The General Preparation Phase of a College 100 meter Sprinter

A brief analysis and training program

Introduction

Sprinting is an activity that depends on the coordination of both nerves and muscles, and on the ability of the central nervous system to eliminate as many braking and friction movements as possible. Mechanically, sprinting is not a complex skill. Neurologically speaking, sprinting is complex sequence of firing by motor neurons to activate the muscles to move the human lever system in order to effectively apply force. A sprinter's performance is mainly determined by the force and speed with which muscles can contract and relax and, because of the cyclic motion, the correct timing of the change from contraction (force application) to relaxation. (USATF 1999, Schmolinsky 1983, Pfaff 2001).

This paper will focus on a 12 week general preparation phase (also known as pre-season, fall training, etc.) for a 100 meter sprinter. The program is targeted for a Division-I college level. The program is based on the assumption that the athlete is starting with some form of fitness before beginning the program (i.e. running, soccer, basketball) in other words, the athlete is assumed to NOT be totally untrained. Due to the volume of information needed to explain a complete general preparation program, some information will be given but not explained. Such as the weight training program (an entirely separate paper), warm-ups and sprint drills, specific plyometric exercises, specific general strength exercise, specific medicine ball exercises, etc. Before elaborating on the 12 week program the requirements (performance, biomechanical, and athlete characteristics) of the 100 meter sprint need to be defined.

Performance factors in sprinting

The sprinter's goal is to develop the highest possible horizontal velocity. For elite sprinters, this velocity is developed over the course of 43-46 strides (men) and 47-52 strides (women) that makes up the 100m race. A stride consists of a support and a recovery phase. The sprinter's horizontal propulsion is only produced during the support phase. The support leg applies force against the ground in a backward-downward direction (the "action") and the ground "reaction" results in the horizontal propulsion in a forward-upward direction.

There is only a little time available for the sprinter to apply force during the support phase. At the point of maximum velocity, the foot is only on the ground 0.08-0.09 s during the support phase. Thus, the sprinter must be able to effectively apply force during this short time period to maintain horizontal velocity. This alone highlights the necessity of sprinters having the ability to apply large amounts of force in a very short time period (i.e. be powerful).

Mathematically, sprinting velocity is the product of stride length and stride frequency. These two factors interact in the 100 meters: after they have reached a certain point following a phase of mutually increasing (within the first 50m) an increase in either parameter will result in a corresponding decrease in the other (i.e. if the sprinter increases his stride length after 50m then the stride rate must decrease and vice versa). This point in the race depends on many factors (body type, power production, training status, fatigue level, etc.) and is individual to each athlete. So there is an optimal stride length and frequency for each athlete.

Biomechanical factors in the 100m sprint

Each sprint is fundamentally divided into different phases:

1. The reaction phase at the start
2. The acceleration phase (increase in speed)
3. The phase of maximum speed (constant speed)
4. The deceleration phase (decreasing speed)
5. The finish

During the reaction phase the sprinter uses the resistance of the starting blocks to initially accelerate from a complete rest position. An explosive force production of the legs in a very short time is vital for a successful start. After the start signal the sprinter must develop horizontal forces reaching up to 1.5 times body weight in less than 0.4 seconds. The reaction time (the time between the start signal to the first movement of the sprinter) is of relatively small importance to the overall result (relative to the other phases of the race). Average reaction time values for elite sprinters range from 0.12-0.18 s which constitutes only 1-2% of the total 100m time (the percentage is even smaller for slower sprinters). However, the desired psychological advantage at the start can last through to the finish.

After leaving the starting blocks the sprinter increases his running speed in the acceleration phase by continually increasing stride length and stride frequency. This segment begins with the full block clearance and concludes when there is no further positive change in velocity. Depending on the level of the sprinter this segment occurs from approximately 2 meters to 25-50 meters. The greater velocity developed by the sprinter, the longer the acceleration phase. Although, maximum velocity is usually realized within 4-5 seconds after the start, regardless of the maximum velocity generated. During this phase men achieve stride frequencies of up to 4.6 strides per second and women reach 4.8 strides per second. The length of the acceleration phase increases at higher performance levels and this is the most important phase for the race performance. Top sprinters reach their maximum speed after about 45-60m (men) and 40-50m (women).

