Speed Development
Instructing and Training Power Athletes

Chapter 1

It can be argued that speed, be it in Olympic sport or team sport, is the most important biomotor ability. Strangely, speed development is still archaic in practice and still poorly researched by the scientific community. For such a valuable asset to performance, one would figure that this value would be supported by sound principles and well applied science. Coaching speed is something very analogous to farming, in which time and patience can pay off in the long term when a foundation of basic components are planted. One common problem with speed is that talent will often incorrectly mask or give credit to clearly poor training and coaching programs, leaving coaches and athletes with misinformation that can stagnate or injure an athlete. It is essential that simple physics and basic anatomy illustrate the most obvious patterns of how athletes are improving from training methods. Furthermore, meet results or player testing should guide the growth of the athlete through objective data and criteria that is clear and repeatable.

In order to explore how to improve speed, the rudimentary and elementary review of very basic concepts and terminology must be revisited. The blinding of the obvious problems we see are because the fundamentals of high school physics are replaced with esoteric theories that seduce instead of reveal. Instead of regurgitating the basics with a stale summary, some additional insights are included to help illustrate primary factors in successful speed development.

Acceleration- The rate at which the velocity of an athletics body changes with time.

Maximum Velocity- The highest possible speed attained by an athlete in locomotion, specifically their center of mass.

Speed Reserve- When a sub-maximal speed is used, be it from fatigue or sporting limitations, is a percentage of maximal output by the athlete.

Deceleration- The ability to reduce forces, usually eccentrically, in a way that decreases the velocity of a limb or an athlete's body.

Clearly, the above definitions are specific to sprinting and have some imperfect definitions, but they are solid working examples of laws of motion in a functional language. The most useful information is when both clarity and timeless science is observed in a way that removes opinion and reveals causation. Speed training, be it instruction of mechanics and execution and/or in combination of training application, should be carefully recorded. Data in the form of video and electronic timing is the gold standard to demonstrate what is actually happening from mechanics and simple timing splits. Perceived intensities, subjective data, and crude metrics such as distance is not enough to fully explain what is happening day to day during practice. Success has come from less accurate and precise measures, but only when accuracy and precision is standard, can we truly share the results of the findings in a program. Even weight training at first glance seems to be an easy modality to measure since weights are labeled, the output has an intent (current level of ability and effort) and an execution (bar velocity and weight), but the true response is far more difficult to capture. Advancements in GPS player tracking have evolved, but center of mass changes in speed don't tell the entire story. With the complexities of the human body in both anatomy and physiology, the easiest way to build a foundation of measurement it to start simple and add as much detail as necessary. Simple speed testing in the form of electronic timing is sufficient to gauge the effectiveness of a program.

Building on the definitions, the most straightforward question is how the athletes get faster in regards to the various speed qualities. Simply put, this involves a combination of instruction and adaptation from training. As information moves away from physics to physiology, the degree of confidence on the true cellular mechanisms become less. Researchers are improving in exploring the neuroscience of sprint training, but many legacy studies on kinetics and kinematics are in desperate need for recreation because of poor study design. With problems such as low level athletes, short study periods, questionable training designs, and even inappropriate use of methods and materials, the need to get raw fundamental knowledge is still in need. For example, many studies are conducted on treadmills (sometimes valuable), but acceleration is much more sensitive to restricted harnesses that create false readings. Another example of poor study design is the failure to use conventional training programs with multivariate data. The most realistic of all studies is to show what actual coaches are doing. Isolation of variables is important, including the use of controls, but overly simplified programs will often times emphasize the results of a training modality, thus leading coaches to be misinformed in the value of a single option or exercise.

Science and technology should not be dismissed because of the limitations to studies, but should be interpreted with extreme care and combed over for gaps involving real world applications. As electromyography, tensiomyography, force sensors, motion capture, biochemistry, and other technology based measurements evolve, a better cause and effect will be documented in speed development. After the relationships are established with accepted evidence, applied sciences in the form of solid training and coaching can harness the revelations from labs, be it on the track or on the field. Regardless of the available technologies and research available, logic and reason stand as the most coveted beacons because science without wisdom is a rudderless boat. Experience with the unfortunate but precious reliance of a little trial and error, can remove methods that are less effective and demonstrate that history needs to be shared in a way in which the information can be trusted. Proper use of technology can help to solidify the history of how athletes are trained, which can then be passed on to newer generations of coaches and athletes.

Testing Linear Speed Qualities Testing the athlete's ability to run fast in a general manner is not only useful, it may be the most rationale way to see if one is effectively training. Speed can be subdivided in countless ways, but general tests of speed and speed endurance are objective indicators of current abilities and the rate of improvement. Gross testing has limits that are obvious, as skills of athletes and the constraints of game rules will reduce the transfer of general or global abilities to team sport, but in the sprinting events, a clear relationship between improvement in practice and what is happening in meets should be accepted as the direct cause and effect. Sorting through the context and very minor details of the testing data is necessary, as a coach should be looking for glaring changes, rather than sorting through data and panning for gold. Data mining can be helpful for finding possible causes of injury with pressure mapping, motion capture, high speed video, and surface EMG, but useable improvement is more obvious. Field tests in the form of actual linear sprints is the most common way to gauge how fast one is able to accelerate, achieve top velocity, and fatigue. Other forms of displacement of the center of mass in the form of agility tests, be it choreographed or reactionary tests, are also possible with current technology.

