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Turning the page to Outdoor Season

TRACK COACH

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The official technical publication of USA Track & Field

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FORMERLY TRACK TECHNIQUE

251 — SPRING 2025

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FROM THE EDITOR

JASON KARP

PHD, MBA

SYMMORPHOSIS

In 2004, while working on my PhD in exercise physiology, I was assigned a research paper on evolution and the limits of athletic performance. I was asked to outline what I considered to be crucial evolutionary improvements in humans, when those traits first showed up in our evolutionary history and how they enabled humans to become a successful species, and how, given these evolutionary traits, I can explain and quantify human diversity to answer the question, "How does an understanding of evolution contribute to the understanding of human athletic achievement?"

I was given one week to write the paper.

Of course, it was a difficult paper to write. I highlighted traits like the opposable thumb, upright posture, enlarged neocortex, aerobic and anaerobic metabolic capacities, and the quantities of muscular force and mechanical power that can be generated and sustained, and then discussed them in light of evolutionary theories like Darwin's natural selection, genetic drift and gene flow, divergence of character, and an esoteric anatomical theory called symmorphosis.

First proposed by Swiss anatomist Dr. Ewald Weibel in 1981, symmorphosis suggests that an organism's structural design is regulated by its functional demand. As Weibel wrote, "…the quantity of structure incorporated into an animal's functional system is matched to what is needed: enough but not too much."

Weibel proposed that demand, which occurs over millions of years as the body interacts with its environment, drives a change in an organism's structure. And any extra baggage is not supported and becomes extinct. From an evolutionary perspective, the human body can change, and the limits of human athletic performance can only be exceeded, if the demand on the human body increases.

One example of symmorphosis is the human lung, in which the structure of the lung's alveoli—an ultrathin wall that's scrunched up like a head of broccoli to maximize its surface area—is precisely matched to the body's oxygen needs. It is neither under-designed nor over-designed for its function of oxygen diffusion into blood vessels, and any significant change in its structure would compromise its function.

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Editorial Column

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Like the long, evolutionary process of symmorphosis that is experienced by a species to give us the lungs we now have, remarkable microstructural changes also occur on an individual level in the short term (weeks to months in our lifetime) in response to specific demands, physical training being the most potent.

For example, in response to specific physical training, the athlete's muscle fibers increase their metabolic machinery, bones increase their density, cardiac and skeletal muscles enlarge, new blood vessels sprout around muscle fibers, and more neurons are formed that connect the central nervous system to muscle. Singularly and collectively, these structural changes, which are quite sensitive to imposed demands, enhance the athlete's function. Indeed, the human body — and the structure of all organisms — evolves to cope with all but the most extreme demands to which it is subjected.

In this April 2025 issue of *Track Coach*, my first as editor, we remember symmorphosis and focus on the biomechanics of track and field, placing demands on the athlete's structure (technique) to enhance his or her function.

OPTIMAL STRIDE RATE IN DISTANCE RUNNING

BY IAIN HUNTER, PHD

Iain Hunter, PhD, is a biomechanics professor at Brigham Young University. His research focuses on distance running mechanics, footwear, and steeplechase technique. He has worked as a professor since 2001 and is part of the sports science committee with USA Track and Field, focusing on steeplechase. A competitive runner himself, he has a range of racing abilities from 800 meters through the marathon, with best times of 1:49.92 and 2:20:53. In 2023, he was ranked #1 in the world for over 50-year-olds in the marathon by Abbott World Majors.

Distance runners and coaches are often intrigued by the idea of optimizing running mechanics to improve performance. One aspect frequently discussed is stride rate (also called stride frequency or cadence), with a common belief that adjusting stride rate can improve running economy. However, extensive research suggests that runners naturally select a stride rate that minimizes energy expenditure, making stride rate a highly individual characteristic.

SELF-SELECTED STRIDE RATE AND RUNNING ECONOMY

The distance runner's body intuitively chooses a stride rate that feels most comfortable. Imagine hopping or jumping in place. There is a frequency that feels most natural. This natural self-selection minimizes the energy cost by capitalizing on the biomechanical and physiological characteristics unique to the individual. When runners deviate from their natural stride frequency, the energy cost of running typically increases, indicating that self-selected stride rates are remarkably effective at minimizing energy expenditure (Cavanagh & Williams, 1982, Hunter & Smith, 2007).

In a study that used a metronome and a treadmill at a fixed speed, runners adjusted their stride rate while having oxygen uptake measured. The researchers found that deviations from the naturally selected stride length significantly increased oxygen consumption, underscoring the body's efficiency in selecting its preferred stride pattern. This has been shown to occur in a rested state, fatigued state, while running uphill, and among inexperienced runners (Hunter et al., 2017).

THE LEG AS A SPRING: UNDERSTANDING NATURAL FREQUENCY

Biomechanically, the human leg during running behaves much like a spring system, characterized by a natural frequency influenced by factors such as leg length, muscular activation patterns, and the stiffness of tendons and connective tissues. This spring-like behavior facilitates efficient energy storage and return, making running more economical. Imagine a spring with a mass hanging from a ceiling. The frequency with which the mass would bounce up and down depends on the length of the spring, the spring's stiffness, and the mass of the weight. Now, imagine flipping that spring upside-down and you have the mass of a runner on a leg spring attached to the ground. Runners can change the stiffness of that spring by altering muscle activity, which results in a different stride rate, stride length, and speed, but the body always wants to settle on what feels most comfortable.

Hunter and Smith (2007) further explored how optimal stride frequency shifts with fatigue during extended, high-intensity running. Their study showed that as runners became fatigued during a one-hour treadmill run, they naturally adjusted stride frequency and leg stiffness in an attempt to maintain optimal running economy. For about half of the runners, that led to a shorter stride rate when maintaining running speed. This subconscious strategy highlights the dynamic nature of the body's response, adjusting naturally as muscles fatigue in order to minimize energy expenditure.

INDIVIDUAL VARIATION AND THE COST OF MIMICRY

Runners often look to elite athletes, attempting to replicate their stride patterns in hopes for improving performance. However, this approach ignores individual anthropometric variations. The optimal stride rate for minimizing energy cost varies significantly between individuals due to differences in anatomy, muscle activation strategies, training history, and physiological capacity. When a runner attempts to copy the stride rate of another runner, particularly if it substantially differs from his or her natural frequency, the movement becomes metabolically more costly. This forced adjustment can lead to increased muscular fatigue and worsened running economy.

THE HUMAN LEG DURING RUNNING BEHAVES MUCH LIKE A SPRING SYSTEM, CHARACTERIZED BY A NATURAL FREQUENCY INFLUENCED BY FACTORS SUCH AS LEG LENGTH, MUSCULAR ACTIVATION PATTERNS, AND THE STIFFNESS OF TENDONS AND CONNECTIVE TISSUES.

STRIDE RATE MAY CHANGE OVER TIME

A common question remains as to whether a runner should gradually change his or her stride rate over time to improve performance. There is currently a lack of research to say whether running economy would improve or worsen with long-term changes to stride rate. So, for now, the answer is uncertain. However, we do know that with training, there may be some alterations in preferred stride rate. Other than during the years of physical maturation, the skeleton will stay relatively unchanged, so if training leads to different body weights or changes in muscle power, there may be a change in preferred stride rate that follows. Intentional changes in stride rate without the body first adapting to training generally results in a worsening of running economy and is not advised. Once the body changes through training, then any preferred stride rate changes will naturally occur leading to optimizing running economy.

STRIDE RATE CHANGES WITH SPEED

At the 2023 USATF Outdoor Track & Field Championships, I measured the stride rates at approximately two-thirds of the way into each track race, from 100 to 10,000 meters. The results are shown in Figure 1. As expected, the faster the race, the faster the stride rate and stride length. However, there is a clear distinction between sprinters and distance runners. Notice how, from 100 to 400 meters (sprinting), the decline in stride rate is much steeper than between 800 to 10,000 meters (middle- and long-distance running). In other words, stride rate changes a lot less between distance running races than it does between sprint races. This is due to the purposes of each technique: sprinters are focused on speed and power, while distance runners are focused on economy of movement. And it turns out that there is a narrow range of stride rates that enable runners to be most economical (Cavanagh, 1990).

When we consider an individual runner, we still see increases in stride rate and length with

