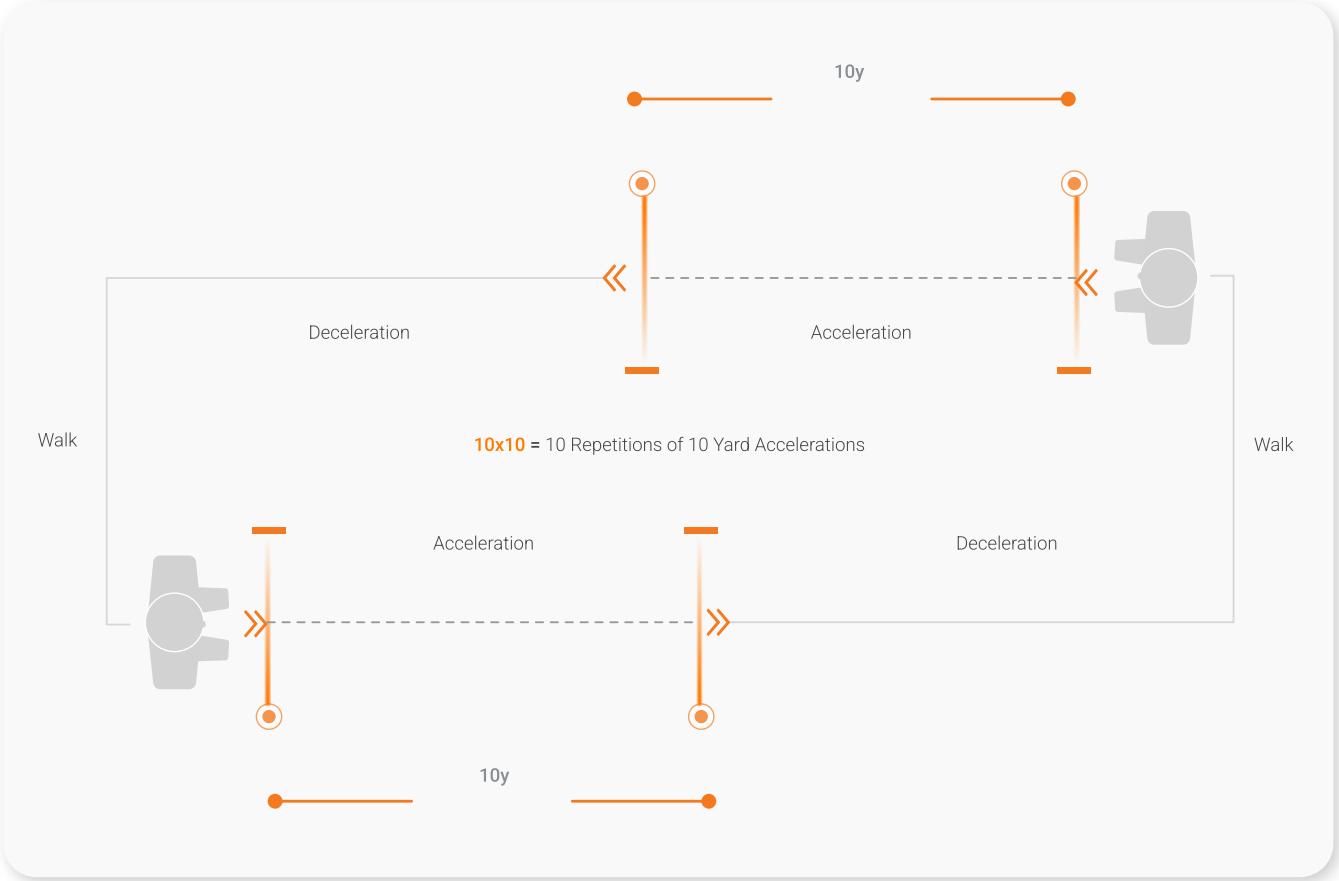
Their goal was to understand how Brady's performance metrics varied under different recovery conditions, ranging from no rest to 15 seconds between sprints. The testing setup involved placing four total timing gates at the start and end of two 10y shuttle courses. involved placing four total timing gates at the start and end of two 10m shuttle courses.