Linear speed tests such as acceleration for distances of the first 10-30m and max velocity tests of of the same distances near the athlete's top speed, are excellent tools, provided they are done with logical interpretation. Speed endurance tests such the popular 150m sprint or longer, are excellent measures as well, provided they are compared properly and the same conditions are repeated. Several variables can interfere with creating conclusions because changes in testing environment (internal or external) can render a test nearly useless. For example, an athlete being tested at the end of a training cycle, which is then compared the next year with a more rested time period, may create false positives or similar scenarios. An athlete tested with a much different venue or volitional motivation such as a small crowd, could reduce the output. Therefore, it's important to remain consistent with testing procedures. The more the athlete is tested or trained with electronic timing, the coach will be able to see what is truly going on in a program. Speed assessment needs to be within a fraction of a percentage of intensity because a small percentage in output could spell injury or lack of stimulus for adaptation. While volume and frequency may be primary variables, one can't fully look at intensity with any kind of precision and accuracy without electronic timing. For example, in the 100m dash, a 2% difference in performance could spell last place or a gold medal in the finals of the World Championships. With practice, electronic timing can add an irrefutable point of reference to what the real output was, provided that the physiological responses of fatigue and other objective indicators are done. As a result, the cause and effect of loading on the body can be observed.

Testing acceleration requires not only a specific distance to be measured, but also the specific starting position, be it stationary or moving. Athletes in team sports will sometimes exhibit a walking or slow run prior to a burst of acceleration, but static starts are appropriate to observe the ability to overcome inertia. Deeper positions of acceleration, meaning a greater lean with the center of mass, can improve performances of time, but they may not be a true indicator of game speed. Coaches in athletics (track and field) elect to use both crouch starts (long sprints) and three or four "point" starts (short sprints) with all four limbs making ground contact. Getting splits every ten meters is especially helpful as it needs to be specific where total times are coming from in regards to the acceleration curve. A standing start with a modest lean may be more useful for coaches to truly gauge functional and transferrable speed in team sport, but specific testing in starting blocks is specific to the needs of sprinters. In addition to other field tests such as jumps and throws, correlations to different methods of improving speed from indirect options such as resistance training may be helpful with intermediate to advanced athletes. Neophytes can also be tested, but with such introductory training ages, beginners tend to be highly unstable with testing involving technique. Thus, the data may not be as concrete. No matter what tests are performed, good record keeping not only shows how the athlete is improving, but how the program improves all of the athletes.

Figure 2 - Vermeil's chart of the modalities that influence the development in speed, involving the various segments of sprinting acceleration on behalf of elite performers. Most early acceleration options are influential to team sport as well.

Medium	0-5m	5-10m	10-20m	20-30m	30-40m	40-50m	50-60m	60-70m *
Pure Sprinting	Medium	High	High	High	High	High	High	High
Resisted Sprinting	High	High	High	Low	Low	None	None	None
Plyometric Activities	Low	High	High	High	Medium	None	None	None
Medicine Ball Throws	Medium	Medium	Medium	Medium	None	None	None	None
Explosive Jumping	High	High	Medium	Low	None	None	None	None
Olympic Lifting	High	Medium	Low	None	None	None	None	None
Heavy Squatting	High	Low	None	None	None	None	None	None

Developing Speed Improving an athlete's speed is the cornerstone to most performance enhancement programs and should be centrally focused on all year. It can be argued that developing speed is managing risk, since speed training is not just teaching mechanical efficiency, it's also creating mechanical strain in order to create adaptations to both the anatomy and physiology of the body. The coach is required to understand what probable approaches will increase the rate of improvement of speed in a safe and repeatable manner, in regards to a wide array of talent and learning styles. Chronological age, training age, and biological age will have to be considered to evaluate a program's effectiveness, since speed is one of the most stubborn attributes to improve. Athletes can double the load on a lower body exercise such as a barbell back squat, but speed improvements come in percent improvements close to 1% annually, making most training programs humbled by the slow rate of improvement. The decay of improvements is similar to the acceleration pattern shown in Figure 1, where the athlete eventually hits a genetic ceiling and improvements are extremely small, if at all. At this point, speed development may be trumped by career development and decisions must be made if the risk is appropriate, whether the individual is a team sport athlete or a pure sprinter in track and field. It's up to the coach to make decisions as to what is in the best interest of the athlete by initiating a program that is conservative enough to remove unnecessary risk without challenging the body to force improvement. Coaches should have the long term vision to guide athletes each season for sufficient rates of improvement, without taking risks on behalf of the seduction of "speed greed" by ego driven results. A solid program will enable athletes to achieve goals and protect the athlete's body and mind from forcing improvements with the wrong approaches to speed development.

The Warm-Up Strangely, the most bastardized component of training for any activity is the failure to implement a comprehensive warm-up to adequately prepare an athlete for speed training. With the reinvention in naming conventions to use the term movement preparation, the irony involves the decrease of movement in favor of activities that are non effective and inappropriately placed in training. A warm-up may be an antiquated term, but the simple need to increase body temperature is a primary way to decrease injury and increase performance of contractile tissues. The warm-up begins at the end of the previous workout, when an athlete "cools down" with regenerative activities such as self therapy and decompression. The adage from Gary Winckler, of ending the workout the way you want to start the next training session, is frighteningly not adhered to by the majority of performance coaches. Track coaches, understanding the demands on the body, have had success with the progression of general to specific activities that gradually increase the demand of the body. An approach that starts with locomotive exercises commonly used as drills, serve as a diagnostic evaluation and a way to improve basic biomotor skills such as coordination. While transfer to technique at high velocity is debated, they are specific enough to create lower leg adaptations that are both morphological and neurological for running based athletes. The warm-up is not an isolated time period, just the early phase of training that includes less risky velocities from tissues that are not prepared. Warm-ups will vary based on the training needs of the day and the time in season that may require various lengths of time. The overall need to increase core temperature can never be compromised and dynamic actions paired with selective exercises can progressively train an athlete without losing precious access to training.

