Developing maximum running speed

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One of the major problems facing us in reading, interpreting and using various forms and studies on developing maximum speed is the lack of common and accurate terminology. Scientists often disagree on many areas. What are we, as coaches, to do?

Before I continue, let me clearly state, I am a working coach who applies scientific information I understand to a given environment and the individual athletes within that framework. To bridge the gap between science and coaching can sometimes leave one frustrated. I simply wish to leave you with some food for thought on how to develop maximum running speed. In this regard one must: 1. Pinpoint fundamentals and offer accurate and working definitions of terms; 2. Ensure that sufficient consideration is given to the biomechanics, physiology and specificity of developing maximum speed; and 3. Present hands-on teaching methods and innovative ideas to meet the above objectives.

Differences in the interpretation of the correct methods to develop maximum speed have led to a variety of successful systems. As a coach and not a scientist, you must be able to interpret, adjust and apply current scientific information to suit your given situation and athletes. Keeping in mind that all programs must first be designed to prevent injuries, a coach can then develop a system based upon:

1. The age and number of years an athlete has been involved in sport;
2. The athlete's individual strengths and weaknesses based on a battery of tests (30 m run, jumps decathlon, body measurements, etc.); and
3. An event-specific program based on specialization—in this case, sprinting speed.

Defining speed

"Sprinters are born, not made" is an axiom of many coaches. Does this really apply? Let's consider a few facts about physiology in terms of energy systems. The anaerobic (without oxygen), alactic (without lactate) energy system, more commonly referred to as speed, is best challenged as an athlete approaches maximum or top speed between 30 and 60 meters while running at 95% to 100% of maximum. This high intensity work occurs without the buildup of significant lactate (lactic acid, hydrogen ions and other wastes). This speed component of anaerobic metabolism lasts for approximately six seconds and should be trained when no muscle fatigue is present (usually after 24 to 36 hours of rest or very low intensity work).

Speed is defined as runs at 95% to 100% over 30 to 60 m or six seconds of running at maximum effort.

Background

Sprinting is learned through motor educability. The technique of sprinting must be rehearsed at slow speeds and then transferred to runs at maximum speed. An athlete may run as fast as their technique allows. Sprinting involves moving the body's limbs at the highest possible velocity or speed. The stimulation, excitation and correct firing of the motor units makes it possible for high frequency movements to occur. The whole process is not totally clear but the complex coordination and timing of the motor units and muscles most certainly must be rehearsed at high speeds in order to implant the correct patterns.

Speed is limited by one's technique. An athlete cannot run faster than his or her technique will allow. There is no room for error. Repetition of mistakes means perfection of errors.

Speed = stride frequency X stride length.

Stride frequency is directly related to the number of fast and slow twitch fibers found in the muscle. More specifically, it involves the selective recruitment of motor unit pathways to improve the firing of the correct motor units to give the greatest rate of force production. Sprinters with more fast twitch fibers (primarily in the flexors) have a higher threshold for firing which do not fire under moderate work loads. Speed seems to be far more related to synchronizing and firing the correct motor units than to the high lactate environment using different energy systems.

Stride length can be improved by developing muscular strength, power, strength endurance and proper running technique. Impulse = force X time. In the initial acceleration phase for sprinting, there is a relatively long period of time to develop and apply force to create maximum impulse. The angular velocity of the lower leg is relatively slow and as speed increases, the time, force and impulse decrease ... and the angular velocity increases. Flexibility and a correct warm-up will affect stride length and frequency if not done correctly. Stride length may be optimal for a particular athlete based on their limb segment length.

It is easy to see that developments in speed are highly specific. To summarize: 1) Speed must be done at a level using brief intervals with high angular velocity. This will ultimately bring into play the correct neuromuscular pathways and energy sources used. 2) Skill development (technique) must be pre-learned, rehearsed and perfected before it can be done at brief interval, high speed levels. 3) Flexibility must be developed, maintained and developed year round. 4) Strength developments must be parallel with developments in speed.

Technique

First derivatives

In many European countries today, skill or technique development for speed involves drills of extremely rapid movements with a series of sensations where the legs are in exact symmetry. Athletes rehearse every conceivable sensation at high velocity. Drills designed to focus on the exact components of high velocity running are known as first derivatives.

