# E-BOOK

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EVERY MILLISECOND COUNTS

SPEED SENSOR

# K-POWER

**Hybrid Sprint & VBT Sensor combined**

VELOCITY-BASED TRAINING

SPRINT


WIRELESS

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# INTRODUCTION

In the relentless pursuit of peak athletic performance, athletes and coaches are constantly seeking an edge. While traditional training methodologies have laid a foundational understanding, the modern era demands greater precision, individualization, and objectivity. The days of relying solely on subjective feel or rigid percentage-based programs are evolving. We now stand at the forefront of a technological revolution in athletic training, where data-driven insights can unlock new levels of potential.

This ebook delves into the transformative power of **Velocity-Based Training (VBT)** and **Force-Velocity (F-V)** profiling – cutting-edge approaches that tailor training stimuli directly to an athlete's daily readiness and specific adaptation goals. We will explore how measuring the speed of movement provides a clear window into an athlete's neuromuscular status, allowing for more effective load prescription, fatigue management, and ultimately, superior results.

At the heart of this evolution is innovative technology like the K-Power sensor. This ebook will not only unpack some of the science behind VBT and F-V profiling but also demonstrate how the K-Power sensor makes these advanced methodologies accessible and practical for coaches, athletes, and performance specialists. From understanding the evolution of training technology to leveraging K-Power’s key features for real-time feedback and insightful analytics, you will gain a comprehensive understanding of how to integrate these powerful tools into your training arsenal. Prepare to discover how you can train smarter, optimize every session, and achieve breakthroughs in performance.

# The Evolution of Training Technology

Over the past few decades, the fitness and athletic performance industry has witnessed significant technological advancements. From wearable fitness trackers that measure heart rate and steps, to advanced motion capture systems used by professional teams, technology has become deeply embedded in training. Today, we are entering a new era where velocity—the speed at which an athlete moves a load or completes a specific motion—can be accurately measured and leveraged for performance gains.

- **Early Innovations:** Simple devices like stopwatch timers and linear position transducers were initial attempts to measure performance.
- **Transition to Digital:** As sensors and microprocessors became more affordable, digital accelerometers and optical trackers emerged, offering more precise data.
- **Today's Environment:** The training world is seeing a surge of innovations like force plates, inertial sensors, and now ultra wide band (UWB)

**Figure 1.** The Evolution of time measurement Tools

Limitation: Captured only moments, not continuous time

## Our Solution:

# K-POWER
## SPEED SENSOR

### Hybrid - Sprint & VBT Sensor

## K-Power breakthrough Innovation

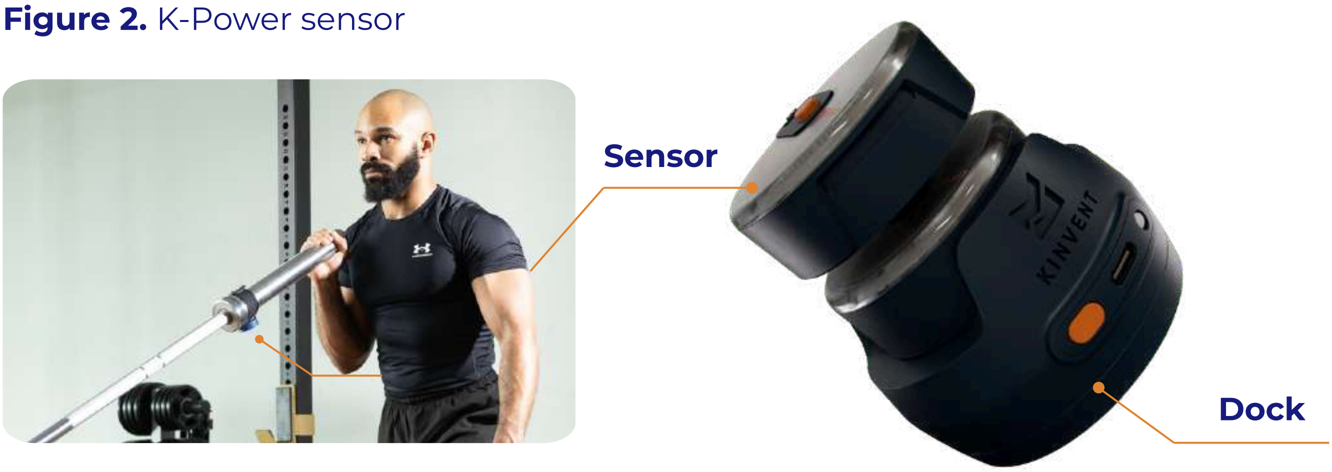
The development of the K-power sensor for velocity-based training involved merging hardware and software elements into a compact and user-friendly format. Integrating **miniaturized electronics** like microprocessors and antennas allows for a sleek and lightweight design. **Battery efficiency** is achieved through low-power UWB pulses, extending battery life for long training sessions. The sensor's **rugged build** using durable materials ensures protection against sweat, impacts, and general wear and tear in athletic environments.