In the phase of maximum velocity (at 50-80m) the sprinters cover a distance of 20-30m at their highest speed. This segment begins when there is no further positive change in velocity and concludes when a negative change in velocity begins. This is where the maximum speeds of 12 m/s (men) and 11 m/s (women) are achieved. Stride length and stride frequency vary among sprinters and each will have an optimal ratio for maximum velocity. This is also the phase where the ground contact times are the shortest.

The final 10-20m constitute the deceleration phase. This phase begins when a negative change in velocity is seen and ends two to four strides before the finish line. The length of this segment is dependent on the length of the acceleration and maximum velocity segment. Fatigue, especially of the nervous system, leads to a decreased stride frequency which the sprinter attempts to compensate by increasing stride length. Some sprinters appear to get faster at the end of the race but this is only an illusion resulting from varying rates of fatigue of the other athletes.

The finish (the final 2 - 4 strides) is the decisive stage of the race especially between sprinters with minimal differences in ability. Competition rules state that the clock stops when the trunk of the body passes the finish line. A strong forward lean is an advantage to the sprinter. This can be achieved by flexing the hips while simultaneously swinging back the arms. See Table I for a summary of important biomechanical factors for the 100m sprint (Pfaff 2001, Seagrave et al., Schmolinsky 1983, IAF Biomechanical Research Project 1997, Dyson 1977).

Table I: Important biomechanical data for the 100m sprint*

100m	Men	Women
World Record	9.79 s	10.49 s
Reaction time at the start	0.12-0.16 s	0.12-0.18 s
Duration of acceleration	45-60m	40-50m
Maximum speed	12m/s	11m/s
Average speed	10.21m/s	9.53m/s
Position of maximum speed	45-60m	40-50m
Stride length	2.15-2.27m	1.90-2.10m
Stride frequency (strides/s)	4.40-4.58m	4.20-4.80m
Number of strides/100m	43-46	47-52

*modified from IAF Biomechanics Research Project (1997)

Athlete characteristics

Coordination - the skill of sprinting at very high rates of movement requires great coordination (i.e. nervous system control). This is often overlooked in many training programs and is probably the most critical aspect for effective sprinting.

Speed - this is obviously an important factor. Speed is closely tied to coordination (nervous system again), the ability to move the limbs at high velocities and express power through those movements to propel the body down the track at high velocities.

Strength/Power - sprinters must overcome their own inertia as quickly as possible, development of the ability to produce large amounts of power with the muscles involved is absolutely necessary.

Flexibility - good sprinters possess a high degree of flexibility in the hips and ankles. Increased flexibility allows for less muscle resistance through any given range of motion.

Reaction Time - a short reaction time is a must for an event that is over in 10 - 12 seconds. All elite sprinters have short reactions times (0.12-0.19 seconds) (Schmolinsky 1983, Bowerman et al. 1991, Bellotti, Pfaff 2001).

For the sprint events, Torim (1988) identifies physical performance capacities and their importance rank for the sprints (see Table II). This table gives an accurate description of the demands of the 100m sprint. Maximal speed (i.e. velocity in m/s) is the most important factor. A high maximal speed is essential and without it the other components don't matter as other, faster, athletes will win the race. Acceleration (m/s^2) is the second most important because the slowest segment of the 100m is the first 30m out of the blocks. The athlete's ability to overcome inertia and accelerate the body results in a faster acceleration phase which covers more distance and, consequently, reduces the overall 100m time. Reaction time is also important, time is lost in the period between the firing of the gun and the initiation of movement by the athlete. Specific endurance can be defined as endurance specific to the 100m event. This takes the form of runs of 50-200m with varying recoveries. General endurance can be defined as runs over 200m up to long jogs/runs. Development of these five characteristics, and considering the skill component of sprinting in the 100m sprinter is how a training program should be based (Torim 1988, Schmolinsky 1983, Pfaff 2001).