While experimenting with different levels of intensity at high speeds athletes learn to relax, change gear and perfect technique. Remember, any change in technique is a change which will affect one's speed. It has been my observation of Eastern European athletes that first derivatives are done best when the recovery foot is pulled through above the driving knee. A loose quad will allow this to happen, which will ultimately increase the angular velocity of the whole lower leg. It is also obvious that runs at top speed come through the ankles. Simply, how fast can you move your feet and ankles?

Examples of first derivatives are:

Runs downhill or with the wind at high velocity.

Many European countries have indoor training areas which have movable surfaces which can be elevated to a 3–5% incline to allow the athletes to run virtually downhill at whatever angle they wish.

The USSR has a computerized pully system which pulls athletes at whatever speed they choose year round.

Second derivatives

Basically, sprinting involves falling forward and recovering. To develop the correct stride length and maximizeone's frequency requires a series of basic drills which can isolate and combine a joint(s) to the specificity of sprinting at high velocity. These basic or general drills are called second derivatives.

To begin, carefully examine the diagrams of the A and B exercises (**Figure 1**). They involve three forms: walking (marching), skipping and running (sprinting).

Sprinting involves learning through kinesthesis— teaching the body to feel certain sensations. The learning and perfection of technique must be done correctly. Doing technique incorrectly means perfection of errors. Therefore, stop if this happens. To make corrections of poor technique may take months or even years.

A's, or high knee lift drills, begin with one leg. Stress the actions of: a high knee lift, hips tall, cocked ankle, arm alignment in front of the body, active ankle landing and staying stretched tall. The arm action should be a punching action from the hip to shoulder height. Once one leg has been perfected, do the other leg and then alternate legs. After the basic walking (marching) drills, progress to skipping and then running on the spot. A coach may choose to walk (slowly) beside the athletes while they perform these drills in order to encourage, instruct and evaluate technique. **B's**, or leg extensions, follow the same learning sequence. Avoid B's in the running form. Combinations of A's and B's can be done with each leg doing an A or B exercise.

Remember, an athlete can only run as fast as his or her technique allows. If two athletes are equal, the one who makes the least mistakes will come out ahead. In addition, poor technique will lead to poor body position, slower turnover, over striding, collapsed hips, braking and tension. An athlete is only as strong as his weakest link!

The warm-up

To meet the needs of our training group we have four different warm-up series . . . each with a definite purpose and sequence. Too often, warm-up procedures are non-structured, non-specific and lack in rehearsing the specifics of one's event. If repetition is the mother of learning, then warming up must follow similarly to prevent injuries. Warming up basically reduces the number of muscles that may become injured or strained. Furthermore, poor flexibility brings about injury, excessive tension in muscles, loss of leg velocity and loss of muscle looseness necessary for maximum speed runs. A properly designed and sequenced warm-up has a direct correlation with the results an athlete wishes to achieve at top speed.

Three laws of training apply to flexibility: 1) specificity—exercises must focus on the joint(s) action and event demands. 2) overload—gains in flexibility occur when the limits of existing range of movement are reached regularly, allowing new limits to be set. 3) *reversibility—improvements in* flexibility will be lost if regular work is not maintained. An elite athlete may deteriorate after three days if some form of flexibility is not done. Because the body is built for speed and to do work, it becomes evident that no use means a loss of flexibility and possible injury.

For simplicity, the warm-up used for a speed session will be broken into two parts:

Part 1 (20–30 minutes maximum) Do in flats:

This initial series of exercises involves 'kinetic' flexibility (also called ballistic, bouncing, dynamic) using repeated movements through a range of motion at a joint(s) by applying momentum (swing, bouncing, flexing actions). All joints are worked gradually and easily. Kinesthesis combines the technical skills of sprinting with the correct neuromuscular patterns necessary to stimulate the complexities of the flexors and extensors associated with high velocity running. No static flexibility (holding, PNF) is done before maximum velocity runs, although a great deal of this type of work has been done in the *lead up and even pre-competition series*. Basically, Part 1 involves an 800–200 m jog followed by: 3 X 50–100m (easy jog); upper body kinetic flexibility (shoulder rotations, arm circles, hip circles; 3 X 50–100m (increase tempo of jog); lower body kinetic flexibility (ankle stretches, toe touching, bum kicks, A's, B's knee lifts to front and side, swinging leg drills to front and side of body, lots of leg shaking between exercises.)

Part 2 (30–40 minutes) Do in spikes.