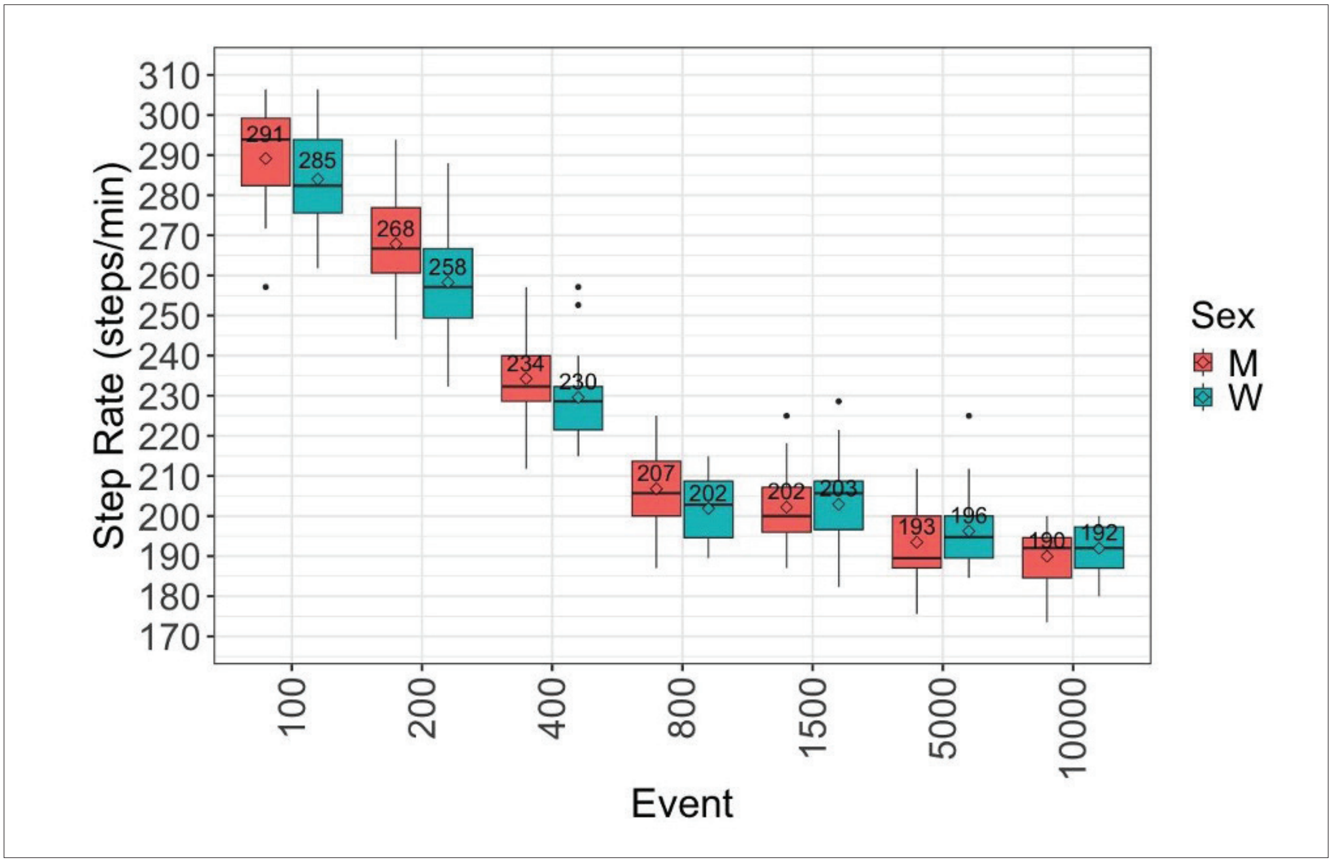

Figure 1: Stride rates for all finalists at the 2023 USATF Outdoor Championships. The horizontal line in each box represents the median and the diamond represents the mean.

speed. Figures 2 and 3 show the step rates and stride lengths in a runner who was tested in our running mechanics lab at Brigham Young University (red data points). The speeds represent 8:30, 7:30, 6:30, 5:30, and 4:30 per mile. For comparison, the blue data points are everyone we have tested. For this individual, the main approach to increasing speed is by utilizing a greater stride length. Other runners often choose increases in stride rate as their primary method for increasing running speed.

The approach of how each component changes with increasing speed comes down to leg length, available power, foot strike, origin and insertion locations of tendons onto bones, stiffness of tendons, ratios of muscle to tendon lengths, and likely many other unknown factors. Some of these can be modified while others cannot. As a runner goes through various changes in his or her conditioning, there may be different preferred stride rates and lengths for each speed, but the body will fall into these without any coaching required.

PRACTICAL ADVICE FOR COACHES AND ATHLETES

Coaches and runners should approach stride rate optimization with caution. Rather than attempting to enforce a predetermined ideal stride rate, training should encourage athletes to explore their natural, self-selected cadence and focus on correct mechanics (e.g., foot landing directly underneath center of gravity, full hip extension at push-off, etc.) and application of force to the ground. The conditioning of each athlete may lead to changes in the preferred and most economical stride rate, but it does not need to be consciously changed.

In 1984, Dr. Jack Daniels measured step rates among 47 men and women at the Olympic Games. He observed that only one runner had a rate lower than 180 steps per minute. In my observations from the 2023 USATF Championships, it was even higher, with the average being 190 steps per minute or greater for each event. So, what is optimal for running economy?

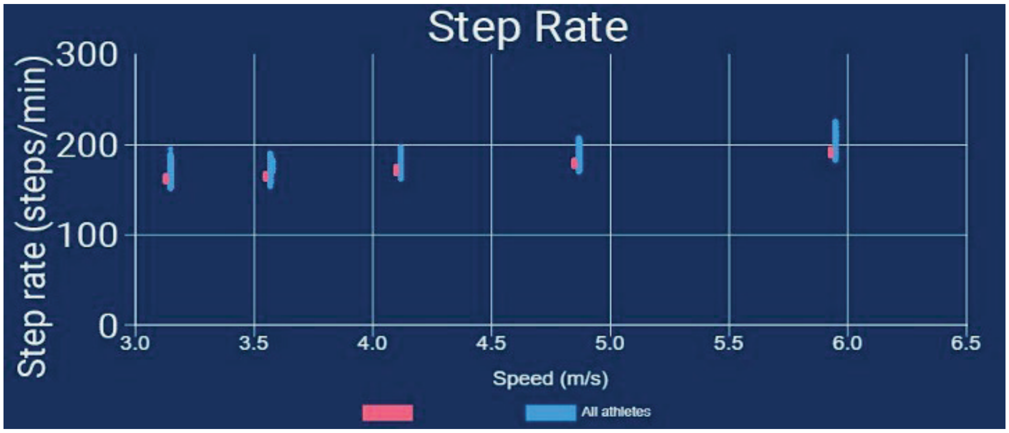

Figure 2: Step rates of runners and an individual tested in our running mechanics lab at Brigham Young University.

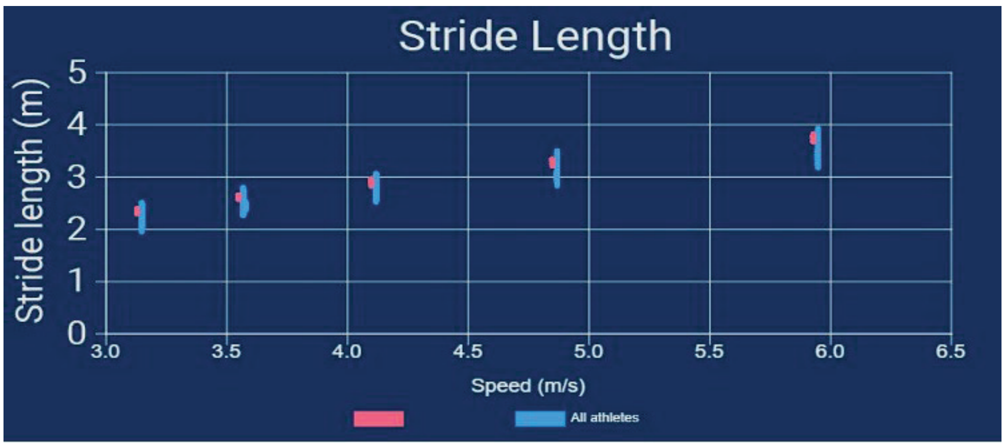

Figure 3: Stride lengths of runners and an individual tested in our running mechanics lab at Brigham Young University.

Some have claimed 180 steps per minute is a good place to start, but it depends on running speed and the factors I've discussed above. To enhance running economy naturally, coaches might focus training on improving overall strength, muscular endurance, and tendon elasticity. Plyometric exercises, resistance training, and consistent running practice naturally optimize the movement patterns of the leg's spring-like properties, indirectly influencing a runner's optimal stride rate.

FUTURE DIRECTIONS

Some work has been completed on adjusting stride rates to reduce injury risk, but much remains unknown. In addition to stride rate, there are some biomechanical factors worth investigating as runners aim to become more economical. For example, Moore et al. (2012) noticed changes in a few biomechanical factors—a less extended knee at toe off, peak dorsiflexion occurring later in stance, and a slower eversion velocity at touchdown—that led to improved running economy that were naturally adopted with training. However, we may be able to speed up the adoption of better technique through specific conditioning. Further work is needed to determine the best approaches to train these biomechanical factors.

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DISCUS MECHANICS: GETTING ON BALANCE EARLIER IN THE UNWIND

BY MAC WILKINS

Mac Wilkins is a four-time Olympian, 1976 Olympic gold medalist, 1984 Olympic silver medalist, and four-time world record setter in the discus. He was the top-ranked discus thrower in the world in 1976 and 1980 and was the top-ranked U.S. discus thrower eight times. A former college and USATF coach, he currently lives in southern California and advises throwers of all levels and ages.

Getting the discus thrower's weight on balance is an important part of discus throwing success, with getting on balance late in the "unwind" phase of the throw causing potential problems, such as fouling at the back of the ring and the loss of power. Getting the athlete's weight to the on-balance position earlier in the unwind requires that the pivot side, foot, knee, shoulder, arm, and eyes remain together in a vertical plane from about 0 degrees to 180 degrees, the direction of the throw. In other words, the left side is stacked from the 12 o'clock to 6 o'clock positions.

Get balanced first to load the left at the 9 o'clock position, as the right leg is pulled off the ground.

PHOTO COURTESY OF MAC WILKINS

Load your left side so your foot is flat on the ground at the 9 o'clock position and the right foot is just coming off the ground.

PHOTO COURTESY OF LJ SILVESTER

The right foot must come off the ground as the body weight drops onto the left foot while the left foot is pointing to the 9 o'clock position. If the left foot is turned to 8 o'clock or 7 o'clock when the drop occurs, the athlete's balance and throwing mechanics are compromised.

PHOTO COURTESY OF DR. BING YU

The left foot does not need to be flat on the ground at the 9 o'clock position, but it may be. The left foot does not need to pivot 90 degrees to the direction of the throw, but it might, even though it starts completely flat on the ground at the 9 o'clock position. There are two key goals for this move.

1. A balanced and centered posture to create more power and an effective power position.

2. The left heel will rise as the athlete turns and loads and will not be forced down onto the rim.

As a result, the athlete won't foul or even look like he or she was thinking about pushing off the rim at the back.

The prime action or position is that the heel of the pivot foot raises up or is up off the ground as the left knee and the body weight drop during the single-leg support phase. It is not forced down on the rim during this time.