## K-power Key Features and Innovations

The sensor boasts several key features and innovations, including **real-time data transmission** for instant feedback. **Automated rep counting** is enabled through advanced algorithms that detect and log individual repetitions. **Cloud connectivity** enables automatic data uploads for long-term storage, historical trend analysis, and remote coaching.

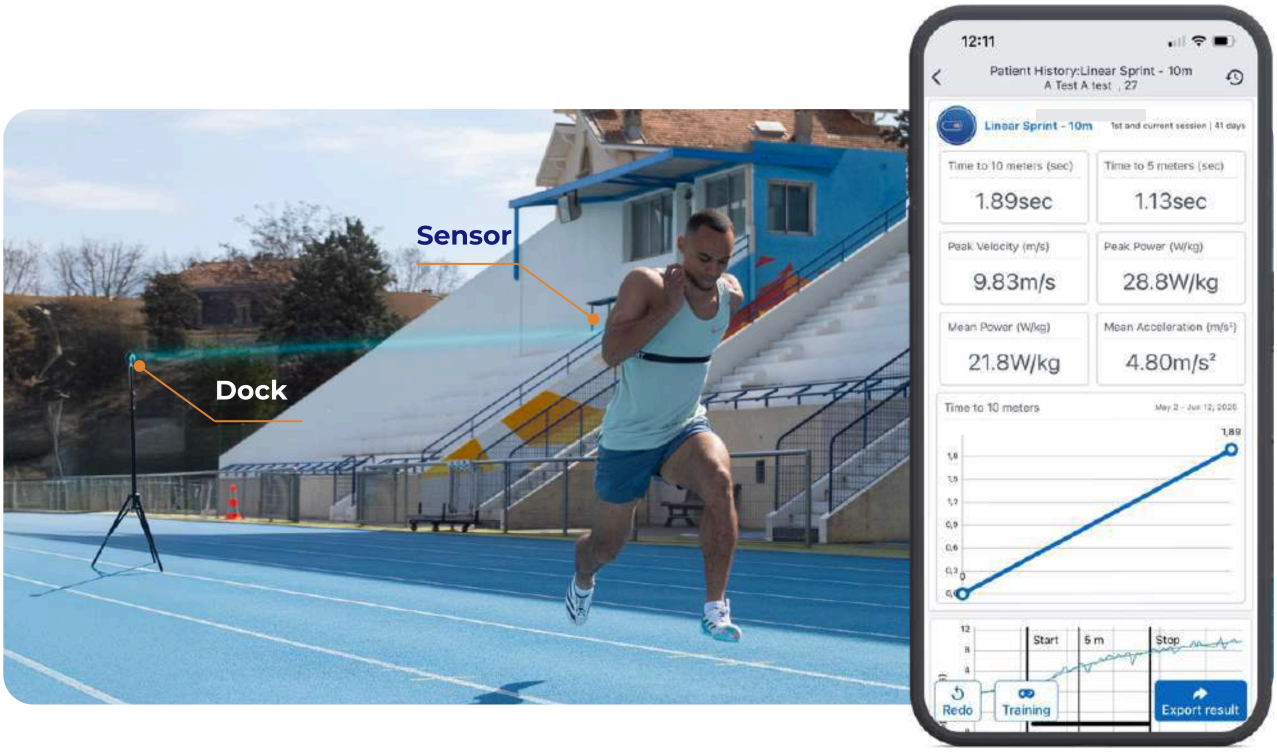
**Calibration protocols** ensure precise sensor readings in different training environments. **Signal interference management** algorithms detect and compensate for environmental interference, maintaining data quality. The sensor's design prioritizes **reproducibility**, delivering consistent measurements when testing athletes over extended periods.

