Introduction to sprinting

by Loren Seagrave

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"The traditional view, that sprinting is a simple, natural and non-technical event is mistaken. It should be regarded as s skill, which has to be learnt and developed.

The system of training called 'Speed Dynamics' was designed with this in view. After a full explanation of the three basic principles of this system, the author goes on to describe the 9 components of a sprint race that need to be developed to achieve success in these events.

A very detailed account is given of the numerous evaluation tests used in the Speed Dynamics system. These are divided into psychological, physiological, technical and tactical sections.

The many different components of the training programme are then detailed, with practical suggestions for the most effective methods of executing them."

Photo: Scuola dello Sport

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1 Introduction

When I was a novice track coach, a wise old sage and veteran coach suggested to me, "work with the sprinters, young man, that is the place to start". When I asked why I was most qualified to coach sprinters, he responded, "Because you don't need to know anything to coach a sprinter, and you're perfect for the job!". "Either they have it or they don't" he said. "Just line'em up and let 'em run".

As the days went by, I learned the hard way that coaching sprinters, or developing speed in any athlete, is one of the most difficult challenges one can meet. Yet, most coaches have traditionally spent precious little time investigating why and how sprinters do what they do. In this presentation, we will explore the intricacies of speed development and provide a practical programme of training that will enhance the performance of any athlete.

2 Importance of speed development

Regardless of the race distance, the single most important performance characteristic is speed. When distance runners cross the finish line, they are not commended for their great aerobic capacity. The hurdler does not earn points for technical merit or grace of execution. What matters most in races of all distances is the **speed** demonstrated to the finish line. Therefore, **every** athlete, regardless of the athletic endeavour, should have a speed development programme.

However, the majority of athletes are never offered a pure speed development training programme by the coach. Why? Of all the factors we can identify which limit performance, the greatest is perhaps the widely accepted belief that "sprinters are born, not made". Many in the athletic community have come to accept the notion that speed is a capacity beyond our reach and control. The truth is that nothing limits the potential for improvement in speed, with the possible exception of this antiquated attitude.

Speed is not a simple matter of leg length, muscle fibre type, race, culture or environment.

While genetic predisposition *will* influence *every* human capability, greatest error one can make is to underestimate the range of potential that exists in every person. Countless case histories confirm the ability of human beings to overcome apparent physical limitations, and achieve levels of performance previously thought to be impossible. While it may be true that you cannot turn a carthorse into a thoroughbred, dramatic improvements of athletic skills and the development of new ones are within the grasp of any performer. We must first, however, embrace the belief that our athletic destiny is not among the stars, it is within ourselves.

If an athlete does not demonstrate obvious sprinting ability at an early age, or on the first day of training, he or she should not necessarily be directed toward some other discipline. Over time, the capacity to run faster can be developed. Here is the simple truth. Speed is not a matter of fate, a question of luck or even a gift of genetics. **Speed is a skill!** Like any skill, it can be learned and developed by those who know how.

3 The speed dynamics philosophy

Speed Dynamics is a name given to a new philosophy of training. This scientific approach to performance optimization is best introduced by identifying the three principles of this training system.

3.1 Training principle 1: Adopt a multi-track plan of training with special emphasis on the neurological system

The traditional approach to the training of sprinters has emphasized only one of the body's physiological systems – the muscular system in the belief that if you make athletes stronger, they will in turn become faster. While the importance of strength and power development should not be underrated, strength gains will not produce a proportional improvement in speed.

Many other components contribute to faster finishing times. The Speed Dynamics approach to sprint training acknowledges the performance impact of more of the body's physiological systems and demands that proper attention be given to many capacities, including:

- Strength and power
- Dynamic mobility
- Flexibility
- Energy system development
- Skill acquisition
- Neuro-muscular refinement.

While the primary training emphasis will change from day to day, some attention will be given regularly to each of these components. However, one specific training target will require emphasis on a daily basis. While all of the above capacities contribute to athletic success, the most critical of them concerns the nervous system.

The neurological system is responsible for initiating every subtle and obvious movement of the human body. It is more than a sophisticated electrical mechanism. It also functions like a computer programme which determines which muscles work, when they fire, at what speed and in what sequence.

The importance of the nervous system to athletic performance can be demonstrated by this simple test:

While seated, tap the toes on both feet as fast as you can. Keeping the heels on the ground, lift the toes up and down as fast as possible for a period of 10 seconds.

Now let us examine some of the sensations of this test. Within 2 seconds of beginning the toe tapping, some discomfort is usually felt on or around the tibia. The muscle pain is a result of the agonist and antagonist muscles of the lower leg both trying to do their respective jobs at the same time. This lack of neuro-muscular co-ordination is the key limiting factor in athletic performance.

Co-Ordination: The ability to turn "on" a muscle as you simultaneously turn "off" the one that opposes it.

Did you notice during the toe tapping test that one foot moved faster than the other? If one side of your body is moving faster than the other, athletic performance will certainly be compromised.

For many test participants, speed of foot slows significantly, or even crawls to a halt, between 7-10 seconds. This symptom of neuro-fatigue is yet another concern for those looking to improve sprint performance.

So what does this test prove? Even if you are strong enough to put your feet through the floor, strength alone will not guarantee a great sprint performance. If the neurological system is not in tune, sprinting becomes a lost cause.

3.2 Training principle 2: Practice makes permanent

We are all familiar with the old cliché "practice makes perfect". In the science of speed development, however, it may be more precise to say "practice makes permanent". This is especially true where the neuro-muscular system is concerned.

The nervous system is designed to execute precisely the commands it receives from the brain. Moreover, it is also capable of executing batch commands. In this way, many intricate, separate movements are combined into an efficient sequence of co-ordinated efforts, which work together as if they were one.

When a particular pattern of movement is initiated by the nervous system and then is regularly repeated, a dynamic stereotype is created. With a dynamic stereotype, we fix the pattern of force in motion permanently.

> Dynamic stereotype: To fix the pattern of force in motion permanently through a process of repeated rehearsals.

We should understand that the neuro-muscular system cannot distinguish between the movement patterns you desire and those you actually rehearse. Therefore, every step we take in training must have a specific purpose and clear objective in mind. When the majority of training efforts are performed at sub-maximal speeds, we inadvertently create a slow, undesirable neuromuscular stereotype. The old sprinting myths of "too much speed will make you stale" or "too much speed will lead to injury" must not guide the planning of contemporary sprint coaches.

Practice makes perfect? Well, only if you practice perfectly! The coach is challenged to provide the athlete with the necessary coaching cues and critical feedback that will assure the repeated rehearsal of the precise movement patterns responsible for great sprinting.