The pivot foot turns smoothly and more completely to the target during the single leg support phase. However, it can also work well as a shorter faster pivot if it is started when balanced. Note Mykolas Alekna's world record (74.35 meters; 243'11"). How much the athlete "cuts the corner" or makes it a longer, rounder turn is personal preference, but the athlete must first be balanced.

This is a simultaneous load (drop) and turn. It is not a quick, partial pivot and then a drop-and-load.

Work on the sequence: "left down, right up," as they occur together.

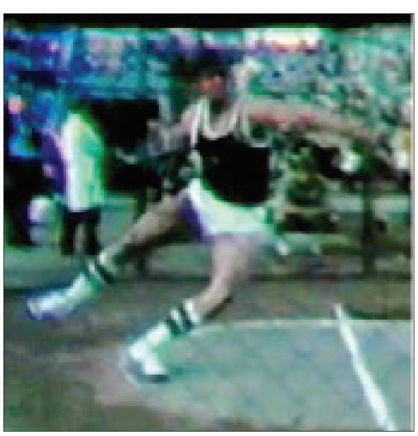
The right leg is not working to get off the ground but rather being pulled by the athlete's balanced weight. If there is any weight on the right foot, it will stay on the ground. If the athlete feels the right leg working, he or she is not balanced.

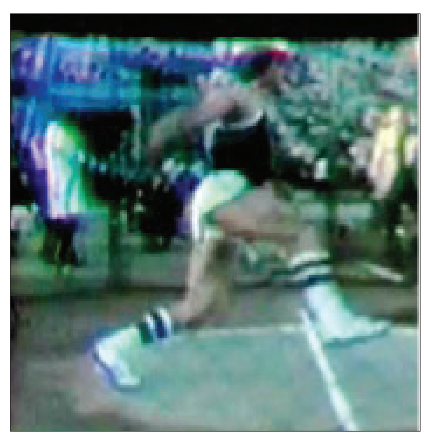
If there is "torque" between the knee/hips and the shoulders where the left knee leads the upper body into the turn (keep the arm behind the knee) and then drops to the middle before the shoulders get on-balance, the athlete won't be balanced. As Estonian discus thrower Gerd Kanter said, "I really don't like throwers who give up their hips too early." When this occurs, the lower body will have to wait for the shoulders to be balanced, and the mechanics work against the athlete, causing the heel to drop. If the shoulders don't get balanced, the hips will go one way and the upper body will take a different path through the circle.

THE RIGHT LEG IS NOT WORKING TO GET OFF THE GROUND BUT RATHER BEING PULLED BY THE ATHLETE'S BALANCED WEIGHT.

In my opinion, it is the case that the longer single axis for rotation is better than a couple of shorter axes, even though there may be a delay or separation between the two. It seems counterintuitive to eliminate separation between the hips and shoulders, but my

PHOTOS COURTESY OF IVER HOLE





observations and experience lead me to this conclusion. A single longer axis creates more power and eliminates the probability of two masses (upper and lower body) moving in different lines through the circle.

Getting the athlete's weight to the balance point later in the unwind, when the leading side has turned past the 9 o'clock position and is more in the direction of the throw results in several negative consequences. Loading later in the unwind puts the pivot heel in a biomechanical position where it will drop toward the rim as the body weight is loaded onto it as the thrower moves into the single-leg support phase. In this case, there may be a foul or the appearance of a foul that is difficult to judge accurately. Discus throwers may be given a pass on this point, as contrasted to shot putters, an example of which is Ryan Crouser in the 2017 World Championships, when he lost a big throw to a called foul at the back of the circle. It's best to give the official no cause for a second thought on the legality of the throw.

Getting on-balance late or not at all usually results in little or no rotation of the pivot foot in the single-leg support phase. While still in the double-leg support phase at the back of the circle, the pivot foot makes a quick move to about 110 to 120 degrees (8 o'clock position) and stops turning and remains fixed until leaving the ground. If this incomplete rotation doesn't lead to stress on the foot, knee, or hip, it sure looks awkward.

Often, especially in beginners, this move is caused by an overactive upper body, primarily the lead arm and head. The upper body leads or dives into the middle of the circle, leaving the lower body behind. Leading or diving with the head and left shoulder can create too much opening between the lead side and the sweep side. This upper body posture creates a falling mass that the lower body needs to "catch up" to. It also creates a sweep-leg carriage, leading more with the top of the thigh rather than the inside of the thigh. This is not the most effective way to create power. Many top throwers lead a little with the upper body using an "open-then-close" action. This may be a little exaggerated, but only to clearly show the point.

PHOTO COURTESY OF MAC WILKINS

Note the upper body posture, right-leg carriage, and height of the left heel.

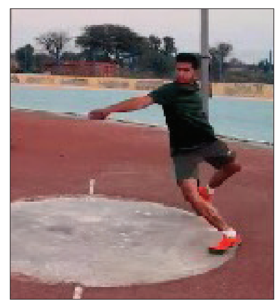
The athlete should avoid opening and turning past the 9 o'clock position with both feet on the ground…

PHOTO COURTESY OF MAC WILKINS

…so he or she can avoid this late-drop sequence.

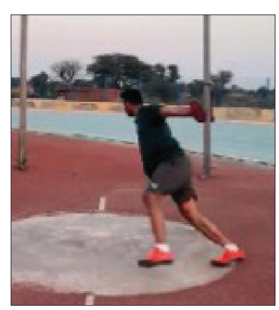
PHOTO COURTESY OF MAC WILKINS

Not on Balance



Dropping Late

Heel Drops to Rim



Heel Still on the Rim

This short pivot and fixed foot can also occur when the left knee turns ahead of the left shoulder. During the unwind, the lower body moves to the on-balance position ahead of the upper body as the shoulders remain turned slightly behind the hips from the windup. This occurs because the lead shoulder is lagging behind the rotation of the pivot knee. The lower body will stop turning but will pull, without moving forward on the lagging upper body and right leg. This can create a nice sense of power. However, it can lead to two problems. First, the delayed drop or load onto the left will create a position where it is difficult to hold the heel up. The structure of the leg and foot cannot resist gravity in this position. Second, the rhythm of this left side stopping to pull the right side can be inconsistent and require the feeling of needing the strength to deadlift a house to throw far rather than the feeling of throwing far with wet spaghetti-noodle arms.

Mykolas Alekna throws with a partial rotation of his left foot. In fact, it's fixed for much of the single-leg support phase. But, he does this while getting the left side balanced nearly in a vertical plane. You can see his left foot come off the ground on the outside of the foot. It's as if he intentionally under-completes his left side to set up even more resistance and torque when his powerful right side overcomes the left. I have also seen Ryan Crouser drop and turn on his left with his heel coming up away from the rim.

While technique changes throughout a thrower's career, the general technical guidelines still hold true.

SPRINT HURDLE TECHNIQUE

BY TONY VENEY

Tony Veney is the sprint, hurdles, and jumps coach at Chapman University. His 48-year career has included coaching positions at Oregon, Portland State, CSU Northridge, and the Sprint Sport Academy in Chengdu, China.

The women's 100-meter and men's 110-meter sprint hurdles are two track events that blend a litany of qualities not seen in their non-hurdle sprint counterparts. But whether hurdles are on the track or not, the one element consistent in events is the unavoidable development of raw, unadulterated speed! Too often, coaches build their sprint forces around everyone who can meet well known standards for sprint identification (e.g., 30-meter starts, 30-meter fly runs, multi jump/bounding, as well as various speed-endurance distances), and erroneously relegate those who fall short of these parameters to the hurdle events. The sprint hurdler not only needs to develop the same qualities as the flat sprint, but must also incorporate:

1. Hurdle start and acceleration
2. Hurdle speed development
3. Hurdle speed rhythm
4. Hurdle speed rhythm endurance
5. Hurdle clearance technique
6. Between hurdles run technique
7. Run to finish

HURDLE START AND ACCELERATION

The hurdle start has all the same qualities as in the flat sprint, but only through the first 3 to 4 steps after leaving the blocks. Unlike the flat sprint, during which a 100- or 200-meter sprinter can stay in an uphill-like posture for as long 30 meters (with stride length, stride frequency, ground contact, and airtime changing until transitioning to max velocity), the sprint hurdler must prepare for a hurdle clearance after 13.0 meters (women) and 13.72 meters (men). This distance demands a carefully programmed stride pattern of 8 steps to the first hurdle. This means the hurdler must acquire a more upright sprint posture (after the first 3 to 4 steps) to prepare for the elongated sprint stride over hurdle #1.

To practice, set up a 4x4 stride pattern, with the hurdler running aggressively for 4 steps as if it were a flat 100-meter sprint start. Complete the last 3 to 4 steps before the first hurdle with a slightly more upright posture to allow an aggressive hurdle attack. This is a more effective position for hurdle clearance. Strides 6 to 8 should emphasize an increase in the sprint cadence, which resembles the stride frequency between the hurdles. The next 2 steps enable the hurdler to rise to a more upright position, readying the hurdler to visually pick up the hurdle and steer into the take-off step. Many first hurdle hits are caused by an overly aggressive 8-step approach, trying to be fastest rather than trying to run the fastest rhythmically. Failing to adjust the stride pattern on the hurdle approach is disastrous for the hurdler, as his or her lengthening stride pattern will put the athlete too close to the hurdle, causing a deceleration, or, worse, a collision with the barrier. There has been a trend to use a 7-step approach, which generates more speed to the first hurdle. However, the hurdler or hurdle coach who wishes to transition from an 8-step to 7-step approach must do so carefully, considering the power demands necessary to perfect this technical pattern. To increase power, incorporate specific strength and power training, including standing long jumps of 3, 5, and 10 bounds that can increase acceleration power to reach hurdle #1 in 7 steps. Increasing these jump distances in shorter time frames can either reveal abilities to make the hurdler a candidate for a 7-step approach or reveal weaknesses that should keep the hurdler at an 8-step approach. The athlete's height alone cannot be the reason to run 7 steps. Being tall is not a prerequisite for moving to the 7-step approach if the athlete cannot generate the necessary strength and elastic power needed to run a step less during his or her hurdle approach.