Current fads based on the misinterpretation of muscle physiology, increased the popularity of self-therapy techniques with foam rollers and low load muscle activation exercises. Based on peer reviewed literature, it is superior to include self-therapy at the conclusion of training and to do more demanding training sessions that increase the development of muscles that are perhaps prone to atrophy from a reduction of conventional approaches such as high velocity sprinting. With EMG studies showing many of the muscles being engaged from general exercises at high intensity, it's better to train with a better program than to include last minute routines. The rise of "track side therapy" in order to manage injuries must be questioned at lower levels since elite senior athletes are not ideal models for developing athletes. At times, elite coaches in conjunction with experienced therapists may need such approaches, but it's better to reduce the demand of the training session rather than try to force a session that may not be appropriate at that time. Warming up for training should be sacred and never truncated because of time, as an incomplete warm-up will surely increase the risk of injury and dramatically impair the training session.

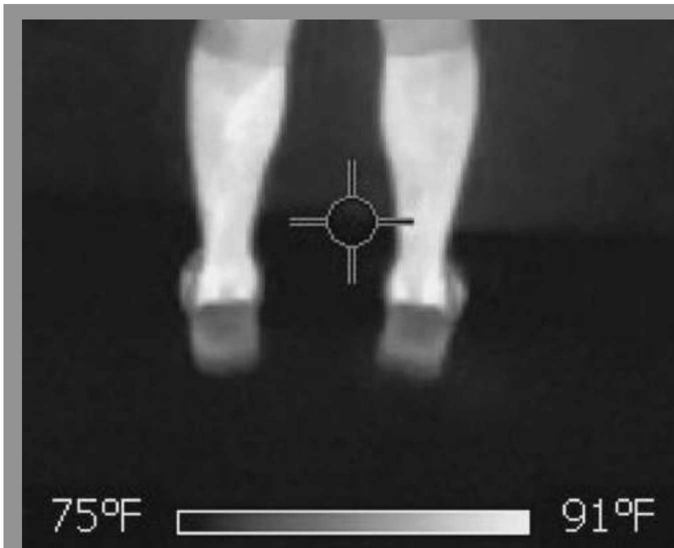


Figure 3 - A thermogram of an African American speed athlete, illustrates the heat radiating through the training flats and how the achilles tendon is significantly cooler than the other areas near the ankle and lower leg after a 50 minute warm up session.

Speed Training Modalities

Nearly all carefully applied modalities will improve speed indirectly, but improving speed should be done through direct means such as actual sprinting and supportive activities like weight training and explosive exercise. A harmonious blend of locomotive activities and general training is likely necessary because of the nature of cyclical motions causing overuse injury or pattern overload. Training a motion with overload from weights or resistance modalities may induce an increase of overuse injuries, so general training can help challenge the biochemistry of the body as well as the general distribution of work anatomically. Coaches will need to monitor both the rate of speed development and the stress the training is applying on the body. Below are several options to improve speed development with unique pros and cons of each modality.

Pure Sprinting- The most most straightforward method to improving speed is simply sprinting at various distances and speeds with appropriate volumes. Global speed does have carryover to some change of direction abilities and speed training is one of the most effective ways to reduce injuries if the program is managed properly. Linear sprinting can be broken into three primary options:

- **Acceleration-** Distances of 10-60m, short sprints with stationary starts or walking approaches are the most direct ways to help team sport speed and success in the 100m. Specific postures ranging from block usage to standing starts can be done to help prepare specifically for the individual sport and to break stereotypes when athletes are stale.

- **Maximal Speed-** The development of maximal speed requires a spectrum of velocities to increase relaxation rates and reduce overtraining. Most of the racing from competition will be the stimulus of breaking speed barriers and should be counted as part of the training. The use of flying sprints in addition to float drills are common approaches to athletes who are deficient in top speed qualities. Zones of 10-30m are appropriate for intensive development and longer distances at rhythmic execution can help ingrain a systemic ability to sprint at high speeds.

- **Speed Endurance-** Over-distance and volume can specifically work in the areas during a race that will be affected by deceleration from fatigue or give the ability to repeat output repeatedly. The length of the repetition, density from reduced rest, and total volume will directly and indirectly affect speed endurance. Several classifications of speed have been theorized to challenge specific bioenergetics of the body. It's unlikely that the energy systems can be significantly enhanced selectively when performing sprints that are longer to warrant it's use. Most of the adaptations of intensive speed work will wash out lower output training and applications should be thought of as secondary options. An emphasis on velocity metrics with meet or testing performance is a better approach than the pursuit of taxing physiological systems of the body. A contemporary approach removes estimation and is more direct in results.

Plyometrics - Jump training in various forms is a very effective way to add general lower body power to speed athletes while adding some specific qualities that weight training can't provide such as foot and ankle stiffness. Both horizontal jumps and vertical movements create unique mechanical strains on the lower body, resulting in performance enhancements to various locations of the acceleration curve. Jump training can range from very low amplitude activities to the most demanding depth jumps from high altitudes. No matter how effective jumping is, the transfer is only mild and limited to the unique demands of sprinting.

