USATF

TRACK COACH

2024 / ISSUE 249

Team USA at Paris 2024

TRACK COACH

Fall 2024 — 249

The official technical publication of USA Track & Field

USATF

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FORMERLY TRACK TECHNIQUE

249 — FALL 2024

The official technical publication of USA Track & Field

USATF

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PUBLICATION

Track Coach is published quarterly by Track & Field News, 2570 W. El Camino Real, #220, Mountain View, CA 94040 USA.

Winter 2025 issue (No. 250) e-mailed to subscribers in January 2025.

SUBSCRIPTIONS

$19.95 per year, U.S. or foreign. Track Coach became a digital-only publication in 2015. Track & Field News subscribers get free access to all Track Coach articles. See www.trackandfieldnews.com. Click on "subscribe"

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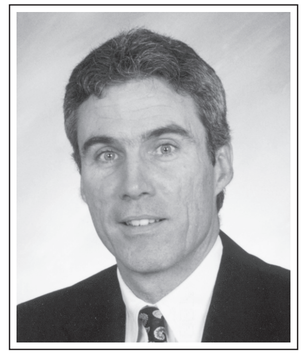
FROM THE EDITOR

RUSS EBBETS

BROOKS JOHNSON



The first time I met Brooks Johnson was at a Level 1 School Kevin McGill hosted at Columbia University in NYC in the early 1990's. In truth, Brooks was not an "early adopter" of the Coaching Education model. The curriculum and program that had been assembled by McGill, Vern Gambetta, Loren Seagrave, Gary Winckler, Bob Williams and Joe Vigil was minimalized and marginalized by many of the top U.S. veteran coaches. By this time, I had already done one master's thesis on the necessity of a program such as this and also completed two study tours to the Soviet Union and East Germany to marvel at the effectiveness of their well-established programs of talent identification and career development. By the 1990's USATF's Coaching Ed was no longer a "hard sell." My first Level 1 school in Boston had three instructors and two participants. By the time of McGill's Columbia school we had a classroom full of 40 participants with many of the top high school and collegiate coaches from throughout the Northeast prepared and excited for the 21-hour weekend program. In truth, Brooks assumed the role of "that guy" who felt it necessary to comment or question virtually every point made not so much for clarification but rather to highlight the weaknesses of the teaching staff. Cocksure and hard-headed, Brooks engaged me in a hallway discussion that scratched the edge of civility and was finally diffused by Kevin McGill's intervention. I never forgot the interchange and over the next decade essentially avoided Brooks whenever possible.

Imagine my surprise in 2005 when I was chosen to be the U.S. National Team chiropractor for the IAAF World Championships in Helsinki. The honor and excitement was soon tempered when I found out our team manager would be none other than Brooks Johnson.

For this World Championships USATF resolved to bring the 4x1 sprinters, both men and women two weeks early for a relay camp to eliminate the recent history of poor stick work and dropped batons with an intensive team approach that would address the issue and prepare our national squads to battle the world. Upon arrival in Helsinki Brooks addressed both teams and underscored how the relay camp would progress, why this process would work and how the medal count at these international championships would either positively or negatively affect the sport's public image in the U.S. that in turn would either positively or negatively impact fundraising, athlete support and help create a more professional model for the future. I remember the athletes

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EDITORIAL COLUMN

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being attentive and hard-working as they cycled through two-a-day workouts in the two weeks before the Helsinki Worlds.

These international assignments are a series of "long days" with morning, afternoon and occasionally evening therapy sessions. There is much structured time and little free time as the different four-person squads practiced and competed in some practice meets in Sweden and Denmark, if memory serves me.

On my one day off I had contacted the Finnish Chiropractic Association to introduce myself and offer to speak in Helsinki on the role a chiropractor plays for the U.S. National Team. To my good fortune they accepted my offer and quickly assembled a group of 20+ American-educated Finnish chiropractors for a lunchtime presentation and discussion. Lunch was reindeer, Santa's reindeer, and it was delicious.

As the meeting adjourned, I was taxied back to the U.S. team bus at one of the famous amusement parks in Helsinki. The younger sprinters on the team, Justin Gatlin, Shawn Crawford, Alison Felix and Joanna Hayes all made a day of it while the bus awaited their return from their afternoon off. When I returned to the bus there was only one person on the bus, Brooks Johnson. I sat near the front and we talked.

I explained to Brooks that I had just addressed the Finnish chiropractors of Helsinki for a lunchtime talk. He was intrigued and many, many questions followed. Eventually I got to the point how I emphasized the import of the foot and how during the 1980's, in my coaching days, I used foot drills with much success for injury prevention and speed development. Brooks spoke with enthusiasm how he had done similar drills during his tenure at Stanford when he had many of the great early collegiate female distance runners (notably Patti Sue Plumer among others) and also noted similar successes. In the two hour's time we had to kill until the athletes returned he questioned me at length how I came up with my "thoughts and theories" on the foot. The time available allowed me to review my Soviet studies, coaching background, my master's thesis and how I was able to combine all this knowledge into my lower extremity course I taught at NY Chiropractic College. In the end he asked if I had heard of the High Performance Summits he organized in Las Vegas each December? I had not but he extended to me the opportunity to speak for 90 minutes on my thoughts the coming December to address coaches from throughout the U.S. on how to improve distance running of the national teams. I welcomed the opportunity and began to work on my presentation as soon as I returned to the U.S. from the Helsinki World Championships.

In the early 2000's the East African dominance of the middle and long distances at the international level was without equal. The U.S. languished as a top five country and medal production or significant performances were spotty at best for both the men and women. Brooks's vision was a long view, not a quick band aid approach. As the Summit grew close I remember finalizing what was to be my opening statement, "It has only taken me 18 years to get this audience…" and then I was off on a series of 12 topics that justified my claims using neurology, kinesiology, biomechanics, neuroplasticity, technique and training to create an argument that American distance running could transform itself with a different approach. The December 2005 presentation went very well and I was asked to return in 2006 to give a similar talk.

It should be noted that the Helsinki men's 4x1 dropped the stick. On the 1-2 exchange the baton flew up in the air and that was the end of the U.S.'s race. The relay exchanges are a clear example of the psychomotor skill called Fitt's Law. Fitt's Law states that the more rapidly one tries to do any activity the sloppier the whole process becomes. This applies to many activities from relay racing to stacking plastic cups on YouTube. The solution here is to automate the whole process, as much as possible and then practice what can be done.

In a previous *Track Coach* we addressed the many aspects of the short relay with a panel of experts that included Brooks Johnson. Dennis Grady was a participant in the roundtable and he has penned his thoughts on the why's and how's that hopefully will mark a new starting point that will help the national teams achieve the results their unquestioned potential signifies.And former *TC* editor Kevin McGill has sent us a letter deploring the recent lack of international success by U.S. men's long throwers—and how we might improve those results.

Long ago teammate of mine Jerry Bouma penned a short piece on what it means to be part of a team. He is a product of one of America's storied programs (Villanova) and the support I received following an August health scare has been nothing short of fantastic and will no doubt underscore the importance of a shared heritage and development.

Finally, a farewell to Brooks. Brooks Johnson passed on June 29, 2024 at age 90 narrowly missing the outstanding performances of the women's U.S. 4x1 team at the recent Paris Olympics. Brooks, thank you for a lifetime's worth of efforts to improve this sport and leaving an indelible mark. May you rest in peace, my friend.

WHAT'S IN A TEAM?

BY JERRY BOUMA

Jerry Bouma was a middle distance runner for Villanova in the 70's. He has had a long career as a management conultant in Edmonton, Alberta, Canada.

What does it mean to be part of a team? This question was suddenly posed to me by my long-time friend and former Villanova teammate Russ Ebbets the day I learned he was submitting to surgery to remove a brain tumour.

It struck me that Russ's question arose in his hour of greatest need. Without question, he was at his most vulnerable. Would he survive? Would he emerge ever to be the same again? I could discern by his question, that this was a time when he needed to know that he was not alone. That his life's work (and struggles) had not been in vain. He needed to know that he was part of a team!

So, let first address the more fundamental question: What makes a team?

My thoughts moved quickly to paraphrase the 'team' question to a question posed by Shakespeare: What's in a name that a rose known by any other would smell as sweet? And then to my own experience as a member of the Villanova track team 50 years ago.

So, what's in a team: that a group of athletes bound together for a short period of time, as students—3 to 4 years at the most—and in our case, who continue to gather on an annual basis some 40, 50, or even 60 years later? Indeed, what does it mean to be part of that sort of team?

The factors are many. And complex. Nor are any two situations or cohorts ever quite the same. Track & field (athletics) is such a unique sport—and arguably the ultimate paradox—a sport defined by supreme individualism yet producing star performers shaped within a team environment whose bonds endure the years and the generations.

The more obvious reasons are rooted in that common purpose, a culture of winning, the shared experience, the fighting of tough battles together, not unlike a "Band of Brothers" in a wartime. And fused by the many miles run together; the grueling interval workouts; the critical hills in the various running loops that broke

even the best runners among us. Add to this mix, the unique Villanova experience of "indoors yet outdoors": those winter workouts on the "Boards"—our 11 laps to the mile track set up on the football practice field. Ofttimes covered with snow, wrapped with a wicked west wind on a cold January day. And the meals together, the rooming together, the classes together, the lonely weekends together when the campus emptied except for us few non-locals or foreign athletes who came from too far away to even consider a trip home ……
But it is more than that! For that matter, many teams experience the thrill of winning a big race, a relay, a championship and even generate a star in their midst for a period of time. But is that enough to generate the continued gathering that defines the Villanova Team experience who come together year after year?

So, what's this more? It is indeed a merger of special ingredients. Perhaps it is type of athlete who was recruited in the first place; or that one star who really cared about his teammates and established the essential "caring" dynamic which then passed from cohort to cohort. Or maybe it requires a process cemented by a certain "cultural dissonance" or an element of adversity that needed to be overcome (albeit subconsciously). Again, Villanova was powerfully influenced by the legendary Irish pipeline—and more precisely, a Dublin-Cork axis. Most came from modest backgrounds, who found themselves immersed in a totally different middle to upper-class society—face to face with the American Dream in full measure, seeing and knowing that this was their opportunity to succeed. The pressure was on!

Interestingly, that same dissonance factor was manifested within the Western Kentucky University team with a decided British-Bristol factor; or the East Tennessee team which also had that Irish influence although different than Villanova, defined by a west Ireland Limerick-Leitrim dimension.

To be sure, the stars emerged as the team leaders, setting the tone and holding court. But these stars would readily cite the support of their teammates for their success. Teammates who toiled in relative obscurity to grind out the miles and the repeat intervals only to be passed and surpassed time and time by their more talented counterparts. But not forgotten.

As the years passed and athletic performance became a more distant memory, the allure and influence of the stars would be balanced by other team members who took up the mantle of leadership. Sometimes this would be the third or fourth man on a relay team. Sometimes, this was someone who never made any of the teams—track, relay or cross-country. But always someone who knew the value of team; of loyalty; of culture; and fully appreciated the lifelong impact of the team experience. So back to the question: What does it mean to be part of a team?

