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Strengthening the Springs: Improving Sprint Performance via Strength Training

Brad H. Deweese
East Tennessee State University

Christopher Bellon
East Tennessee State University

Eric Magrum
East Tennessee State University

Christopher Taber
Sacred Heart University, taberc@sacredheart.edu

Timothy J. Suchomel
East Stroudsburg University of Pennsylvania

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STRAIGHTEN UP

GROWING PAINS

STRENGTHENING THE SPRINGS

IMPROVING SPRINT PERFORMANCE VIA STRENGTH TRAINING

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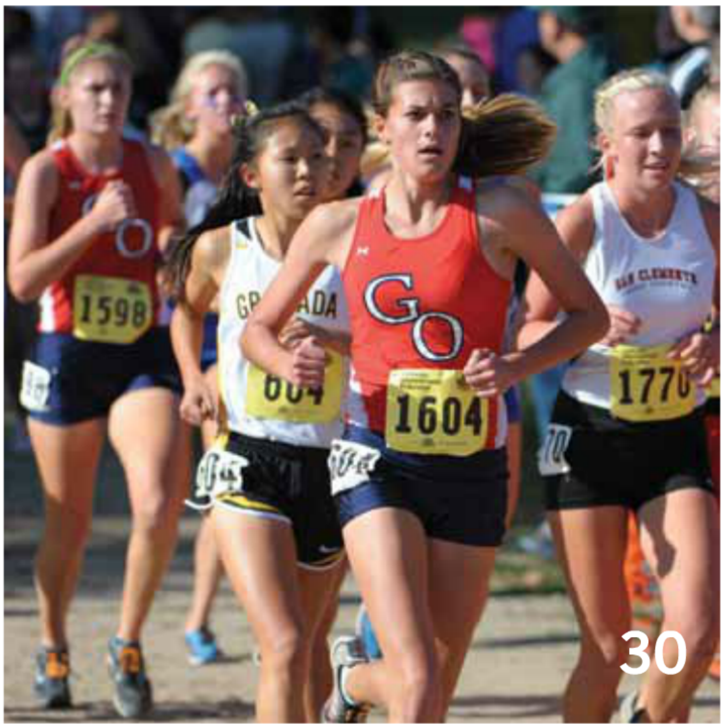

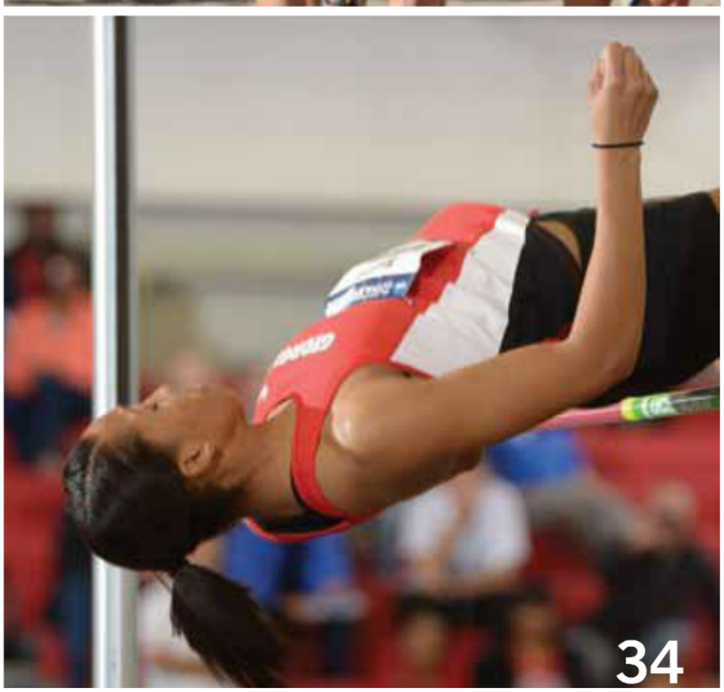

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STRENGTHENING THE SPRINGS

HOW THE INCLUSION OF PROPERLY SEQUENCED WEIGHTLIFTING DERIVATIVES INTO THE STRENGTH-TRAINING PROGRAM CAN IMPROVE SPRINT PERFORMANCE.