Table II: Physical performance capacities and importance rank for the sprints. (1 = most important)*

Capacity	100m	200m	400m
Reaction speed	3	4	4-5
Acceleration	2	3	3
Maximal speed	1	1-2	2
Speed endurance	4	1-2	1
General endurance	5	5	4-5

*from: Torim (1988)

From the above event parameters a training program should be directed toward the development of power, maximal speed, and short-term speed endurance (i.e. anaerobic capacity) in the 100 meter sprinter.

The athlete needs to run workouts that allow him to experience running fast in order to learn how to coordinate his limbs at those velocities. He also needs to learn the correct technique of sprinting so he can exert the maximum amount of force in a short amount of time while minimizing errors in technique that may slow the sprinter. In other words, the sprinter must "run fast to run fast". Workouts over 20 - 200 meters are the typical range for this type of training.

The athlete also needs to be able to tolerate increased H^+ ion concentration in the muscle in order to coordinate and maintain technique at high velocities. There are many combinations of workouts that achieve this kind of stress (and consequently adaptation) but they usually take the form of repeat 200 - 400 meter runs (Pfaff 2001, Bowerman et al. 1991, Schmolinsky 1983, Bellotti).

Periodization

The 12 week program is given on pages 10-12 and the explanation of the terms used is given below. The 12 week period is defined as the General Preparation phase. The General Preparation phase is broken down into 3 mesocycles (Mesocycle I - September, Mesocycle II - October, and Mesocycle III - November). Each mesocycle is split into 4 weekly microcycles with 3 weeks of conditioning and 1 week of recovery/testing. Types of training desired in any given week include: 1 day of acceleration/speed development (usually Monday), 1-2 days of speed endurance (usually Wednesday and/or Saturday), 1 day of power training (usually Friday), 2 days of strength and/or plyometric work (usually Tuesday and Thursday), and most importantly, 1 day of active rest (Sunday).

Explanation of program terms:

Workouts are stated in the following format -

repetitions x distance @ intensity (given as % of 100m race pace) w/ rest intervals (i.e. 5x100m @ 90% w/ 3' rec.)

WU: (Warm-up) consists of a 600m jog, stretching, dynamic flexibility, and about 200m total of sprint drills.

CD: (Cool-down) consists of walking or light jogging and stretching.

Weights: weight-room sessions of mainly Olympic lifts. The weight training program would be a whole separate paper and will not be discussed here. However, the athlete can be assumed to be working on Olympic lifts (M,W,F) to increase power production and supplementary lifts (T,Th,Sa) the increase strength.

Jump: refers to some form of plyometrics. A jump circuit is a series of 8-10 different jumps, each one done for the specified amount of time. Jump tech is a series of four exercises performed into the sand pit, each are measured for distance and recorded to chart improvement over the course of the season. Jump hurdle hops is simply a number of hurdles set close to each other and the athlete hops over each one (two-footed). Jump bounds is a series of bounds on grass. All of these plyometrics work on the explosive power of the sprinter. The goal with these plyometrics is to develop the ability to apply force in a short amount of time (remember, ground contact times in the 100m sprint are very short).

Examples:
Jump circuit - Lunge jumps, Tuck jumps, Lateral squat jumps, Straddle jumps

Jump tech - Standing long jump, Standing triple jump, 3 double leg bounds, Left-Left-Right-Right.
Jump hurdle hops - 10 hurdles lined up.
Jump bounds - Straight leg bounds, Bent leg bounds, L-L-R-R bounds.

GS: (General Strength) consists of a few different series of body-weight exercises. This type of circuit is done to strengthen areas of the body not always hit with weight training.

Examples:
V-sits, Back hyperextension, Pushups, Situps, Single leg squats, etc.

Hurdle Mobility: a series of hurdle drills done to improve flexibility, strength and coordination.

Examples: Hurdle walkovers, Hurdle walkover skips, Lateral alternate lead leg skips (straight and bent leg), etc.

Throw: a series of throws with a medicine ball or, when in a testing phase, a metal shot. Done to improve strength while completing a movement (i.e. resistance during a twisting movement, etc.)

Hills: Runs up a short, relatively steep hill to improve the athletes ability to produce power while running and increase leg strength.