This second part of the warm-up is extremely specific to high velocity running (First derivative): 2 X 40 gradual acceleration with a walk back for recovery; 2 X 50m as follows: falling start and gradual acceleration for 20m; after 20m stress fast frequency, fast feet, short arm action for *next 30m; 2 X 20m stressing fast frequency*, fast feet, fast hand (no emphasis on stride length or tension of any form in runs); 2–3 X 60m as follows: falling start and gradual acceleration for 30m followed by 30m of fast frequency, fast feet and hands; and good recovery between repetitions (5–8 minutes) and 20 minute break before racing.

To conclude, during major competitions, athletes should warm up by themselves with no distractions. The rehearsal done in the warm-up is critical in the total puzzle of developing maximum speed.

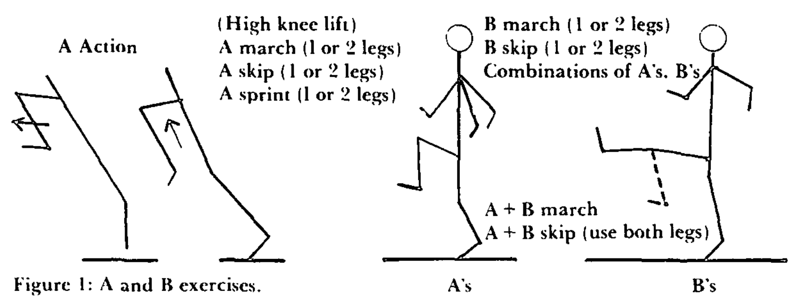

Figure 1: A and B exercises.

Developing Speed

Strength

One of the problems facing us in interpreting and using various forms of strength training is the lack of common and accurate terminology. Strength is the ability of a muscle to exert force (tension) against a resistance. Strength gains result from using a resistance. Three types of strength need to be defined more specifically.

Gross or maximum strength is closely related to isometric contractions, as it involves optimal muscle tension at very low velocity. It is best developed by loading between 90% (sub max) and 100% (max) doing a small number of reps (1–5) and 3–5 sets with a varied recovery of 2–5 minutes.

Power (explosive, fast, elastic) strength is the maximum force a muscle can exert over a short period of time (less than 10 seconds or less than 10 reps) while producing muscle force under conditions of speed. It is best developed by loading between 75% and 90% maximum, doing 6–8 (10) reps with 3–4 sets and 1–3 minutes recovery.

Strength endurance is the ability of a muscle to maintain its contractile force over a period of time (more than 10 seconds or more than 10 reps). It is best developed by loading between 50% to 75% of maximum, doing 12–24 (or more) reps with 3–4 sets and varied recovery of 45 to 90 seconds.

Basically, strength gains result from using a resistance in one of the following methods:

1. Using body weight as a resistance (circuit or stage training using basic exercises such as push-ups, sit-ups, squats, chinnies);
2. Using ones own falling body weight as a resistance (depth jumping, hurdle hops, bounding) (known as special strength or plyometrics);
3. Using weight as a resistance;
4. Using weighted objects while simulating specific skills (weight vest, weighted shoes, sandbags, medicine balls); and
5. Mechanical devices used as a resistance to specific movements (cables, accelerator, harness, computerized pully).

All strength programs should first be designed to prevent injuries and then to develop strength and speed. Obviously, increases in strength will ultimately assist in a longer stride length, more ankle drive, a stronger pillar (abdomen and back) to absorb lines of force, and less chance of injuries. Whatever method of strength a coach uses, it must be designed with developing speed in mind. Without getting into the complexities of strength training and its endless ramifications, I would like to make a few basic suggestions with regard to developing speed in line with strength.

Pillar

The area of the abdomen and back should be one of the major concerns in the development of speed. All forces go through this area and if it is not strong, technical problems will immediately become evident. Running tall requires the pillar to support the upper body in a way that the attachments (arms and legs) can work together without rotations, collapsing, overstriding, hips dropping and non-active foot placement. Our training cycles involve thousands of abdomen and back exercises using strength endurance (e.g. 5,000 sit-ups in one session).