**Figure 2.** K-Power sensor



Building upon the evolution of training technology, which has brought us sophisticated tools for measuring and analyzing athletic performance, we now turn our attention to two particularly impactful concepts. The idea of an optimal mechanical force–velocity (F–V) profile for sprint acceleration and the application of velocity-based training (VBT) in the weight room represent a significant leap forward. These methodologies are powerful because they allow you to **individualize** and **objectively monitor** an athlete's training—ultimately yielding bigger performance gains with less wasted effort. Here's why each is so useful:

## Optimal Force–Velocity Profiling for Sprint Acceleration




- **Identifies Individual Strengths & Weaknesses**

  By assessing an athlete's F–V profile (i.e., how much horizontal force they can apply at different running velocities), you can see if they are "force-deficient" (good top-speed mechanics but poor drive phase) or "velocity-deficient" (great force at low speed but lacking long-limb turnover). This diagnostic pinpoints exactly whether to emphasize heavy, strength-oriented drills (to boost $F_0$) or high-speed, elastic drills (to boost $V_0$).

- **Tailors Training Stimuli**

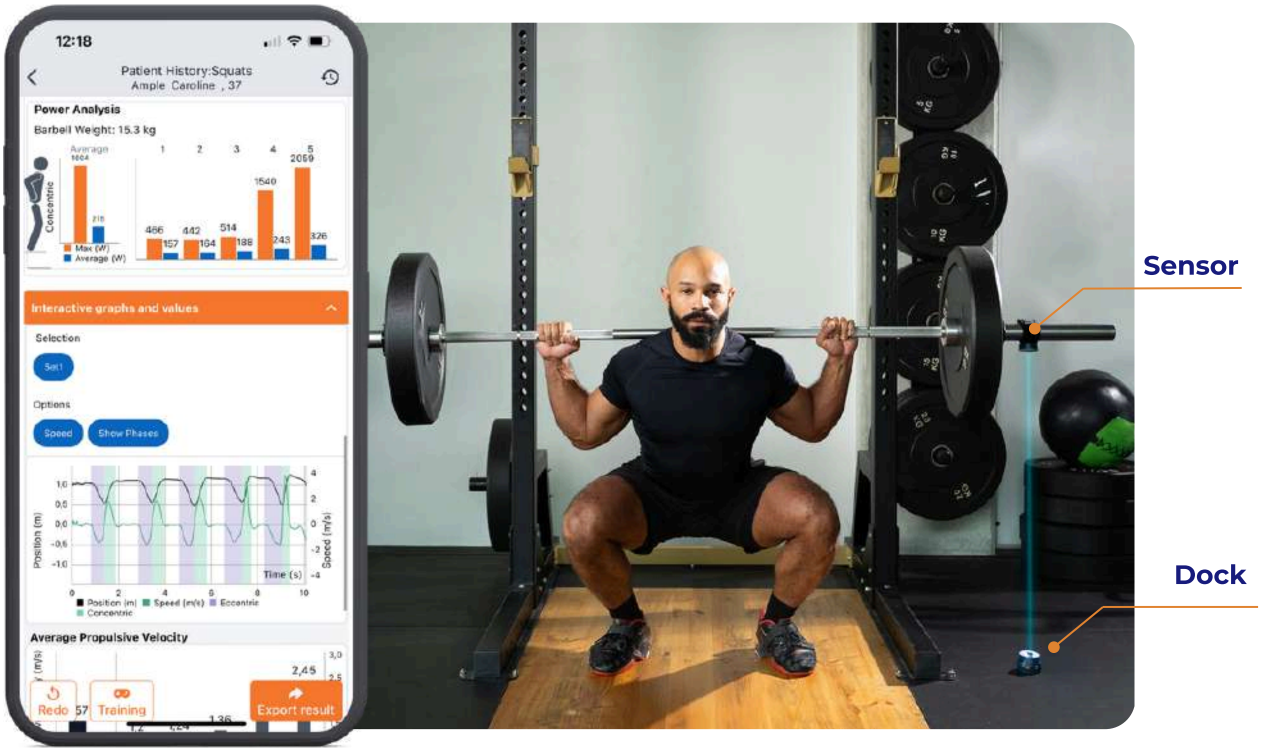
  Rather than "one-size-fits-all" sprint programs, you can prescribe targeted interventions:

  - **Force-oriented** work (sled pushes, heavy sled pulls, heavy resisted sprints) when low-speed force is lacking.
  - **Velocity-oriented** work (overspeed towing, flying sprints, high-step-frequency drills) when high-speed turnover is lacking.