3.3 Training principle 3: Coach with the *Whole-Part-Whole* method of instruction

When a novice track athlete stands at the start of the 100 metres race and gazes towards the finish, it may be difficult to convince him that this race is the shortest distance contested. The finish line can certainly appear to be far, far away. Any new endeavour can be overwhelming, if we attempt to master it all at once.

The Speed Dynamics philosophy has adopted the practice of addressing any new learning experience by reducing the challenge down to small, understandable component parts. Much as we study academics, one chapter at a time, we should also address mastery of new athletic skills in the same way.

Over the course of the sprint race, many significant components can be identified. In order to excel as a sprinter, each component must be mastered individually, then re-assembled to produce a successful race. We have identified 9 components for our study.

Number 1: The warm up

Often overlooked when evaluating the entire scope of the sprint race, the warm up is essential for optimal performance and injury prevention. However, the warm up should not be considered merely as a means of preparing for training – it is itself a training unit.

Number 2: The start

The start is a series of complicated motor skills, which when executed properly, produce force, thus allowing the athlete to overcome inertia and begin acceleration. Often occurring in less than one second, the start includes reaction time, force application and the first two running steps.

Number 3: Pure acceleration

The pure acceleration phase is the first of two links between the initial movement of the start and maximum velocity sprinting. The initial 8-10 strides represent this phase.

Number 4: Transition

The transition phase completes the link to maximum speed sprinting. It must be differentiated from pure acceleration because of gradual and subtle mechanical changes in the running stride. This phase typically lasts for 7 strides.

Number 5: Maximum velocity

The phase of maximum velocity is the heart of the sprint race (*Figure 1*). It is characterized by the optimal stride frequency and stride length. Usually achieved after 4-5 seconds of maximum effort, this component has a duration often as short as 2-3 seconds. Accomplished performers look to enter this phase at or about 40 metres into the sprint race.

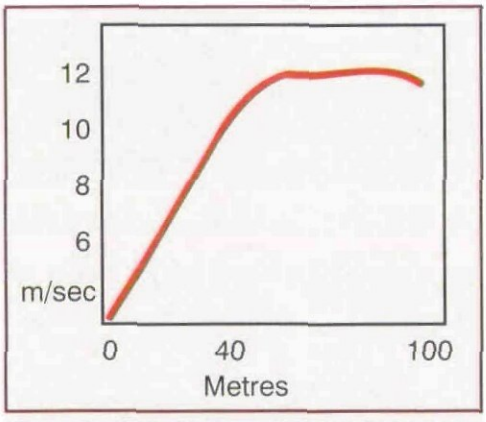

Figure 1: Velocity curve 100 metres sprint

Number 6: Speed maintenance

This phase is identified by a gradual decline in velocity, due to various elements of fatigue. This

component is characterized by a decrease in stride frequency and an increase in stride length.

Number 7: The finish

Many races have been lost or qualifying standards just missed because of a poor finishing technique.

Number 8: Coast and stop

All too often athletes turn off their concentration as they cross the finish line, allowing abrupt breaking forces to be absorbed by the legs. Proper coast and stop techniques are essential in preventing post race trauma.

Number 9: Restoration and recovery

Few sprinters have the luxury of performing in a single race in one competition. They may, in fact, be required to run as many as ten races in two days. Bringing the body's physiological systems back to the basal level quickly and effectively prepares the athlete for either the next race or tomorrow's training session.

In the chapters that follow, we will address each of the above described components in much greater detail.

4 Testing and evaluation

Today's medical practitioners recognize thousands of different ailments which confront their patients. Just as the physician examines each patient, in order to attend properly to the individual needs, so must coaches explore the personal capacities of each athlete under their charge. Only then can an appropriate training programme be prescribed to address the unique strengths and weaknesses of each individual athlete.

Sadly, many coaches offer only one master training plan for all of their sprinters to follow. Certainly some commonalities will be found, when the training programmes of sprinters are compared. However, only by respecting and addressing the unique qualities and objectives of each athlete can we achieve the highest level of performance.

Training can begin and for that matter, before the training programme can be composed, we need to "test for success". A complete examination of each individual athlete will provide the coach with the information necessary to make proper decisions concerning all aspects of the coach - athlete relationship. We will introduce tests that will explore each of the following categories:

- Psychological
- Physiological
- Technical
- Tactical.

Imagine testing a young prospect and assessing that the potential exists for record shattering performances by this athlete. We should understand that, even if you create a practically perfect training programme to meet the physiological potential of the performer, nothing will be accomplished, if the athlete's goals do not line up with those of the coach. If you want your athlete to win a national championship, but your athlete is just looking for a better fit on her bikini, then the conflicting objectives will make for a difficult and unsuccessful relationship.

4.1 Psychological evaluation

The evaluation process should begin with an athlete's questionnaire. A written survey will identify many critically important factors which will influence training plans and event selection. The questionnaire should include sections which explore relevant statistical, personal, medical and volitional data. This procedure is appropriate, not only for the new additions to a team, but the veteran performers as well. Coaches must be appraised of the changes that have occurred in the body, mind and environment of their performers. By understanding the unique circumstances surrounding the person, not just the performer, we are able to match the most appropriate training methods to the individual needs.

4.1.1 Statistical data

The survey process begins with questions such as name, address and telephone number. What is the date of birth, grade point average, and college board scores of the athlete? What course of study are they enrolled in? How many hours is the student-athlete taking in class?

It is also helpful to note the shoe size and uniform requirements in this section. With a master list of this information on hand, emergency equipment problems will disappear.

One of the most important inquiries concerns the determination of Training Age, i.e. athletic experience expressed in years.

> Training age: A measurement of athletic experience, expressed in years.

Training age is determined by totalling the amount of time spent in a structured athletic programme. The athlete who participates in sport for only three months per year, over a total of 4 seasons, has a training age of one year. Though a 4 year veteran, a training age of 1 year suggests that the performer is still in athletic infancy. This important characteristic should have a great influence on the training loads prescribed for the performer.

4.1.2 Personal data

This section of the questionnaire examines the home environment, family influences, personal achievements and employment status of the individual. Are both parents living? If so, do they both work? Does the performer live in a single parent home or with grandparents? How many brothers and sisters does the athlete have? What are their ages? Are any of the siblings athletes? Are the parents experienced in athletics? Does the performer have a nickname? Is the athlete a member of any club or organization?

For the mature athlete, we also determine marital status. It is importance to discover if the performer has a full or part time job. The type of work is also important. The recovery needs of an office worker, as opposed to a tradesman, are obviously quite different and would influence training differently.

We will also explore the other areas of the athlete's life that have provided an opportunity for success. Has the athlete earned any awards for academics, art, drama or sport? It is important to give the performers the opportunity to share with you the other achievements in their life. This data also serves to identify the intangible qualities they may possess, such as determination, dedication, persistence and loyalty, which may be carried over to their athletics career.