Resistance Training- Traditional strength training in the form of power lifting and Olympic lifting are excellent options for increasing both hypertrophy and and maximal strength. Unilateral training does have favorable benefits to reducing injuries by recruiting stabilizers and synergists, but the specificity of the single leg training has not shown to be superior to combination approaches. The inclusion of maximal strength in any form is limited mainly to overcoming inertia and serves as more of a biochemical and structural agent for programs.

Weighted Sleds- Sprinting, specifically in horizontal form, can be overloaded naturally with low to moderate weighted sleds, since heavy options can be counteracted by a conventional well organized lifting program. It's important to focus on the velocity decay of sled use and not the percentage of body mass, since an elite sprinter may have the same weight as a sub-elite or novice athlete. Since the weight and coefficient of friction are considered part of the variables, the distances used and the weights prescribed will have a range of responses to the acceleration curve of 0-50m. Therefore, programs should consider what properties of sprinting are occurring with the loads used, be it mechanical, temporal time sequences, and/or elastic responses.

Hill Sprinting- Similar to sled use in acceleration, hill sprints of low grade are excellent tools if available. It is noted that any downhill sprinting should be reduced to a 1% decline and most of the use of hill sprinting encourages loading to the achilles and anterior thigh. Hill sprints are excellent options for encouraging arm action and the active use of the hip flexors and they can be classified as a specific strengthening option by emphasizing the higher recruitment pattern of sprinting. While the hip extension motion is cut off, some activity in the posterior chain exists due to postural and stabilization needs.

General Exercises- Due to the fact that sprinting is a total body activity, system strength and structural balance is an excellent way to ensure energy transmission is preserved. Historically, athletes have had world class speed with near pedestrian levels of strength, even with lower body exercises. The most logical conclusion is that each athlete has his or her own strength profile and much of the general exercises can serve as postural, neuroendocrine, mobility, and work capacity purposes. This can be accomplished in the form of routines, such as circuits and other conditioning methods.

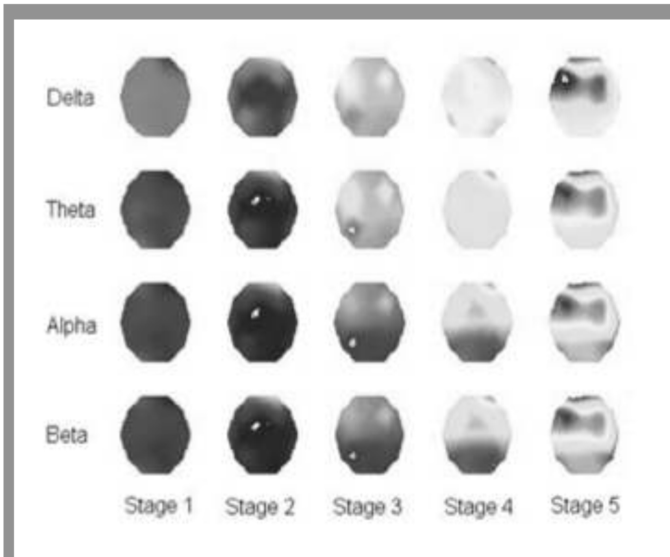
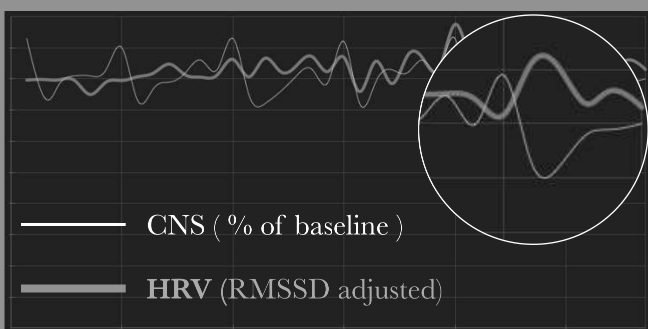


Figure 4 - Fatigue can show up in an array of areas of the body such as the brain (top) with EEG or in the CNS with devices that measure global nerve response (bottom). The acute response of immediate fatigue with EEG to the loading response, systemically to the nervous system, are areas that coaches must take note of. Notice the similarities between HRV and CNS patterns during weekly competition and key differences between fatigue and parasympathetic balance.



Speed Training Loading

The act of speed training in addition to the supportive power activities can be prescribed as mechanical, neurological, and psychological does of stress. Empirical recovery times between doses have been applied by coaches in order to sufficiently recover from training, but not all systems of the body restore their current homeostasis baselines at time points of training. Therefore, the slowest remodeling periods of connective tissues and mental burnout should be monitored closely. Recovery then must be considered a compromise of time periods to what is satisfactory for most of the systems involved with speed training. All training, including recovery style options, must be carefully composed by sequences based on biological principles of training. For example, the placement of acceleration that is heavy in both volume and external load from sled use early in the week, may be incompatible to max velocity work later on, when knee stiffness is impaired by the mechanical bias of deep acceleration work. The athlete may be recovered physiologically, but the neuromuscular readiness of the muscle groups may be fatigued and exposed to injury. In order to optimally calibrate recovery from the training stimulus of speed training, a comprehensive monitoring program that factors in parasympathetic balance, global central fatigue, alpha wave or other brain status, tensiomyography of the body, and individual subjective indicators such as motivation and mood. Monitoring the recovery response is only beneficial when the actual training load is established with accurate timing, precision record keeping of volumes and contextual details, and feedback of the athlete during the sessions. Monitoring is the response of training and no matter how advanced the program is in regards to observing the effects of the training, a program must have a plan that has a high rate of results from design. Fatigue in any form will manifest in many ways during the warm-up and the most sensitive marker of athlete readiness is available through biofeedback of the ground contacts and the amazing observation of a trained coaching eye. Coaches should be supported with additional objective tools with current technologies, but the human sensory abilities are still superior than most machines.