HURDLE SPEED DEVELOPMENT

Hurdle speed development includes a similar battery of tests and evaluations the coach should implement when training a 100-meter sprinter: 30-meter acceleration, fast starting block clearance, 30-meter flying sprint, and maximal velocity achievement. Jump testing is also critical, including standing long jump, standing triple jump, and jump for distance with 3, 5, and 10 bounds.

HURDLE SPEED RHYTHM

Hurdle speed rhythm running is adjusting the sprint hurdler's natural non-hurdle race stride length to one that links more effectively to the demands of the hurdle event. The stride length for a male sprinter ranges from 2.35 meters to 2.75 meters (2.55m average). The stride length for a female sprinter ranges from 2.15 meters to 2.50 meters (2.33m average). Maximal flat sprinting seeks to produce the longest sprint stride and highest stride frequency possible. With that in mind, for the hurdles, the goal is to achieve the most favorable length and frequency possible within the confines of a set hurdle distance. Although the distance between hurdles is 9.14 meters and 8.50 meters for men and women, respectively, the hurdle distance is not the same as the hurdle running distance. The 110-meter high hurdle race requires an average take-off distance of 2.1 to 2.2 meters before the hurdle and a touchdown distance of approximately 1.4 meters after the hurdle. The 100-meter hurdle race requires an average take-off distance of 1.9 to 2.0 meters before the hurdle and a touchdown distance of approximately 1.0 meter after the hurdle. This means that those two races require average step lengths of 1.85 meters for men and 1.83 meters for women, when average take-off and touchdowns are subtracted. This requires highly technical rhythmic sprinting, resulting in an average stride length that's 27% shorter than male and 22% shorter than female flat sprinters. Hurdlers must spend time developing this "feel" for the speed rhythm or may find themselves lengthening their steps to match their non-hurdle sprint step length.

HURDLERS MUST TRAIN VISUAL STEERING, WHICH TEACHES THEM HOW TO STAY QUICK BETWEEN THE HURDLES, FOCUSING ON THE RUNNING DISTANCE RATHER THAN TRYING TO RUN TO THE NEXT HURDLE. RATHER, THEY MUST TRAIN TO RUN TO THE NEXT TAKE-OFF.

Hurdlers must train visual steering, which teaches them how to stay quick between the hurdles, focusing on the running distance rather than trying to run to the next hurdle. Rather, they must train to run to the next take-off. Training high-level frequency sprinting must be incorporated early and often in the hurdler's macrocycle. Navigation of the set distances between the hurdles requires a high level of frequency skill exemplified by the comparison between male and female sprint hurdlers of various performance times. For example, these two average hurdlers must navigate through the following hurdle parameters experienced by elite hurdlers (Table 1).

Here's how these average sprint hurdlers compare to elite sprint hurdlers (Table 2).

As you can see, elite and average hurdlers take the same number of steps. With the race restricted to a set distance between hurdles, *stride frequency* becomes the quality all hurdlers must master. Mature hurdlers can resist the urge to lengthen their strides and reach for the next hurdle as central nervous system (CNS) fatigue attempts to slow them down, while the average hurdler "falls into the quicksand" as he or she begins to slow down. When faced with growing CNS fatigue, the less seasoned hurdler "opens" his or her stride, believing this technical change will stop the deceleration. On the contrary, the lengthening of the stride by reaching while becoming fatigued causes the hurdler to cast the lower leg in front of his or her hips, landing ahead of the center of mass, which results in "braking" and a further slowing of the speed. However, the unseasoned hurdler doesn't believe this is the root of the problem, so he or she opens the stride even larger, unaware this is the very thing slowing him or her down. The hurdler then starts to doubt whether he or she is fast enough to run the sprint hurdles (although that ability depends on how quickly he or she can run between hurdles). Imagine driving a car and setting the parking brake every time you accelerate. You'll start to think your car isn't very fast. As sprint hurdle coaches, we must stop the athletes from braking themselves. One way to do this is to practice running the hurdles at distances less than the actual race hurdle distance, which can enable the hurdler to improve his or her visual steering prior to the hurdle clearance. This is similar to the repeated approach drills for the long jump, enabling the jumper to feel his or her way to the take-off board.

Table 1

	Harry-Hit-a-Hurdle	Becky-Bang-a-Barrier
Avg. Stride Length	2.40m	2.25m
Hurdle Spacing	9.14m	8.50m
Take-off Distance	2.10m	2.00m
Touchdown Distance	1.40m	1.10m
Hurdle Stride	3.50m	3.10m
Hurdle Running Distance	5.64m	5.40m
Average Hurdle Stride	1.88m	1.80m

HURDLE SPEED RHYTHM ENDURANCE

Hurdle speed rhythm endurance helps the hurdler tolerate or resist the influences speed endurance has on the later stages of the race. Both 110- and 100-meter sprint races follow similar velocity curves compared to the flat 100-meter race. After 7 to 8 seconds of intense sprint hurdling, the hurdler must manage an additional 5 to 7 seconds while attempting to manage the effect of normal sprint deceleration. Hurdle speed rhythm endurance workouts include short- distance reps with short recovery intervals. For example, have the athlete practice the hurdle start with an increased approach distance from 13 to 16 meters (women) and from 13.72 to 16.5 meters (men), which would produce a higher hurdle velocity, making it easier to run at the critical race speed earlier and sustaining it for longer. Try five-stride hurdling with hurdles set at 10 to 12 meters apart. The last stride before the hurdle becomes significantly faster, while the support time of the final stride is reduced. This increases average speed and frequency by 4 and 7%, respectively. Another drill is to hurdle over 12 barriers using a reduced hurdle spacing for hurdles 6 to 9 (7.5 meters for women and 8.5 meters for men) so the hurdler can adapt to the change in frequency.

Table 2

	Allen Johnson (12.91 sec)	Harry-Hit-A-Hurdle (15.55 sec)	Dawn Harper (12.41 sec)	Becky Bang-a-Barrier (14.99 sec)
Steps to hurdle 1	8	8	8	8
Steps between hurdles	3	3	3	3
Hurdle clearances	10	10	10	10
Steps to finish	5	5	5	5
Total steps	50	50	50	50
Total steps	50	50	50	50

rhythm endurance runs are to get the hurdler to accelerate over the last 4 to 5 clearances. Running hurdles that are lower and closer by 10% to 20% forces the hurdler to perform movements that closely mimic the speed and technical competency of the race. This can seldom be accomplished when the athlete runs at race hurdle height and spacing in a training setting. Running low and close to the hurdles is less exhausting and more closely mimics how the athlete should "feel" (even when fatigued) and how to manage the race. On race day, any concessions made during training by running at a lower hurdle height and closer to the hurdles will be made up for by having competition to race against and the excitement and anticipation that accompanies a race. Although training with race hurdle height and distance is also important, changing these variables will help the athlete feel the difference between where he or she is and where he or she wants to be.

When running out to 12 (or more) shortened-distance hurdles, the athlete is learning proper hurdle mechanics and race management while fatigued. By reducing the running distance by 3 to 5 inches per hurdle, the athlete can run 12 or more hurdles and is forced to run at a high level of technical competency over the last 4 hurdles. This kind of endurance hurdling will keep the hurdler from starting to bound and lengthening his or her stride. Some examples of rhythm endurance workouts are:

- 2-4 x 12 hurdles (gun started), low and close, with 10-15 minutes recovery

- 2-4 x 12 hurdles, pulling the 6th and 9th hurdles out, boosting their speed over the remaining hurdles

- 2-4 x 12 hurdles, with hurdles 1-5-9 at 20 inches and the rest at 30 inches. The first hurdle sends the hurdler flying to the second hurdle with a big boost, and a lower 5th and 9th hurdle gives the hurdler another boost so he or she can feel the continuance of race speed and technical quality while tiring.

- 5 hurdles at 30 inches and 8.2 meters apart from a 3-point start (or block start). After the 5th hurdle, the athlete runs to the finish line (and practices leaning at the finish), and after one minute (or more time, if needed), he or she repeats the sprint running in the opposite direction with the hurdles at 30 inches (or lower) and 8 meters apart.

HURDLE CLEARANCE

Once the athlete has mastered sprinting into the hurdle, proper take-off and clearance mechanics are next to master. The take-off is similar to a long jump take-off, enlisting a close-to-the-hips pull of the take-off leg back and under the center of mass in a cut-like step. In conjunction with the cut step is an opposite backward arm swing that enables the hurdler to extend the opposite arm, as if to reach for a doorknob. The lead knee should rise as high as possible, keeping the take-off foot on the ground as long as possible. This coordination creates an elongated sprint stride. As soon as the hurdler sees the lead hand, the hurdler must continue to run off and away from the hurdle. Letting the arms float causes the arm action to slow, resulting in a poor touchdown, causing a loss of hurdle velocity. Many hurdlers use a cross-arm technique, but the cross-body lead arm is often followed by a sweeping of the lead arm, twisting the upper body and losing hurdle velocity. If the hurdler must use a cross-arm technique, the continued running motion must be triggered by the trail elbow (swinging the arm back instead of around the body using the hand as the focus of the trail action). Since the women's hurdles are considerably lower, a fast lead-leg and trail-leg is needed for a fast clearance. This is why lower and closer hurdle runs are critical to train the hurdler to feel how fast the hurdles will be approaching. Because men have a higher hurdle, which requires an "up-over-down" clearance, the arm action takes a little longer.

BETWEEN HURDLES RUN TECHNIQUE

Because the hurdler's stride is significantly shorter than his or her optimal sprint stride, a stride that resembles a shuffle is needed between hurdles. Maximal running mechanics execute a "stepping over the opposite knee" with the recovery leg. But because the hurdler must negotiate a set distance, a lower, more hamstring-dominant running technique is necessary. This is why training sessions should incorporate lower and closer height and spacing, so the hurdler can acquire high-level steering between the barriers.