- **Maximizes Transfer to Acceleration**

  Studies show that correcting an athlete's F–V imbalance yields larger improvements in actual sprint times than generic acceleration work alone, because you're directly training the neuromuscular qualities that limit them most.

# Velocity-Based Training in the Weight Room




- **Objective Load Prescription & Auto-Regulation**

  Instead of arbitrarily picking a % of 1-RM, you monitor the actual bar velocity of each rep. If an athlete is slower than target velocity—indicating fatigue or suboptimal readiness—you can automatically reduce load or volume in real time, maintaining optimal stimulus without overreaching.

- **Ensures Desired Neuromuscular Stimulus**

  Different velocity zones correspond to distinct training goals:

  - **Rapid force development** (>1.3m/s) for rapid force development
  - **High-velocity, low-load** (1.0-1.3 m/s) for Speed-Strength
  - **Moderate-velocity,** moderate-load (0.75–1.00 m/s) for power
  - **Low-velocity, high-load** (< 0.75 m/s) for maximal strength

  **VBT ensures you're actually working in the right zone rather than guessing.**

- **Monitors Fatigue & Readiness**

  A drop in velocity for a given load signals acute fatigue. Coaches can use velocity loss thresholds (e.g. 10% decline) to decide when to end a set, preventing excessive fatigue and preserving quality of movement.

- **Enhances Motivation & Engagement**

  Instant feedback on every rep often increases athlete engagement and effort, which can translate into better long-term adaptations.

# Training Modes :
# VBT × Sprint F–V Profiling

## Bringing Them Together

By combining F–V profiling on the track with VBT in the gym, you create a feedback-driven ecosystem:

1. **Profile** ➔ determine if an athlete needs more force or velocity.
2. **Select** ➔ choose gym exercises and load–velocity zones that target that deficiency.
3. **Monitor** ➔ use VBT to ensure each rep actually stimulates the intended adaptation, and to auto-regulate day-to-day readiness.
4. **Re-profile** ➔ periodically reassess the sprint F–V curve to confirm that the chosen interventions are shifting their profile toward the individualized optimum.

This integration leads to **faster acceleration, greater top-speed potential**, and **more efficient training** overall—because you're always tuning both the "what" (exercise choice) and the "how" (load and velocity) to the athlete's current needs.

## Horizontal Sprint Performance Assessment

By extracting key sprint metrics—time-to-5 m, time-to-10 m, maximal velocity ($V_{max}$), average acceleration (ā), and mean horizontal power ($P_h$)—the K-Power model delivers actionable insights across several dimensions:

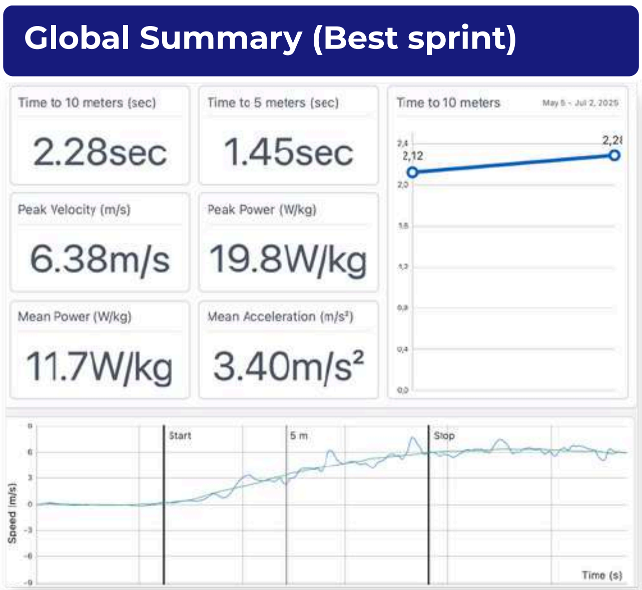



**Figure 3.** Instant results of K-power a 10m sprint horizontal assessment

# Key Outputs & Metrics

- **Early Acceleration (5 m & 10 m times):**
  - **Why it matters:** These splits isolate the athlete's drive-phase effectiveness and initial force application. Improvements here typically translate to better performance in sports with short-burst efforts (e.g., rugby, soccer) where the first few meters often decide outcomes.
  - ***Practical use:*** Coaches can track how technique changes (e.g., block start vs. standing start) or specific force-oriented drills (e.g., sled pulls) impact those initial phases.