Cycling Rest Periods A fractal pattern, as alluded to by planning and periodization expert Dr. Freeman, is visible in design from the repeating cycle of sessions, microcycles, mesocycles, macrocycles, and seasons. Rest, the compliment to stress, repeats, and it is modulated by the necessary need to restore the body to a higher state of performance. A necessary time or passive recovery is needed in explosive training both acutely and in training cycles. The infusion of rest periods or reduction of output must be incorporated by analyzing the biological needs of training and the calendar of competition and preparation times. Rest mirrors stress and it should be as carefully integrated as the training elements, in order to elicit a supercompensation or the acquisition of a quality. The most delicate of balance involves the timing and dose of loading speed and the detraining effects during competition and tapers with athletics. Similar needs such as long seasons where athletes are in a virtual limbo of monotony from a fixed schedule that is constantly repeating, risks staleness and detraining of developed qualities of speed and power. Prolonged seasons with shortened preparations are a universal problem and should be countered with higher precisions of selected dose response approaches, in order to mitigate risk, but to apply a sufficient stress to preserve or enhance a quality.

Rest periods, starting with the intra repetition time and extending through each training session, should be cross-validated with outputs that will naturally undulate in a wave pattern. Some loading designs may be very simple and nearly linear in appearance, but the responses of a biological organism is highly complicated and will respond with a near infinite number of possible patterns. Coaches should see specific output benchmarks with measures of specific capacities to reduce the inability to taper from insufficient volumes. Classic coaching words and Dr. Young's adage of being "fresh and fit", is a mantra that is antagonistic to the risk of "quick to ripe, quick to rot" when too much rest and too little stimulus is present. When the last taper occurs, the athlete and coach is literally cashing in all resources for one final absolute window of peaking. Coaches have realized that peaking is also a mental process and efforts to support psychological peaking should be a priority.

Speed Development Instruction

Teaching should be a minimal component of learning, as the athlete is responsible for his or her improvement in executing a task. Task based motor skill acquisition is the most powerful way to learn to execute needed skills or sport movements. The current and past addiction to verbal instruction is perhaps the most corrupted element in coaching, as many are lured into a state of unnecessary feedback or inappropriate cueing of athletes. Be it ego, lack of experience, or ignorance of the instructor, teaching should be about supporting the self-organizing absorption of motor skills from selective tasks and not dependent on verbiage. Word choice is necessary and is helpful in guiding athletes, but the indirect and subtle skill acquisition from non-verbal options such as an emotionally healthy learning environment, optimal stress states, physical preparation, and training design, is far more powerful than retroactive verbal fault corrections. Skipping cues allows for a more unfiltered acquisition of feedback from the task to the body, as interpretation from a perspective that is not first person is corrupt from the start. On the other hand, much of the verbal support done by experienced master coaches boarders between award winning poetry and near spell casting, since a long relationship between a coach and an athlete is often symbiotic. Experienced coaches will see patterns of learning styles and communication approaches that will match individual athletes. The interpersonal skills of the coach and the culture of the program will dictate much of the success of athletes, provided they are equally engaged with the same passion to improve. Teaching athletes speed should involve, in equality, sensations of execution, applied sports physics in laymen's terms, and the right instructions to what is expected for the selected task.

Most of the efforts of coaches should focus on defending the natural ability to run from interference of the environment and cognitive overriding errors of the athlete. Previous injury, stylistic habits from earlier periods, and even emotional elements can destroy the body's pre-programmed gait cycle. Much of the stride pattern of athletes is a mix of central pattern generators, stretch reflexes, and ground reaction forces that interact with the unique anatomy and biochemistry of the body. Knowing that much of the visible action is happening from unconscious sources, the fluid speed of a relaxed and alert athlete should not be tampered by coaches. Coaches should approach speed development as a process of revealing a sculpture by focusing on the minimal amount of guidance and remove what is unnecessary. The patient ability to allow athletes to experience and problem solve is the highest sign of mastery when it's tempting to resort to the comfort of talking about the problem one is seeing. Athletes that are given the right task will eventually learn deeper and ironically quicker in the long term, as opposed to working with overzealous coaches who play a role of being teacher driven versus student supported.

Figure 5- Intervention Strategies of Skill Errors

Fault	Possible Cause	Mechanical Intervention	Coaching Intervention
Excessive backside recovery of the heel, commonly known as butt kicking when the athlete is vertical or straight up.	Lumbar lordosis from either lack of oblique strength or genetics that predispose athletes to spinal structure that places the athlete in anterior tilt.	Intensive strengthening of the oblique system with bodyweight and external load patterns.	Postural awareness of pelvis with sub-maximal sprints to encourage more front side mechanics.
Casting of the foot excessively during recovery during early acceleration and when sprinting upright.	Posterior tilted pelvis from kyphotic spine and anterior chain tightness of both the abdominal region and lower extremities.	Extensive manual therapy on anterior chains with possible posterior chain development from resistance training.	Programming acceleration with the use of hill or sled use while focusing on vertical postures during full sprints.
Insufficient stride length and fatigue rates at the sprinter's max velocity stage of 100m races or near the end of 400m.	Insufficient exposure to acidosis or over-distance. Possible trust issue of executing relaxation versus favoring more contraction type action.	The use of speed endurance work to see the effects of fatigue versus maximal speed abilities in practice.	Inclusion of the precise velocity prescriptions for max speed and acceptance of pain during longer sprints.
Slight sitting posture during maximal speed in short sprint but not in practices or longer sprints in relays.	Vertical force production or lack of stiffness in the knee during early foot contact or posterior chain weakness during mid to late stance.	Specific strengthening in the posterior chain and use of vertical plyometrics for stiffness of the lower leg.	Athletes can be instructed to step over in order to allow the natural foot strike, rather than muscling the strides.
Lateral body sway and or leg displacement during initial acceleration or early departure from blocks.	Artificially deep projection angles can exacerbate insufficient knee extensor abilities. Foot structure and function may play a role as well.	Footwear modification as well as possible soft tissue therapy of the hip rotators may improve efficiency linearly.	None. It is not known how all lateral shifting contributes to performance so interventions may decrease acceleration.