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THE ART OF SPRINT DRILLS FOR IMPROVING SPRINT MECHANICS

BY RYAN BANTA

Ryan Banta was inducted into the Missouri Track & Field and Cross-Country Coaches Association (MTCCCA) Hall of Fame in 2021. He is the 2022 USTFCCCA Girls' Coach of the Year and two-time MTCCCA Coach of the Year. He is author of *Sprinter's Compendium* and has a Master of Education from University of Missouri in educational, school, and counseling psychology with an emphasis in positive coaching, and is USATF Level II certified in sprints/hurdles/relays, endurance, and jumps.

"Biomechanical laws are like all other laws; live within them and you'll do fine, break them and you are in trouble."

— Donald Chu, plyometrics guru

You cannot be a successful sprint coach without understanding biomechanics. Perhaps that's why much has been written about sprint drills, like the 'A' skip, 'B' skip, and quick-leg. While coaches have used these drills for a long time, the devil is in the details, and so we can make these drills unique by manipulating the details, such as surface, hand position, loading, and straight vs. curved and hilly vs. flat terrain. We can also combine drills and skills. For example, when training at maximum velocity, the exercises done at the beginning of a practice session should mimic the neuromuscular recruitment of muscle fibers the athlete will experience later in the session.

When an athlete runs at maximum velocity and is therefore recruiting muscle fibers as quickly as possible, it is imperative to protect the athlete from getting injured. The speed and forces sprinters produce make them susceptible to various risks, including muscle and joint injuries, because of the speed and timing required to reach important biomechanical positions in such a short time. Running with maximum efficiency at high speed is not necessarily natural, and so athletes need to learn optimal body-segment positions, which need to be taught appropriately. Another value of drill manipulation is to help diagnose potential issues during warm-up before athletes perform the main part of the workout.

A great drill strategy is to package your drills, setting two-day rotations for two weeks at a time. Packing your exercises this way keeps them fresh for your athletes and prevents them from overloading certain muscle groups. It also helps with focus on proper drill execution, preventing athletes from losing focus when getting comfortable with a routine.

Every two weeks, the packages of drills should change and build on previous skills. For example, progress from a walking quick leg to a jogging quick leg, alternating quick leg, double quick leg, or progressing from quick ankles to a quick leg, and so on. The drill packages should mimic your focus for that particular training microcycle.

Using drills to correct poor technique takes a long time, perhaps even more than 500 hours (USATF Super Clinics, 2004). If this is indeed the case, working on an athlete's biomechanics must start on the first day of his or her freshman year of high school. It takes an athlete's commitment to the process and constant cueing from the coach to achieve optimal mechanics.

The ultimate goal in training sprint drills is to increase movement efficiency (economy), which comes from sprinters' improved biomechanics. It should be noted that efficiency in sprinting means having biomotor fluidity, rather than using less energy and oxygen to run at a given speed, as is the case in distance running. The more efficient the athlete, the less energy he or she expends on maximal effort or running multiple races in a single meet and the less likely to get injured. By moving appropriately, the athlete is less likely to fall in the "overflow" trap, in which an athlete recruits less efficient or inappropriate muscle fibers to run at a fast speed. These muscles might not be a part of the normal firing pattern or lack contractile resiliency to be used long enough without being overly stressed and causing an injury. The fewer injuries, the longer an athlete will be able to train and compete. The longer the athlete can compete, the more likely he or she will reach significant breakthroughs and set new personal bests. Between the sexes, anecdotally, women may be able to get away with suboptimal technique more frequently than do men, decreasing the frequency of injury, especially at lower performance levels, because they run at slower absolute speeds and have more innate suppleness (Fudge, 2017). Additionally, improved mechanics strengthens typically underused but important muscles in the sprint cycle. When done correctly, they enable the sprinter to optimize force production against the ground and improve stride length.

The younger the athletes, the easier it is to get them to ingrain and adopt new technical skills. Think of programming the body like programming a computer. Computer programming is done in zeros and ones; fast and slow for a sprinter. The more an athlete's body is programmed to move fast, the quicker the sprinter will become. The opposite is true if the athlete spends too much time learning skills at a slow speed.

To correctly program the athlete's computer, the drills must be done when the athlete is as fresh as possible. Do not try to teach these skills when the sprinter just finished a long interval workout, when energy stores and central nervous system are drained. Attempting to teach athletes new skills in a fatigued state will do more harm than good because the sprinter will learn unhealthy habits or sustain an injury. When tired, a runner contacts the ground differently and teaches the body to perform skills at a sub-optimal firing pattern, which can become challenging to reprogram.

Many coaches leave poor biomechanics alone by claiming that biomechanical anomaly is simply the athlete's style. However, an athlete's "style" may be a cover-up for poor mechanics. Coaches must cue athletes to move appropriately while running, changing the drill stimulus on a regular basis to avoid habituation and plateaus. Several "tricks" to accomplish continued progression include:

- Adding mini-sprints
- Different hand positions
- Changing surfaces
- Performing drills on the curve
- Exercises on an incline or decline

Not all aspects of sprinting will be trained on the same day, as we don't want the body to get mixed signals. Rather, program individual drills, drill routines, and training blocks with *modules* or *packages*.

FRONT-SIDE MECHANICS

Sprinters tend to have many discrepancies in front-side mechanics (Mann, 2024). These discrepancies exist because elite sprinters project power, are technically better at "stepping over the knee," and have greater range of motion during maximal sprinting compared to lower-level sprinters. As coaches, we should not simply ignore this as "talent being talented." Change can happen. When athletes change their technique, many expose themselves to an increased risk of injury. How do you manage the transition to improved skill acquisition while limiting the risk of damage?

Coaches should periodize the teaching of sprint mechanics to help build the skills in athletes, progressing from general skills to precise movements. Each package of drills should be designed to build off the skills mastered in the previous package. Start with basic activities, adding new wrinkles and greater complexity as the athletes progress. Set up these skills to develop athletes, not just sprinters. The consistent variety allows the athlete to have a starting point with new skills, while, at the same time, he or she is stimulated by the slight tweaking throughout the season. Only give athletes a particular drill or exercise after setting up the necessary bio-motor foundation. An athlete needs to learn what an A skip looks like before he or she can move to a B skip or an A-B skip complex. Better yet, sprinters need to learn basic dorsiflexion of the foot before they can appropriately perform an A skip. Foot placement during drills is also essential. For example, sprint coach Dan Pfaff has his athletes use a full-footed landing when doing drills to help dissipate forces over the entire foot. As the sprinter increases the speed of the drills, he or she will naturally land farther up to the ball of the foot.

MORE EFFICIENCY EQUALS MORE SPEED

Training the sprinter's biomechanics improves specific strength and posture stabilization that reduces the sprinter's loss of speed near the end of races. Sprinting at high speeds is a series of explosive, well-timed movements with increasingly shorter windows of error as the athlete improves. All things being equal, the sprinter who maintains his or her highest speed for the longest time and decelerates the least is routinely the sprinter who wins and runs the fastest time. For example, the top three sprinters in the 100-meter World Championships final had a degradation of speed of only 2% of their maximum speed. Maintaining maximum velocity is critical, and biomechanical efficiency is essential to hold those high speeds for as long as possible. One way to practice this is to train in spikes. Although training in spikes may confer less protection from the large forces incurred when landing, it offers the maximum return in effort, intensity, and technique, and enables the sprinter to stay more on the front of the foot, thus making the athlete more efficient.

MAXIMIZING STRIDE LENGTH

Among all biomechanical factors considered, data suggest that stride length is the most significant determining factor that separates the highest performers in the World Championships from those who do not make the finals (Hanon & Gajer, 2009). Figure 1 suggests that a longer stride length is extremely advantageous to faster times in a world-class 400-meter competition. In Pierre-Jean Vazel's database of more than 550 athletes who have run sub 10.30 seconds for 100 meters, stride length averages 1.4 times the athlete's height. An athlete's stride length relates to his or her power. When performing wicket drills or stride length runs, the muscle power necessary to achieve a stride length of 1.4 times height should therefore be the goal for developmental sprinters when training to improve stride length.

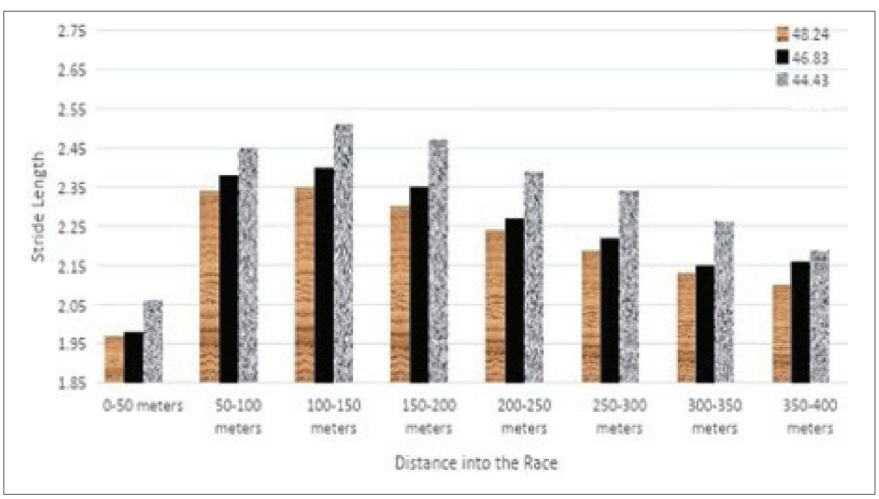

Figure 1: The relationship between stride length and distance covered in 400-meter race. Note how the faster runners have a longer stride length in each segment of the race than the slower runners and that, for all three runners, stride length increases up to 100-150 meters, then decreases for the rest of the race, regardless of the final 400-meter time. Redrawn from *Hanon & Gajer*, 2009.

Stride rate, the other kinematic variable that affects speed, remains remarkably stable among sprinters.