4.1.3 Medical data

A complete medical history should be included in the questionnaire, giving the attending physician's name, date of last examination, any prescribed medications and allergies. Any injuries, especially those suffered in athletics, should be documented with the diagnosis, therapy and current status listed.

Of course, this line of questioning does not substitute for a complete medical examination. Instead, it is meant to indicate areas of concern, which the coach can then address.

4.1.4 Volitional data

Volition is defined as "the act or power of the will". In this section we attempt to discover the motivation, tolerance and objectives of the performer.

It is best to begin this section by simply asking, "why are you here?" The wide range of responses to this question may surprise you. Some athletes participate because they are looking to earn a scholarship. Some are attracted to the comradeship of a team environment. Others may be compelled to participate due to pressure from parents and friends. They may have joined the squad simply out of love for the game or to improve their fitness. And of course, there are always those few who really are not sure why they have signed up! Perhaps they stumbled into your door by chance or out of curiosity.

Novice performers who are unconvinced of their athletic potential will demand a special rapport with the coach. The athletic infancy of the rookie will require not only reduced training loads, but special encouragement as well. The experienced performer, with Olympic aspirations, will likely have a very different relationship with the coach, as well as significantly more challenging work loads.

As the questionnaire continues, we ask about the goals of the athlete. Do they even have any? It has been said that,"if you don't know where you are going, any road will take you there". Without a clearly defined goal, the significance of daily units of training can be easily lost.

When an athlete responds to a goal inquiry by saying, "I want to run as fast as I can!", or "I will do my very best" you can be sure that the prospects for success are in jeopardy. Here is a checklist to assist your athletes to establish meaningful and useful goals.

4.2 Establishing goals

1) Create a clear, concise performance goal

You will never see the 7th place finisher in a race awarded the gold medal, simply because "he tried his very best"! In this sport, it is time and place that matter, not our intentions. Therefore, goal statements must reflect this reality. Create a goal that is clear, concise and specific.

- List the event(s) to be run.
- Distinguish between indoor and outdoor competition.
- Consider how the track size and surface type at competitions will influence performance.
- List the environmental conditions; heat, humidity and altitude.
- Calculate the specific time(s) to be run and the split times along the way.

For example, 400 metres runners will require more than just a finish time, to prepare properly for and evaluate their racing speciality. Check points at 100 metre intervals will provide valuable data.

2) Validate the goal times

If goals are not realistic, they will have no value. Reasonable goal times can be established with either of two methods. First, a percentage of improvement can be placed against recent, past performances, to reflect the benefit of experience and additional training. The appropriate percentage factor will vary according to the

training age of the performer. Accomplished athletes might work for a 1% improvement in performance. Developing athletes may be able to justify as much as a 5% performance gain.

The second method is to utilise test data and performance prediction formulae, to project a goal time. These specific tests and formulae will be provided later in this presentation.

3) Establish long term goals

The business of moving to the finish line faster will require time, not only to learn many new skills but also to make significant physiological changes. We must acknowledge the necessity for a long term training programme, by structuring goals to span from 12 months to as many as several years. Athletes should be reminded that "great things have no fear of time".

4) Reduce your goal to a daily plan of action

If you are about to set out on a journey of 1,000 miles, and only have one week to get to your destination, you will have to budget your time and effort carefully. To reach our destination in 7 days means that we shall have to cover more than 142 miles per day. We can think of our sprint goals in the same way.

The objective you establish for your focal competition will be gradually approached over time. To stay on course for our destination, we will need to determine what is required in training each day, This will be based on personal experience and training theory.

5) Set a deadline

To achieve a goal performance at any time is commendable. However, championship opportunities are always tied to the calendar. We must co-ordinate our performance goals with the naturally occurring deadlines of competition.

6) Establish checkpoints

Do not expect, what you are not willing to inspect! Success can slip away, if we do not hold ourselves accountable. Regular checks should be made to determine if we are still on course to reach our goal performances in the allotted time. A training journal is the best tool for this purpose. Recording the details of training each day will guarantee that we have the information required to make the proper adjustments.

7) Post the goals in six different places

The brain will process as many as 60,000 thoughts each day. However, too few of these thoughts represent our most ambitious goals. Since the mind will follow the direction of its currently most dominant thought, we must be regularly reminded of our objectives. When the thought is current, the mind moves us toward that goal. This simple premise will have profound results. Post a written copy of the performance goal(s) in as many as six places within the athlete's environment. In this way, the performer is certain to be regularly reminded of the ambitious tasks to be achieved.

4.3 Physiological factors in performance

Many physiological factors will influence performance potential. We can divide these into two categories: genetic endowment and general health considerations.

4.3.1 Genetic endowment

An individual's gene pool sets the stage for a lifetime of performance. The people we are, and the things we do, are largely the result of our unique genetic heritage. Nothing demonstrates this fact more than athletics. Possession of the genetic traits necessary for participation in sport, is not only desirable; it may in fact be essential.

It should be understood, however, that each human being possesses vast and largely unexplored resources, which can provide a lifetime of meaningful pursuits. While genetics do determine who among us has the greatest pool of resources, nothing prevents any one of us from exploring and developing the outer limits of our potential.

Anthropomorphic characteristics, such as leg length, can provide a significant advantage to the athlete. Any basketball coach will tell you, "you can't coach height". Either you have it or you don't. Individuals of any physical stature, however, can master the skills of the game and learn to adapt to competitive disadvantages.

Repeated studies have shown how cardio-vascular capacity is linked to genetic make-up. Again it should be emphasized that the greatest gift of genetics is the opportunity to improve the abilities we are born with.

A muscle biopsy will reveal the ratio of fast-twitch to slow-twitch fibres you possess. A preponderance of one type or the other will influence your respective abilities to run fast or run far. Since such a test is painful and impractical, field tests are often used to estimate these fibre type ratios.

Scientific study has revealed that a specific training stimulus can evoke an uncharacteristic response in muscle. Simply stated, train like a sprinter, and slow twitch fibres may begin to respond like fast twitch ones. Furthermore, other studies suggest that new hypertrophy may include a different ratio of muscle fibre type, based solely on the demands made by environment and training. Clearly, whatever your fibre

type ratios may be, you can increase the function and efficiency of your muscular system through proper training and vigorous effort.

4.3.2 General health considerations

In developed nations, the diet enjoyed today represents a dramatic change from the standards of just fifty years ago. However, although advanced technology for increased farm production, refrigeration and transportation have produced a greater abundance and availability of more types of foods, the average diet may still be lacking. The processing of our foodstuffs may make preparation easier, but the cost is a far lower nutritional content, as well as exposure to questionable additives and preservatives. Typical diets, consisting of high levels of fat, refined products, sugar, caffeine and salt, do not promote performance optimization.