BY BRAD H. DEWEESE, EDD, CHRIS BELLON, MS, ERIC MAGRUM, MS, CHRISTOPHER TABER, MS, TIMOTHY J. SUCHOMEL, PHD

"If you want to be fast, you have to run fast." While no practice or training tool is more specific to sprint development than consistent exposure to high-quality sprinting, there are obvious advantages to the incorporation of supplemental training tactics (48). Specifically, there is ample evidence sprint performance can be bolstered through a strength-training program that enhances "usable" strength while minimizing excessive body mass. Therefore the purpose of this article is to provide an overview on the nature of sprinting, while highlighting the benefits of including weight-training exercises that maximize the translation of strength-gains to the track, namely the weightlifting derivatives.

OVERVIEW ON SPRINTING

Sprinting has been defined as a volitional activity that represents how fast an athlete can move down the track through a rapid, un-paced, maximal run that lasts less than 15 seconds (47). While correct, this definition does not highlight the many underlying components that lead to sprint race success (Figure 1). For instance, elite sprinters generate and yield forces up to four times body mass during each stance phase (39). In addition, these forces are produced during very brief ground contacts, nearing .80-.90 milliseconds at maximum velocity (70). Furthermore, the ground contacts of more successful sprinters demonstrate an asymmetrical force curve where most of the force is produced within the first half of the stance phase (8).

In sum, these findings lead to an acknowledgement that sprint performance is dictated by the ability to generate high rates of force development (RFD), which can be defined as the change in force divided by the change in time. As such, strength-training programs should attempt to maximize a sprinter's ability to produce high RFD and tolerate the resultant ground reaction forces (GRF), which are defined as the forces exerted by the ground back onto the moving body.

SPECIFICITY

Employing training methods that are similar (task/mechanically) to sprinting, will serve to improve a sprinter's RFD on the track. This can be accomplished by increasing the specificity of additional training means. For the purpose of this paper, specificity can be divided into mechanical and task similarities. Mechanical specificity explains the kinetic (force, RFD, power) and kinematic (range of motion, spatio-temporal characteristics) association between an exercise and a physical performance. These variables are often supported and result from task specificity, which deals with the manner in which motor unit synchronization and whole muscle activation patterns occur (13).

Considering the components of specificity, an ideal strength-training regimen would include exercises that promote high levels of force production in a swift manner that parallel the mechanics and muscle activation patterns found in sprint running. Furthermore, an argument can be made that weight training exercises utilizing and overloading the stretch-shortening cycle (SSC) may be of upmost benefit. Recall from DeWeese et al (2015) that upright sprinting has been loosely described as locomotion using the Spring Mass Model, where a runner's gait cycle manifests from the compression and resultant propulsion of a coiled spring. This arbitrary spring is analogical of the neural, musculature, and connective tissues that are responsible for the SSC, which is a ballistic contraction in response to a forceful lengthening.

While myriad exercises and combinations of training tools are available, a great deal of literature and anecdotal information points to the weightlifting (WL) movements as one of the most efficient methods of priming a sprinter for enhanced RFD production while ensuring the transfer of training effect through mechanical and