Individualizing the different maximum velocity targets and stride lengths means a coach needs to employ several different wicket setups for the variety of different strides. Stride length is created by the vertical and horizontal ground reaction forces, per Newton's third law of motion, as the athlete's foot lands and subsequently produces force against the ground during the stance phase. Vazel stated during the World Speed Summit that he uses two drills to improve vertical or horizontal forces (Vazel 2016). He sets up miniature hurdles to improve vertical forces with increasing spacing as the sprinter runs down the track over the hurdles. The athlete running over the mini-hurdles should start at the first barrier, running as if he or she is performing an "A" run. The second drill also includes mini-hurdles set up at the goal stride-length distance apart from one another. In this second drill, the sprinter starts going over the barrier with a slow bound, blending into an exaggerated run and finishing with a high-speed run. However, be careful when planning a sprinter's emphasis in training, as both stride-frequency and stride-length sprinters tend to do better practicing their strengths. Please note, the coach needs to be cautious to not over-emphasize stride length to the detriment of stride frequency.

'A' RUN

The 'A' run should be a staple drill in any sprint program. It teaches a large number of positive aspects of maximum velocity biomechanics. The 'A' Run is a practice sprint with exaggerated high knees focusing on front-side mechanics and lifting the legs off the ground. The drill is intended to simulate what the sprinter will experience in a controlled environment when he or she reaches maximum velocity. Coach your athletes to do the 'A' run correctly. They must do high-knee drills while sprinting. Cues I often use for the 'A' Run are "be bouncy, stay tall, or run above the track."

AN ATHLETE'S STRIDE LENGTH RELATES TO HIS OR HER POWER.

Some athletes will get stuck trying to exaggerate the movements in the 'A' run. The coach should remind them to keep the action fast. If an athlete still has issues performing the skills correctly, you can use mini-hurdles spread out far enough to maintain good speed while forcing the sprinter to lift the knees to navigate the hurdles properly. If athletes still struggle to learn the movements, you can record a video of them doing the drill. Then show them the correct model, followed by their next attempt at the drill, and another example of the drill performed correctly.

An 'A' run is difficult to maintain at first if the athlete doesn't have the power or balance to move down the track in the correct positions. As the athlete improves his or her drill execution, extend the distance of the drill, with the maximum length capped at 50 meters. Once athletes perform the 'A' run technically sound and at a good speed, their sprint times should start dropping.

DRIVE FOR 8 INTO 'A' RUN

After a sprinter has mastered the 'A' Run, have the athlete run from a standing start and add a drive phase to the drill. Using a designated drive phase to go with the exaggerated mechanics of the 'A' Run gets the sprinter close to blending the beginning stages of the sprint race. Start by performing eight driving contacts to ensure the athlete drives for a reasonable distance. Some athletes will drive for too short of a distance without a designated number of driving steps, and others will push too far. Eight-driving contacts are four left and four right steps. This drill can also be used to prepare the athlete for what comes later in the training session. If the athlete creates eight powerful contacts, you can choose to do more later as he or she masters the skill. Once the drive steps are complete, the athlete should flow into the fully upright exaggerated running mechanics of the 'A' Run.

The drill should be used later in the track season's competition or championship phase.

'A' RUN WITH 5 STEPS LOW-HEEL RECOVERY + 5 STEPS HIGH-HEEL RECOVERY

This drill forces the athletes to think and pulls them out of their comfort zone. The key to this drill is that no matter the heel recovery, you must challenge your sprinters to keep the training dynamic, elastic, and quick. Runners can reach speed threshold by becoming hardwired due to consistent training rhythms. This speed threshold has been called a dynamic stereotype. Gary Winckler developed a special preparation to disrupt this artificial ceiling to push the limits of individual speed. You can give verbal cues as to what the athlete is doing in the drill concerning his or her heel recovery: "high," "low," and "go." Give these three cues repeatedly until all the athletes have finished their exercise. As the athletes on your team wait in line to repeat the drill, their first move is the 'A' run with high-heel recovery. Then, after a couple seconds, say, "Low," and the athlete will respond with a low-heel recovery resembling a shuffle, during which the athlete steps over the ankle in a rotary movement. Finally, cue the next athlete to start the exercise by saying, "Go," and repeat the process.

'A' RUN WITH SPEED CHANGE

'A' run with a change in speeds is another excellent practice that helps fight a sprinter's dynamic stereotype. However, this exercise differs because the sprinter must keep his or her heel recovery high like a traditional 'A' Run the entire distance of the exercise. The variation in this drill comes from the speed. The athlete will be at fast and slow speeds at specific points during the drill. Constant change in speed forces the athlete to concentrate and does a fabulous job of exposing the neurological system to a new stimulus. As with the previous drill, cue the athlete in what his or she is doing at any particular moment in the exercise, with commands of "Fast," "Slow," and "Go" for the entire distance of the drill. When prompting the athletes "Slow," they should slow down but try not to break the rhythm or mechanics of the movement. When you cue "Go," the next line of athletes begins the drill and follows the groups in front of them until they reach the end.

'A' RUN WITH ALTERNATING STRAIGHT-LEG RUN

'A' Run alternating into a straight-leg bound is an advanced drill used by more experienced sprinters needing a new stimulus. This drill requires a lot of coordination in a controlled environment. It also helps strengthen the athlete in areas he or she needs for sprinting, including the hip flexors and hamstrings, and does an exceptional job of warming up the sprinter for what he or she will do in the training session. As with the previous two drills, cue the sprinters about what to do at particular moments in the drill. That forces them to pay attention and makes them aware of their bodies' levers at different points in space. This drill, along with the previous two, are very demanding, and should therefore be performed later in an athlete's training cycle, which gives him or her a continued challenge at the end of the year.

MINI-HURDLE RHYTHM (WICKET) RUNS

To help train the 'A' Run positions, you need to force the sprinter to get his or her feet off the ground quickly without sacrificing speed. A common biomechanical flaw with developmental sprinters running at maximum velocity is that many have limited front-side mechanics due to a lack of heel recovery. Having sprinters run over mini-hurdles is one of the best activities to improve heel recovery. An acceleration zone before the

mini-hurdles is essential to simulate the speeds the sprinter achieves during maximum velocity. After the acceleration zone, the coach should set up several mini-hurdles to force the sprinter into a particular step pattern with a high heel recovery. As the sprinter improves, adding distance between hurdles and increasing the number of obstacles will be essential.

Another strategy coaches can use is a standing start and a several wickets close together. As the sprinter runs over the wickets, the distance between each mini-hurdle expands. Progressively spreading out the barriers trains acceleration and stride length. Only add distances and hurdles as long as the sprinter improves his or her speed over 10, 20, or 30 meters. If the sprinter loses rhythm and/or speed, reduce the space between or number of hurdles. If the sprinter continues to lose speed, it is time to stop the workout. An athlete can sprint over the mini-hurdles and then have a cone he or she must reach after completing the first part of the rhythm run. You can also use the wickets during an interval workout. For example, the sprinter would run over the wickets, then, after a short recovery period, perform a near-maximal sprint.

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Sprint Hurdle Technique

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RUN TO FINISH

Since automatic timing can separate athletes by milliseconds, neglecting technique and training that focuses on running from the final hurdle to the finish is a critical hurdle mistake. When the hurdler touches down off the tenth hurdle, he or she must transition from the shuffle-type stride used between hurdles to an aggressive sprint stride that more closely resembles a normal sprint stride. From the 10th hurdle touchdown, the athlete takes a "hard 5" strides, with the fifth step pushing through the finish line. Workouts should incorporate running off of every set of hurdles with a "hard 5" finish. Regardless of how many hurdles used in training, include a finish line for the hurdlers to run a "hard 5" so it becomes automatic.

THE BIOMECHANICS OF ECCENTRIC AND CONCENTRIC ACTIONS IN THE HIGH JUMP

BY SUE HUMPHREY

Sue Humphrey is a highly respected track and field coach, with decades of experience at the collegiate, national, and Olympic levels. A trailblazer in coaching, she has served on 3 USA Olympic Staffs, including as the 2004 Olympic Women's Head Coach. Specializing in high jump and athlete development, Humphrey coached 1996 Olympic Champion and American recordholder, Charles Austin and Coleen Rienstra Sommer, the first woman to jump 2.00 meters indoors. She continues to impact the track and field community through coaching education and leadership through the Gold Medal Coaches Summits.

Defying gravity with every leap, high jumpers push the limits of human biomechanics, seamlessly converting speed and power into breathtaking vertical elevations. Every movement leading up to takeoff plays a critical role in determining an athlete's ability to successfully clear the bar. What separates good high jumpers from great ones is the precision of technique and the mastery of takeoff mechanics.

The key biomechanical factors include rhythm and acceleration, proper foot placement at takeoff, a slight lowering of the center of gravity, a powerful takeoff using the entire foot and opposite free knee drive, and the hinge moment.

Influencing these biomechanical factors and jump performance are the eccentric and concentric muscle actions during takeoff. The eccentric phase, characterized by controlled muscle lengthening, is essential for storing elastic energy and preparing the jumper for an explosive lift-off. This is followed by the concentric phase, during which muscle shortening generates the vertical force needed to propel the athlete upward.

Understanding the interplay between these biomechanical principles enables the optimization of technique, enhancement of performance, and injury risk minimization in high jumpers. In preparing for these muscle actions, the hinge moment will put the body in the best possible position through the final steps of the approach.