The capacity of the body to adapt to stress and restore its numerous physiological systems is directly linked to proper nutrition and sufficient rest. While this presentation will not deal with these considerations in depth, the importance of an athlete's nutritional status should not be underestimated.

4.3.3 Evaluating body composition

Body composition testing of athletic prospects is useful, both for the purpose of evaluation and for the planning of training. A favourable ratio of muscle to fat enables the performer to maximize force output. There are many different methods of measuring the athlete's percentage of body fat, such as hydrostatic weighing, x-ray, skin calliper measurements and infra-red sensing. Coaches should look for a value of 6-10% for men and 10-12% for women

4.4 Field tests

4.4.1 Physiological field tests

The energy system capacities of the athlete are evaluated by means of exercises that test speed endurance, sprint endurance, special endurance and aerobic or work capacity. Various strength and power capacities are also evaluated. The ability to accelerate, which utilises both physiological and technical resources, will also be measured. The field tests which provide the data we seek are detailed in the pages which follow.

4.4.2 Technical field tests

The ability to reduce the time necessary to reach the finish line is a technical skill. Therefore, testing for the maximum velocity capacity of a performer falls into this category. Evaluations are also made of the mechanical components of speed, stride length and stride frequency. Motor skills are also included in this category of testing.

4.4.3 Tactical tests

The tactical skills in sprinting are primarily those which concern creation and implementation of a Race Model. The athlete should be questioned, usually in written form, as to the composition of the Race Model and the nuances of its use. We will discuss the concept of Race Modelling in greater detail later in this presentation.

4.5 The test course

The test course will consist of an acceleration zone of 15-25 metres and a test zone of 30 metres. Developing performers should utilize the 15 metre zone, and accomplished athletes the 20-25 metres zone.

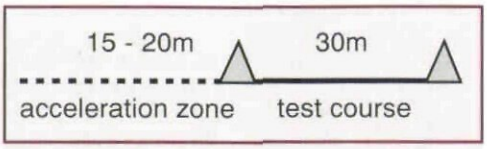

Figure 2: Test course

4.6 Measuring stride length

The athlete uses the acceleration zone to gain maximum speed through the 30 metre test course, within which the distance is measured from one toe point to the other. It is best to measure two successive strides, to determine if any bilateral discrepancies exist.

Optimal stride length is 2.3 times the leg length of the athlete. Leg length is defined as the distance from the greater trochanter to the sole of the foot.

This test works well on a cinder surface, where footprints are easily recognized. On a synthetic surface, apply a light coating of sawdust or other fine material on the test course to highlight footprints.

4.7 Measuring stride frequency

During the test course, the coach will start a watch when the right or left foot of the athlete is in the support phase and stop it five right foot contacts later, thus recording the time taken for ten strides.

Dividing the number of strides taken by the time recorded gives the number of strides run during 1 second. E.g. for a time of 2.2 seconds taken for 10 strides, the stride frequency is 4.5 strides per second.

Stride Frequency values to be expected are, for the developing athlete, 4.0 to 4.5 strides per second and, for the accomplished sprinter, 4.8 to 5.0 strides per second. Improving the stride length

and stride frequency capacities are discussed in greater detail in other chapters.

4.8 Maximum velocity

This is evaluated by recording the time taken for the athlete to sprint, after a flying start, at full speed from the start to the end of the 30 metres test zone.

The distance run (30 metres) divided by the time recorded gives the maximum velocity of the athlete in metres per second;

The fastest men and women to date have posted marks of 12 and 10 metres per second respectively. Developing athletes will register values close to 10 metres per second for boys and 8 metres per second for girls.

4.9 Acceleration

This is evaluated by timing a full speed sprint, from a standing or crouch start, Timing starts from the first movement of the rear foot of the athlete. Only experienced athletes, typically of at least university level, should use a crouch start.

The acceleration ability of an athlete can be judged by subtracting the flying start 30 metres time from the standing or crouch start time. Accomplished performers register a 1.0 second differential, while the developing athlete's mark falls into the 1.4 to 1.6 range. The lowering of this differential is the best evidence of improvement in the acceleration phase.

4.10 Sprint endurance

To evaluate this, a second 30 metre test zone should be added to the existing one. The athlete then sprints, at full speed, through the acceleration zone and both 30 metre test zones. Time the effort from the start of the first zone, take a split time at 30 metres and a finish time at 60 metres (*Figure 3*).

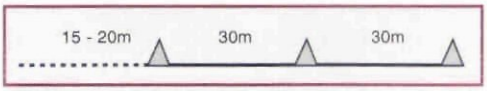

Figure 3: Sprint endurance test

Sprint endurance can be evaluated by comparing the times recorded in both 30 metre test zones. If the first 30 metres were covered in 3.0 seconds, the second zone should take no more than 3.09 seconds. This 3% variance is expected for the elite sprinter. Developing performers may show a differential of 5-6%.

4.11 Speed endurance

This is measured by timing a maximum effort sprint, from a standing or crouch start, over 150 metres. The average velocity is calculated by dividing distance by time. For a time of 20 seconds, the average velocity is 7.5 metres per second.

The objective in training is to narrow the gap between the average and maximum velocity values. If the performer has shown a maximum velocity of 10 metres per second and a speed endurance mean velocity of 7.5 metres per second, we can conclude that the speed endurance capacity is 75% relative to maximum speed. We will look to increase this percentage through training.

4.12 Special endurance

Evaluation is made by timing the athlete over a full effort 300 metres run, again from a crouch or standing start. Once again, the mean velocity is calculated. If the performers time was 40 seconds, the mean velocity for special endurance is 7.5 metres per second. If the maximum velocity of the athlete is 10 metres per second, we can conclude that the special endurance of the individual is 75%, as compared to maximum values

4.13 Measuring aerobic capacity

Aerobic or work capacity refers to the amount of work an athlete is capable of. We may also identify the capability to expand the sprinter's range of performance to middle distance with this testing.

There are many different ways of measuring aerobic capacity. The simplest field test is conducted by measuring the distance covered in a twelve minute run.

Developing athletes will typically travel 2,200 to 2,600 metres in twelve minutes. Accomplished performers will cover 2,800 to 3,200 metres.

4.14 Elastic strength

We recommend the vertical jump test to measure elastic strength. The developing female will achieve between 46 to 56 cm while her elite counterpart will register from 61 to 71cm. The developing male will record from 61 to 66cm, and the elite male from 71 to 82cm.

4.15 Elastic power

The 5 stride bounding test (bunny hops) for distance will provide the best assessment of an athlete's power capacity. The best athletes in this exercise will show high levels of negative foot speed, stable joint systems and little lateral deviation on landing.