Ankle

Runs at top speed go through the ankles. The ankle is a major area for strength concern. Injuries to the achilles, calf, feet and ankle joint itself can put an athlete out for a season. By using strength endurance and exercises such as ankle hops, toe raises at different angles, walking on toes,

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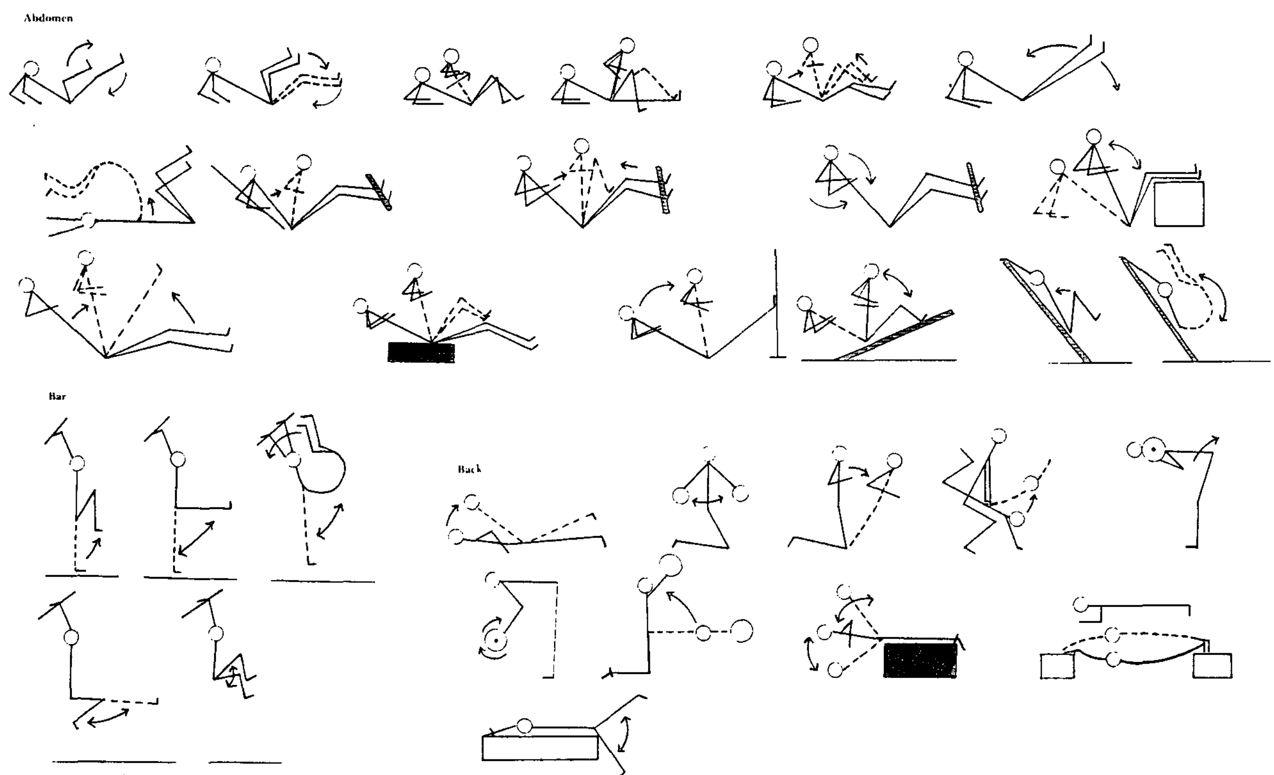
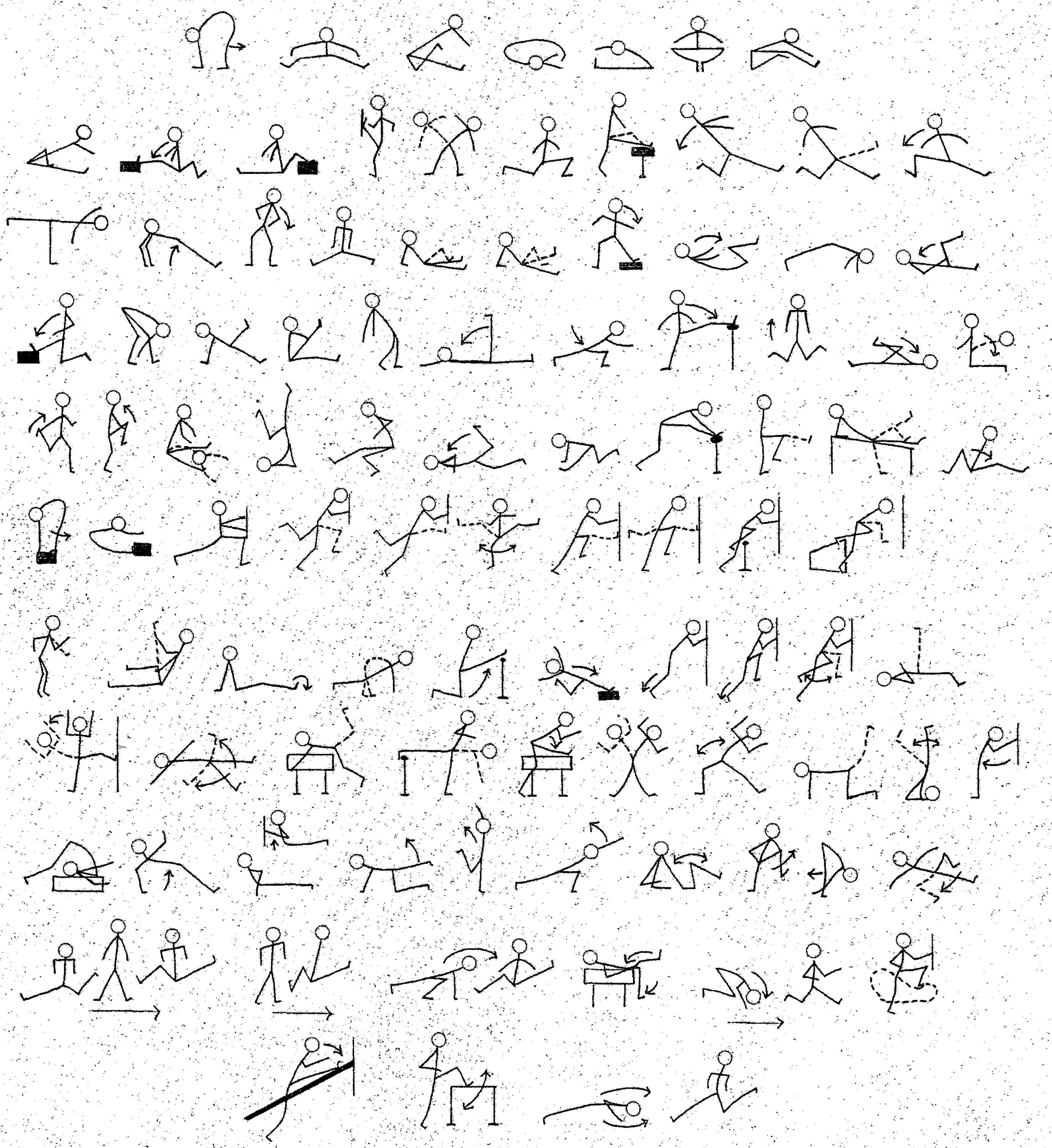