Eccentric muscle actions play a crucial role in high jump performance, particularly in the penultimate step and takeoff phase. During the penultimate step, the athlete's center of gravity is lowered, and the four quadriceps muscles (rectus femoris, vastus intermedius, vastus medialis, vastus lateralis), along with the gluteus maximus, lengthen under tension, store elastic energy, and absorb impact. This eccentric loading enables high jumpers to generate a rather large ground reaction force at takeoff, up to 4 to 5 times their body weight. At the same time, the three hamstrings muscles (biceps femoris, semimembranosus, semitendinosus) co-contract with the quadriceps muscles to stabilize the knee joint. The calf muscles (gastrocnemius, soleus) stretch slightly to absorb horizontal momentum and set the athlete up for a powerful, vertical takeoff. The core muscles (rectus abdominis, obliques, transversus admininis) work together with the leg muscles to maintain posture and prevent unnecessary loss of energy. The eccentrically contracted muscles then release the elastic energy for the ensuing explosive takeoff, as the athlete's quadriceps extend the knee, propelling the athlete upwards, the gluteus maximus extends the hip, providing additional power for vertical lift, and the calf muscles plantarflex the foot, enabling an effective push-off. The hamstrings assist in knee flexion and contribute to hip extension, which helps optimize takeoff mechanics.

This rapid sequence of active muscle lengthening (eccentric) immediately followed by muscle shortening (concentric) is called the *stretch-shortening cycle* (SSC) and is fundamental to an efficient energy transfer in the high jump. Research since the 1960s has shown that greater muscular forces can be generated during a concentric muscle action when that action is immediately preceded by a quick eccentric action (Bosco & Komi, 1979; Cavagna et al., 1968; Komi, 1984; Thys et al., 1972). The stored potential energy during the eccentric muscle action rapidly converts into kinetic energy during the concentric action, generating the necessary vertical force for lift-off. Although a brief transition phase occurs between eccentric and concentric actions (i.e., an isometric muscle action), this phase should be noticeably short to maximize the elastic energy transfer from eccentric to concentric for the explosive takeoff.

Elite jumpers maximize SSC efficiency by reducing ground contact time (approximately 0.12 to 0.14 second) while maintaining high force output (Dapena, 1980; Dapena & Chung, 1988). Spending too much time on the ground at takeoff creates too much downward velocity and loss of potential elastic energy to convert into effective vertical lift. Therefore, the jumper should minimize the time it takes for the final two steps while maintaining ideal body positions.

The high jump takeoff angle (approximately 40 to 50 degrees) is influenced by the timing and coordination of concentric actions. If the concentric force is applied too early or too late, the jump will be inefficient, either losing height or sacrificing momentum.

ECCENTRIC STRENGTH

Athletes with greater eccentric strength can manage higher loads and produce greater vertical lift. Eccentric strength training helps prevent knee, Achilles tendon, and hamstring injuries, which are common in jumpers due to the high forces involved. To enhance eccentric strength, high jumpers should incorporate depth jumps (eccentric loading followed by explosive takeoff), slow eccentric squats (with about a 4- to 6-second lowering phase), Nordic hamstring curls and single-leg eccentric exercises (e.g., Bulgarian split squats) in their training.

THIS RAPID SEQUENCE OF ACTIVE MUSCLE LENGTHENING (ECCENTRIC) IMMEDIATELY FOLLOWED BY MUSCLE SHORTENING (CONCENTRIC) IS CALLED THE STRETCH-SHORTENING CYCLE (SSC) AND IS FUNDAMENTAL TO AN EFFICIENT ENERGY TRANSFER IN THE HIGH JUMP.

CONCENTRIC STRENGTH

To improve concentric strength, high jumpers should focus on including Olympic lifts (power cleans, snatches) for explosive strength, squat variations (box squats, Bulgarian split squats) for lower-body force production, plyometrics (depth jumps, bounding drills) to enhance SSC efficiency, and concentric- and isometric-only exercises (trap bar deadlifts, sled pushes) for force application specificity.

HINGE MOMENT

The hinge moment, which is the

biomechanical action occurring at the hip joint during the final steps of the takeoff phase, is one of the most crucial yet often overlooked elements of the high jump. It is essential in converting horizontal velocity into vertical lift, ensuring an optimal flight path over the bar. Incorporating a refined hinge moment into a jumper's technique can significantly enhance performance, providing the necessary efficiency to reach new heights, while maintaining control throughout the jump.

The fundamental principle of the hinge moment follows Newton's first law of motion: an object in motion continues in motion unless acted upon by an external force. This explains why a high jumper must maintain an erect posture through the curve while keeping the shoulders slightly behind the hips in the penultimate and final takeoff steps.

Throughout the curved approach, athletes must maintain an upright posture to optimize their takeoff mechanics. When an athlete fully understands and applies the hinge moment principle, he or she will adopt a more pronounced hip-led posture, maintaining slight shoulder displacement behind the hips through the final strides. This positioning effectively sets up the body for an optimal takeoff by maximizing vertical force application.

Upon ground contact of the takeoff foot, the torso remains upright while the hip joint functions as a pivot point, facilitating a natural transition into a more vertical orientation while the foot is still in contact with the ground. This strategic positioning ensures an efficient transfer of horizontal velocity into vertical lift. It's during this part of the jump that the heel spikes of the athlete's shoe become more important than the spikes of the forefoot.

Coaching the hinge moment can be enforced by running circles, repeated take offs, and curved runs using a "lead with your hips" cue. High jump running posture is altered through the final steps to keep the jumper in the correct position, with shoulders slightly over and behind the hips. In this position, when the jumper plants at takeoff, all body parts above the planted foot are accelerated forward. When the active free knee and arm action contribute to this conversion from horizontal to vertical, a more effective takeoff is executed. If the jumper is out of this hip position and the shoulders are too far forward when the foot is planted, vertical lift is compromised and the jumper has limited conversion.

The hinge moment in the high jump heavily involves multiple muscle groups working together to generate power, control rotation, and optimize takeoff. The primary muscle groups that play a role are also involved in the eccentric-concentric process discussed above. While the gluteus maximus provides the explosive push needed at takeoff, the gluteus medius and minimus help stabilize the hips, and the hamstrings assist in hip extension and help control knee flexion during takeoff. The eccentric loading in the penultimate step actively stretches the hamstrings, allowing for a powerful recoil during takeoff. The quadriceps are crucial for knee extension, allowing the jumper to push off forcefully from the ground and absorbing much of the impact during the penultimate step, preventing excessive knee collapse. Finally, the hip flexors (iliopsoas, rectus femoris, sartorius), especially during the free-leg drive, contribute to upward lift and proper body positioning at takeoff by aiding in the transition from horizontal to vertical motion at foot plant.

Other muscle groups provide overall support to the jumper's body positions through the approach and actual jump. The core muscles stabilize the upper body during the hinge moment, the calf muscles contribute to ankle plantarflexion at the final push against the ground at takeoff, and the adductors and abductors assist in lateral stability and control to prevent the knee and hip from collapsing inward during takeoff.

To develop an effective hinge moment, high jumpers should focus on hip mobility, explosive power drills, and proper takeoff mechanics. Strength training exercises such as single-leg squats, step-ups, and plyometric drills help reinforce this movement pattern.

OPTIMIZING HIP POSITIONING

Ensuring correct hip positioning in the final strides is paramount for maximizing vertical displacement. Poor hip alignment results in excessive horizontal momentum retention, reducing the effectiveness of vertical force application. Additionally, improper force absorption can increase stress on the knee and ankle joints, increasing the risk of injury. Athletes often describe a properly executed

Teaching Eccentric-Concentric & Stretch-Shortening Cycle Actions
By connecting the drills to high jump movements, young athletes will understand how to effectively use eccentric-concentric actions along with hinge moment to jump higher and more efficiently.

Slow Drop-to-Jump Drill (Absorbing & Exploding)
This exercise helps young athletes understand how to absorb and reapply force efficiently. Start with the athlete standing on a 6- to 12-inch box, step off, and land softly by bending knees (eccentric absorption). Then, have the athlete immediately jump up as high as possible (concentric explosion). Have the jumper use different flexion angles when landing to experience the varied reactions he or she will have (i.e., the greater flexion will yield a slower reaction vertically). Too much downward velocity when jumping will negatively affect the vertical lift.

Pogos (Reactive Bouncing)
This exercise teaches jumpers to develop a quick, elastic stretch-reflex action. Athletes jump up and down in place with their knees slightly bent. They immediately bounce on the balls of their feet with stiff, dorsiflexed ankles while keying on short ground contact time and quick rebounds. This drill lets the jumper feel the stiff reaction effect of the stretch-shortening cycle.

Weighted/Unweighted Countermovement Jumps
These exercises reinforce various loads and how to explode from different resistance. Have the athlete stand tall, then quickly squat down (eccentric) and explode up (concentric) into a max-height jump. Have the athlete first do this exercise a few times with resistance, and then without resistance to feel how faster eccentric and concentric actions transfer to the high jump takeoff. Emphasize a fast downward movement, which creates a stronger upward force.

One-Legged Step Hop Drill
This drill will mimic high jump takeoff mechanics while teaching eccentric loading. The athlete jogs toward the high jump pit and takes a big step onto one foot (just like a high jump approach), while using the hinge moment body positions. He or she should keep the takeoff leg fairly stiff with a slight flexion of the knee and immediately explode upwards. The takeoff leg will flex minimally when taking off, but it must be strong enough to counter the negative downward velocity created.

Weighted Eccentric Squats
This exercise trains the muscles to absorb high-impact forces required during the eccentric contraction. Have the athlete hold light-weighted dumbbells and slowly lower him or herself into a squat. After a 3- to 5-second eccentric phase, the athlete quickly explodes upward. Teaching stronger eccentric control will lead to more powerful jumps.

Reactive Bounding
To teach a quick transition from landing to jumping, the athlete will perform continuous bounds from one foot to the other, focusing on spring-like action, keeping the knees slightly bent on landing. Again, coaches should stress that athletes must minimize time on the ground and use the stretch reflex to propel upward and forward.

Single-Leg Hurdle Hops
This drill trains high-speed takeoff mechanics while emphasizing a quick eccentric reaction. Coaches should set up low hurdles (12-18 inches) spaced evenly apart. Have the jumpers hop continuously on one leg, clearing each hurdle with minimal ground contact time. Vary the height of the hurdles based on the ability of the athlete. Stress that athletes must land lightly on the ball of the foot and then immediately spring into the next hop. Execute this drill with both legs for overall strength and balance.