Expect developing women to bound from 11.5 to 12.8 metres, and elite women from 12.8 to 14 metres. Developing men will bound between 12

metres and 13.5 metres, and elite men from 14 to 15 metres.

4.16 General strength and power

While many tests may be appropriate for this purpose, the *overhead/backwards shot throw* has proved to be very effective.

The *kneeling basket ball test* can also be used. From a kneeling position, the athlete throws a regulation size basketball as far as possible and the total flight distance of the ball is measured. A chair, with back against the athlete, should be placed behind to limit body lean. The torso should remain perpendicular to the ground during this test.

In the latter test, developing females will record efforts between 11 to 18.5 metres. Efforts beyond 13.5 metres indicate potential for throwing events. Elite females will register throws of 19-26 metres. Boys produce efforts between 18-24.5 metres while elite men score from 24-31 metres.

4.17 Incline power test

The athlete is timed running at full speed up a flight of stairs, either taking the steps one by one or just getting to the top as fast as possible. The test results are influenced by a number of variables, including the slope, height and depth of the stairs.

The formula to evaluate this test is:

$$\frac{\text{mass of the athlete x total vertical displacement}}{\text{time}}$$

The displacement is calculated by the height of each stair multiplied by the total number of stairs. In this test, the higher the resultant number the better.

4.18 Test administration

To ensure that test results yield their full value, the following guidelines should be followed:

1) Standardize all instruction.

All pertinent data regarding the tests to be taken, the order of execution and performance guidelines should be recorded and made available to all participants.

2) Warm up procedures and test rehearsal.

The warm up session for the evaluations should also be standardized, to avoid both insufficient or excess preparation. Specific rehearsals of each test should be limited to a given number

3) Tests should be organized to complement each other.

If participation in a single test leaves the performer at a disadvantage for the next evaluation, the results will be inconsequential. The tests conducted each day, as well as those that follow the next day, should be as compatible as possible.

4) Monitor and enforce the determined recovery time between each evaluation.

For best results, recovery times must be uniform and consistent for all participants.

5) Make certain that the test environment, climate and equipment are consistent for all those evaluated.

The facility utilized, the time of day tests are conducted and the implements used, all influence results.

6) The stage of training of the participants should be consistent.

Testing and re-testing should be conducted when the athletes are in the middle of the same training phase.

7) Repeat the testing programme at regular, predictable intervals.

This is essential, in order to record changes and improvement in performance.

5 The maximum velocity phase

Seeking improvement in the maximum velocity capacity of the athlete will be our first training focus. Gains in this performance phase are fundamental for success in sprinting. Though the duration of this racing segment is often as short as 2-4 seconds, its impact on the final result will be profound.

In strength training, we understand that when an athlete's maximum strength increases, every other form of strength will benefit as well. Just as we prescribe work in the weights room based on a percentage of an athlete's maximum strength capacity, so too will we address speed development. With improvement in the maximum velocity of a performer, measurable benefits will filter down to every other movement skill.

Our objective in maximum velocity training is to break through the dynamic stereotypes which limit performance, and create new, improved motor patterns. These new motor patterns will result in an improved efficiency of movement, mechanical gains in force output and a reduction in time spent on the ground and in the air.

Once again, we will utilize a multi-facetted approach. While gains in many different personal faculties can influence maximum velocity performance, we will rely primarily on four methods to improve this racing segment:

- **Neuro-motor skill acquisition**

  The maximum velocity capacity can be increased by learning the optimal mechanical movements required in sprinting. These skills will allow for a reduction in time spent on the ground and in the air while sprinting. This improved efficiency of movement is achieved through the repeated rehearsal of the drill sequences, which emulate the optimal patterns of movement required.

- **Improve the general and specific strength and power capacities**

  We can increase force production, reduce the time necessary for its application and increase the consistency of preferred running mechanics, through improvements in general and specific strength and power.

- **Motor behaviour modification at speed**

  New motor patterns are best incorporated while simulating the maximum velocity segment of the sprint race. This is accomplished with "speed work" training units, designed to reflect the characteristics of maximum velocity sprinting.

- **Contrast training**

  We can further address changes in motor patterns through training that is somewhat easier or more difficult than normal. This contrast of training loads disturbs neuro-motor patterns, allowing for a new, improved pattern to be ingrained.

5.1 Training at speed

Speed work, as commonly interpreted, does not fit into the Speed Dynamics philosophy. Traditional speed work sessions, with efforts for 10,20, 30 seconds or more do not replicate the actual short duration of maximum velocity. Since the neuromuscular system can only fire for maximum levels for 2-3 seconds speed work must reflect this reality.

> Speed work: Training which replicates the actual short duration of maximum velocity sprinting

5.2 'Fly in' sprints

'Fly in' sprints offer an excellent means for developing maximum speed. The training course is composed of a fly or acceleration zone of 15-25 metres and an action zone of 20-40 metres (*Figure 4*). The objective of these 'fly in' efforts is to isolate the maximum velocity phase of the race, so that specific improvements can be made. Transit time through the action zone is never more than 2-4 seconds, as is true in the maximum velocity phase of sprinting.

The length of the action zone is determined by the maximum velocity capacity of the performer, as measured in the fly 30 test. The developing athlete will typically begin training with an action zone of 20 metres in length, while the accomplished performer will initially utilize a 30 metre zone In time, the length of these respective zones can increase (if warranted by performance) to 30 metres for the developing performer and 40 metres for the accomplished athlete.

The acceleration and action zones can be distinguished by means of traffic cones or hurdles, set on either side of the dedicated lane (*Figure 3*). Instruct the athlete to begin the effort at the start of the acceleration zone. The sprinter accelerates through the fly zone. Speed is increased gradually as the athlete approaches the beginning of the action zone. During acceleration, the performer gradually inhales. When the start of the action zone is reached, the athlete holds his breath and sprints faster than ever before and continues to hold the breath through the first 10 metres or 4 to 6 steps of the action zone. After completing the first 10 metre segment, he continues the maximum sprinting effort but exhales and breathes normally for the remainder of the exercise. It is wise also to mark this special 10 metre segment with cones or hurdles as described above. As the end of the action zone is passed, the effort ends with the use of proper coast and stop mechanics.

The coach will cue the specific movements desired during maximum velocity sprinting. "Toe up", "step over the knee", "grab back" and other cues will assist the performer to develop the sprinting auto pilot we seek in competition.