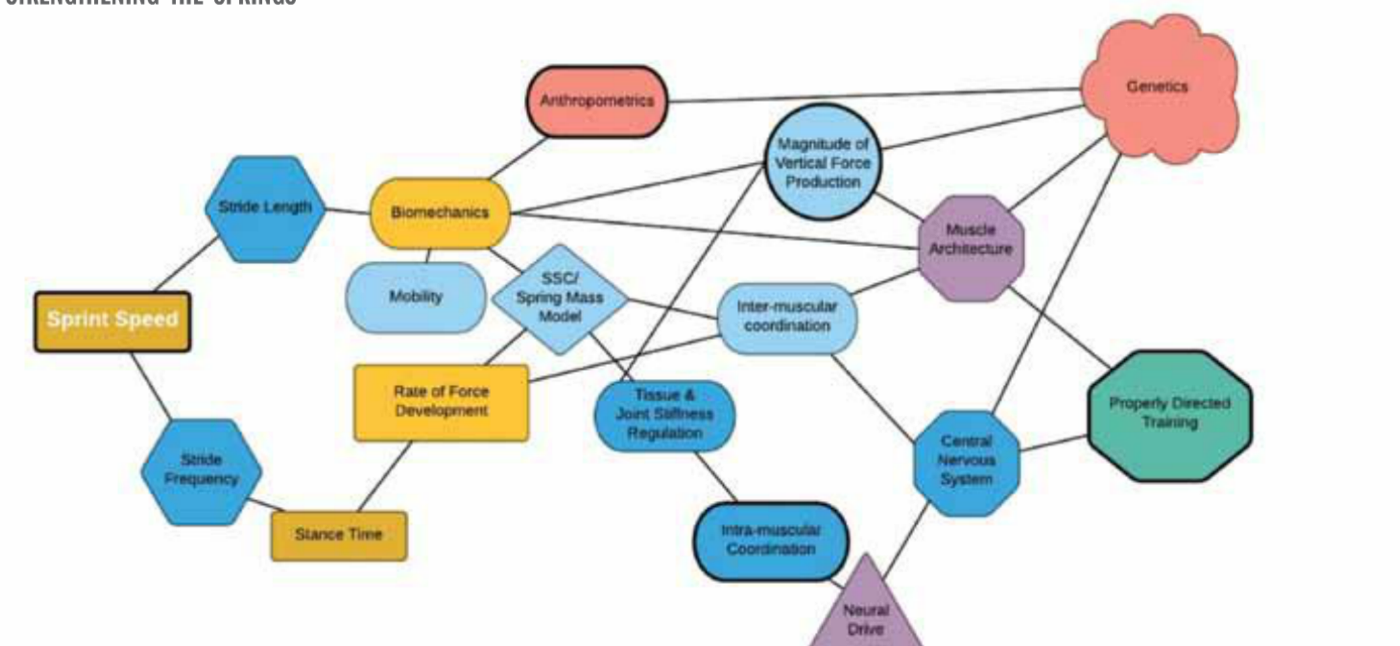


Figure 1: A detailed map of the underlying constructs of sprint speed

task similarities.

THE LIMITATIONS ON SPRINT PERFORMANCE MAY CLARIFY EXERCISE SELECTION

Most often, academic literature measures the usefulness of various strength-training exercises in terms of power, which can be considered a work-rate. As a result, many within the profession elect to perform potentiation complexes (PC) as they seemingly parallel the power outputs of traditional WL movements. These complexes most often pair a "heavy" exercise (squat) with a "light" exercise (countermovement jump) in hopes that the heavy lift allows the velocity of the subsequent lighter exercise to be enhanced following a sufficient recovery period. The enhanced performance characteristics resulting from the pairing of exercises may lead to superior neurological and physiological adaptations in comparison to performing these exercises separately (56). Practically speaking, this may be a reason why many coaches find PC to be a more appealing option than WL as familiarity with these exercises is usually higher in these circumstances. Additionally, there is a wealth of literature supporting the concept that PC have been shown to display comparable, if not greater, power outputs when compared to WL. Since sprint velocity has displayed a close relationship with high power outputs, this argument is considered justifiable by most (12, 44).

Despite the validity of this argument, there is also a great deal of research indicating that sprint velocity is ultimately governed by other limiting factors (8, 69). While power is a measure of work performed and provides a casual relationship to athletic performance, it does not clearly articulate the relationship between the many training tools and their effectiveness for sprinters. As stated earlier, sprint performance is maximized by an athlete's ability to produce high rates of force development with each ground contact. Furthermore, the force generated and placed onto the track yields a nearly equal amount of ground reaction forces. Simply put, the magnitude of force an athlete can apply to the ground with each foot contact is the most influential factor in determining their sprint velocity. As such, implementing exercises that elicit high GRF's is of primary importance to improving an athlete's sprint speed. When compared with WL, PC may not produce the same GRF's. Based on this information, omitting WL from strength training programs may limit an athlete's ability to develop the higher GRF's necessary to produce greater sprint velocities. This may also hinder the athlete's capacity to make improvements in their in sprint mechanics due to the fact that sprint kinetics play a pivotal role in determining the outcome of an athlete's movement parameters (44). In other words, if an athlete cannot produce sufficient force during ground contact, they may not be able to achieve the positions necessary to produce optimal sprint technique. Accordingly, the argument of which method of strength and power development reigns superior is ultimately superfluous. Both WL and PC can serve as vital components in maximizing improvements in sprint performance. Therefore, it is the responsibility of the coach to invest the time in developing a comprehensive curriculum of strength and power training modalities that can provide the greatest benefit to the athlete.