Figure 5- Correcting faults or errors in technique requires the athlete to be consistently exhibiting the problem before an intervention is suggested. Much of the verbal request from cues are done in vain, since athletes may not having the prerequisites in strength or joint positioning and sometimes the anatomical ability to execute specific movements. The examples above show how complicated common errors are to fully change mechanics.

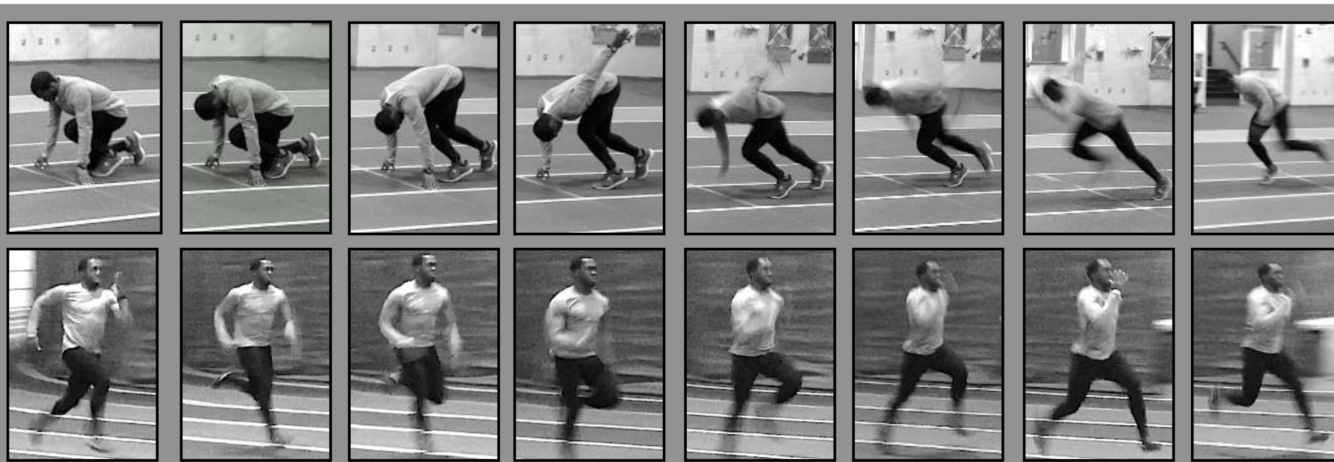


Figure 6 - Simple use of a smartphone app such as Dartfish, can capture gross issues and deliver immediate feedback if needed, but most of the time, video should be reviewed outside of training. The cloud storage options allow the athlete to take ownership of his or her practice performances when available.

Shaping sprinting technique is analogous to the bonsai tree art form where the athlete and coach support a style that fits the unique needs of the athlete, based on the architecture of the body and the biochemical composition of the athlete's muscle fibers. Bonsai tree uses a huge amount of cultivation techniques to support the art form, but the process is very methodological and very slow. Training and teaching should, like bonsai trees, be rushed or expedited, since natural changes take time. If bonsai analogy can be implemented, the coach will understand the motions of what to prune and reinforce, rather than a rapidly deforest the natural rhythm.

Locomotion in all forms must follow the laws of Sir Isaac Newton, but be interpreted by both anatomy and coaching theory. The human body is far more complicated than a letter on a formula or skeleton on a computer screen. Rather, it's a living ecosystem with supportive habitats. Unfortunately, the natural and optimal running mechanics can be tainted by an array of factors to an athlete. Maximal performance of sport is a different beast than evolutionary biology, as it's extremely artificial and sometimes unnatural. Due to the artificial demands, some coaching must be done to allow an athlete's talent to surface properly. The most common approach, right or wrong, is to focus on the upper and lower extremities and axial skeleton from a technique development. While segregation of the body into parts or regions is convenient, it should be noted that the body is interconnected. The rise of the understanding of the kinetic chain from the ground up and the exploration of neuroscience from the top down, can enable coaches to make better adjustments to running mechanics, based on general models.

Body Alignment - Posture, specifically the orientation of the pelvis and the lean of the body, will be the primary root of how forces are applied through the skeleton and how muscles are recruited. The alignment of the body does have a mechanical influence to force production, but the body does overcome limitations from neuromuscular adaptations and some conscious override. The pelvis structure and the athlete's ability to keep the joint system oscillating from high rate coordination, is essential for maximum speed, but important during acceleration. The pelvis will dictate the free or swing leg position before foot strike, so not all influences from the ground up will be dependent on foot mechanics and architecture.