Testing: occurs during rest weeks. These weeks are used to quantify improvement as the season progresses and to give the athlete rest in order to compensate and prepare for the next mesocycle.

Examples:
1-RM testing of the Olympic lifts in the weight room
Time trials over a specified distance
Jumps and or Throws for distance.

General Preparation
Mesocycle I - September - 3 weeks
Weekly Microcycle

Monday: (Intensity = Hard)
1. WU 2. 5x20m, 5x30m, 5x40m @ 90-95% w/ 1' + 3' rec.
3. Jump - circuit x 1 (30"on, 60"off) 4. Weights 5. CD

Tuesday: (Intensity = Easy)
1. WU 2. Jump - tech x 3 3. GS - circuit x 2 (25"on, 60"off)
4. Hurdle Mobility - 3x10 hurdles 5. Weights 6. CD

Wednesday: (Intensity = Hard)
1. WU 2. 3x350m @ 75% w/ 3' rec.
3. Throw - MB 3x10 4. Weights 5. CD

Thursday: (Intensity = Easy)
1. WU 2. Jump - tech x 1 3. GS - circuit x 2 as Tuesday
4. Hurdle Mobility - 3x10 hurdles 5. Weights 6. CD

Friday: (Intensity = Moderate)
1. WU 2. Hills - 3x5x40m @ your pace w/ walk back rec. and 3' b/w sets.
3. Jump - circuit x 1 (30"on, 60"off) 4. Weights 5. CD

Saturday: (Intensity = Hard)
1. WU 2. Week 1 - 5x250m @ 75-80%, Week 2 - 6x200m @ 80%, Week 3 - 8x150m @ 80-85% w/ 2' rec. (all 3 weeks) 3. Throw - MB 2x10 4. Weights 5. CD

Sunday: (Intensity = Easy)
Active Rest

Recovery Week - September

Monday: (Intensity = Moderate)
1. WU 2. 8-10x30m @ your pace w/ full rec. 3. Throw - Testing (measure for distance). 4. Weights - Testing 5. CD

Tuesday: (Intensity = Easy)
1. WU 2. Jump - 3x10 hurdle hops 3. Weights - Testing 4. CD

Wednesday: (Intensity = Easy)
Active Rest

Thursday: (Intensity = Hard)
1. WU 2. 5x50m build-ups 3. Test - 300m time trial 4. Weights - Testing 5. CD

Friday: (Intensity = Moderate)
1. WU 2. 8-10x30m as Monday 3. Weights - Testing 4. CD

Saturday: (Intensity = Easy)
Complete Rest

Sunday: (Intensity = Easy)
Active Rest

General Preparation
Mesocycle II - October - 3 weeks
Weekly Microcycle

Monday: (Intensity = Hard)
1. WU 2. 4-5x30,40,50m ladder @ 90-95% w/ walk back rec. and 3' b/w sets
3. Jump - 2x30-40m bounds 4. Weights 5. CD

Tuesday: (Intensity = Easy)
1. WU 2. GS - circuit 2x10 3. Throw - MB 1x10
4. Hurdle Mobility 3-4x5 hurdles 5. Weights 6. CD

Wednesday: (Intensity = Hard)
1. WU 2. 8-10x100m build-ups w/ 3'-5' rec 3. Throw - MB 1x5 4. Weights
5. CD

Thursday: (Intensity = Easy)
1. WU 2. Jump - 4x50-100m bounds on grass 3. GS - circuit 2x15 4. Weights
5. CD

Friday: (Intensity = Moderate)
1. WU 2. Hills - 3x6x40-50m @ your pace w/ walk back rec. and 3' b/w sets.
3. Jump - tech x 5 4. Weights 5. CD

Saturday: (Intensity = Hard)
1. WU 2. Week 1 - 2x2x250m @ 80-85%, Week 2 - 2x3x200m @ 85%,
Week 3 - 2x4x150 @ 90% w/ 3' + 5' rec. (all 3 weeks) 3. Hurdle Mobility - 2x10 hurdles. 4. Weights 5. CD