This setup allowed Brady accelerate through two gates, 10y apart, decelerate, walk a few steps to the left and turn around to get set up for the next acceleration, rather than having to run back to his original starting point.

Findings

Variability in performance over Brady's ten repetitions showed a linear increase in his acceleration times. This is confirmed with other training data that demonstrates poorly trained athletes showed a higher variability of around 0.50 seconds during the 10x10 protocol.

This information informed his reconditioning protocol to help ensure a safe and effective return to the soccer field by training his acceleration, endurance, and maximum velocity sprinting performance.



The 10 x 10

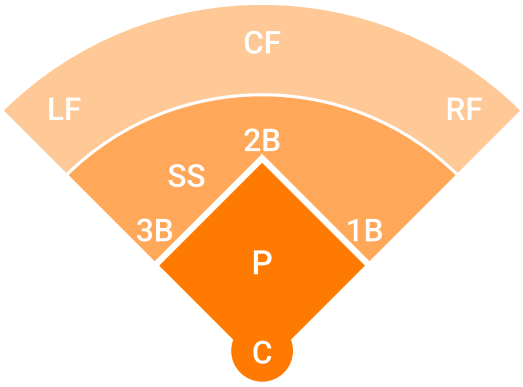
Assessing **Speed and Change of Direction** for Softball

Jamie Youngson

Strength and Conditioning coach
Client Success Manager, VALD

Riley is a 15-year-old high school Softball player who needs to improve her speed and agility.

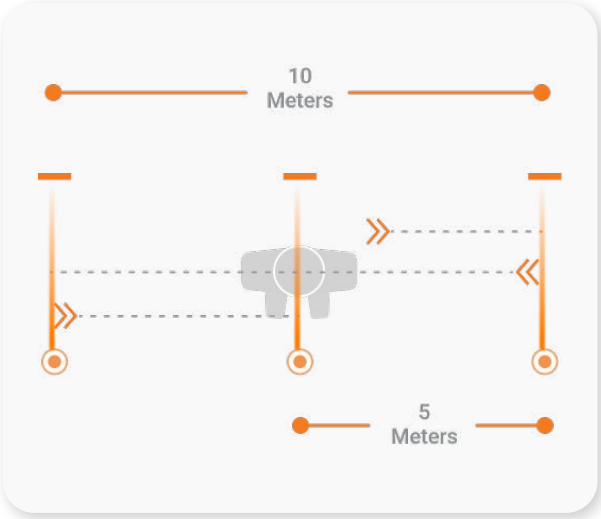
When in the field, she consistently plays Shortstop where effective agility is crucial for her to react quickly, change direction swiftly, make precise movements to field ground balls, execute double plays and cover a large portion of the infield.



Softball field positions

Testing – **Considerations and Approach**

To better understand Riley's ability to change direction, her coaches and strength and conditioning coach decided that the Pro-Agility (5-10-5) Test offers a good solution to assess her speed over short distances and COD ability. It is a reliable and time-efficient method of assessment, where each test takes around five seconds, allowing coaches to test (2-3 trials each) a large number of athletes in quick succession.



5-10-5

Importantly, Riley was afforded four minutes of recovery between trials to avoid fatigue negatively impacting her scores. Riley was also instructed to alternate the direction of turn as she initiated each trial (i.e., Trail 1 – move to the right and Trial 2 – move to the left). To ensure she didn't favor one side over the other.

In addition to the Pro-Agility Test, Riley also completed the Countermovement Jump (CMJ), as it is known that CMJ performance is highly correlated with Pro-Agility performance (Jones & Lorenzo, 2013).

Findings and Practical Applications

Results showed that Riley was quicker turning from her right side compared to her left (comparing split times 0-10m versus 10-20m), with an overall time of 5.32 seconds.

Using published normative scores (Haff & Triplett, 2015) and considering her CMJ results (i.e., 12.6in/32cm), Riley's coaches are able to devise a plan and program to help improve her COD for Softball and, ultimately, agility needs for Shortstop.