Arm Carriage - Contributions of the arm action to sprinting performance is helpful to mange forces through the spine and pelvis and to contribute to vertical force production. Arm action is synchronized with lower body force production capabilities and the timing is highly regulated by reflexes and central pattern generators. Some conscious guidance of the arms can modify some characteristics such as stroke length of the swing or some positioning. Much of the conscious action should be pulling based as the humoral action is stemming from the back musculature, but it is counteracted by pectoral stretch reflexes and supported by the deltoids. Coaching contributions should focus on reducing athlete errors from poor mechanical strategies rather than instructing on what to do with verbal cues. Arm actions at 4-5 strides a second are working with fractions of a second that are too fast to make precise adjustments beyond gross changes. Reminding the athlete to hit specific reference points is a realistic option based on the limitations of the sprint cycle time frames.

Leg Response - Several beliefs regarding the contribution of conscious versus reflexive contributions to leg mechanics exist, but the most conservative understanding is that three primary influences must be considered before drawing conclusions. First, the anatomy and current readiness of the neuromuscular system will play a part on technique based on skeletal structure and tissue dynamics. Second, is the athlete's execution of a sporting skill, where small errors in technique may undue the natural stride internally. Finally, the interaction between the foot strike and the ground, upon which the stretch reflexes and the laws of physics will perform the gait cycle without conscious effort of the athlete. Those three influences mentioned may have overlap or segregation, but it's up to the coach to know what motor skill strategies are likely to transfer with the speed of execution at fractions of a second. Coaches should take an approach of what not to coach and what to influence from training and therapy first, thus allowing the natural stride to reveal itself slowly as the athlete becomes more experienced and better conditioned from training.

Training Session Design

Constructing speed sessions must be straightforward and produce a stimulus that will either increase capacity or create an ability to produce more speed directly. Ornamental designs are not only unnecessary, but will sometimes mute the purpose of training by not having a clear message to the biology of the athlete. Simplicity is not the only option in clarity, as many complex and complicated factors may be involved in working with an athlete. Speed training requires not only a plan of the session, but a holistic seasonal progression that allows a repeatable improvement curve, that is at par with the competition level in one's competitive setting. Designing a speed session also requires record keeping of the Key Performance Indicators of the modality, such as velocities, volumes, and specific details of rest and technique. Classic approaches of pure sprinting with complementary support work of plyometrics, general training, resistance training, and other options are time tested and historically effective. New exotic options are unproven and commonly ineffective as innovation is unlikely to be found in a sporting action that is natural. Coaches should be focused on creating workouts that are easily translated and clearly purposeful for that training session and speed training in the form of sprinting is the the most effective option. Following classical USATF models, one can design down to earth training sessions that are effective.

Figure 7 - Example Speed Sessions

Session Structure	Rest Times	Velocity	Surface	Density	Training Purpose
3 x 4 x 20m Block Sprints (Indoor Track)	**Repetition** 2-5 minutes **Set** 5 minutes	92-98%	Track	Low	This workout develops the ability to accelerate specifically from blocks and provides enough volume to increase capacity.
3 - 5 x 150m Sprints (Outdoor Track)	**Repetition** 3-5 minutes **Set** None	90-95%	Track	Low	This workout provides anaerobic conditioning for the 100-200m sprinter, allowing for a full range of qualities to be developed.
4 - 6 x 250m Sprints (Outdoor Track)	**Repetition** 1.5-3 minutes **Set** None	80-90%	Track	Moderate	This workout provides a major ability to handle acidosis for the most advanced of sprinters, specifically in the 200-400m.
5-6 x 30m Flying Sprints (Outdoor Track)	**Repetition** 5-10 minutes **Set** None	96-98%	Track	Low	This workout provides a specific rehearsal to upright mechanics and the ability to imprint faster motor skills to the sprinter.

Countless permutations and adjustments can be made to the most straightforward training options in order to optimize the specific training session. Rotating surfaces, change of footwear, and managing velocities and distances are essential to ensuring the workout hits the precise target for the speed session. The most important consideration is the context of the velocity, based on the abilities of the athlete and the current training state, with the expression of speed with timing. Many factors will influence the ability to create output and electronic timing is the only way to create a fair comparison as to what is happening on a day to day basis. Athletes will have a small decrement in output from competitions because of arousal and training period. Each athlete has an individual ability to express speed in practice, since some athletes will respond differently to meet or competition environments physiologically. Coaches must create unique practice calibration adjustments based on meet performances, testing, training sessions, and the period of time in training to ensure progress is made. The sensitivity to fatigue and precision of sprinting should incorporate technologies that will capture the sprinting times in both total times and individual splits or zones. Just capturing volumes and estimated times is not enough to gauge the training load in a relative manner. The actual output in precision form must be compared to either historical records of the previous year or to normative data from other athletes.

While simple at first glance, times and distances will be the best benchmarks on a season timeline for a coach to use. Straying from times or velocities can create a murky interpretation of what is truly happening, since other modalities are not direct influences and are subject to subjective analysis. Coaches can see a cause and effect when previous season data is used if training plans change, such as the impact of sled use in acceleration, the specific changes in speed endurance from longer runs, and the top speed improvement rates from vertical plyometrics. All secondary options are used not for intrinsic purposes, but for the ability to transfer to specific areas of speed and they must show up in the practice and meet data. Sometimes, transmutation is delayed as not all training adaptations are rapid, but some pattern in reasonable time should manifest in practice and competition. With improvements being so small in speed, 1% for example, anything outside specific sprinting is likely not to make an impact more than a fraction of that outside beginner or intermediate athletes. Coaches are to understand that diminishing returns will present themselves and programs must prepare for stagnation by using the right progression and not painting themselves into a corner by reducing options. Risk with any variable, such as intensity or volume may be necessary to break through plateaus, but most of the progress should be from training design and good planning. Seasonal progress versus the misconception that one session will make or break improvement is the most likely improvement process early on. Some breakthroughs from sessions, in which the athletes can draw their abilities together have been valuable, but consistency of training should be coveted by training. Consistency, be it in the execution of mechanics or velocities, can stabilize the foundation of improvement, as training requires reference points that can be properly targeted.