5.3 Breath control

One of the unusual nuances of this training is the breath control recommended. Research has shown that holding one's breath actually increases the ability to apply force. This action which can be traced back to the "fight or flight reflex"

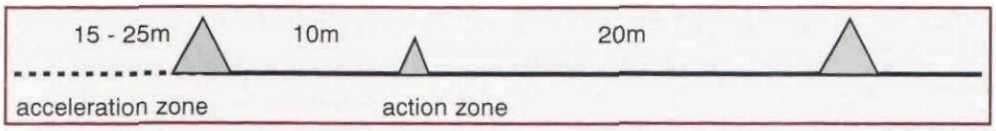

Figure 4: Fly in sprints

of our ancient ancestors, causes advantageous physiological changes to take place. Evidence suggests that, instinctively, we have always been aware of this advantage. From the attempt to pry loose the stubborn lid on a jar to the Herculean effort of a maximum lift in the weights room, holding one's breath makes the task easier to execute.

Holding one's breath increases thoracic and inter-abdominal pressure, which serves to act as an air splint for the spine. Stabilization of the spine improves the ability to apply force. Furthermore, breath control increases intra-cranial blood pressure, which leads to an improved ability to recruit motor units. In short, our ability to apply great force into the track improves when holding the breath. Breath control is only useful if it can be implemented practically. The use of breath control in 'fly in' sprints and the 'Ins and Outs' training, discussed later, will lay a foundation for the construction of a race model over the course of the season. This model will allow the new sprinting skills developed in training to be transferred to competition.

Another advantage of the breath control technique is the improved awareness it prompts in the sprinter. Holding one's breath is a dramatic cue, which signals to the athlete that a special focus is now required. Also, it creates a definite sense of urgency about reaching the next check point. No longer will the performer simply coast through a sprint session, without appreciating the attention to detail required for success in this event.

5.4 Sets, reps and recovery

'Fly in' sprints denote a type of training which targets the neuro-muscular system to prompt gains in maximum speed. They are not intended to stress metabolic systems. Therefore the duration of recovery between repetitions and sets will always be denoted as 'full'. Regardless of the period of training, the neuro-muscular system is a delicate mechanism that requires full recovery in order to produce maximum benefits. Full recovery will amount to four to six minutes between repetitions and upwards of ten minutes between sets.

These 'fly' efforts should be introduced with a single set of 3 repetitions. As work continues, additional sets can be added. Performers should aspire to a total of three sets with three repetitions in each set. Total volume for the developing athlete should not exceed 500 metres per week. The elite performer may reach as much as 900 metres per week.

Young, developing athletes, however, will demonstrate different recovery needs. Since the young person's neurological system is more pliable than the adult's, less recovery time is generally needed. Due to the low training age of the developing performer, the stress levels of a training stimulus tend to be lower and, therefore, will require less recovery time. This is an excellent example of the rule, "Understand the rules of training, before you attempt to break them". Now that we are aware of the general rules of recovery in speed development work, we are then able to refine them to accommodate unique training circumstances.

A second consideration regarding adjustments in recovery time for the novice athlete is the short attention span typical of this group. Often the youngster cannot maintain concentration through a long recovery phase. In this instance, continuing the work without much delay may be the best plan.

Speed development sessions can be utilized two to three times per micro-cycle (week). Gains in the performance of the neuromuscular system, however, are contingent on sufficient time for restoration. Always allow 48 to 72 hours of recovery time between speed work sessions.

How do we know if the athlete's neuro-muscular system is fully recovered? The receptiveness of the neurological system can be evaluated at any time with a simple diagnostic test. Just as the endurance athlete tests readiness by monitoring heart rate data, so the sprinter can judge status of the neurological system with the use of a stopwatch.

The performer starts a watch and immediately clicks off as many splits as possible during a ten second period of time. Note the range of split times registered and the consistency of the effort. Typically, the athlete will produce split times of .16 to .20 when rested. If the neurological system is fatigued, the split times will increase and become more inconsistent.

Prior to a speed training session, if recovery is in doubt, the stop watch test can offer valuable feedback. If the performer shows a marked increase in the split times registered, it may be wise to postpone the speed work session until the next day.

6 Ins and Outs training

Beginning within the first 3 weeks of training, 'Ins and Outs' represent a masterful means of speed development work. Because the nervous system can perform at maximum level only for a very short time, we must replicate in training the actual short duration of maximum velocity. While this replication began with 'fly in' type sprints, it is advanced to a new level with 'Ins and Outs'.

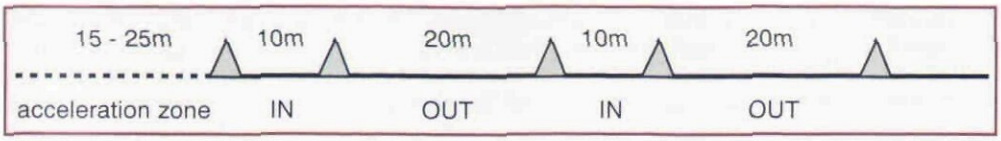

Figure 5: Ins and Outs course

The 'Ins and Outs' course is simply an extension of that of the 'fly in' sprints. It is composed of an acceleration zone of 20-25 metres, followed by an 'In' zone of 10 metres and an 'Out' zone of 20 metres. This is followed by another 'In' zone of 10 metres and an 'Out' zone of 20 metres. Total distance of the initial 'Ins and Outs' session is 60 metres, plus the length of the acceleration zone. Each 'In and Out' segment is identified either by a hurdle or traffic cone set in an adjacent lane (*Figure 5*).

The athletes are instructed to accelerate through the fly zone. The level of effort is just slightly below maximum. During acceleration, the athletes gradually inhale. As the first marker is reached, with lungs full of air, the performers hold their breath and attempt to run faster than they ever have before. With a focus on proper sprint mechanics, this maximum effort is maintained through the 10 metre "In" zone.

At the next marker or 'Out' cue, the athletes will exhale and then continue to breath normally through to the end of the 20 metre 'Out' zone. The performers are not loafing during the 'Out' phase, but rather will just slightly ease the level of intensity. Frequency should be maintained and the symptoms of deceleration avoided.

The cue 'freewheel' has been successful in relating to the athlete the proper focus for the 'Out' phase. The sensation felt while sprinting through the 'Out' zone is like that experienced by a cyclist on a downhill section of road. As gravity pulls the rider forward, less pressure needs to be applied to the pedals to maintain their turnover or frequency. In the same way, the sprinter relies on the momentum already gained and 'freewheels' through the 'Out' zone while maintaining stride rate.

The next marker starts another 'In' segment. Once again the athletes holds a deep breath, and sprint faster than ever before. 10 metres later the 'Out' phase is reached. The performers breathe normally and maintain frequency to the end of the zone. Proper coast and stop mechanics follow each trial run of 'Ins and Outs' training.