Being part of a team is being part of a distinct culture—a culture that embraces you and a culture that you are proud to pass on. Being part of a team is having a clear, common goal.

- Being part of a team is having leaders to look up to.

- Being part of a team is going to the cafeteria knowing that no matter what day or time, there is a seat for you at the 'track' table.

- Being part of a team of a team is being given a hard time and taking it with a smile.

- Being part of a team is giving a teammate a hard time, all the while keeping a smile.

- Being part of a team is having to listen for the 100th time to a teammate's regaling how great his high school two-mile relay team was.

- Being part of a team is when a teammate notices that you are avoiding practice and asking if something is wrong.

- Being part of a team is jogging your first 50 meters after a serious injury and to hear the supporting shout of a teammate.

- Being part of a team is having a teammate to help you out when you are struggling with a course and need a lending hand.

- Being part of a team is seeing a teammate, whose grief-stricken face tells you that he just received the news that he lost his mother and spending the morning with him.

- Being part of a team is responding when one of your teammates is struggling with a brain tumour and asks you to write something about "being part of a team".

TIPPING THE BALANCE

BY LINDSAY WOODFORD

Overtraining can have catastrophic consequences on performance.This article is adaplted from its first appearance in *Athletics Weekly,* January 18, 2018.

Overtraining syndrome can be devastatin since highly motivated athletes are forced to cope with the frustration of reduced performance and taking extended periods off training and competition.

What sets high performance athletes apart? Exceptional physical features, together with high commitment and motivation are important attributes, but so are unique mental and emotional states.

And when faced with frustrating setbacks, the same qualities of commitment and motivation that elevate athletes above the pressures of competition can make them their own worse enemies.

It is not uncommon for elite athletes, especially younger athletes, to push themselves too far, to overreach and experience extreme fatigue on a regular basis. Such excessive training loads coupled with insufficient recovery can mean they never reach their full potential. So, what are the warning signs and what can be done to prevent this catastrophic cascade of events?

WHY WE NEED RECOVERY

Recovery following vigorous training is essential for improving athletic performance. In normal circumstances, most athletes will experience some level of fatigue, depression, feelings of burnout, anxiety, irritability and difficulty concentrating or sleeping when participating in heavy training or competition.

They may also experience muscle soreness, decreased coordination, reduced libido and frequent colds. This training state is known as "overreaching" and these symptoms are an expected and accepted effect of vigorous training. If the athlete then follows with a period of lighter training the associated symptoms and reduced performance capacity will quickly be resolved. It is during this tapering period that the athlete's performance capacity will increase beyond his/her pretraining baseline. This is known as "supercompensation". Training programs should be designed in a cyclical way (periodization) to allow time for Recovery with progressive overload.

PUSHING TOO FAR

While overreaching is a vital part of training for improved performance, if it continues for too long and recovery does not occur within two weeks, an athlete is at risk of developing overtraining syndrome. The exact prevalence of overtraining syndrome is not known, but reports suggest that the risk is

Over the limit: pushing yourself too hard can seriously impact performance

nervous system, hypothalamic dysfunction and elevated cytokine levels. However, no single marker can be taken as an indicator of impending overtraining syndrome. Until a definitive diagnostic tool for overtraining syndrome is developed, regular monitoring of a combination of performance, physiological, biochemical, immunological and psychological variables seems to be the best strategy to help identify athletes who are failing to cope with the stress of training. The checklist on the next page will help athletes, coaches and athlete support personnel to identify the warning signs for overtraining in the hope that they can prevent it and also exclude other possible explanations for underperformance.

DIAGNOSIS

Despite overtraining syndrome being well documented in scientific literature, there is no reliable and

higher for females, elite athletes and those participating in individual and endurance sports. Overtraining syndrome can be devastating since highly motivated athletes are forced to cope with the frustration of reduced performance and taking extended periods off training and competition.

GET TO THE ROOT CAUSE

There is much debate in the sport science literature regarding the etiology of overtraining syndrome. Various physiological mechanisms have been proposed to influence an athlete's vulnerability to the overtraining state. These include low muscle glycogen, decreased glutamine, central fatigue, oxidative stress, imbalance in the autonomic

Vary it: monotony of training is a risk factor

CHECKLIST: IDENTIFYING OVERTRAINING SYNDROME

- Decrease in performance that lasts several weeks or months
- Persistent fatigue
- Muscle fatigue
- Increased sense of effort in training
- Loss of competitive drive
- Sleep disturbances
- Elevated resting heart rate
- Mood disturbances - increased irritability, anxiety, depression
- Loss of appetite
- Weight loss
- Loss of libido
- Excessive sweating
- Recurrent infections
- Cervical lymphadenopathy (swollen glands, sore throat)
- Increased fall in blood pressure and increase in heart rate on standing

CHECKLIST: PREVENTING OVERTRAINING SYNDROME

- Keep a training diary to monitor performance during training and competition
- Avoid excessive monotony of training—cross train
- Individualize the intensity of training
- Periodization
- Optimize nutrition, hydration and sleep
- Be aware of external stressors that can add to the physical strain of training (work/home problems, house moves etc.
- Take the time to recover after illness or injury
- Treat early signs of OTS with relative rest and a phased return to training

practical diagnostic test for the condition. Likewise, the underlying mechanism for the performance decrements have not yet been identified. Further research is desperately needed to provide evidence based diagnostic, treatment and return to play approaches for this complex condition. Monitoring and treating a persistently fatigued athlete can be challenging, as the root cause of the fatigue is often not recognized until months of poor performance have passed. Making an accurate diagnosis can prove tricky as there are often numerous other medical and psychological conditions that present with similar symptoms. Overtraining syndrome can only be diagnosed once all of these other causes have been excluded.

DESPITE OVERTRAINING SYNDROME BEING WELL DOCUMENTED IN SCIENTIFIC LITERATURE, THERE IS NO RELIABLE AND PRACTICAL DIAGNOSTIC TEST FOR THE CONDITION.

TREATMENT

If an athlete is diagnosed with overtraining syndrome the current recommended treatment is rest. In some circumstances, "relative rest" is advised, with the athlete building up his training volume prior to intensity, starting from 5-10 minutes daily until reaching one hour. Given the psychological implications of the syndrome, athletes should consider involving a sport psychologist.

If stress, depression and/or anxiety are increased with full rest, relative rest with well-defined training parameters should be provided. Due to the complexities surrounding the diagnosis and treatment of overtraining syndrome, early identification and prevention is of the utmost importance.

Lindsay Woodford is a chartered sport and exercise psychologist at The Sporting Mindset and lecturer at the University of the West of England, Bristol. For more information on sport psychology please see thesportingmindset.com.

USING SPORT SCIENCE TO IMPROVE COACHING: A CASE STUDY OF FELISHA JOHNSON'S ROAD TO RIO

BY LAWRENCE W. JUDGE, PHILLIP J. CHEETHAM, BRIAN FOX, MAKENZIE A. SCHOEFF, HENRY WANG, MARY MOMPER AND D. CLARK DICKIN.

This article's lead researcher is Larry Judge, professor and senior research fellow at Ball State University in Muncie, Indiana. He has contributed often over the years to the pages of *Track Coach*. This study follows the pre-Olympic buildup of shot putter Felisha Johnson in 2016 and was first published in the *International Journal of Sports Science and Coaching,* Volume 16(3), 2021.

ABSTRACT

During a shot put, there are different finite variables that can be controlled by the thrower, including release angle, release height, release direction, and release velocity. Previous studies have determined thresholds of release velocity necessary for achieving certain distances, and this case study sought to expand upon that concept. Conclusions from key biomechanical data can make a significant difference in the performance of athletes in the shot put if properly understood by coaches. By utilizing this scientific approach to the shot put event, the throws coach will be able to determine more accurate adjustments and devise training stimuli to better accommodate the athlete. In this case study, researchers and the coach attempted to bridge the gap in the approach to teaching and coaching the glide shot put by using a physics- based equation regarding projectile motion in tandem with biomechanical analyses. The use of immediate feedback via video analysis was an essential part the coaching and teaching system. The athlete's release angles decreased, and her maximum release velocities increased from 12.5m/s in 2015

to 13.1 m/s in 2016. This USATF coaching education shot put project is an example in which the cooperation between sport science and coaching helped to produce an Olympic berth (19.24m/63'1½") by Felisha Johnson in the women's shot put in 2016.

INTRODUCTION

The elite level shot put as a track & field event is a harmonious combination of strength, power, and proper technique. It is difficult to replicate the exact parameters needed for an ideal throw, but the implementation of biomechanical data can allow coaches to have a better grasp of the ideal parameters for their athlete. Recent research on the shot put has yielded valuable kinematic information for elite athletes.(1) By utilizing this evidence based approach, the coach can determine the velocity of release (e.g. >13 m/s) and angle of release (e.g. 36 degrees) necessary for elite performance.

The conclusions that can be made from a segment of video on a particular throw depend on a number of factors related to the type of video, the way in which the video was recorded, and the skills of the videographer and the researcher. Keep in mind, any individual throw by an athlete could be unique and atypical. Using information gathered in training and competition may allow more accurate technical adjustments to be made, and training stimuli can be devised to better accommodate the athlete's target performance.

Biomechanical studies have been conducted regarding the shot put event in track & field, serving to quantify and describe the ideal range of conditions necessary for a successful throw.(1,2) However, few studies have observed the progress of an athlete throughout a comprehensive training program, using kinematic analyses in tandem with experienced coaching.(2,3) While coaches typically seek to increase uniform power production in their athletes to improve performance, the concept of utilizing real time kinematic feedback and the inclusion of physics principles can effectively allow coaches and athletes to make minute adjustments during practice. Proof based on the video evidence of the immutable laws of physics is both convincing and motivating to athletes. Kinematic feedback also allows a coach to work backwards and design and later adjust training program variables to achieve a desired kinematic result.

The athlete has control over four variables that directly influence the distance of the throw: release height, release angle, release direction, and release velocity.(4,5) Previous studies have observed that release velocity is highly correlated with superior shot put performance,(5 9) and as the mathematical equation used to calculate throw distance is based on the quadratic equation, modifying the release velocity is theorized to have the greatest effect on the throw distance.(10) Other studies have suggested that neither release velocity nor other release parameters have any effect on throw distance.(11,12) However, as the reported data for these release parameters do not match values observed in elite and sub-elite shot put athletes, there stands reason to believe that the former data may be flawed and possibly incorrect. Similarly, it could be argued that release height is an anthropometric measure, coming as a result of the athlete's height and arm length, and thus is unchangeable. However, release height may be affected by technical execution. For example, if the athlete utilizes an active reverse and jumps rather than just blocking and using fixed feet, this would slightly increase their release height relative to the ground.(1) Hubbard et al (2001) also suggests that release height can be minutely affected by increasing release angle.(13) Based on these concepts, release height can become a modifiable variable. Release direction also has an effect on distance and is especially important with regard to fouls.