WEIGHTLIFTING DERIVATIVES

The use of weightlifting movements (WL) to develop neuromuscular strength and power in athletes has long been a topic of debate in the realm of athletics. While the strength and power gains that can be derived from this type of training are clear (66), many coaches still argue against the use of these exercises. Although there are multiple reasons underpinning this school of thought, the most central argument in this debate is with respect to the time investment required to learn WL. Essentially, many believe that fostering competence in these exercises requires too much of a time commitment for both the athlete and the coach. Additionally, some literature has demonstrated that strength and power capabilities can also be improved more through alternative means, namely the aforementioned potentiation complexes. While there is some evidence that supports this notion, the questions surrounding this dispute should not pertain to which methodology is superior, but rather how the combination of the two can synergistically enhance sprint speed.

The primary concern of spending an inordinate amount of time teaching the WL is often misunderstood, as it is commonly believed that in order to reap the benefits of WL, one must complete a full snatch or clean from the floor. However, many of the

strength and power adaptations of the full lifts can be realized by implementing the derivatives of these exercises, such as a clean grip mid-thigh pull or clean pull (19, 20, 60). This is significant from the perspective of both pedagogy and performance, as simpler movements are easier to teach and can be overloaded to a greater extent. Therefore, the time investment involved in teaching these exercises is not nearly as significant as many coaches perceive it to be. Additionally, the greater loads used in these lifts may also provide greater physiological and neurological stimuli from which superior strength and speed adaptations can be developed.

PHASIC PROGRESSION IN PRESCRIPTION OF WEIGHTLIFTING DERIVATIVES

DeWeese et al. previously described a training system, termed Seamless Sequential Integration (SSI), that promotes enhancements in sprint speed through a short to long approach on the track that coincides with loading and organizational tactics embedded within conjugate sequential programming (15, 17). Further, this model considers a harmonious relationship with non-track training, including strength development. In short, the aim of this model is to enhance and exploit acceleration ability, which serves to enhance the sprinter's speed reserve, thus improving race economy.

Coinciding with "on the track" programming, the strength training must be planned and carried out in such a way that athlete's build a "strength reserve" that sets the foundation for success in higher velocity movements. This sequenced training is supported by the works of Minetti and Zamparo (2002) who demonstrate that long-term tactics which enhance strength or the ability to produce, exert, (and tolerate) force against the environment allow for the successful execution of swifter movements in subsequent phases through enhanced power output.

One such method of ensuring increased movement speed is the development of a properly directed training plan that unifies the training goals on the track and in the weight room. In this manner, the requisite skillset needed for sprinting (properly directing forces) and physiological/neurological underpinnings (Cross sectional area/fiber type transitions/RFD) are developed in unison. As such, the remainder of this article will provide an overview on how best to utilize weightlifting derivatives and other strength-training methods with sprint training.

GENERAL PREPARATORY PHASE

Within SSI or a similar short-to-long program, the primary goal of the general preparatory phase is to maximize accelerative ability in order to augment a sprinter's top speed and resultant speed reserve in later phases. Typically, acceleration training includes resisted-runs (inclines, towing) and short-distance sprints that provide opportunities to direct high propulsive forces into the track for as long as possible. Simultaneously, the weight training begins with an emphasis on strength-endurance proceeded by an introduction to maximal strength, furthering the sprinter's work capacity and Type II muscle cross-sectional area that ultimately serve as the foundation for improvements in muscular strength and power in subsequent training phases (4, 56). While training volumes are typically higher within this period of an annual plan, coaches can emphasize force production off the track through exercises that mimic acceleration-specific positions and time constraints.