Sunday: (Intensity = Easy)
Active Rest

Recovery Week - October

Monday: (Intensity = Moderate)
1. WU 2. 12x30-50m @ your pace w/ full rec. 3. Weights - Testing 4. CD

Tuesday: (Intensity = Moderate)
1. WU 2. Test - 100m standing start 3. Weights - Testing 4. CD

Wednesday: (Intensity = Easy)
Complete Rest

Thursday: (Intensity = Hard)
1. WU 2. Test - 300m time trial 3. Weights - Testing 4. CD

Friday: (Intensity = Moderate)
1. WU 2. 4-6x50m build-ups 3. Jump - Test 4. Weights - Testing 5. CD

Saturday: (Intensity = Easy)
Active Rest

Sunday: (Intensity = Easy)
Complete Rest

General Preparation
Mesocycle III - November - 3 weeks
Weekly Microcycle

Monday: (Intensity = Hard)
1. WU 2. 5x20,30,40m ladder @ 90-100% w/ walk back rec. and 3-4' b/w sets.
3. Jump - 2x10 hurdle hops 4. Weights 5. CD

Tuesday: (Intensity = Easy)
1. WU 2. GS - circuit 2x20 3. Throw - MB 2x10 4. Hurdle Mobility - 1x10 hurdles 5. Weights 6. CD

Wednesday: (Intensity = Hard)
1. WU 2. 3x4x100m build-ups w/ 3' rec. and 5-8' b/w sets.
3. Throw - MB 1x5 4. Weights 5. CD

Thursday: (Intensity = Easy)
1. WU 2. GS - circuit 2x25 3. Throw - MB 1x10 4. Hurdle Mobility - 2x10 hurdles 5. Weights 6. CD

Friday: (Intensity = Moderate)
1. WU 2. Hills - 3x8x40-50m @ your pace w/ walk back rec. and 3' b/w sets.
3. Jump - 8x5 hurdle hops 4. Weights 5. CD

Saturday: (Intensity = Hard)
1. WU 2. Week 1 - 2x2x250m @ 85-90%, Week 2 -2x3x200m @ 90-95%, Week 3 - 2x4x150m @ 90-100% w/ 3'+ 5' rec. (all 3 weeks)
3. Hurdle Mobility - 2x10 hurdles 4. Weights 5. CD

Sunday: (Intensity = Easy)
Active Rest

Recovery Week - November

Monday: (Intensity = Moderate)
1. WU 2. 10-12x20-30m @ your pace w/ full recovery 3. Jump - 5x5 hurdle hops 4. Weights - Testing 5. CD

Tuesday: (Intensity = Easy)
1. WU 2. Jump - tech x 4 3. Weights - Testing 4. CD

Wednesday: (Intensity = Hard)
1. WU 2. Test - 200m time trial 3. GS - circuit x15 4. Hurdle Mobility - 2x10 hurdles 5. CD

Thursday: (Intensity = Easy)
Complete Rest

Friday: (Intensity = Moderate)
1. WU 2. Test - 100m time trial 3. GS - circuit 2x10 4. Hurdle Mobility - 2x10 hurdles 5. CD

Saturday: (Intensity = Easy)
Active Rest

Sunday: (Intensity = Easy)
Complete Rest

Figure I shows a snapshot of the volume (in meters) of running over the first three mesocycles. The volume classified as warm-ups is on a second axis due to the large volume of running/jogging compared with the other categories. As Figure I shows, power and speed/acceleration workouts increase while the volume of speed endurance/H^+ tolerance workouts decreases over the course of three mesocycles (see also Table III). This graph, however, does not show intensity of the workouts. This is important because while the volume may decrease the intensity of the workouts may increase. As you can see from the workout lists, the intensity (% of 100 meter race pace) increases with each mesocycle throughout the 12 weeks.