Several studies have been done to understand the ideal ranges of each of these variables. Optimal release height has been shown to fall between 2.0 and 2.2 meters in elite athletes(7) and junior athletes,(6) although some studies have shown optimal performance with release heights in the range of 2.2-2.35 meters.(14) Obviously, athletes with larger statures (i.e., increased height or longer arm length) will be at an advantage in the shot put, as they will be granted a greater release height, increasing the amount of time the shot has in the air to travel horizontally.

Based on physics principles of projectile motion, the optimal release angle for an object landing at the

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same height at which it is released is 45 degrees.(5) This angle ensures both the greatest amount of air time as well as the greatest horizontal velocity. However, due to the fact that the shot is not landing at the same height of its release (as well as a few other factors), 45 degrees may not be the optimal release angle to increase throw distance. An angle of forty-two degrees may be better for a release height of 2 m, based on the projectile equations. Linthorne (2001) reported from several studies that the range of release angles for world class shot put athletes varied from 27^45 degrees, with an average of 37 degrees.(7) Many studies observing release angles of elite and sub-elite shot put athletes have displayed release angles below 40 degrees, ranging from 32 - 38 degrees for optimal distance.(8) This is potentially due to the fact that athletes can produce more force in the horizontal direction, so having an angle below 45 degrees may be advantageous mechanically. Additionally, a higher release angle has a larger gravity component action on the shot put, making it harder to accelerate.

As previously mentioned, release velocity has been shown to have the greatest effect on throw distance, both in practical application and mathematical simulation. The release velocities required to reach elite performances of 19 meters (women) and 21meters (men) have been established in the literature.(10) New radar and video technology for measuring the release characteristics of shot put throws has been developed for use by potential United States of Ameerica (USA) Olympic and Paralympic athletes. Hundreds of throws have now been captured and analyzed at the Chula Vista Olympic Training Center since 2015. These data have been helpful in tracking athletes' progress through each season up to and including major competitions, and of course, the Olympics.

The technology uses a combination radar and a video device positioned approximately six meters behind the ring at approximately 1.6 meters high on a tripod. The radar bounces a signal off the shot put and measures the phase shift of the returning signal. Using digital signal processing methods, the system is able to calculate both the distance and landing position of the implement, in addition to several release characteristics, including speed, angle, direction, and height. Video of each throw is also included with the data. It is captured, trimmed, and transmitted to the computer together with the data for each throw. The software allows all the data and video to be tagged to each athlete and exported to a spread sheet for later analysis. All of this information is gathered without any need to interfere with the athlete, allowing a training session to progress at its normal rate totally unencumbered.

Alternatively, if the athlete or coach wishes, they can review the data and video after each throw to make indicated technique changes.

Upon completion of the training session, the data is immediately uploaded to the cloud. Data from past years has been available, allowing for comparisons and statistical analysis. A web-based user interface has been built, allowing the coach and athlete to review their data on a regular basis without the need for the radar unit's computer. Training issues can be identified and progress tracked from the coach's own computer at home or in the office.

Previous studies have determined thresholds for obtaining certain throw distances.(10) However, having more tangible, immediate feedback supported by physics and biomechanical principles can be beneficial for coaches and athletes if interpreted properly. To our knowledge, few studies have been performed observing changes in athlete performance as a result of this combined training approach. Thus, the purpose of the present study was to examine the effect of an evidence-based comprehensive training protocol that utilized knowledge of results, integrated physical capacity development, and technical interventions based on a quantitative biomechanical analysis on an athlete's performance. The United States Track and Field (USATF) shot put project is an example of cooperation between sport science and coaching education, which helped to produce Felisha Johnson's Olympic Trials (19.24 m) performance in the women's shot put in 2016. This paper will address how the data was used to track and modify her training program, leading to her accomplishment of of her goal of becoming a USA Olympian at the Rio Olympic Games in 2016 (Figure 1).

METHODS

Participant

The participant in the present study was 26 years of age. Anthropmetric characteristcs were as follows:

Figure 1: Felisha Johnson competing at the 2016 Rio Olympic Games.

height 185 cm (Seca metric stadiometer, Chino, CA), weight of 127 kg (Seca electronic stadiometer, Chino CA) and body fat of 19.8% (Lange skinfold calipers, Cambridge, MD) and a 3-site method (tricep, thigh, suprailium). Before any data was collected, the participant was informed of the study purpose, along with any associated risks and benefits. In accordance with the university institutional review board and the Declaration of Helsinki, the participant gave her informed consent and completed a health history questionnaire before the first test session. The Institutional Review Board at Ball State University approved the present investigation. The participant was required to keep a detailed weekly online training log and to email the log to the coach. The coach reported, via a datasheet, the throwing volume, resistance training volume, as well as the participant's season bests in the indoor shot put, outdoor shot put, weight throw event, and weight room IRMs for the bench press, power clean, and squat exercises. In total, the datasheet consisted of eight items. Following the coaches report, the data for the athlete was entered into a spreadsheet program, and the data report sheet was destroyed.

Data collection

Kinematic data from the video record of athlete Felisha Johnson was collected at the 2015 indoor and outdoor (see figure 2) nationals and 2016 indoor and outdoor (see figure 3) USATF National Championships. Two digital video cameras (Canon Elura 60) were used to record a control object and Felisha Johnson's performances at a sampling rate of 60 Hz. The cameras were placed near the shot put throwing circle spaced approximately 90° apart. Following collection of the performance data, the calibration frame was placed in the center of the throwing circle and recorded so that the direct linear transformation (DLT) procedure could be performed.(15)

Kinematic variables including release height, release velocity, release angle, release direction, and distance travelled were collected using a Trackman Doppler Radar system (Scottsdale, AZ). The radar system was then used for subsequent practices to offer real time biomechanical feedback to the athlete, coach, and biomechanist. The Trackman system has been validated in providing accurate ball parameters in golf,(16) and has been implemented at the Olympic Training Center in Chula Vista, CA, since 2015 to analyze shotput and hammer throws.

Figure 2: Sequence Photo of Felisha Johnson Throwing at the 2015 USATF Nationals in Eugene OR.

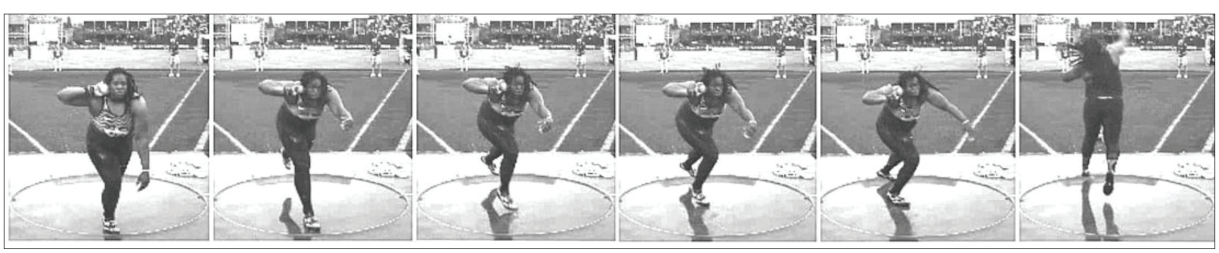

Figure 3: Sequence Photo of Felisha Johnson Throwing at the 2016 Olympic Trials in Eugene OR.

Data reduction

Video data was digitized using MaxTraq (InnoVision Systems, Columbiaville, MI). The video records of each performance were manually digitized at a sampling rate of 60 frames per second from two frames before the initiation of the throw to four frames after the release of the shot. In each digitized field, 23 points were manually digitized to model the athlete-plus-shot system (APSS, see Young(17) for details). The digitized 2D data was time synced based on the release of the shot. A second event, front foot touch down (FFTD), was used to verify the accuracy of the synchronization. All analyzed clips met both synchronization criteria. The DLT procedure was used to determine 3 D coordinates of 22 body landmarks and the center of the shot for each trial. The digitized control object coordinates were used to estimate the DLT parameters for each camera. The 3 D coordinate data were smoothed using a fourth-order zero-lag Butterworth low pass digital filter with a cutoff frequency at 6 Hz.18

Data processing

After data was acquired, the kinematic variables were integrated into a quadratic equation to provide a close estimate of the throw distance based on principles of projectile motion (equation (1)). There does exist a slight discrepancy between the measured distance and the mathematical distance due to the mathematical distance not taking into account the dimensions of the toe board. Once these variables are included, the biomechanist can make small adjustments to these variables to predict the parameters necessary for a desired throw distance.

Table 1: Optimizattion model criterion.

VARIABLE	DESIRED CHARACTERISTICS
PCOM	Greater values are beneficial
RK @ RFTD	Lower values are beneficial
SH @ RFTD	Greater values are beneficial
SH @ Release	Approaching neutral alignment (0° separation)
FK @ Release	Close to full extension (180°) as possible
Release angle	Between 32° to 37° to maximize release velocity
HRD	Greater values are beneficial
PCOM - Peak vertical displacement of the center of mass of the Athlete- plus-shot-system during the flight phase; RK - Rear knee angle; FK - Front knee angle; SH - Shoulder-hip separation angle; HRD - Horizontal release distance.	

$$L = \frac{v_r cos\theta_r}{g} * (v_r sin\theta_r + \sqrt{(v_r sin\theta_r)^2 + 2gh_r})$$

In which L = throw distance, V_r = release velocity, θ_r = release angle, g = acceleration due to gravity (a positive value in this instance), and h_r = release height.

Parameter selection

A seven variable technical model of elite women's shot put was used for a technical intervention between 2015 and 2016. This technical model was developed from the findings of previous research.1 The goal of this prior research was to determine the most critical variables for success in elite women's shot putting.(17,19,20) The seven kinematic variables indicated as being related to elite performance were used as the basis of the athlete's technical focus and subsequent feedback. The seven variables are presented in Table 1. Although release velocity is clearly a significant indicator for performance, it was excluded from the variables due to the fact that it was measured daily, and the athlete and coach received immediate data on release angle and release velocity. Likewise, because previous research(17) has indicated that release velocity explains so much of the variance of a throw by itself (90+%), it was concluded that it could mask the importance of other variables that may be more applicable to beneficially affecting a technical intervention.

Data analysis

The method employed in this study to break down the throw into phases by predetermined events allowed for comparison of this research with previous research conducted on the shot put. This method has been used previously to examine the shot put.(17,19,20)

Training program

The goal of the athlete's training program was to expedite the acquisition of the skills and abilities required to duplicate the required speed and angle of release necessary for effective performance (to make the U.S. Rio Olympic Team). The training program components included: hurdle mobility, plyometrics, throwing, throwing drills, bodyweight work, and traditional "weight training" activities. The program included a high percentage of multi-jointed movements with significant tissue under tension and emphasis on power output. Examples included: (1) Olympic lifts and modifications (e.g., cleans, snatch, high pulls, DB cleans, DB jumps) (2) Static lifts (e.g., squat, bench, incline, deadlift, RDL, pullovers, assisted pullups). The athlete's training program paid attention to ratio of push and pull movements (1 push: 2 pulls). A typical session began with one Olympic lift, progressed to an Olympic lift derivative, and then concluded with one upper body static lift and one lower body static exercise.