Sport	Population	Gender	Number of Athletes	Time (s)
Soccer	Women	College	51	**4.88** ± 0.20
	Women	High School	83	**4.91** ± 0.22
	Men	College	12	**4.80** ± 0.33
Lacrosse	Women	College	79	**4.99** ± 0.24
		High School	84	**4.99** ± 0.23
		College	11	**4.92** ± 0.22
Baseball	Men	MLB	62	**4.42** ± 0.90
		AAA	52	**4.53** ± 0.20
		AA	50	**4.42** ± 0.68
		A	84	**4.48** ± 0.54
		Rookie	90	**4.54** ± 0.19
Non-Specific	Women	Recreational	20	**5.23** ± 0.25
	Men		24	**4.67** ± 0.21

5-10-5 Test normative data – mean and standard deviation (Haff & Triplett, 2015)

Assessment of **Maximum Velocity** for Football

Ryan McLaughlin

Sports Scientist and Business Development Manager, VALD

Malone University Football coaches came into their recent off-season facing a challenge.

Their season was characterized by understaffing and inadequate time to pour through the mountains of GPS data they had collected. There were too many variables to track and the coaches needed a simple measure that they could all hang their hats on.

The coaching staff decided on tracking maximum velocity sprinting times as a Key Performance Indicator (KPI) for their athlete's speed capabilities.

Testing Approach and Setup

The coaching staff landed on the flying 10y sprint. as it is a widely accepted method of assessing an athlete's maximum speed while sprinting. This test typically involves a 20-30y build-up before recording the fastest 10y effort. They also wanted to understand the acceleration ability of the athlete during the build-up, so they used multiple timing gates to obtain this information.

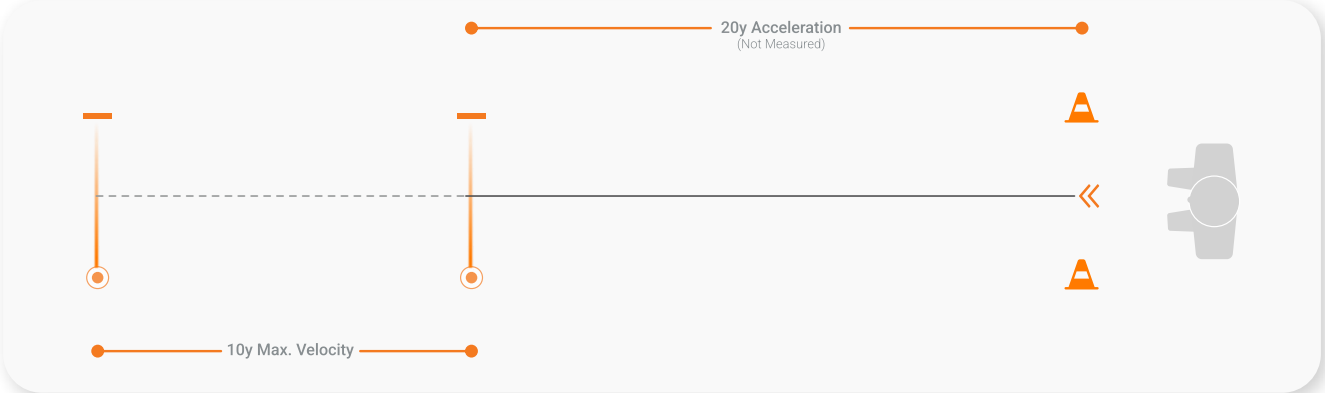
The timing gate set up was as follows:

Gate 1: Start gate using a break beam start with the athlete's front foot 30cm behind the gate as per recommendations from Altmann et al. 2015.

Gate 2: Positioned 10y from the start gate to obtain a split time quantifying the acceleration ability of the athlete.

Gate 3: Positioned 30y from the start gate and the beginning of the 10m fly effort.

Gate 4: Positioned 40y from the start gate and 10y after gate 3. This allows for a 10y flying sprint time to be collected.



While this gate layout provides specific information about the acceleration and max speed of the athlete, it also provides a basic start-to-finish time for their 40y sprint, which allows for times that are comparable to those observed at traditional testing events such as athlete combines.