- **Maximal Velocity ($V_{max}$):**
  - **Why it matters:** Although rarely reached in most games, $V_{max}$ represents the athlete's top-speed ceiling. Monitoring changes in $V_{max}$ helps to identify whether interventions aimed at velocity (e.g., overspeed training) are transferring to higher running speeds.

- **Maximal Velocity ($V_{max}$):**
  - **Why it matters:** Rather than looking at a single split, $\bar{a}$ over the full acceleration phase captures how consistently an athlete can sustain high propulsive forces.
  - **Practical use:** This metric is sensitive to both fatigue and technical drift; day-to-day fluctuations can guide autoregulation of training load.

- **Mean Horizontal Power ($P_h$):**
  - **Why it matters:** Power integrates both force and velocity into a single value, linking gym-based strength/power measures directly to on-track performance.
  - **Practical use:** By comparing $P_h$ with weight-room power outputs, practitioners can assess transfer of strength and power training to horizontal propulsion.

Together, these outputs give a comprehensive, phase-specific, and transfer-oriented profile of sprint acceleration—enabling targeted diagnostics, individualized programming, and clear feedback loops to the practitioner.

# Key Outputs & Metrics

Beyond basic splits and power estimates, the continuous, high-resolution velocity v(t) and acceleration a(t) traces from our UWB–IMU fusion enable computation of the full suite of mechanical variables described by Samozino and Morin [1,2]:

**1 - Horizontal Force–Velocity Profile**

- **Instantaneous horizontal force:**
  $F_h(t) = m \cdot a(t)$

  where m is the athlete's body mass.

- **Linear regression:**
  Fit

  $F_{h,i} = F_0 + S_{Fv} v_i$
  to obtain:
  - **Theoretical maximal force F0** (intercept at v=0)
  - **Theoretical maximal velocity** $V_0 = -F_0 / S_{Fv}$ (zero-force intercept)
  - **Slope** $S_{Fv}$ of the F–v relationship

**2 - Maximal Horizontal Power**

$P_{max} = 1/4\, F_0 V_0$

which corresponds to the peak of the parabolic power–velocity curve.

**3 - Mechanical Effectiveness (Ratio of Force)**

- **Instantaneous ratio of horizontal force:**
  $RF(t) = F_h(t) / ||F(t)||$

  where F(t) is the total ground reaction force vector.

- **Key metrics:**
  - **Maximum ratio RFmax (at the very first steps)**
  - **Decrease in ratio of force**
    $DRF = \Delta RF / \Delta v$

    quantifies how rapidly horizontal effectiveness drops as speed increases.

# Key Outputs & Metrics

### 4 - Acceleration-Phase Metrics

- **Optimal F–v Profile:**
  Using Samozino's analytical model, compute each athlete's **individual optimal slope** S⋆ such that, for a given Pmax, performance is maximized.

- **Profile Imbalance:**
  ΔS=SFv−S⋆, indicating whether the athlete is relatively "force-deficient" (ΔS<0) or "velocity-deficient" (ΔS>0).