Strength exercises

99 Flexibility Exercises



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toe in, toe out walks, cable work and eventually work over hurdles (hops, jumps), depth jumping and bounding, many potential problem areas are eliminated. Wear leg (ankle) warmers for this work.

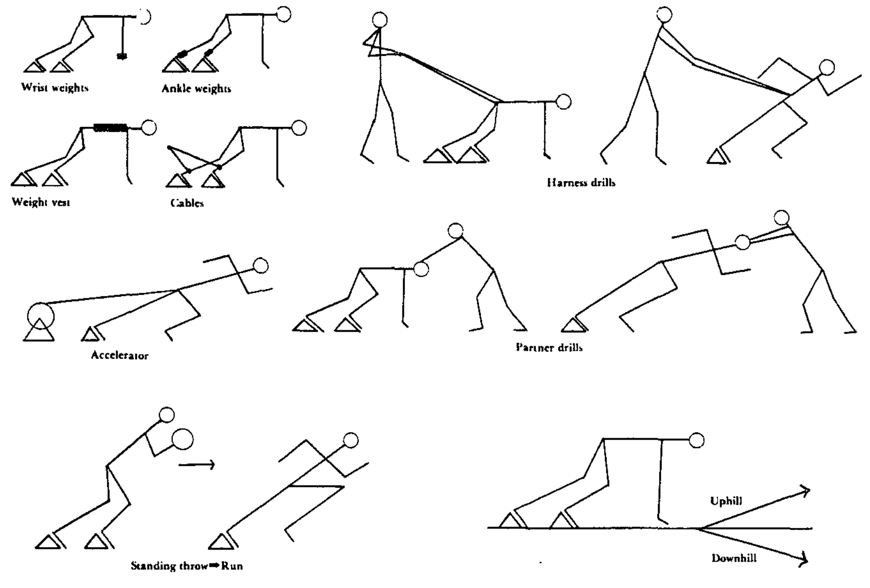
A's

Running knee lifts (A's) are universally accepted as a method to develop technique under power (speed) and strength endurance conditions. For power, A's are done in the running form for 10 to 20 meters with anything over 20 meters being strength endurance. We have done up 300 meters of running A's in one session. The technical and strength components of this drill cannot be expressed enough in the development of speed variables.