When considering the design variables that make up the training program (i.e., training load, training volume, exercise selection, and training frequency), each variable's threshold necessary to create a quality training plan depended upon the athlete's training age, strengths and weaknesses, the phase of the training year, and many other factors. For the athlete in the present study, there was a balancing of the training loads with restorative and prophylactic (injury prevention) measures.

A classic Matveyev periodization model was utilized with the athlete(21) and was based on previous research.(1) The mesocycle sequencing of the training program began with hypertrophy methods, progressing into strength building methods, followed by neural activation methods, and finally speed-strength methods. The total cycle was repeated three times annually. For example, the first mesocycle emphasized strength-endurance, basic conditioning, and hypertrophy methods (mid-Aug. - early Sept.) The second mesocycle emphasized basic strength with an emphasis on improving the back squat (late Sept.- early Oct). The third mesocycle emphasized strength/power using 3- 4 weeks of neural activation methods with an emphasis on Olympic lifts, Olympic lifting derivatives, and plyometrics (late Oct- early Nov). The fourth mesocycle emphasized explosive power and speed development using time controlled speed-strength methods (late Nov.-early Dec). The sequence was then repeated following a regeneration period (December holiday).

NUMEROUS STUDIES AND REVIEW ARTICLES HAVE RECOMMENDED AND SUPPORTED THE USE OF EXPLOSIVE EXERCISES FOR SHOT PUTTERS.

Olympic-style lifts (Clean, Jerk, Snatch) and their derivatives (Pulls and Shrugs) were the primary focus of the resistance training program. Numerous studies and review articles have recommended and supported the use of explosive exercises for shot putters.(22-26) In addition to the weight lifting exercises, throws, sprint drills, and jumps, the workout contained sport-specific release movements that force core stabilization in high velocity activities. Sport-specific exercises that mirror sport-specific release parameters are an effective way to develop specific throwing strength. Heavier throwing implements (e.g 7.26 kg shot puts) were used for power development, and lighter implements were used for speed development. These shot put release exercises were designed to emulate key sport-specific (the inside out pushing motion) release positions.

Following the 2015 season, the volume of throws was incrementally increased due to the relatively young training age of the athlete and to make up for the lack of experience with the shot put. With the Rio Olympic Games quickly approaching, increasing the demands of training was determined as the best way to secure a berth on the United States Olympic team for the athlete. The number of total throws increased from 3320 in 2015 to 4900 in 2016 (Table 2). Keep in mind that these numbers included everything that was done with a delivery. This includes full throws and also extraneous drills (i.e. throws on knees, kettlebell throws) with a release. Throws were completed with shot puts ranging from 3.5 kg to 7.26 kg. The athlete also continued training the 20lb weight throw event, which is an indoor event thrown with technique similar to the hammer throw. Throws were completed

Table 2: Throwing volume (number of throws per year).

YEAR	SHOT PUT THROWS	WEIGHT THROWS	TOTAL
2016	3420	1480	4900
2015	2290	1150	3430
2014	2180	1050	3230

Table 3: Values for the optimization model variables for pre and post-technical intervention.

YEAR	MARK	PCOM	RK @ RFTD	SH @ RFTD	FK @ RFTD	SH@ RLS	RLS ANGLE	HDR (m)
2015 (o)	18.24	0.18	128.1	49.6	171.1	-25.8	39.10	0.19
2016 (o)	19.24	0.20	112.2	71.5	173.2	-22.4	36.90	0.28

PCOM - Peak vertical displacement of the center of mass of the athlete-plus-shot-system during flight the flight phase; RK - Rear knee angle; FK - Front knee angle; FFTD - Front foot touchdown; SH - Shoulder-hip separation angle; RFTD - Rear foot touchdown; HRD - Horizontal release distance.

in the 20lb weight throw event with implements ranging from 9 kg to 14.5 kg. The majority of the weight throws were performed in the Fall and Winter months as a core training exercise. During the pre-competitive phase, three (two throwing and one resistance training) workouts were performed daily. This was reduced to two workouts a day (one throwing and one resistance training) during the competitive phase. Two training days were generally followed by one recovery day. During the lead-up to the Olympic Trials, the emphasis was on improving maximum strength in the lower body (back squat strength).

WHILE THE IMPORTANCE OF RELEASE VELOCITY APPEARS TO BE LINEAR, THAT IS NOT THE CASE WITH RELEASE ANGLE.

Kinematic feedback

Following the competition in 2015, the athlete's coach and the biomechanist responsible for the kinematic analysis at the Olympic and Paralympic Training Center in Chula Vista, CA reviewed the video record of each throw in the competition using the aforementioned technical model for elite women's shot put performance as the guideline for suggestions. Several weeks following the conclusion of the 2015 season, a detailed biomechanical analysis report was sent to the coach. This report provided quantitative data on the seven kinematic variables previously noted as being important for success in the women's shot put.(8) Recommendations to improve performance and address technical weaknesses (as based on the seven variable technical model) were also provided.

Statistical analysis

In 2015, the athlete finished seventh in the United States National Championships in Eugene, OR and did not qualify for a berth on the United States World Championships Team. In 2016, the thrower did qualify for the final and thus took six total attempts. After her first three attempts, she was in eighth place. In the fifth round, the athlete recorded her best throw of 19.24 meters and moved into the lead in the competition. The athlete ultimately finished third in the competition to make the United States Olympic team. To maintain relative consistency of trials between years, the best throws from 2015 and 2016 were included in this analysis.

Parameters were examined from the athlete's best throw from the 2015 USATF National Championships and the best throw from the 2016 USATF National Championships (Olympic Trials). A Shapiro-Wilk test was used to determine the normality of the raw data. The test indicated that the data were normally distributed. Stata software from StataCorp LP (Austin, TX) was used to perform the analysis.

RESULTS

Based on equation one, researchers can modify variables to seek desired throw distances. In order to do this, researchers grouped throws by similar variables (i.e., grouped throws that maintained a certain release velocity) and observed how the other variables affected the resultant throw distance.

Release velocity

Researchers initially chose to isolate the importance of release velocity. By maintaining a release angle of 36 degrees and a release height of 2.3 meters, researchers incrementally increased the release velocity by 0.1 m/s from 12.4 to 13.0m/s and observed an average distance increase of 25 cm (range: 24-26cm) for each 0.1 m/s (from 17.61m to 19.12m).

Release angle

While the importance of release velocity appears to be linear, that is not the case with release angle. By isolating throws which maintained a release velocity of 13 m/s and a release height of

2.3 meters, researchers incrementally increased release angle by 2 degrees. At lower release angles, 2 degree increases led to greater throw distances (37 cm increase from 30 to 32 degrees) but yielded lesser increases as angles increased (9 cm increase from 38 to 40 degrees). Researchers found that when release angles reached 44 degrees, throw distances no longer increased, but decreased by approximately 5 cm.

Release height

While maintaining a release angle of 38 degrees and a release velocity of 13 m/s, researchers increased release height from 2.0 to 2.4 meters by 10 cm increments. Researchers found that for every 10 cm added to release height, there was also a 10 cm increase in throw distance (from 18.99m to 19.38m).

However, increasing both release angle and release height had a more substantial effect. Researchers increased release angle, determined how release height increased as a result, and observed the changes to throw distance while maintaining a constant release velocity. Similar to how release angles caused lesser increases in distance as angles increased, increases in release angle (and release height as a result) caused an increase of 33 cm from 34 to 36 degrees, but only a 10 cm increase in distance from 40 to 42 degrees.

Descriptive statistics

The seven variables of the optimization model are presented in Table 3. Additional temporal (Table 4) and release parameter (Table 5) data presented to the coach and athlete are also provided for comparison against previous studies. These data are in agreement with previous literature,17 indicating that the data collected for this study is comparable to those used in previous research on the event.

Table 4: Values for pre and post-technical intervention values for the temporal parameters.

YEAR	MARK	FLIGHT	TRANSITION	COMPLETION	DELIVERY
2015	18.24	0.16	0.18	0.21	0.39
2016	19.24	0.14	0.14	0.23	0.37

Table 5: Pre and post-intervention release parameters (indoor and outdoor throws).

YEAR	MARK	VELOCITY (M/S)	ANGLE (DEG.)	HEIGHT (M)
2015 (i)	17.83	12.4	42.1	2.21
2015 (o)	18.24	12.5	39.1	2.17
2016 (i)	18.29	12.6	36.4	2.12
2016 (o)	19.24	13.1	36.9	2.19

The athlete's performance improved more than 1 m, approximately 5.48%, from 2015 to 2016. As would be expected, release velocity increased 4.8% (12.5m/s to 13.1 m/s). The results of the comparative analysis on the seven optimization model variables indicated positive changes in all variables. Changes were considered positive if the pre- to post-technical intervention numbers moved toward the desired value as indicated in Table 1. The results of the pre- and post-intervention comparative analysis are presented in Table 3.

DISCUSSION

Shot-putting is a complex three-dimensional movement in track & field that presents many technical challenges. Felisha Johnson utilized the glide technique throughout her training and competition. Her anthropometries (Table 6) allowed her several advantages over other female shotputters, including an increased release height due to her 185 cm stature, and a stronger frame for greater force production (weight: 127 kg, body fat: 19.3%). As a result of effective, multidimensional training methods and fine-tuned form, Felisha was able to clinch a United States Olympic berth with one of the top throws recorded by an American female (Table 7).

Technical interventions

In the shot put, each stage of movement flows directly into the next; thus, the performance in one stage will directly affect the performance of subsequent stages. Felisha had difficulty maintaining a consistent starting depth in the back of the ring and would lose posture by rounding her back by the end of the preparation phase. An improper starting position in the preparation phase led to increased variability in how force and impulse were produced throughout the rest of the movement. A weak postural position then caused a delay in FFTD due to the tendency of her left leg to hang on the glide. A delayed FFTD then led to a delay

Table 6: Testing data. Personal Information. (Lawrence North, HS) year 2009.
Height: 185 cm Weight: 127 kg. Born: July 24, 1989 High School: Indianapolis, IN

Year	Body mass (kg)	Body fat percent	Overhead back shot put (m)	St. long jump (m)	Power clean (kg)	Vertical jump (cm)	Power snatch (kg)	Squat (kg)	Bench press (kg)
2016	127	19.80	19.63	2.71	135	72	86	204	136
2015	135	24.10	18.60	2.60	130	65	80	192	136
2014	133	25.10	18.29	2.47	120	64	80	192	142

Table 7: Progression and Finish at major championships.

Year	Shot put (m)	Weight throw (m)	Domestic indoor competitions	Domestic outdoor competitions	International competiton
2016	19.26	24.22	5th USATF SP 2nd USATF WT	3rd OT SP	13th OG
2015	18.73	23.53	5th USATF SP 1st USATF WT	7th USATF SP	
2014	19.18	23.45	3rd USATF SP 4th USATF WT	2nd USATF SP	
2013	18.27	22.95	4th USATF WT	5th USATF SP	7th FISU
2012	17.35	23.52		13th OT SP	
2011	16.55	21.67			

in establishing a base, and reduced the effectiveness of shoulder-hip angle separation, which is essential for power production.(1,2,27,28) Researchers determined that this lag in the left leg needed to improve; time to FFTD needed to decrease in order to establish a more effective power position (increased shoulder-hip angle separation about the transverse axis), allowing Felisha to ideally produce more rotational torque and increase core musculature stretch to facilitate an increased influence of the stretch shortening cycle.(10) The coach observed these deficiencies and modified Felisha's starting position to be more upright, and time was spent modifying the subsequent unseating and glide building momentum phases.