During the initial phase of 'Ins and Outs' training, the 'In' zone should be 10 metres and the 'Out' zone 20 metres. Four to six weeks later, the length of the zones should be adjusted to 15 metres each. As a final reflection of improvement,during the last four to six weeks of training. the 'In' zones should be increased to 20 metres and the 'Out' zones reduced to 10 metres,

The number of peaks or 'Ins' per trial will depend on the phase of training and the experience of the performer. A 2 peak, or 60 metre, course is a good place to start. Three peaks of 90 metres or 4 peaks of 120 metres are recommended for the advanced sprinter or one lap specialist (*Figure 6*).

As in the speed work discussed previously, full recovery between sets (10 minutes) and repetitions (4-6 minutes) is appropriate. Once again, the performers should work up to 3 sets of 3 repetitions. Total volume should be carefully monitored, so that it does not exceed the weekly limit of 500 metres for developing and accomplished performers and 900 metres for the elite athletes.

7 Contrast training

The system of contrast training is an excellent means to transform simple sprinting into a plyometric means of speed development. Here our objective is to fool the neuro-muscular system into performing at a higher level. The neuromuscular system can be disturbed by making the

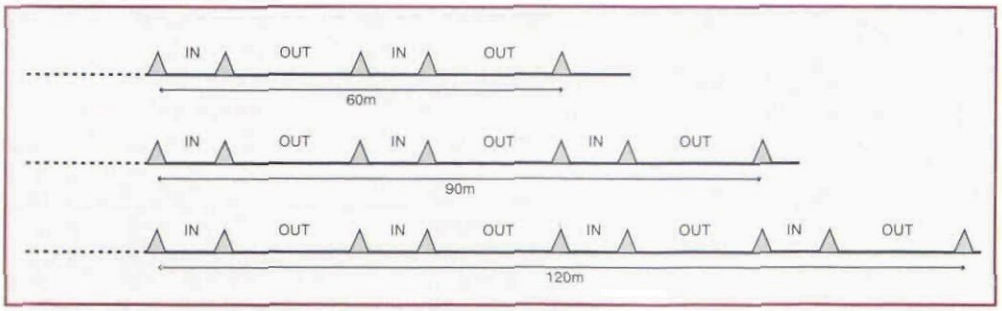

Figure 6: Ins and Outs couses of 60m, 90m and 120m

sprinting task either a little more difficult or a trifle easier than normal.

7.1 Resistance methods

Resistance training is the first component of the contrast formula. Many different means of resistance training are available to the athlete. Mother nature can provide one source of resistance - sprinting into a head wind.

Running against the wind will increase the demand on the strength and power required during the support phase of sprinting. The wind resistance, by supplying a slightly different stimulus, will also challenge the neuro-muscular system to improve its responsiveness. The body will react and adapt to the new stressor, and this begins the process of breaking through the dynamic stereotypes limiting improvements in performance.

Where resistance forces can be controlled, the added loads prescribed by the coach should not diminish by more than 10% the athlete's normal training values. A greater performance decrement indicates the likelihood of faulty maximum velocity mechanics. Hill running has long been a favourite training tool of coaches. Since running up a hill is harder than running on a flat surface, many assume the benefits of training will rise in direct proportion to the gradient of the hill. However, 'harder' is not necessarily 'better', where developing one's maximum velocity capacity is concerned. While running up a steep hill may be appropriate for acceleration training, a slight uphill gradient will offer the best venue for maximum speed development work.

A 1% slope, like that found on a soccer field, provides the subtle resistance appropriate for this type of training. The coach should also consider the effects of the surface on which the athlete runs. A soft surface will significantly increase the time spent on the ground, over and above the effect of the gradient. Since we seek no more than a 10% reduction in performance, a slight incline over a soft course may produce too great a contrast to the sprint systems.

A much more controllable means of resistance is sprinting with the addition of a weighted vest. Sprinting into the wind or up a gradual slope provides just a pure horizontal resistance. This type of training can be effective in its way, but offers little plyometric effect. Furthermore, wind resistance is impossible to control or adequately gauge and precise uphill slopes with resilient surface can be difficult to come by.

With the addition of a weighted vest, we effectively increase the mass of the sprinter and expand the stimulus to the stretch-shortening phenomena. The result is an increase in strength and power. Increasing the mass of the athlete can be accomplished with weighted belts or weighted pants. It is desirable to distribute the additional load over as much of the musculature as possible, to sustain balance. Added weight should be placed some distance away from the ankles and wrists, to prevent injury and disturbance of desired mechanics.

Another means of resistance that has proved effective is to provide an opposing force from behind the athlete. When trying to effect changes at or near maximum velocity, the resistance caused by an external force should be quite low. When towing an object, the amount of weight involved may be less important than the frictional drag produced. For example, if a flatbed sledge is utilized, and no provisions are made to reduce the frictional drag, the resulting load would be too great and offer no benefits for maximum velocity training. However, towing a sledge on grass or a loose surface would be appropriate. An automobile tyre provides an adequate resistance,by reducing the surface area in contact with the track. Smaller tyres are recommended. Weight can be added inside the tyre to increase resistance load without changing surface contact.

> Contrast training rule: Never exceed normal training values by more than 10%.

Moving pulley systems can also provide a precise amount of resistance to the performer. With this type of system, one end of a line is attached to the athlete via a belt or vest. The line passes through a pulley which is held by the coach. The other end of the line is tied to a fixed position between the athlete and the coach. The pulley moves freely over the line, providing a 2:1 mechanical advantage to the coach. In this way, the coach will travel half the distance and at half the speed of the resisted athlete. Fine adjustments can be made to the resistance level and all of the action can be comfortably monitored.

Regardless of the type of resistance provided, the athletes must be able to forget that they are being resisted. Their focus must be exclusively on the execution of perfect running mechanics. Coaches should once again provide cues to the performer, such as "step over the knee", "grab back the track", and "accelerate the thigh". Never forget how the 10% rule applies to this type of training. If the resistance force is too great, maximum velocity mechanics will suffer.

7.2 Assistance methods

Assistance training also attempts to disturb the neuro-motor patterns of the athlete, in order to effect an improvement in performance. Assistance training, by making the task of sprinting

somewhat easier than normal, decreases the demand on strength and power, and will effectively reduce the time the athlete spends on the ground while sprinting.

Running with a tailwind or down a gradual slope can provide the subtle assistance needed in this type of training. Pulling the athlete with an elastic cable has long been a favourite tool of coaches. Some use of this type of device may be appropriate for acceleration training. For maximum velocity work of this kind, however, it is fatally flawed.

When the cable is stretched, a great amount of assistance is offered initially, but this quickly disappears from the moment the run begins. Furthermore, the rebound of any elastic device will change as it is used. It is difficult to control the amount of assistance given with this method. Finally, elastic cords are prone to break quite unexpectedly. This is an unnecessary danger for the coach or athlete to accept.