Calculating Speed

The coaching staff then calculated game speed based on a SimpliFaster blog post written by Tony Holler. Since the staff implemented a 10y split, they divided 20.45 by their 10y split time to calculate miles per hour (mph) (or if using 10m, they would use 22.37).

Example Calculations:

Athlete 1:

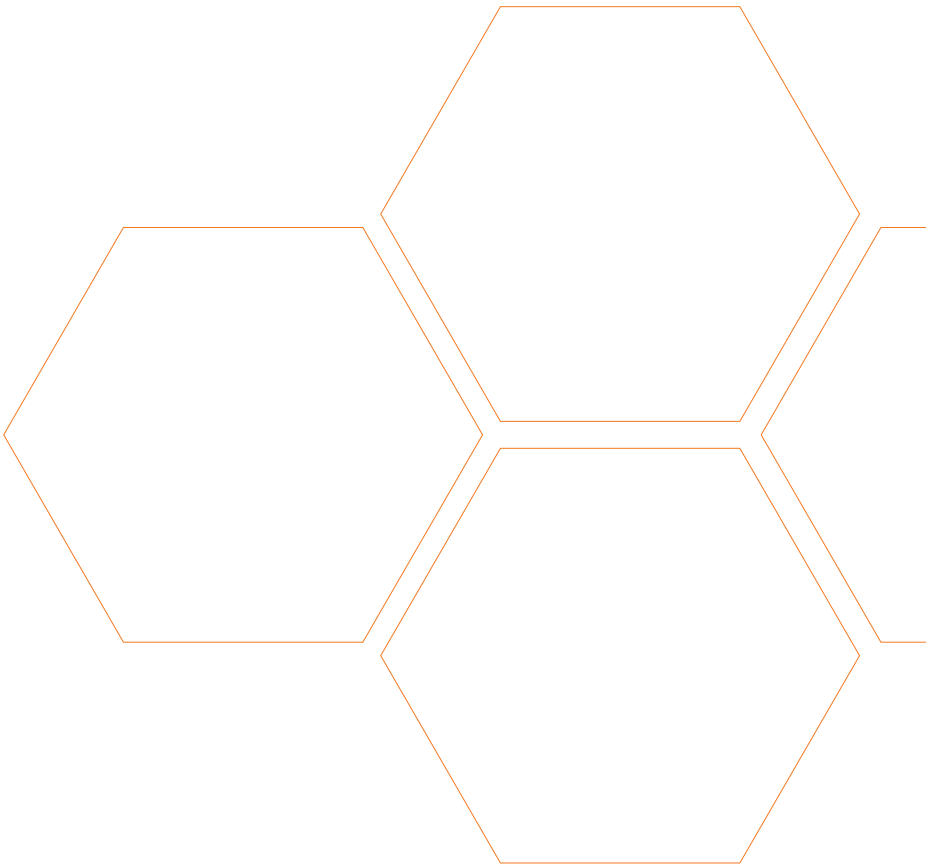
- Flying 10y split time = 0.98 seconds
- 20.45 / 0.98 = ***20.87mph***
- 0-10y acceleration split time = 1.48 seconds
- 20.45 / 1.48 = ***13.82mph***

Athlete 2:

- Flying 10m split time = 1.09 seconds
- 22.37 / 1.09 = ***20.52mph***
- 0-10m acceleration split time = 1.54 seconds
- 22.37 / 1.54 = ***14.53mph***