It was determined that the main point of focus for Felisha would be modifying joint power production, especially through the lower extremity joints (hip, knee, and ankle). Deficiencies in her lower extremity control (used to generate linear impulse) suggested that changes to joint power production efficiency were needed. The objective of the coach was to modify Felisha's current movement pattern in order to optimize her lower extremity joint angles during power production and to properly load the neuromuscular components responsible for the movement.

DEFICIENCIES IN HER LOWER EXTREMITY CONTROL SUGGESTED CHANGES TO JOINT POWER PRODUCTION EFFICIENCY WERE NEEDED.

Felisha's starting position was changed to improve her posture throughout the rest of the movement; this was accomplished by flattening her back and maintaining a more upright posture, while also establishing a proper starting depth. The coach used posture-specific exercises to reinforce these changes, including multiple glides with a bar (broomstick and cross bar), glides while wearing a weighted vest, and glides with ankle weights.

Felisha's initial shot put technique consisted of a long-short pattern in her hips, defined as a longer glide and a shorter (narrower) stance following FFTD.(10) One of the most important aspects of this technique is ankle flexibility and hip mobility, requiring the thrower to turn the right foot to 90 degrees in the middle of the ring relative to the direction of the throw. When working through this technique with Felisha, it became apparent that she did not have the ankle flexibility and hip mobility needed to properly execute this manuver. In order to better accommodate her abilities, her technique was changed to a short-long glide instead, defined as a shorter glide phase and a wider (longer) stance at FFTD.(10) This allows for the right foot to be positioned at a more comfortable angle of 135 degrees (versus 90 degrees) in the power position and for the stance in the power position to be slightly wider than shoulder width.

The next modification was to increase rear knee (RK) flexion angles at RFTD, as suggested by prior literature.(1,29,30)

According to Judge and Young (2010), the short-long glide is characterized by a shorter glide phase and a wider stance at FFTD.(10) This technical variation allowed Felisha to employ a lift and rotate movement strategy following FFTD. In the short-long technique, the right foot is positioned closer to 135 degrees, and the base is slightly wider then shoulder width. After finding a comfortable power position, the focus was on increasing RK flexion. Previous research has indicated that it is beneficial to make RFTD with greater RK flexion.(17,29,30) In 2015, Felisha had a tendency to raise her torso prematurely during the momentum building phase of the glide and project forward in the transition phase to the power position. The rounded back and excessive tilt in the torso in the starting position in the back of the ring also contributed to the lack of RK flexion. The center of mass needed to be positioned behind the blocking leg at FFTD to create the blocking impulse and angular impulse needed to initiate rotation. This premature "opening" of the upper body (shoulders) caused her to primarily utilize the musculature in the shoulder and arm to generate force. Controlling the angle of the trunk and keeping the upper body closed was a point of emphasis,(31) and glides with a high jump cross bar helped Felisha feel the desired position. As evidenced by the hip and pelvis angles at the power position in the throws from 2016, the athlete's hips were in a fairly low position, and the shoulders were in a closed position at FFTD, although the upper body was fairly erect.

Figure 4: Felisha Johnson performing a hip pop drill in 2016.

As previously mentioned, the shot put has several stages, each transitioning smoothly into the next, and each stage affecting the next. Another obstacle Felisha was faced with was making the transition phase between the glide and power positions as efficient as possible, namely by reducing the pause during this phase. An ideal transition phase should be seamless, as the relationship between the transitional phase and the lift/rotate phase is generally indicative of the athletic ability and fitness of the thrower. In Felisha's case, a smoother transition phase was taught by performing throws in smaller 1.828 meter throwing circles (six foot ring); this makes movement across the ring easier, thus making transitions smoother. As Felisha got more comfortable with throws in this smaller ring, the length of the glide was gradually increased and the standard (seven foot) throwing ring was re-introduced.

Following FFTD, three important actions occur: trunk rotation, hip drift, and trunk elevation performed by the legs. Felisha's hip mobility was developed by implementing specific drills into her specific warmup (such as the hip pop drill), which helped improve her hip mobility, allowing for more aggressive rotation of the trunk (Figure 4). This, coupled with a more aggressive trunk elevation by the legs, helped Felisha minimize her drift. Several studies have discussed the importance of a greater shoulder-hip separation angle in trunk whip speed and amplitude development.(20,31-34) Increasing Felisha's hip mobility (thus increasing shoulder-hip separation angle at FFTD) allowed for increased rotational torque through increased utilization of the stretch shortening cycle and better recruitment of larger lower extremity muscles, facilitating the necessary acceleration of proximal and distal segments.

In 2015, the athlete had trouble creating the necessary release velocity to finish in the top three at the National Championships due to poor arm strike mechanics and blocking action. This was due in part to a lack of specific strength. Bartonietz suggests that power summation is a primary factor separating elite throwers from inferior throwers.(35) The lack of a blocking force of the left side was a possible limiting factor in achieving release velocity. The stopping force of the front leg was needed to contribute to the transfer of force to the putting arm.

A technical adjustment in this area was needed to foster the neces-

Figure 5: New Upright starting Position.

sary increase in release speed necessary for overall improvement. Felisha was taught to sequentially turn and move forward the left arm and upper body with the right arm remaining in position so that the elbow remained in line with the path of the shot. Later, after the upper and lower body is properly positioned, the left arm blocks this rotation by pulling downward and inward close to the rib cage of the non-throwing side of the body. When working on this technical point, the athlete stated that she had difficulty feeling the left arm during the throw.

Achieving additional shoulder and hip separation (S-H) prior to delivery was a technical focus during training sessions. The orientation of the hips relative to the orientation of the shoulders was continually reinforced through drills and was a continual theme (focus) in training. A neutral position, or zero degrees of separation, occurs when the shoulders and hips are aligned with one another, as would be the case in anatomical position. A positive angle occurs when the throwing side shoulder is posterior to the throwing side hip.(10)

In 2015, Felisha performed a larger percentage of her full technique throws in training with the reverse. Although reversing the feet was beneficial for her overall rhythm, it limited her development of S-H separation and development of a solid blocking action. The reverse gave the athlete a false feeling of S-H separation, overall hip mobility, and hip rotation. Some authors argue that a large amount of reversing in training may mask certain technical flaws.(1) In 2016, the athlete performed 75% of her training throws with no reverse to work on the blocking action of the left side. The additional no-reverse training throws allowed the athlete to feel exactly how much S-H separation and hip rotation was being achieved on each training throw. This helped her improve her mobility, overall hip drive, blocking action, and subsequent release velocity.

ACHIEVING ADDITIONAL SHOULDER AND HIP SEPARATION (S-H) PRIOR TO DELIVERY WAS A TECHNICAL FOCUS DURING TRAINING SESSIONS.

To increase release velocity, the arm strike was another area that needed improvement from 2015 to 2016. Release velocity was compromised at release when the athlete turned her head prematurely toward the landing area and, as a result, would drop her elbow prematurely and flatten the orbit of the shoulders.(2) A technical intervention was needed to help her keep her shoulder orbit and the elbow behind the shot. The starting position in the back of the ring was adjusted to be a more upright torso position with a flat back (Figure 5). Before Felisha would enter the ring to throw, an object was placed four meters behind the circle as a focal point. The athlete was instructed to keep her eyes on the spot (focal point) until the implement left her hand. This technical cue helped the athlete keep her eyes focused on the spot while she turned her hips and maintained the orbit in the shoulders, which helped her keep her elbow behind the shot put.

As mentioned previously, there are four kinematic variables that can be controlled by the athlete to affect throw distance: release height, release angle, release direction, and release velocity. Regarding principles of projectile motion, an optimal release angle for a projectile (when the desired outcome is the greatest throw distance) is 45 degrees. Past literature has suggested that for the furthest throw distance in shotputters, optimal release angles fall somewhere between 40 and 43 degrees. Felisha's release angles fell within this range during 2015, which could potentially be explained by her coach's preferences in high school. More current literature suggests that optimal release angles for the shot put fall between 36 and 38 degrees.(36,37) It is thought that the discrepancy in optimal release angles between principle and the shotput activity is due to the inability to undergo adequate force production at a 45 degree angle, causing the optimal release angle to be slightly more horizontal. This could be related to the body's ability to produce vertical vs. horizontal force through the recruitment of more horizontal adductors vs the smaller abductors of the shoulder. Note: For a 2m release height, the optimum calculated angle is 42 degrees. Forty-five degrees is only optimal when the release height and landing height are the same.

Felisha's throws in 2015 were slightly higher than the desired 36-38 degree range, with her best throw having a release angle of 39.1 degrees. This angle was lowered in 2016 to fall within the desired range, with her best throw having a release angle of 36.9 degrees. This reduction in release angle is likely to have played a role in her increased throw distance; her top throw in 2016 was recorded at 19.24 m, whereas her best 2015 throw was recorded at 18.24m. This reinforces the concept that release angle and release velocity are inversely correlated.(4,7,13,38) As Felisha's release angles decreased, her release velocities increased, from 12.5 m/s in 2015 to 13.1 m/s in 2016. This of course is only the case within a specific range of release angles. Once the throw becomes too flat then the distance decreases.

While resistance training interventions will be discussed in the next section, it is important to note here that an explanation of this modification to release angle can be attributed to Felisha's training with incline bench press. Increasing strength and power with overhead exercises or exercises that work at oblique angles (such as the incline bench press) could contribute to the athlete's increase in performance. Regarding technical interventions, Felisha developed further specific strength in the arm strike movement pattern, which was one of the most effective technical interventions employed. Performing throws from modified positions, such as a kneeling position, as well as utilizing overweight implements (i.e., 7.26 kg shot put) and a 10 kg weight vest allowed for the development of arm strike strength and proper release mechanics.

AS FELISHA'S RELEASE ANGLES DECREASED, HER RELEASE VELOCITIES INCREASED.

In the present study, it is important to note that the most effective variable to modify for the purpose of increased throw distance was release velocity. While the importance of release angle and release height are not to be ignored, the focus of the athlete was to improve specific arm strike strength and power in order to produce the greatest release velocity. The focus in training was on keeping the important aspects of the technical model consistent from throw to throw. The instantaneous feedback received from the video and radar device allowed for minor adjustments to be made on the fly; if the desired distance was not achieved in a certain throw, the variables that the athlete has control over could be looked at, and the coach could make slight adjustments to form as needed. These minute adjustments, based on video footage and radar values, allow both the coach and the athlete to feel more confident about their training.