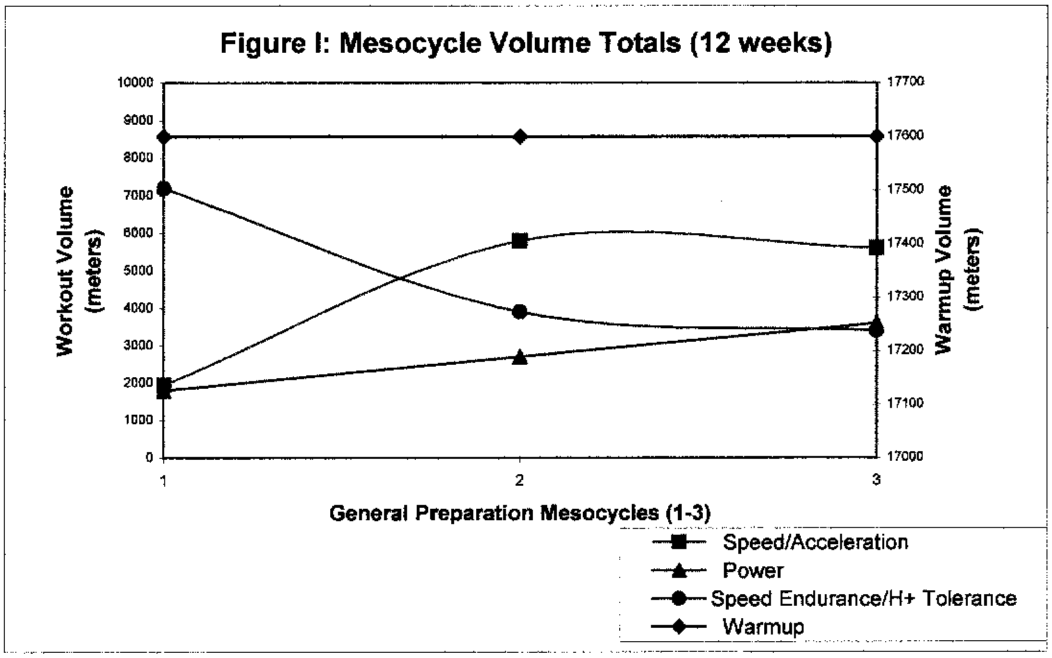

Table III: Volume (in meters) of the General Preparation phase

General Preparation					
	Mesocycle I - September				
	Weekly Microcycle				
	1	2	3	4 - Rest	Totals
Volume (meters): Warm-up Speed/Acceleration Power Speed Endurance/H^- Tolerance Total:	 4800 450 600 2300 8150	 4800 450 600 2300 8150	 4800 450 600 2300 8150	 3200 480-600 0 300 4230-4350	 17600 1830-1950 1800 7200 28430-28550
	Mesocycle II - October				
	Weekly Microcycle				
	1	2	3	4 - Rest	Totals
Volume (meters): Warm-up Speed/Acceleration Power Speed Endurance/H^+ Tolerance Total:	 4800 1280-1600 720-900 1000-1200 7800-8500	 4800 1280-1600 720-900 1000-1200 7800-8500	 4800 1280-1600 720-900 1000-1200 7800-8500	 3200 660-1000 0 300 4160-4500	 17600 4500-5800 2160-2700 3300-3900 27560-30000
	Mesocycle III - November				
	Weekly Microcycle				
	1	2	3	4 - Rest	Totals
Volume (meters): Warm-up Speed/Acceleration Power Speed Endurance/H^+ Tolerance Total:	 4800 1650 960-1200 1000 8410-8650	 4800 1650 960-1200 1200 8410-8650	 4800 1650 960-1200 1200 8410-8650	 3200 500-660 0 0 3700-3860	 17600 5450-5610 2880-3600 3400 28930-29810

Concluding Remarks

This program is geared toward the development of maximal speed and power in a 100 meter sprinter. To make improvements in maximal speed an athlete needs multiple runs at or near maximal speed (Pfaff 2001, Schmolinsky 1983). This is the only time the athlete can learn to apply force correctly to result in a higher maximal velocity (Pfaff

2001). Qualities in the 100 meter sprint that are addressed in this training program are power (Olympic lifts, Hill running, plyometric bounds, etc.), maximal velocity (runs up to 80-100 meters, plyometrics, etc.), acceleration development (20-40 meters), and speed endurance (200-400 meters).

References

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