Sharing the **"Why"**

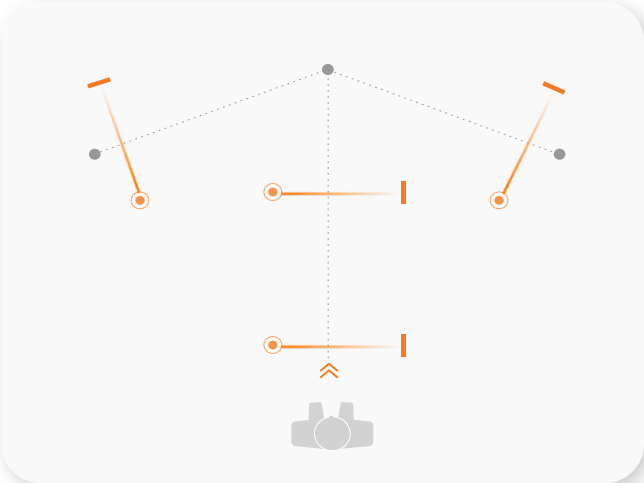
This approach allowed the Malone University coaching staff to determine maximum speed capabilities for all of their athletes in the space of a single session. This helped the staff categorize their athletes based on speed and provide more tailored training interventions for each group.



Multidirectional Return to Sport
Assessment and Training Considerations

Dylan Carmody

Physical Therapist, Strength & Conditioning Coach
North America Marketing Manager, VALD



Christina Harris has been rehabilitating from a left ACL reconstruction (ACL-R). She has passed all of her absolute and symmetry-based strength benchmarks and is eager to make a strong push to make the starting lineup for her college soccer team.

She is currently doing strength training and has skills-based conditioning 2x per week involving maximum effort straight-line accelerations and curvilinear running. However, she has only recently re-introduced COD tasks in her training.

As part of Christina's return to sport clearance, she must pass multiple COD and agility tests to ensure a safe return to sport, one of which is a reactive agility "cut drill."

In this assessment, performed using a SmartSpeed Plus timing gate system, she will run through the first gate towards a cone, triggering one of three possible gates to flash, forcing her to react and run through that gate as quickly as possible. Christina's assessment results were as follows:

Trial	COD to Right	COD to Left	Asymmetry
1	2.6s	2.9s	19%
2	2.4s	3.1s	33%
3	2.3s	2.8s	43%
Average	2.43s	2.93s	22%

This data shows that Christina can change directions more efficiently when her injured limb is used as the cutting or plant limb. Her coach suspects this deficit is due to the penultimate foot contact or the foot contact before she plants, which is a primary deceleration step in COD mechanics.

The data shows that when planting on her right leg, she was unable to change directions as efficiently due to her left leg's inability to decelerate her momentum efficiently. Therefore, there are greater eccentric force demands on the left limb when changing direction to the right and vice versa.

Her ability to change direction will be largely influenced by her ability to decelerate her momentum during the second to last foot contact, likely explaining the >30% asymmetry in COD time.

This assessment is corroborated by a force plate test battery where her eccentric deceleration impulse asymmetry was 18%, favoring her right side. These impairments help to influence her performance staff to begin specific high-speed deceleration training exercises during the preseason training schedule.

After three weeks of incorporating exercises specific to eccentric rate of force development (RFD), Christina's cut drill performance was re-assessed:

Trial	COD to Right	COD to Left	Asymmetry
1	2.5s	2.7s	8%
2	2.3s	2.6s	13%
3	2.3s	2.7s	17%
Average	2.36s	2.67s	13%

While these numbers are not perfectly symmetrical, her COD performance has improved on both limbs and she satisfied the 15% asymmetry criteria that Christina, the performance staff and the coaching staff have agreed to trial return to full practice participation.

In combination with Christina's RFD training, she gained more confidence in her COD abilities by playing game-like scenarios and practicing various COD tasks. The combination of the adaptations from her training, confidence from her performance and continued injury recovery all likely played into her gains in speed training.

This trial will assess her tolerance to game-like demands, with continued monitoring and reassessment before a complete return to full game demands occurs.

What **Next?**

Speed is simple but testing, understanding and mastering it may not be. We hope this guide has provided the tools to advance your speed testing and training practices.

At VALD, our team of dedicated Client Success Managers is here to help you get the most out of your systems and achieve your team's performance goals – whatever they may be. In the case of SmartSpeed, they help users choose the right drills, plan their testing for maximum efficiency and results, and ensure their VALD Hub reporting is configured to give them the insights they need when they need it.

We have collated a range of useful resources to explore and leading industry professionals worth following below to help you continue your speed testing and training learning journey.

If you want to learn more, drop us a line at **info@vald.com**.

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