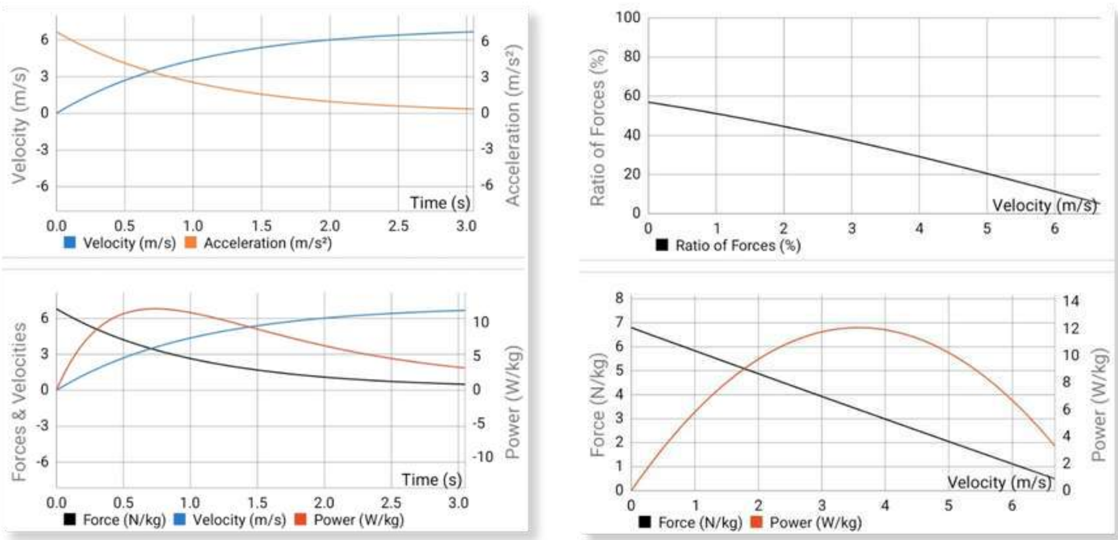



**Figure 4:** Velocity Rise Phase Analysis

# Key Outputs & Metrics

## Vertical Velocity Assessment (VTB)

Velocity-based training has increased the understanding of the force-velocity relationship. While the Force-Velocity Curve traditionally illustrated this relationship, it's recognized that force and velocity don't always interact curvilinearly. This realization led to the development of the Strength-Velocity Continuum, initially presented as the Strength Continuum by Bosco in 1995 and later refined with velocity-based training. Table 1 demonstrates that as the load increases (higher percentage of 1RM), movement velocity decreases. The table also indicates the physical qualities being developed at specific percentages of 1RM and their associated velocities. A key benefit of velocity-based training is its ability to differentiate training adaptations along this continuum using movement velocity.

| Percentage of 1-RM | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| None | Starting | | Speed | | Strength | | Accelerative | | Absolute | |

| | Strength | Strength | Speed | Strength | Strength |
|---|---|---|---|---|---|
| **Empirical and arbitrary velocity ranges (m/s [1])** | | | | | |
| | >1.3 | 1.3 - 1 | 1 - 0.75 | 0.75 - 0.5 | <0.5 |
| **Research Supported Velocity Ranges (m/s [3])** | | | | | |
| **Back Squat [4]** | - | - | - | - | <0.54 |
| **Bench Press [4,5]** | >1.3 | 1.3 - 0.9 | 0.95 - 0.63 | 0.63-0.32 | <0.32 |
| **Prone Pull [5]** | >1.52 | 1.52 - 1.23 | 1.23 - 0.94 | 0.94-0.67 | <0.67 |

Velocity-based training (VBT) gives coaches and athletes a more precise way to gauge effort than traditional percentage-of-1RM prescriptions. Imagine two equally strong lifters both squatting at 80 % of their 1RM, but one pushes with maximal intent while the other doesn't—clearly, the first is working harder even though the load is the same. VBT captures that difference by measuring bar speed, ensuring each session truly matches the athlete's capacity and goals.

Traditional intensity prescriptions rely on periodic 1RM tests, yet research shows daily strength can swing up to ±18 % around that value [6-8], meaning an "80 %" squat on Monday might feel very different on Tuesday. Rather than chase shifting 1RM numbers, VBT uses real-time velocity to adjust loads on the fly. This not only accounts for day-to-day freshness but also keeps athletes training at their ideal intensity.

In short, VBT transforms intensity from a static percentage into a dynamic, effort-based metric—helping athletes train smarter and coaches program more effectively. Keep reading for more advantages of this approach.

# Implementation & Best Practices


## Mean Concentric Velocity

The mean concentric velocity is the average speed of the bar (or load) throughout the entire lifting (concentric) phase. It's best suited for traditional strength movements—squats, deadlifts, bench presses—because these exercises include periods of both acceleration and deceleration. By tracking the overall concentric speed, coaches can gauge how efficiently an athlete moves the load under varying levels of fatigue or effort.

**Why It Matters in VBT:**

Monitoring mean concentric velocity lets you:

- **Adjust Loads Dynamically:** If an athlete's average speed slows below a target zone, reduce weight to maintain optimal training intensity.
- **Track Fatigue & Readiness:** A drop in mean velocity across sets or sessions signals accumulating fatigue or diminished readiness.