Practically speaking, significant training time should be spent on developing the sprinter's overall strength capacity, which will likely improve RFD in later phases. Therefore, exercises such as the barbell back squat along with weightlifting derivatives that emphasize the "first pull" or pull to the knee can strengthen a sprinter's musculature (low back, glutes, hamstring, mid-section) at specific angles related to the start and initial acceleration. For instance, previous research has indicated that a sprinter's knee angles in the starting blocks are approximately 90 degrees (front foot) and 120 degrees (rear foot) which are similar to knee angles during the initial pull (5, 9, 37, 42).

An additional weightlifting derivative that may enhance torso strength is the "bent knee" clean or snatch grip shoulder shrug. Alongside basic upper-body exercises such as the overhead press and bench press, the shrug may bolster postural integrity during acceleration-dependent phases such as the start and transition while also serving as a precursor for more ballistic movements in later phases (e.g. the Mid Thigh Pull). Consequently, these complimentary strength-training exercises may provide the stimulus to develop vertical force production needed to stabilize and offset any rotation of the sprinter's center of mass during block clearance resulting from horizontal displacement.

SPECIAL PREPARATORY PHASE

Seamlessly moving away from the generalized training, the special preparatory period (SPP) serves to utilize a sprinter's enhanced acceleration ability in the development of top speed. This is typically carried out through the prescription of more specific training runs that promote optimal transition mechanics with drills such as acceleration holds, low-load resisted runs (up to 30m), and longer-segment accelerations (approximately up to 50m). These practices are then followed with an introduction to maximum-velocity sprinting through training sessions that may include fly-in sprints and "in and out's." Collectively, these efforts seek to improve the sprinter's speed reserve, which can be used to optimize long-sprint tactics within practice sessions dedicated to race modeling, split runs, or special endurance.

Concurrently, the emphasis in the weight room should be to increase maximal strength with greater loading (decreased repetitions and higher intensities) through more complex movements that develop musculature necessary for optimized top speed mechanics. Recall that during this time the sprinter is accelerating for longer distances and simultaneously achieving higher velocities. These higher velocities are the product of increasing vertical force production, which may be harnessed from the exposure to maximal strength work in the weight room.

Coinciding with the need to produce high forces is the fact that this strength must be demonstrated within a short period of time. As such, exercises that promote "strength-speed," which can be generalized to describe as the intent to move a relatively heavy load quickly, should be introduced within this phase so to begin the enhancement of RFD.

Along with the continuing prescription of strength-staples such as the squat, weightlifting derivatives that simulate and overload the rapid triple extension associated with acceleration and top-speed running can be utilized (60). For instance, the pull from floor (PF) requires the athlete to utilize a large portion of their muscle mass to move an external load that is typically heavier than what they can power clean or snatch, through a complete range of motion (19, 25). As a result, both work capacity as well as hypertrophic adaptations developed within the GPP may be maintained (68). In addition, specific adaptations may include greater Type II/I functional cross-sectional area and pennation angle changes which both serve to increase the sprinter's physical readiness (1, 6, 29, 30, 34, 35).

In addition to the pull from floor, the mid-thigh pull (MTP) is an additional weightlifting derivative that vertically overloads the

athlete in a position that is relative to top speed mechanics (17). Coinciding with the knee angle of 120-140 degrees, a tall torso, and shortened range of motion, the MTP emphasizes the triple extension movement to a great extent. Furthermore, this exercise is a sound teaching tool and precursor to the mid-thigh clean or snatch (MTC & MTS).

The MTC and MTS continue to emphasize the biomechanics of the MTP, but the prescription of lighter loads allows the athlete to completely "turn the bar over." This ballistic movement is intended to enhance RFD through the aggressive triple extension of the hip, knee, and ankle joints from a static position. In comparison to a traditional power clean or snatch from the floor or hang, the MTC and MTS remove the stretch-shortening cycle as a result of initiating the pull from technique boxes or a rack.

Collectively, the heavily-loaded pulls from the floor and mid-thigh, along with lower-loaded mid-thigh cleans allow the athlete to a) rehearse movement patterns of the power clean and snatch in an organized manner while b) overloading the triple extension phase of sprinting. In addition, these movements may improve the co-contraction within and between the active musculature surrounding the hips and knees leading to coordinated recruitment patterns of the necessary motor units needed to generate forces necessary to propel a sprinter down the track (17).