Most programs follow an alternating pattern of high intensity and lower intensity to allow restoration of different fatigue and mechanical loading to the body, such as managing strain on the posterior chain and the areas far more prone to injury due to the anatomical structural design of the hamstrings and the fatiguability of the higher Type II composition. Coaches and athletes must collaborate to find what approaches in session design work for both the calendar needs of weather, time available to train, and what workouts respond favorably to the athlete's unique genetic makeup and learning style. Most approaches involve a distribution of goals, ranging from career or lifetime achievements all the way to a specific goal of the individual training session. Goals should have a mix of results based time standards and process goals that include training habits and necessary sacrifices. The most common approach is working backwards with long term planning and major goals. However, training sessions start with the most pragmatic of needs, beginning with the warm-up and finishing with some sort of debriefing regarding the success or learning opportunities of the session. Time is the most precious of commodities since it can't be recreated, so every session should be seen as a singular window of opportunity to move one small step forward.

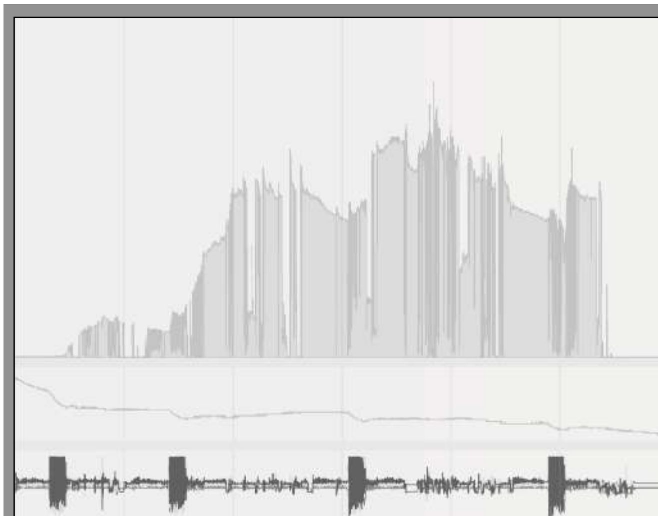
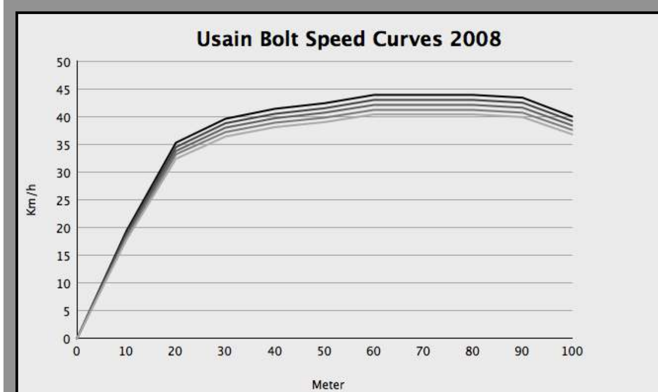


Figure 8 - Galvanic skin response or GSR is at times useful for capturing the intent or involvement of the athlete (top), thus showing potential for output in performance as shown in the velocity graph (bottom). The bottom chart shows a decay of output by Usain Bolt in increments of 2% throughout the 100m race.



Session Analysis During and after training, each session should be treated as a valuable unit of information as to how speed training is interacting with the sprinter or the group of athletes. After a session is planned, the workout must be executed as directed, but any necessary changes should be documented to contrast what was written and what was actually done. The differences noted, with contextual information such as the feedback of the athlete and the actual output should help prepare future planning. When coaches see patterns as to what was planned and what was actually done, they can see the perceptions of what can be done and the reality of what can be achieved. During training, the coach is constantly vigilant to fatigue of the body as overreaching and injury must be safeguarded by monitoring the session output. It's better to leave some of the reserves for later, as depletion work is a very advanced option and should be left to situations where the athlete has hit a plateau for an extended period of time. Most of the time, speed barriers are not genetic limits, but constraints from variables that are difficult to change, such as exposure to the right stimulus or timing of the right competition environment. After training, the data collected will tell a story of the success, the missed opportunity to execute the plan, or expose the session design to the faults in it's construction. Data can be in any form, such as objective data of electronic timing and simple video clips, or the more extensive and revealing information like pressure mapping, force plate analysis, wireless EMG, and motion capture. Physiological responses during and after training are essential in predicting what could happen in the next training session if sufficient rest is or is not given. The environment of each session should be rated based on both the stated subjective effort of the athlete, the environment of the training session, and the actual output demonstrated.

In closing, the development of speed is not a mystery, but an artful biological juggle of many different elements that pertain to a unique person. Using conventional approaches with modern technologies can improve the small margins of performance by increasing the buffer zone of risk, while narrowing the specific path to the athlete. The art and science is not an opposing approach, balanced or mediated by coaches, but a seamlessly integrated approach that can improve athletes without compromise. Without coaches education and mentorships of applied sport science, all the research and progress from research will be hopelessly misdirected in a coaching dark age.