Resistance training interventions

The shot put requires large amounts of force production in a short amount of time in order to maximize performance. It is key that performance is improved by taking into account the athlete's anthropometries, athletic ability, and potential errors throughout their chosen technique. Felisha had a relatively short preparation training phase in 2015 (28 weeks), providing an explanation for her deficiencies in lean body mass, stability and mobility, and strength and power production. Prior observations suggest that elite athletes need anywhere from 32-36 weeks of training in order to achieve their peak performance level.(39) Performance in the weight room, specifically one repetition maximum (1RM), has been shown to be directly related to performance in shot put athletes.(40) Statistically significant linear and quadratic trends exist that relate 1RM measures of the power clean, back squat, and bench press to the personal best of shot put athletes.(41) Similarly, strength in field athletes has been previously described as the basis of high-level performance.(26) Thus, resistance training was another important aspect of Felisha's training in 2016.

Felisha's overhead strength had significant room for improvement coming into 2016. In the shot put, force is generated against the ground by the hips and legs, transmitted up through the trunk, and then applied through the shoulders and arms in an overhead position at release. Overhead exercises are important because they neccessitate a high demand on thoracic mobility, optimal scapulohumeral function, and the high coordination of the entire body. As mentioned previously, several overhead press-like exercises were integrated into her training, including overhead press with barbells and dumbbells, barbell push presses, and split jerks. She continued to perform wide and narrow grip bench press and incline bench press. Because of the additional emphasis on overhead movements, Felisha was able to increase her incline bench 1RM by 15 kg in 2016, from 105 kg to 120 kg.

Lower extremity strength was another key component to Felisha's training in 2016. The coach employed front and back squats, quarter and single leg squats, step ups, and lunges, among other lower body exercises to futher develop lower extremity strength. Prior studies observing electromyographical impulses from core musculature during lower extremity exercises, such as the squat, determined that core muscle activation was equal or greater than activation observed during corespecific exercises.(42) Thus, the importance of lower extremity exercises was twofold; it served not only to improve lower extremity strength and power but also to increase core strength, stability, and mobility, which are essential to proper rotation and force generation during the movement. Felisha was able to improve her squat 1RM by 10 kg coming into 2016, and the researchers believe there to be a direct correlation between the improvement in her squat 1RM and her increased performance in 2016 based on prior literature.(42,43)

Another goal for Felisha was increasing power production through her lifts. Kyriazis et al.(25) found that increased power production in the lower extremities was more strongly correlated with increased shot put performance than muscular strength but also stated that muscular strength development could serve as a foundation for proper muscular power production development.(25) Power development for Felisha consisted of Olympic-style lifts (clean, jerk, and snatch) as well as their derivatives (pulls and shrugs) based on reports from several sources discussing the advantages of the Olympic-style lifts for power production over squat and deadlift exercises.(23,26,44)

Her standing long jump increased from 2.46m in 2015 to 2.65 m in 2016, her vertical jump increased from 61cm in 2015 to 71cm in 2016, and her overhead shot put distance increased from 18.60m to 19.63m. These improvements were attributed to the main Olympic-style lifts, their derivatives, and variations of Olympic-style lifts, including hang snatch, hang cleans, and mid-thigh pulls. The pulling movements exhibited by these exercises and the shot put movement share similar ground reaction forces, musculature recruitment, and force and rate of force development profiles.(35)

Special strength work

A training philosophy called movement pattern specificity, focusing on performance of training exercises that overload the athlete near the specific force velocity requirements for the event performance, was utilized.(1) Following the 2015 season, Felisha started to feel frustrated because she was not able to perform the ideal technique to finish in the top three at the U.S. National Championships. She failed to realize the true cause of her technical difficulties: a lack of special and specific throwing strength. In high school, Felisha Johnson was a basketball player who was a part-time track & field athlete. The movement pattern of shooting a basketball may have been ingrained in her nervous system and interrupted or influenced her throwing mechanics. This shooting movement pattern may have caused her to drop her elbow at the finish.

Felisha became a full-time resident track & field athlete at the Olympic training center in Chula Vista, CA, in 2016. It was there that she was introduced to extreme overweight (e.g., 20% over the competition weight) implement throwing, which had been previously unexplored in her training protocol. By focusing on specific strength in varying positions during the throw, Felisha was able to overcome many of the previously discussed technical challenges. Previous researchers have discussed the benefits of training with overweight implements.(1,45) However, more recent developments have provided a more technical definition among physiologists, called post-activation performance enhancement (PAPE),(46,47) which is defined by utilizing a high force or high power movement in order to increase the magnitude of a subsequent movement (post-activation potentiation).

The concept behind this training protocol was for the athlete to perform the movement at a greater intensity than usual without having to perform high intensity Olympic-style lifts, which could potentially fatigue the athlete more quickly. For Felisha, a ladder system was used in which two implements (10 and 20% greater than competition weight) would be implemented. The objective for this training emphasis was to increase force generation through the movement. Felisha was asked to perform a prescribed number of throws with the 20% implement first while maintaining ideal performance form, and she was then asked to do the same with the 10% implement. By performing the ladder in this way, the competition weight shot would feel easier by comparison, while also reinforcing proper throwing form throughout the movement. Throws were completed twice a day, with 8-10 throws being performed in the morning session, and 20-25 being performed in the afternoon session. This same protocol was followed in competition; Felisha warmed up with the 20% implement, then the 10% implement, and would not perform throws with the competition weight until the competition began. This strategy was implemented into her pre-performance warmups for the 2016 USATF Olympic Trials and was a determining factor for her 2016 Olympic berth.

Recommendations

The movement patterns associated with the glide shot put are directed towards generating the maximum velocity of the shot under the given conditions. The athlete in the present study must continue to develop mobility, strength, and power production in order to make the following technical adjustments

1. Increase the blocking force at the front of the circle.

2. Maintain a loaded position throughout the glide into the push-off phase.

3. Maintain a constant increase in the shot acceleration by starting slowly and constantly raising the speed of the implement.

4. Continue to increase release velocity while maintaining a release angle of approximately 36 degrees as increases in strength and power permit.

5. Explore changing to the more efficient rotational technique (longer path of acceleration).

CONCLUSION

To achieve a longer application of force, Parry O'Brien and his coach pioneered the glide shot put technique by turning his back to the throwing area. The glide technique was subsequently modified and improved by throwers after him. As each phase of the shot put segues smoothly into the next, proper development of strength and power in each phase is essential for maximal performance. Felisha Johnson utilized a sound technical pattern with an optimal release angle that created the velocity necessary to accelerate the implement past the 19m mark. By using a scientific approach to the shot put that provides immediate visual feedback and release data (angle of release, direction of release, speed of release and height of release), the coach was provided with immediate feedback on several variables which the athlete has control over, allowing them to make minute adjustments as needed to improve the athlete's performance and to develop a training protocol based on patterns exhibited by the athlete. Tremendous confidence was developed by relating biomechanical data and underlying principles to the presentation of fundamental techniques of shot putting. Evidence based proof provided by advanced modern technology tied to the laws of physics is both convincing and motivating to athletes. By adopting the above procedure in the selection and development of fundamental skills in the shot put, one can have increased confidence in the soundness of the conclusions. The Rio Olympian Felisha Johnson recorded the second best throw (19.24 meters) of her career at the Olympic Trials, no doubt aided by her ability to train for prolonged stretches without sustaining injury.

ACKNOWLEDGEMENTS

Thank you to USA Track and Field for their support of this study.

REFERENCES

1. Judge LW, Young M and Wanless E. Using sports science and training theory to develop elite performance: a case study of a 2005 world championship finalist in the women's shot put. *Int J Sports Sci Coach* 2011; 6: 365-385.

2. McCoy RW, Gregor RJ, Whiting WC, et al. Kinematic analysis of elite shot-putters. *Track Technique* 1984; 90: 2868-2871.

3. Tsirakos DK, Bartlett RM and Kollias IA. A comparative study of the release and temporal characteristics of shot put. *J Hum Mov Stud* 1995; 28: 227-242.

4. Maheras AV. *The relationship between the angle of release and the velocity of release in the shot put, and the application of the theoretical model to estimate the optimum angle of release.* Doctoral Dissertation, University of Kansas, 1995.

5. Hay JG. *The biomechanics of sports techniques.* Upper Saddle River, NJ: Prentice Hall, 1993.

6. Landolsi M, Labiadh L, Zarrouk F, et al. Kinematic analysis of the shot-put: a method of assessing the mechanical work of the hand action force. *Eur J Sport Sci* 2018; 18: 1208-1216.

7. Linthorne NP. Optimum release angle in the shot put. *J Sports Sci* 2001; 19: 359-372.

8. Young M and Li L. Determination of critical parameters among elite female shot putters. *Sports Biomechanics* 2005; 4: 131-148.

9. Bartonietz K and Borgstom A. The throwing events at the world championships in athletics 1995, Goteborg - technique of the world's best athletes Part 1. shot put and hammer throw - PDF Free Download, https://docplayer. net/184127899-The-throwing-events-at-the-world-championships-in-athletics-1995-goteborg-technique-of-the-world-s-best-athletes-part-1 -shot-put-and-hammerth row.html (accessed 3 November 2020).

10. Judge LW and Young M. *The shot put handbook*. Monterey, CA: Coaches Choice, 2010.

11. Smith SL and Snow RE. Kinematic analysis of U.S. decathlete shot put performance. In: *XIIIth symposium of the international society of biomechanics in sports, Prague*, Czechoslavakia, ISBS.

12. Smith SL and Snow RE. Decathlon shotput testing: 1991 TAC championships. 1992.

13. Hubbard M, de Mestre NJ and Scott J. Dependence of release variables in the shot put. *J Biomech* 2001; 34: 449-456.

14. Coh M, and Stuhec S. 3-D kinematic analysis of the rotational shot put technique. *New Stud Athle* 2005; 20: 57-66.

15. Abdel-Aziz YI and Karara HM. Direct linear transformation from comparator coordinates into object space coordinates in close-range photogrammetry. *Photogramm Eng Remote Sensing* 2015; 81: 103-107.

16. Leach RJ, Forrester S, Mears A, et al. How valid and accurate are measurements of golf impact parameters obtained using commercially available radar and stereoscopic optical launch monitors? https://doi.Org/10.1016/j. measurement.2017.08.009 (2017, accessed 4 November 2020).

17. Young M. *Critical factors in the shot put.* USA: Louisiana State University, 2004.

18. Winter DA, Sidwall HG and Hobson DA. Measurement and reduction of noise in kinematics of locomotion. *J Biomech* 1974; 7: 157-159.

19. Young M. Kinetic linking in the shot put. In: *1st annual Chinese national throws conference*, Beijing, China, May 2009.

20. Young M. *Biomechanical analysis of the men's shot put at the 2004 United States Olympic trials*. USA: University of Louisiana, 2004.

21. Matveyev LP and VB Giljatsova. The dynamics of the training load. *Mod Athle Coach* 1991; 29: 16-19.

22. Bartonietz KE. Biomechanics of the snatch: toward a higher training efficiency. *Strength Cond J* 1996; 18: 24-31.

23. Judge LW. Developing speed strength: in season training program for the collegiate thrower. *Strength Cond J* 2007; 29: 42-54.