EARLY-MID COMPETITION PHASES

Nearing the competitive season, an athlete has graduated from the SPP with an increased speed-reserve following the exposure to concentrated efforts of acceleration work and maximum velocity training while also maximizing long-sprint success through the incorporation of a speed-reserve. Off the track, the strength training served to develop a strength-reserve, which utilized exercises that may have increased the likelihood of a transfer in the training effect through muscle architectural changes (Type II fiber content, pennation angles, fascicle length) and movement similarities (overloading the SSC, co-contraction of hip/knee joints).

Once the season begins, a sprinter's training should prioritize competitive readiness, which is founded upon lowered volume (to allow for recovery and realization of ability) alongside more specific training methods that are balanced around the racing schedule. Typically, a sprinter will take part in practices that retain their accelerative and top speed ability through "maintenance" doses of short sprint work, along with traditional sessions serving to enhance specific racing distance needs (speed endurance, special endurance, etc).

Within the weight room, an early emphasis should be placed on "strength-speed" which was introduced during the SPP. Recall that strength-speed prioritizes the swift movement of heavier loads in order to enhance rate of force development. Adaptations in RFD and peak power produced during the speed strength phase are produced through: increases in motor unit rate coding, neural drive, inter- and possibly intra-muscular coordination, motor unit synchronization and the ability to use the SSC, while decreasing neural inhibitory processes (3, 7, 23, 26, 27, 28, 43, 48, 49, 50, 51, 52).

These adaptations often occur through exercises that are multi-joint and innervate the musculature surrounding the hips and knees. Since the sprinter has invested training time to the pull from floor and mid-thigh clean or snatch, the requisite skill-set is present for the execution of the power clean and snatch (PC & PS). In fact, a properly performed power clean that utilizes the double knee bend (indicative of staging the SSC) has been demonstrated to yield high power outputs and relate strongly to sprint speed and vertical jump height (11). In addition, the PC and PS are believed to enhance the sprinter's ability to generate large vertical forces in the upright position that may counteract the magnitudes of force experienced during the stance phase of sprinting.

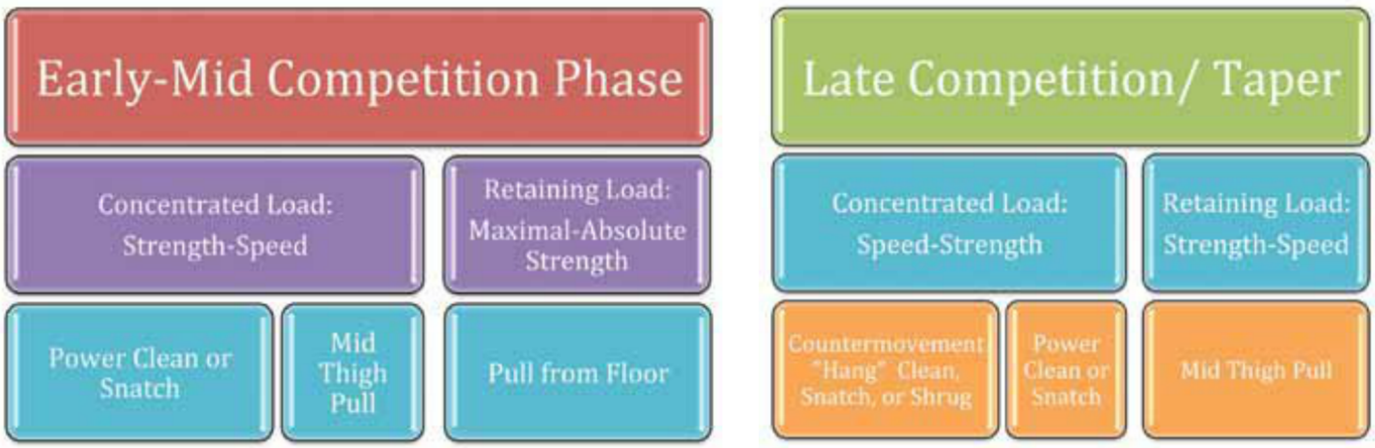
In conjunction with the power clean or snatch, acceleration work can be supported off the track through strength training that maintains the strength-reserve, which was enhanced during the SPP. At this time, the sprinter can perform relatively "heavier" partial back squats to remove the fatiguing-effects of full range of motion efforts, along with WL derivatives such as the MTP. The MTP utilizes loads that can exceed what an athlete can power clean by up to 140 percent, therefore making it an obvious choice to maintain force production (10).