Depth Drop to Bounding
This exercise trains rapid eccentric loading and forces transfer in horizontal and vertical movements. Jumpers step off a 12- to 18-inch box and land on one foot. Upon landing, they immediately push off into three powerful horizontal bounds. It's vital that athletes keep their body tall and reactive and use the stretch reflex to generate force.

Hinge Moment Drills
Teaching the hinge moment positions start with the first step of the high jump approach. On a 10-step approach, jumpers should push out from a static start. By step 3 to 4, the jumper's posture needs to be tall with the shoulders aligned with the hips. When stepping into the curve, the jumper's body positioning changes by using centripetal (center-seeking) force. The inward body lean starts from the ankle through the shoulder. During this transition, the jumper begins to lead with the hips through the curve with the shoulders slightly behind the hips in the inward lean. This "lead with the hips" run needs to continue through takeoff. This is an unusual position and the jumper will feel uncomfortable. Coaches must reinforce this is the proper hinge moment position. When the last few steps are preparing for takeoff, it's common for the jumper to tend to sit back through the penultimate step. However, this must not happen for the hinge moment to be exploited. When the jumper takes off, centrifugal (center-fleeing) forces take over, and the bar is cleared.

takeoff as feeling effortless, a direct result of optimal biomechanical alignment and force application efficiency.

By emphasizing tall posture through the curve, controlled backward lean in the final strides, and proper hip articulation at takeoff, coaches can help athletes achieve a more efficient and mechanically sound high jump performance.

Teaching eccentric-concentric actions to young high jumpers requires simple explanations, visual examples, and drills to help them feel the movement. The key is to show them how muscles absorb force (eccentric) and then explode (concentric) for a powerful takeoff.

Before having them do any drills, have them jump without first bending their knees to see how little rebound they get from not preloading. Then, have them flex their knees and quickly jump up. They will feel the springy lifting effect of how important the eccentric preloading phase is.

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USATF COACHING EDUCATION

USATF CALENDAR OF SCHOOLS

https://www.usatf.org/programs/coaches/calendar-of-schools

April 26-27	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)*
May 17-18	*USATF Level 1 Event Specific Training – Zoom (Pacific Time)*
June 9-11	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)*
June 28-29	*USATF Level 1 Event Specific Training – Zoom (Pacific Time)*
July 18-20	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)*
Aug 16-17	*USATF Level 1 Event Specific Training – Zoom (Pacific Time)*
Sept 13-14	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)*

Dates for summer specialist courses and an announcement on the 2025 Level 2 School are coming soon.

USATF

NEW USATF LEVEL 1 FORMAT FREQUENTLY ASKED QUESTIONS

In May 2024, the USATF Level 1 Program launched in a new blended learning format. Contact hours are now spread across a combination of online self-paced coursework and scheduled Zoom or in person* for the event specific training.

**In Person Level 1 Event-Specific Training offered in select locations only.*

Q: How do I enroll in the Level 1 Program and get started?
A: The Level 1 Program requires a current USATF membership and the individual must be at least 18 years of age. Members meeting these qualifications can enroll from the USATF Calendar of Schools page. After purchase, they can instantly start the course by clicking through to USATF Campus (on the left-hand side menu) from their Sport80 profile.

Q: Which units are completed self-paced and how long do I have to complete them?
A: The first half of the course contains self-paced lessons on Positive Coaching, Ethics and Risk Management, Athlete Development and Lifestyle, Instructional Strategies for Skill Acquisition, Physiology, Biomechanics, Biomotor Abilities for Speed and Power, Training Design, and Sport Psychology. Enrollees have 60 days to complete these units and can request a 30-day extension for a fee ($25).

Q: Once I finish the self-paced units, how do I sign up for the event-specific training?

A: At the conclusion of the self-paced units, your course contains a link to select an upcoming event specific training on Zoom. Event-specific trainings are offered once to twice a month and included in the overall Level 1 Program registration fee ($250). You will receive your digital textbook the week of the event specific training.

Q: Are there in person school options for the USATF Level 1?

A: On occasion, the event specific units only will be presented in person at special events or in large metropolitan locations. Registration will be posted on the calendar of schools for these special schools.

Q: I completed the new USATF Developmental Coach Program. How do I upgrade my certificate to a USATF Level 1 Coach?

A: You must enroll in the Bridge Program to Level 1 to complete the remaining units of the progression. The Bridge Program is specially priced at $185 specifically for Developmental Trained Coaches. They should not purchase the full price Level 1 ($250).

Q: How long is my USATF Level 1 certificate valid for once attained?

A: Level 1 certificates are valid for four calendar years, expiring on December 31 of the fourth year. Coaches must complete an approved USATF continuing education course during the active period and submit a renewal application in the expiring year to renew. Lapsed Level 1 Coaches must retake the latest course and exam to regain their recognition.

https://www.usatf.org/programs/coaches/level-1

KICKSTART YOUR COACHING JOURNEY WITH THE NEW USATF DEVELOPMENTAL COACH PROGRAM

For those new to the world of track and field coaching, the USATF Developmental Coach Program offers an ideal entry point. This comprehensive, online course is tailored for individuals with minimal to no prior coaching experience, including entry-level coaches, volunteers, parents, and administrators. Designed to be completed at your own pace within 60 days, this 5-6 hour program focuses on creating a positive and safe environment for young athletes. Participants will gain valuable knowledge in key areas such as positive coaching practices, ethics and risk management, athlete development, and effective instructional strategies. The course also covers the fundamentals of running, jumping, and throwing events, providing a solid foundation for coaching young athletes. Upon completion, participants earn a USATF Developmental Coach certificate, valid for two calendar years, and become eligible to join the USATF Coaches Registry. This program not only equips new coaches with essential skills but also serves as a steppingstone towards further coaching education, with the Bridge Program to Level 1. A USATF membership and a minimum age of 18 are required to enroll, but no prior coaching experience is necessary.

https://www.usatf.org/programs/coaches/usatf-developmental-coach-program

APPLY NOW FOR 2025 NATIONAL CHAMPIONSHIP MENTORSHIP GRANT

This unique program provides an emerging elite coach a behind the scenes experience of the strategies, meet prep, mental preparation, and "in the moment" coaching in a selected event at the 2025 USATF Outdoor Championships, July 31-August 3, Eugene, OR. Up to eight (8) grants will be awarded, with each recipient receiving a registered coach credential, along with travel assistance, and access to shadow an assigned elite coach.

Application Criteria:

- Must be a current head or assistant coach with a minimum of five years' experience
- Experience coaching an athlete to a USATF Outdoor Championship, USATF U20 Championships, NCAA Outdoor Championships, NAIA Outdoor Championships, or NJCAA Outdoor Championships, or State High School Association Championship within the last five years
- Current member of the USATF Coaches Registry (advanced USATF or USTFCCCA certification preferred)
- Submit a coaching resume and complete the online application

Important Notes:

- All applications must be received by **May 31, 2025, 11:59 PM ET**
- Applicants must meet all program requirements at the time of application

https://www.usatf.org/programs/coaches/grants/national-championship-mentorship-grant

Additional Information:

- All applications will be reviewed by the USATF Coaches Advisory Committee Grants Subcommittee
- Successful applicants will be notified via email and provided with further instructions within two weeks of the application deadline
- Grants cannot be deferred or substituted for another program

INSPIRE AND LEVEL UP WITH AN EMERGING FEMALE COACHING GRANT

The USATF Emerging Female Grant offers female coaches the opportunity to enhance their knowledge by attending a qualifying USATF Coaching Education Program. The grant covers up to the tuition fee and/or any associated room and board costs.

Eligible Programs:

- USATF Level 1 Program
- USATF Level 2 Program
- USATF Level 3 Program
- USATF Marathon Specialist Course
- USATF Cross Country Specialist Course
- USATF Instructor Training Program
- USATF Emerging Elite Coaches Camp

Applicant Criteria:

- Be a female track and field coach
- Be a current USATF member and have completed Safe Sport Training
- Submit a coaching resume and complete the online application

Important Notes:

- Early application is strongly encouraged
- Applicants must meet all program requirements at the time of application

Additional Information:

- Applications are reviewed on the first business day of each month until funds are depleted
- Successful applicants will be notified via email and provided with instructions on how to claim their grant (reimbursement or promo code)
- Grants cannot be deferred or awarded after a program has already taken place
- Recipients are only eligible for one grant per calendar year

https://www.usatf.org/programs/coaches/grants/emerging-female-coaching-grant

FEATURED NEW AND RECENTLY UPDATED USATF CAMPUS COURSES

USATF Campus just got even better with new and updated courses, expanding your continuing education opportunities. The platform now boasts 18 online courses, and among the new and recently updated titles includes: Coaching Race Walking, Motor Learning and Effective Coach Communication, Level 2 Sport Science, The Athlete's Strength and Power, Reactive Strength: The Fundamentals, Reactive Strength: Advanced Concepts, and USADA's Coach's Advantage (free). Individuals can view course descriptions and enroll from Coaching Schools when logged into their USATF Connect profile.

https://www.usatf.org/programs/coaches/usatf-campus-online

SUPPORT CRITICAL COACH SKILL DEVELOPMENT WITH THE FREE CONNECTION BASED COACHING COURSE

USA Track & Field (USATF) joined the U.S. Olympic & Paralympic Committee (USOPC) in their NGB Connection Based Coaching Challenge as a part of the Million Coaches Challenge, an initiative led by the Susan Crown Exchange to train one million coaches in youth development techniques by the end of 2025. Those interested in supporting USATF in the Connection Based Coaching Challenge can sign up for a free series of three 30-minute trainings on the USOPC Mobile Coach Platform by registering under track and field when selecting their NGB of choice. As part of this initiative, USATF and other National Governing Bodies (NGBs) are competing for up to $15,000 in funding to be awarded to the top ranked NGBs with the most coaches trained at the end of the challenge.

https://www.usatf.org/programs/coaches/partner-courses/million-coaches-challenge

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