Devices

Today, many new and creative devices have hit the market. John Mumford, Canada's national sprint coach, has developed an "Accelerator," a device which is attached to an athlete's waist and connected to a wheel with varying tensions. After runs of 30–100m using the accelerator, the resistance is removed and improvements in stride frequency, technique, foot placement and running times are evident. Similar type work can be done with a restraining belt or harness. Work with trampoline cables has a similar effect when used to do A's and then runs over 30–50 meters.

Resistance exercises



Distance	Work outs 1		2		3		4		5		6	
30	3x30	90	4x30	120	5x30	150	2(3x30)	180	2(4x30)	240	2(5x30)	300
40	3x40	120	4x40	160	5x40	200	2(3x40)	240	2(4x40)	320	2(5x40)	400
50	3x50	150	4x50	200	5x50	250	2(3x50)	300	2(4x50)	400	2(5x50)	500
60	3x60	180	4x60	240	5x60	300	2(3x60)	360	2(4x60)	480		
30-40	2x30 1x40	100	3x30 2x40	170	4x30 3x40	240	5x30 4x40	310	2(3x30) 2x40	200	2(4x30)+ 3x40	360
40-50	2x40 1x50	130	3x40 2x50	220	4x40 3x50	310	5x40 4x50	400	2(3x40) 2x50	340	2(4x40)+ 3x50	470
50-60	2x50 1x60	160	3x50 2x60	270	4x50 3x60	380	5x50 4x60	490	2(3x50) 2x60	420		
20-30-40	2(20) 30,40)	180	2(20, 30) 3x40	220	2x20 3(30,40)	250	3(20, 30,40)	280	3(20,30) 4x40	310	3x20 4(30,40)	340
30-40-50	2(30, 40,50)	240	2(30,40) 3x50	290	2x30 3(40,50)	330	3(30, 40,50)	360	3(30,40) 4x50	410	3x30 4(40,50)	450
40-50-60	2(40, 50,60)	300	2(40,50) 3x60	360	2x40 3(50,60)	410	3(40, 50,60)	450	3(40,50) 4x50	470		

Total distance in a workout

Table 1: Sample table for loading and sequencing speed.

Weighted objects

Runs using a weight vest, weight belt, weight shoes or sandbags are not new. Runs with and without these resistances seem to have a positive effect on speed development.

Training

It is very questionable whether training does affect the energy system involved, namely the anaerobic, alactic. Again, as mentioned, speed seems to be more related to the recruitment and firing of fast twitch fibers. The secret to speed may lie in the central nervous system. However, the basic sequencing of loads and correct overloading methods on the body seem to have a very positive influence on speed development. The computer age has brought with it a more in depth scientific pool of knowledge to be used by the coach. For some time progressive loading tables have been used to produce maximum runs using speed. **Table 1** is a sample table for loading and sequencing speed.

Submaximum speed work (90–95%) involving slower runs and more technique emphasis can be done over the same distances, but remember, the recruitment and firing of motor units will not be at the same magnitude. The technical ability of a runner dictates his or her running speed. Components of speed are done year-round with maximum intensity being reached in the major competition phase.

For speed to be maximized, recovery is critical. Usually after 24 to 36 hours rest can ones best results be achieved. Recovery may be in the form of rest or tempo (easy jogging over 100–300m) or a flexibility session. It may involve flushing out the muscles with the use of an electrical stimulator or by using hydrotherapy (water) or a simple massage. Recovery weeks in one's program are also critical. Three-week mini-cycles or 10-day cycles with built in recovery days or even weeks are used. By alternating hard and easy days in a cycle, adequate rest is given to athletes in speed-related events. The day (or two) before a major event are usually recovery days. The system must be cleared out or cooled out before a major athletic event. Any fatigue present will affect results.

Conclusion

The systematic teaching, control and sequencing of speed components from general to specific, from basic to fine details and from the acceleration phase to maximum running speeds should always keep in mind a design to prevent injuries. As a coach, your job is to understand the application and effectiveness of speed to develop each athlete's potential. The quest for knowledge is a journey, not a destination.●