Finally, the coach may consider employing strategies that introduce the concept of "speed-strength" which is defined as the intent to move lighter loads quickly. This tertiary goal that can be increased during the competition phase through the adoption of potentiating clusters that include medicine ball throws and multi-jump activities (plyometrics).

LATE COMPETITION-TAPER PHASE

At the latter stage of competition, a large emphasis is placed on maximizing preparedness through a reduction in overall volume and maintaining intensity through economical training-choices. These choices may include sprints that continue to maintain acceleration ability while fine-tuning race speed and tactics.

In order to ensure that competition is not compromised, strength training should be supplementary and prioritize the retention of strength-speed while shifting toward an objective of maximizing speed-strength, which was introduced during the early to



mid-competitive phase of training. Speed-strength, or the ballistic movement of lighter loads, can be carried out by prescribing potentiating complexes (partial squats followed by jumps or throws), light-weighted jump squats, and WL derivatives such as the countermovement "hang" clean or snatch. The hang clean and snatch are typically prescribed with loads lighter than one can catch from the floor, while continuing to overload the SSC (36). Therefore, executing a hang power clean and snatch with light loads from a position on the mid-thigh yields high velocities, thus increasing power output typical of top-speed sprinting. In addition to, or in place of the hang power clean or snatch, an athlete can perform the countermovement shrug, which utilizes the same movement pattern as the hang clean or snatch minus the catch phase (18). This exercise is suitable for those athletes who have less than proficient technique in the full lifts.

Finally, the sprinter can continue to retain "strength-speed" qualities that were maximized during the previous phase through low-doses of higher force producing WL derivatives, namely the MTP. Recall the MTP uses a very small "concentric" range of motion that allows the athlete to triple-extend with heavy loads. In fact, prescribing this exercise prior to the execution of a hang clean or snatch may serve to potentiate the power output.

CONCLUSION

While success in the sprint events is largely determined by who can get to the finish line first, numerous training factors must be considered when planning the practice schedule. Acknowledging the value of time and the strong relationship between recovery and readiness, training economy should be a top priority. Although no stimulus is more relative to the sprinter as frequent sprinting, appropriate strength training protocols can elicit high specificity while minimizing training time. As discussed throughout this paper, weightlifting derivatives are efficient tools for promoting the movement of both heavy (RFD) and light loads (Power) within brief periods of time. In addition, these exercises can be manipulated to target specific musculature and angles that are indicative of various sprinting phases and mechanics. Moreover, these lifts can be programmed to allow for graduated learning so to minimize the fatiguing effects stemming from the introduction of novelty training. Remember that there is no panacea or "magic" training tool that will ensure the sprinter a podium-worthy performance, but properly aligning the speed work with task and mechanically specific strength training may increase the likelihood of competitive readiness.

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Brad H. DeWeese, EdD is the Head Speed, Strength and Conditioning Coach while also serving as a Sport Physiologist at the East Tennessee State University Olympic Training Site.

Chris Bellon, MS is a PhD student and associate strength & conditioning coach within the ETSU program of Sport Physiology and Performance.

Eric Magrum is a graduate student and assistant strength & conditioning coach within the ETSU program of Sport Physiology and Performance.

Christopher Taber MS is a PhD student and associate strength & conditioning coach within the ETSU program of Sport Physiology and Performance.

Timothy J. Suchomel, PhD is an assistant professor in the Department of Exercise Science at East Stroudsburg University.

The Full Names and Complete Mailing Addresses of the Publisher, Editor and Managing Editor are: Sam Seemes, Mike Corn, 1100 Poydras St., Suite 1750 New Orleans, LA 70163.

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