## Peak Concentric Velocity

Peak concentric velocity records the highest instantaneous speed reached during the concentric phase—often sampled every 5 ms. It's ideal for ballistic or power-driven lifts—power cleans, snatches, jump squats—where the movement includes an acceleration phase followed by a projectile trajectory. Using mean speed here would dilute the explosive portion's impact, especially when the first pull is slow and the second pull is very fast.

**Why It Matters in VBT:**

Tracking peak speed allows you to:

- **Maximize Power Output:** Ensure the athlete produces maximal explosive force rather than only moving the bar quickly on average.
- **Optimize Technique Feedback:** Identify breakdowns in explosive phases (e.g., a weak second pull in a clean).

## Mean Propulsive Velocity

Mean propulsive velocity isolates the portion of the concentric phase where acceleration exceeds gravity ($a \geq -9.81\ m/s^2$). In other words, it measures only the "accelerative" part of the lift, excluding the downward pull of gravity as the lifter slows at the top.

**Why It Matters in VBT:**

Focusing on propulsive velocity helps you:

- **Refine Load Prescription:** Since training adaptations for power and strength relate directly to how forcefully you accelerate the bar, propulsive speed offers a purer signal than overall concentric speed.

- **Prevent Technique Drift:** If an athlete generates insufficient propulsive acceleration, it flags under-performance in the true "force-producing" phase of the lift.

# Example Case Study: Squating with K-Power

**Athlete:** Warren, an intermediate powerlifter aiming to increase his squat 1 Repetition Maximum (1RM) and improve his power output. His current estimated 1RM for the back squat is 180 kg.

**Training Goal for the Session:** Strength-Speed (targeting velocities typically between 1.0 m/s and 0.75 m/s as per the ebook's guidelines for "Strength-Speed" or "Power").

**Equipment:** Barbell, weights, and the K-Power sensor attached to the bar.

## Session Protocol:

### Warm-up & Establishing Daily Readiness:

- Warren performs his usual warm-up routine.
- He then starts his warm-up sets for squats, gradually increasing the weight. With the K-Power sensor providing real-time mean concentric velocity, his coach monitors these initial sets.
- On his final warm-up set with 125 kg, his velocity is 1.1 m/s. Based on his typical velocity profile (if previously established) or general VBT guidelines, this indicates he's well-prepared for the session. This aligns with the ebook's concept of using velocity to objectively prescribe loads.

### Working Sets - Objective Load Prescription & Monitoring:

**Target:** The coach wants Warren to work at a load that allows him to maintain a mean concentric velocity between 0.75 m/s and 0.85 m/s for 3-5 repetitions, focusing on maximal intent for each rep.

**Set 1: Load is set to 145 kg.**

- Rep 1: 0.88 m/s
- Rep 2: 0.85 m/s
- Rep 3: 0.82 m/s
- Rep 4: 0.78 m/s

The K-Power sensor provides instant feedback for each rep. Warren and his coach see that the velocities are within the target for strength-speed/power development.

**Set 2: Load maintained at 145 kg.**

- Rep 1: 0.86 m/s
- Rep 2: 0.83 m/s
- Rep 3: 0.79 m/s
- Rep 4: 0.75 m/s

Velocities are still good, showing consistent effort.

## Fatigue Monitoring & Auto-Regulation:

**Set 3: Load maintained at 145 kg.**

- Rep 1: 0.82 m/s
- Rep 2: 0.77 m/s
- Rep 3: 0.71 m/s (Velocity drops below the 0.75 m/s lower threshold, and is more than a 10% drop from the first rep of this set, and previous sets).

**Decision:** The coach observes this velocity drop, as indicated by the K-Power data. This signals accumulating fatigue. Instead of pushing for more reps at this weight and risking form breakdown or excessive fatigue, the coach instructs Warren to end the set. This is an example of auto-regulating the volume based on real-time objective data, rather than just a prescribed number of reps.

**For the next set, options could be:**

- Reduce the load to 135 kg to try and maintain the target velocity.
- End the squat portion of the workout if the primary goal was quality repetitions within the target velocity zone.

## Post-Session Analysis:

Data from the K-Power sensor, including velocities for each rep, set averages, and any notes, can be automatically uploaded to the cloud.
Over time, Warren and his coach can track his velocity with specific loads, monitor improvements in his F-V profile for the squat, and ensure his training is consistently targeting the desired adaptations.