24. Judge LW. *The complete track and field coaches' guide to conditioning for the throwing events.* Monterey, CA: Coaches Choice, 2008.

25. Kyriazis TA, Terzis G, Boudolos K, et al. Muscular power, neuromuscular activation, and performance in shot put athletes at preseason and at competition period. *J Strength Cond Res* 2009; 23: 1773-1779.

26. Stone MH, Sanborn K, O'Bryant HS, et al. Maximum strength-power-performance relationships in collegiate throwers. *J Strength Cond Res* 2003; 17: 739-745.

27. Lanka JE. Biomechanical investigation of shot putting technique in athletes of different skill level.

28. Zatsiorsky VM, Lanka JJ, and Shalmanov AA. Biomechanical analysis of shot putting technique. *Exer Spo Sci Revi* 1981; 9: 353-389.

29. Alexander MJ, Linder KJ and Whalen M. Structural and biomechanical factors differentiating between male and female shot put athletes. *J Hum Mov Stud* 1996; 103-146.

30. Hay JG, Wilson BD and Dapena *J. Identification of the limiting factors in the performance of a basic human movement*. 1976; 13-19.

31. Ariel G. Computerized biomechanical analysis of the world's best shot putters. *Track Field Q R* 1973; 199-206.

32. Delevan P. Techniques of putting the shot. *Track Field Q Rev* 1973; 211-213.

33. Koltai J. Thoughts on traditional and new putting techniques. In: *The Throws: Contemporary theory, technique and training* (edited by F. Wilt), pp. 34-35. Los Altos, CA: Tafnews Press, 1974.

34. Nett T. Foot contact at the instant of release in throwing. *Track Technique* 1962; 274.

35. Bartonietz K. Strength training for throwers. *The Throws* 2000; 22-26.

36. Dessureault J. Selected kinetic and kinematic factors involved in shotputting. In: Asmussen E and Jorgensen J (eds) *Biomechanics* VI-B. Baltimore: University Park Press, 1978, pp.51-60.

37. Gregor RJ, Edgerton VR, Perrine JJ, et al. Torque-velocity relationships and muscle fiber composition in elite female athletes. *J Appl Physiol Respir Environ Exerc Physiol* 1979; 47: 388-392.

38. de Mestre NJ, Hubbard M and Scott J (1998) Optimizing the shot put. In *Proceedings of the Fourth Conference on Mathematics and Computers in Sport* (edited by N. de Mestre and K. Kumar), pp. 249±257. Gold Coast, Qld: Bond University.

39. Bompa TO. *Theory and methodology of training: the key to athletic performance*. 3rd ed. Dubuque, Iowa: Kendall, Hunt, 1994.

40. Reis VM and Ferreira AJ. The validity of general and specific strength tests to predict the shot put performance - a pilot study. *Int J Perform Anal Sport* 2003; 3: 112-120.

41. Judge LW, Bellar D, Thrasher AB, et al. A pilot study exploring the quadratic nature of the relationship of strength to performance among shot putters. *Int J Exerc Sci* 2013; 6: 171-179.

42. Nuzzo JL, McCaulley GO, Connie P, et al. Trunk muscle activity during stability ball and free weight exercises. *J Strength Cond Res* 2008; 22: 95-102.

43. Stone MH, Moir G, Glaister M, et al. How much strength is necessary? *Phys Therapy Sport* 2002; 3: 88-96.

44. Garhammer J. Power production by Olympic weight- lifters. *Med Sci Sports Exerc* 1980; 12: 54-60.

45. Yessis MD. Training for power sports, part 2. *Strength Cond J* 1995; 17: 68-73.

46. Blazevich AJ and Babault N. Post-activation potentiation versus post-activation performance enhancement in humans: historical perspective, underlying mechanisms, and current issues. *Front Physiol* 2019; 10: 1359.

47. Cuenca-Fernandez F, Smith IC, Jordan MJ, et al. Nonlocalized postactivation performance enhancement (PAPE) effects in trained athletes: a pilot study. *Appl Physiol Nutr Metab* 2017; 42: 1122-1125.

RUNNING IN THE HEAT

BY JASON R. KARP, PHD, MBA

We asked Dr. Karp to write something on how athletes should deal with hot weather.

Last year, I took a sabbatical from my entrepreneurial life in California and became a college professor and assistant cross country and track coach at Georgia Southern University. It would be an understatement to say that running in southern Georgia in the summer is a challenge. The summers are downright sticky, as stepping outside your air conditioned house feels like walking into a steam room. Most people running in the Georgia summer wish they could handle the heat as well as Apollo, the Greek god of the Sun, who was known for bringing heat and light to the Earth. But even Apollo would have a hard time running in the Georgia heat, as it presents a number of thermal and cardiovascular challenges. Many places in the country also experience harsh summer conditions, so knowing how to handle it will protect your athletes.

PHYSIOLOGY OF ENVIRONMENTAL HEAT AND DEHYDRATION

You run outside on a sunny, hot, humid day. The crimson, mid-August sun hangs overhead against the azure sky like the blade of a guillotine. A couple of miles into your run, your body temperature, already on the rise from muscle contraction, increases even more. Since your primary mechanism of cooling your body is through the evaporation of sweat from the skin's surface, your sweat rate increases. As a result, you lose body water and begin to become dehydrated. Despite the occasional compliment you get in the gym about your well-defined muscles, water, not muscle, is the major component of your body. So, when you lose water, there are consequences. A major consequence of dehydration is an increase in core body temperature during exercise, with body temperature rising 0.15 to 0.2 degrees Celsius for every one percent of body weight lost due to sweating.

Water is vital for many chemical reactions that occur inside your cells, including the production of energy for muscle contraction. Therefore, dehydration influences your athletes' workouts. Indeed, exercise performance declines with only a 2 to 3 percent loss of body weight due to fluid loss. Since the effects of heat and dehydration on physiological function summate to have a greater effect than either one alone, being dehydrated when running in the heat causes performance to decline even more, and can even be a recipe for disaster, with the risk of heat-related illnesses rising dramatically. The problem, as you discover about three miles into your run, is that running in the heat makes it very difficult to prevent dehydration, since your sweat rate exceeds your ability to ingest and absorb fluid while running. While mild to moderate exercise typically results in sweat losses of 0.8 to 1.4 liters per hour, high environmental temperature combined with intense exercise can increase sweat rate to 1.4 to 2 liters per hour. However, your gastrointestinal system can absorb only about 0.8 to 1.2 liters of fluid per hour. Thus, heat stress and dehydration often occur together.

Humidity presents an even greater challenge. When it's humid, the air is already saturated with water, limiting the amount of sweat evaporating from your skin. As a result, the ability to dissipate heat is minimized and core body temperature rises rapidly, leading to hyperthermia. In extreme cases, hyperthermia can lead to heat exhaustion and heat stroke. Heat exhaustion, the most common heat illness, is the inability to continue exercise in the heat. Heat stroke, which is a medical emergency, occurs when body temperature rises to a level that causes damage to the body's tissues (>103-104 degrees F). In an attempt to prevent body temperature from rising to dangerous levels while running, your central nervous system orchestrates a complex response in which blood vessels supplying your inner organs constrict, while blood vessels supplying your skin dilate, causing blood to be diverted away from inner organs and directed outward to the skin to increase cooling through the convection of air over the skin's surface. It may seem somewhat counterintuitive that as your core body temperature rises while you run in the heat, skin temperature decreases as a result of convective cooling. More blood being directed to the skin means less blood (and therefore less oxygen) going to the active muscles, causing running pace to decrease and the perception of effort to increase. When your body has a choice between maintaining the exercise intensity and cooling itself so you don't overheat and die, it's going to choose the latter. So, on this hot, humid day, your running pace slows and you feel fatigued. You notice a sprinkler on a neighbor's lawn and run past it, hoping to cool yourself, but you quickly realize that spraying water on your body, while refreshing, is not effective for decreasing body temperature. To decrease body temperature, you need to ingest the fluid. Since you don't want your neighbors to see you trying to drink from their sprinklers, you forego drinking any fluid and continue running.

As if trying to prevent you from overheating on your run weren't enough, accompanying the increase in thermal strain when running in the heat is a greater cardiovascular strain. Profuse sweating to increase evaporative cooling causes a loss of plasma volume from the blood, and total blood volume decreases. When blood volume decreases, stroke volume (the volume of blood pumped by the heart with each beat) decreases. A decreased stroke volume means oxygen flow to your muscles is then compromised, and the running pace decreases. To compensate for the decreased stroke volume, your heart must work harder to pump blood, and heart rate drifts upward in an attempt to maintain cardiac output (the volume of blood pumped by the heart each minute) and blood pressure. This rise in heart rate during prolonged exercise without an increase in intensity is called *cardiac drift*. Heart rate rises 3 to 5 beats per minute for every one percent of body weight loss from dehydration.

IN EXTREME CASES, HYPERTHERMIA CAN LEAD TO HEAT EXHAUSTION AND HEAT STROKE.

Due to both the thermal and cardiovascular strain of running in the heat, the ability to run declines linearly with an increase in environmental temperature. While most research has examined the effect of dehydration on prolonged cardiovascular exercise, resistance exercise performance has also been shown to decrease when dehydrated, however, it seems to take a greater amount of dehydration (at least a 5 percent loss of body weight) to see strength decrements.

After you complete your run fully exhausted, dehydrated, and a little lightheaded, your T-shirt drenched with sweat, you walk into your air conditioned house and ask yourself, "How can I prevent this from happening to my athletes?"

RECOMMENDATIONS FOR EXERCISING IN THE HEAT

The two most important things your athletes can do to prepare themselves for their summer outdoor training sessions are hydrate and acclimatize.

Hydrate

Because of the decrease in running performance and the potential health danger of dehydration, there has been plenty of research (and an onslaught of sports drinks) on strategies to overcome, or at least blunt, the effects of dehydration. Beginning the workout fully hydrated or even "hyper-hydrating" before a workout can delay dehydration when running, maintain running performance, and decrease the risk for heat-related illnesses. Pre-exercise fluid intake enhances the ability to control body temperature and increases plasma volume to maintain cardiac output. Your athletes should drink fluids before they exercise in the heat so they begin every workout fully hydrated, and they should continue to drink during workouts longer than one hour. For specific recommendations on how much and which ingredients to drink, see "What Should Your Athletes Drink?" A good indicator of your athletes' hydration levels is the color of their urine. While it may be outside your coaching scope of practice (and may seem a bit weird) to obtain a urine sample from your athletes, you can educate your athletes about how to monitor their hydration status. The lighter the urine color, the better the level of hydration, so tell your athletes their urine should look like lemonade rather than apple juice.

Acclimatize

Chronically exposing oneself to a hot and humid environment simulates adaptations that lessen the stress. Cardiovascular adaptations to exercising in the heat (e.g., decreased heart rate, increased plasma volume) are nearly complete within 3 to 6 days, while core body temperature and electrolyte concentration changes take 9 to 10 days. Full acclimatization is complete after two weeks, as the increased sweating response catches up to the other adaptations. Therefore, your athletes should take two weeks of slowly introducing themselves to the heat to be fully acclimatized and prepared for prolonged training sessions. When preparing for intermittent exercise (e.g., interval workouts, resistance training), however, your athletes may not need as long to acclimatize. Research has found that just four 30- to 45-minute sessions of intermittent exercise in the heat was enough to cause acclimatization and resulted in an improvement in intermittent running capacity. Furthermore, subjects who went through the acclimatization protocol had a lower core body temperature and an increase in thermal comfort during exercise compared to subjects who did not acclimatize. While exercising in the heat will always present a stress, acclimatization has a moderate prophylactic effect, minimizing the stress and reducing the risk of heat-related illnesses. For specific recommendations about how to acclimatize to the heat, see "How Should Your Athletes Acclimatize to the Heat?"

OTHER STRATEGIES FOR RUNNING IN THE HEAT

If your athletes have a choice of when to run, the best time

What Should Your Athletes Drink?

FLUID (water or sports drink)

Before exercise: 500 milliliters two hours before running

During exercise: 200 milliliters every 15-20 minutes; match fluid intake to equal sweat loss; maintain 400-600 milliliters of fluid in stomach to optimize gastric emptying

After exercise: 1 liter per kilogram of weight lost during running

SODIUM (contained in sports drink or table salt mixed in)

(necessary only if running >60 minutes or if sodium deficient)

Before, during and after exercise: 0.5-0.7 gram per liter of fluid

GLYCEROL (structural backbone of triglycerides available at specialty nutrition stores like GNC or online)

creates osmotic gradient in circulation that causes fluid retention, which facilitates hyper-hydration, protects against dehydration, and maintains body temperature

Before exercise: 1.2 grams per kilogram body weight in 20% glycerol solution within 30-minute period, followed by 26 mL water per kilogram body weight distributed over 90 minutes before running

During exercise: 0.125 gram per kilogram body weight mixed in 5 mL fluid per kilogram body weight.

After exercise: 1.0 gram per kilogram body weight mixed in 1.5 liters fluid

How Should Your Athletes Acclimatize to the Heat?
full acclimatization takes 2 weeks

- Increase core temperature by being outside in heat
- Sweat 400-600 ml/hr
- Outside temp >85 degrees F (30 degrees C)
- Daily exercise
- Continuous, daily exposure:
  - hot & dry: 100 min/day
  - hot & humid: >100 min/day

is the early morning, when the temperature is lower. Not only is it cooler and thus safer to run in the morning than in the afternoon or evening, your athletes may also get a better workout. Research has shown that endurance exercise capacity in the heat is significantly greater in the morning than in the evening, and is accompanied by a lower initial core body and skin temperature. If your athletes must meet you for their runs and workouts during the hotter part of the day, try to maximize time in the shade, wear sunscreen, and recommend loose-fitting, moisture-wicking, light-colored clothes that reflect the sunlight.

Next time your athletes run in the heat, make sure they follow these guidelines. If they adequately hydrate and acclimatize, not only will they crush their workouts and eliminate their risk for heat illness, they may even challenge Apollo's heat.

A competitive runner since sixth grade, Dr. Jason Karp quickly learned how running molds us into better, more deeply conscious people, just as the miles and interval workouts mold us into faster, more enduring runners. This passion Jason found as a kid placed him on a path he still follows as a coach, exercise physiologist, author of 15 books and 400 articles, and recent professor and assistant cross country and track coach at Georgia Southern University. His TED talk, *How Running Like an Animal Makes Us Human*, inspires people all over the world. He is the 2011 IDEA Personal Trainer of the Year and two-time recipient of the President's Council on Sports, Fitness & Nutrition Community Leadership award. His run coaching certification was obtained by coaches and fitness professionals in 26 countries before being acquired by International Sports Sciences Association. In 2021, he became the first American distance running coach to live and coach in Kenya. His book, *Coaching the Kenyans*, as well as his others, are available on Amazon.

USATF COACHING EDUCATION

USATF CALENDAR OF SCHOOLS

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

Oct 18-20	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)**
Nov 16-17	*USATF Level 1 Event Specific Training – Zoom (Pacific Time)**
Nov 17	*USATF Level 3 Program – Zoom Session #1*
Nov 24	*USATF Level 3 Program – Zoom Session #2*
Dec 1-4	*USATF Level 3 Program– In Person Sessions*
Dec 7-8	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)**
Dec 27-29	*USATF Level 1 Event Specific Training – Zoom (Eastern Time)**

**USATF members may only sign up for a USATF Level 1 Event Specific Training after purchasing the USATF Level 1 Program and completing the self-paced learning modules.*

ENDURANCE AND SPRINTS/HURDLES/RELAYS TO BE OFFERED AT THE 2024 USATF LEVEL PROGRAM – REGISTRATION OPENING SOON

The Level 3 program is the highest level of the USATF Coaching Education Program. The 32-hour course further expands on the scientific base included in the previous levels and provides coaches with comprehensive knowledge to master an event discipline. The 2024 USATF Level 3 Program will feature Sprints/Hurdles/Relays and Endurance with instruction from some of the world's best sport scientists and elite coaches. Participants will also work with an advisor to implement a capstone project during the indoor and outdoor season.

APPLICATION REQUIREMENTS

- Minimum five years of track and field, cross country, club or personal run coaching experience and actively coaching throughout enrollment
- Must be the primary coach of a high potential athlete respective to their competition level and have their consent to utilize for the duration of the capstone project
- Hold USATF Level 2 certificate in event discipline seeking to earn Level 3
- Must be a current USATF Coaches Registry Member

GRANTS

Up to four (4) grants are available and provide tuition and shared room and board package at the 2024 USATF Level 3 Program. A separate grant application must be submitted prior to the posted deadline. All complete applications will be reviewed by the USATF Coaching Education Grants Subcommittee for awarding.

Learn more and apply at: https://www.usatf.org/programs/coaches/level-3-information

MILLION COACHES CHALLENGE

COMPLETE THE FREE CONNECTION BASED COACHING COURSE AND HELP USATF CLIMB THE NGB LEADERBOARD

USA Track & Field (USATF) has 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 2025.

Millions of youth are involved with organized sports each year, and coaches play an invaluable role in the development of healthy and successful athletes at all levels and age groups. However, less than a third of the coaches in the U.S. have been trained in proper youth development practices.

In an effort to support the goals of the Million Coaches Challenge, the USOPC has created a free, self-paced online course called Connection Based Coaching, which focuses on teaching social and emotional learning skills. The USOPC aims to train at least 40,000 coaches by 2025 using this curriculum, which consists of three 30-minute modules.

As a part of this initiative, USATF and other National Governing Bodies (NGBs) are participating in the Connection Based Coaching Challenge to help the USOPC reach their 40,000-coach goal with up to $15,000 in funding to be awarded to an NGB with the most coaches trained.

With the goal to train coaches across the country in youth development techniques by 2025, USATF would like to invite members, fans, coaches, and supporters to join the movement to ensure kids across the country have access to coaches who are well versed in youth development techniques to help kids succeed in and out of competition.

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.

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

USATF LEVEL 1 RECERTIFICATION APPLICATION OPENING IN OCTOBER FOR 2024 EXPIRING CERTIFICATES

Members with a Level 1 certificate expiring on December 31, 2024, will be invited to access the re-certification application in October. Members must hold a current USATF membership, current Safe-Sport Training, complete an eligible USATF continuing education course, and submit application and fee to renew their Level 1 certificate for an additional four calendar years.

Eligible USATF Continuing Education Course Options:

1. Complete a minimum of one paid online course on USATF Campus.
2. Complete all three modules of the Connection Based Coaching/Million Coaches Challenge course.
3. Complete a minimum of one USATF Specialist course: USATF Cross Country Specialist Course, USATF Marathon Specialist Course, OR USATF Emerging Elite Coaches Camp

Members who elect to retake the USATF Level 1 Program in lieu of one of the continuing education courses above do not need to complete the recertification application. USATF Level 2 and 3 coaches are exempt from Level 1 recertification and no action is necessary.

Recertification protocols for all USATF Coaching Education Programs are available at: https://www.usatf.org/programs/coaches/recertification.

2024 EMERGING FEMALE COACHING GRANTS AVAILABLE FOR USE TOWARD THE USATF LEVEL 1 OR LEVEL 3 PROGRAM

The Emerging Female Grant is provided by USATF and provides a select number of minority, women track and field coaches the opportunity to attend USATF Coaching Education Schools and USATF specialty courses. Grants are valued at the respective program tuition fee. In addition to meeting course requirements, applicants must be a minority, female coach, USATF 3-Step Safe Sport Compliant, provide a resume of coaching background/experience, and position statement via an online application.

Applications for Emerging Female Grants are accepted on a rolling basis until funds are expended. Applications are reviewed on the first (business) day of each month must be received a minimum of 30 days prior to the start date of the requested program/school. Grant recipients will be notified via email.

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

HAVE YOU VISITED THE NEW USATF CAMPUS E-LEARNING PLATFORM?

USATF Campus is the online learning platform available to all coaches, athletes, and educators with an interest in better understanding human performance. The re-launched platform boasts over 15 sport science courses and also hosts the USATF Professional Pathway courses and exams. Log into your USATF Connect profile and click the USATF Campus link on the left-hand navigation menu to navigate to past trainings or purchase a new course from the catalog below from the Coaching Schools menu. All courses have been refreshed in a new format and many include new content or resources.

SPORT SCIENCE

- Basic Principles of Endurance Training
- Basic Principles of Long Jump
- Basic Principles of Sprinting
- Basis Principles of Training Design
- Coaching Race Walking (coming soon)
- Effective Technique Analysis
- Energy Systems and Biomotor Abilities for Optimal Performance
- Essential Coaching Pedagogy
- Level 2 Sports Science
- Physiology for Long Term Athlete Development
- Reactive Strength: the Fast Stretch Shortening Cycle (SSC)
- Reactive Strength: the Slow Stretch Shortening Cycle (SSC)
- Recognizing Overtraining Causes, Symptoms, and Prevention
- The Skill Learning Process
- Sport Specific Strength and Power
- Understanding Acute Fatigue in Training and Competition

ELECTIVE

- USADA Coaches Advantage (Free)
- Connection Based Coaching (Free) – available on the USOPC Mobile Coach Platform

BENEFITS

- Access to courses for athletes and coaches that are applicable to all sports, plus specialized track and field courses
- Online, asynchronous professional development that is affordable and convenient
- Evidence based sport science courses from 2022 USOPC Coach Educator of the Year and accomplished exercise physiologist and training theory expert, Dr. Christine Brooks
- Methodology, training tips, and words of wisdom from Legend Coach, Dr. Joe Vigil as part of Basic Principles of Endurance Training
- Digital certificate of completion and Skills Passport to manage all your professional development certificates

USATF

2025 USATF NATIONAL TEAM AND MEDICAL STAFF APPLICATIONS OPENING SOON

Watch for national team and medical staff applications to open in October on USATF.org. Selection procedures, position descriptions, and applications will be available at: https://www.usatf.org/programs/elite-athletes/team-usatf

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