## How K-Power Facilitated the Session:

- Objective Load Prescription: K-Power helped determine appropriate working weights based on velocity rather than just percentages of an estimated 1RM, which can fluctuate daily.
- Ensured Desired Neuromuscular Stimulus: By monitoring velocity, they ensured Sarah was training in the correct zone for her strength-speed goal.
- Monitored Fatigue & Readiness: Real-time velocity decreases clearly indicated when fatigue was setting in, allowing for adjustments to prevent overtraining or junk volume.
- Enhanced Motivation & Engagement: Instant feedback on each rep can help athletes maintain focus and maximal intent.
- Data Logging for Trends: The ability to store and analyze data over time supports long-term planning and progress verification.

This case study demonstrates how K-Power and VBT principles can create a more dynamic, responsive, and effective training environment for a weightlifter.


# Conclusion

Throughout this ebook, we've journeyed from the foundational principles of training technology's evolution to the sophisticated applications of Force-Velocity profiling and Velocity-Based Training. The core message is clear: a data-driven, individualized approach to training is no longer a future concept but a present-day reality, capable of yielding significant performance gains with greater efficiency.

By understanding and implementing F-V profiling for sprint acceleration and VBT in the weight room, you empower yourself or your athletes to train with unprecedented precision. The ability to objectively monitor readiness, ensure the desired neuromuscular stimulus with every rep, auto-regulate training loads, and enhance motivation through instant feedback are no longer aspirations but achievable outcomes.

The K-Power sensor, with its blend of miniaturized electronics, robust design, and advanced features like real-time data transmission, automated rep counting, and cloud connectivity, serves as a powerful catalyst in this process. It bridges the gap between complex sports science and practical application, putting actionable insights directly into your hands.

As technology continues to advance, the capacity to refine and personalize training will only grow. We encourage you to embrace the principles outlined herein, experiment with these tools, and witness firsthand the profound impact that training with velocity can have on unlocking true athletic potential. The future of performance is not just about working harder, but about working smarter—and the journey starts now.

## References


1. Morin JB, Samozino P, Murata M, Cross MR, Nagahara R. A simple method for computing sprint acceleration kinetics from running velocity data: replication study with improved design. J Biomech. 2019; 94: 82-87.
2. Samozino P, Rabita G, Dorel S, et al. A simple method for measuring power, force, velocity properties, and mechanical effectiveness in sprint running. Scand J Med Sci Sports. 2016; 26(6): 648-658.
3. DEVELOPING EXPLOSIVE ATHLETES: USE OF VELOCITY BASED TRAINING IN TRAINING ATHLETES: Bryan Mann: 9781540558824: Amazon.com: Books. 2017. DEVELOPING EXPLOSIVE ATHLETES: USE OF VELOCITY BASED TRAINING IN TRAINING ATHLETES: Bryan Mann: 9781540558824
4. Ormsbee MJ, Carzoli JP, Klemp A, Allman BR, Zourdos MC, Kim JS, Panton LB. Efficacy of the Repetitions in Reserve-Based Rating of Perceived Exertion for the Bench Press in Experienced and Novice Benchers. J Strength Cond Res. 2019 Feb;33(2):337-345. doi: 10.1519/JSC.0000000000001901. PMID: 28301439.
5. González-Badillo, J.J., Sánchez-Medina, L. Movement velocity as a measure of loading intensity in resistance training. International Journal of Sports Medicine. 31: 347 – 352. 2010.
6. Sánchez-Medina L, González-Badillo, Pérez CE & Pallarés JG. Velocity- and Power-Load Relationships of the Bench Pull vs. Bench Press Exercises. Int J Sports Med 2014; 35: 209–216.
7. Jovanovic M, and Flanagan EP. (2014). Researched applications of velocity based strength training. J. Aust. Strength Cond. 22(2)58-69. https://www.researchgate.net/publication/265227430_Researched_Applications_of_Velocity_Based_Strength_Training
8. org – The Official Site of the NCAA. 2017. Velocity Based Training | NCAA.org – The Official Site of the NCAA. [ONLINE] Available at: http://www.ncaa.org/health-and-safety/sport-science-institute/velocity-based-training. [Accessed 09 May 2017].
9. Zourdos MC, Dolan C, Quiles JM, Klemp A, Jo E, Loenneke JP, Blanco R, Whitehurst M. Efficacy of daily 1RM training in well-trained powerlifters and weightlifters: a case series. Nutr Hosp 2016;33:437-443.

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