The most precise means of assistance for the athlete is a moving pulley system. This method allows the coach to control precisely the amount of assistance, while easily monitoring the work. The contrast training rule once again applies to this type of work. Look for improvements of no more than 10% over normal training values. For example, assume a performer posts a time of 3.0 seconds in the 30 metre fly. Following the contrast training rule, a 10% improvement would equate to a 2.7 second time in an assisted fly 30. The coach must monitor these contrast training sessions to judge the appropriateness of the aid provided.

Performing the prescribed work within these precise limits is largely a matter of trial and error. After repeated trials, if the person controlling the added force, and the type of aid utilized, is consistent, positive results will materialise. Electronic timing systems represent a breakthrough tool for the understaffed coach. Infra-red sensors can measure the speed of the athlete and transmit the data directly to the coach. No splits are taken manually. All the work is done accurately by the electronics. These systems are now widely available, but not inexpensive.

7.3 Implementing contrast training

After a complete training session warm up, the first set of resisted sprints are performed. Once the method of resistance is selected, the efforts are conducted on a course that includes an acceleration zone of 15-25 metres and a maximum velocity zone of 30 metres. Three repetitions of maximum sprint efforts are performed, with 2 to 5 minutes of recovery between each repetition. The coach must time the efforts to ensure that the 10% contrast training rule is respected. To assure that proper maximum velocity mechanics are maintained, the coach should provide those task specific cues which identify the desired mechanics.

After the first set of resisted efforts, a set of the three assistance efforts are performed. With full recovery from the resisted sprints, the athlete is now assisted through the same training course. Once again, the coach offers feedback on running mechanics, and times the performance only through the 30 metre zone. Three repetitions are performed in this assistance set, with 5 to 8 minutes recovery between sets.

The contrast training session concludes with a set of three sprints over the same course, this time with no resistance or assistance provided. This final set brings the athlete back to the real sensations of sprinting. As before, these sprints are timed and recorded by the coach. The first improvements from contrast training will be found in the front side phase of the sprinter's strides. Look for better ground preparation mechanics and less measurable front side distance with each landing.

Contrast training can be conducted with several different means of resistance used during a single training session. Another formula for contrast training is to run one resisted effort, followed by one assisted effort and finally a normal sprint. These 3 repetitions are repeated in additional sets with full recovery between them.

8 Ground dynamics

The study of ground dynamics provides the coach and athlete with an understanding of those critical factors which influence performance. Here we will address the relationship between the athlete's body and the sprinting surface and identify the most effective means for the two to meet. Once the subtle nuances of movement skill required in high level sprinting are understood, the rituals of training and the drill sequences recommended can be viewed with a new appreciation of their purpose and value.

We should understand that, mechanically, there are only two ways to improve speed: either increase stride length or improve stride frequency. In maximum velocity sprinting, these two components, however, have an inverse relationship. Like interest rates and the stock market, when one goes up the other will go down. One of our training objectives will be to optimize the output of each of these components.

8.1 Stride length

There are two ways to measure stride length. The first and most common way is to measure

from the point where one foot leaves the ground to point where the other foot lands. This measurement is called *actual stride length*. There is a second, more precise measurement called effective stride length. The distance the centre of mass, often identified as the hip joint, travels in the air, from the moment one foot leaves the ground to its return represents *effective stride length*. Effective stride length can be measured accurately only with high speed video or electronic tracking equipment. Coaches should not concern themselves with the precise measurement of effective stride length. More vital is the ability to conceptualise it.

Effective stride length may be improved in three ways:

1) Increase the athlete's capacity to produce force at track level. This will be accomplished when the general and specific strength and power of the athlete improves.
2) Improve the application of force by refining the mechanics of the performer. This improved efficiency of movement will be a career long concern.
3) The final means to improve effective stride length is to reduce the frictional drag or braking created at landing. This deterrent to performance is influenced by several different factors. Drag is influenced by such things as how much surface area of the athlete's shoe comes into contact with the ground and the friction inside the shoe from the movement of the foot. Our efforts however, will focus on the major mechanical and physiological means of reducing frictional drag and its negative results.

8.2 Stride frequency

Conceptualising the performance component of stride length is best accomplished by simply relating it to distance. With stride frequency, time becomes our concern. When we reduce the time necessary to apply force at take off and eliminate wasted time in the air, stride frequency will improve. Achieving meaningful gains in this performance component have traditionally been overlooked. In the Speed Dynamics philosophy, we consider it a primary focus.

Several contributors to improved stride frequency can be identified. Strength and power, dynamic mobility and flexibility all influence stride rate values. However, one performance capacity remains the most critical and vital - improvement of the function and efficiency of the neurological system. It is the nervous system that controls every obvious and subtle movement of the body. Therefore, specific training of the neuro-muscular system can and should begin from the earliest days of preparation.

8.3 Sinusoidal curve

Although sprinters move in a horizontal direction down the track, the forces they produce are both vertical and horizontal. Vertical forces are necessary to lift the centre of mass up and off the ground. Horizontal forces propel the athlete towards the finish line. Gravity then accelerates the sprinter in a negative or downward direction. This continuous process of propelling, dropping and catching the centre of mass creates a roller coaster like displacement, known as a sinusoidal curve.

The wave form produced by elite sprinters is not a perfect sinusoid. If it were, the pattern created by the centre of mass would appear identical whether viewed up side down or right side up. However, since the air time and air distance of the elite sprinter is greater than the ground time and ground distance produced, the wave form created by the path of the centre of mass is an irregular one. However, it is sufficiently like a sinusoid curve to be termed sinusoidal.

Once again, exact measurement of this performance characteristic is not vital. Being aware of the factors which influence the path of the centre of mass however is crucial. A comparison of two very different athletes will assist you in furthering your understanding of this concept. Let us examine the characteristics demonstrated by an athlete bound to a wheel chair and that of an ordinary sprinter.

The wheel chair athlete's centre of mass appears fixed in place, due to the constant support provided by the wheels of the chair. Using the arms as a propulsion force, this athlete will demonstrate near zero vertical displacement of the centre of mass. Because ground support is a constant and the air or flight phase found in sprinting does not exist here, no vertical component is necessary. The athlete's hips travel on virtually a straight, horizontal line.

The ordinary sprinter, using the legs as a propulsion force, does not have continuous ground support, as the wheel chair racer does. Instead the sprinter's centre of mass is propelled up and off the ground at take-off. Gravity then accelerates the sprinter in a negative or downward direction.

The sprinter must produce forces at landing of both a vertical and horizontal nature. The key to enhanced performance will be the ability to optimize these forces, as reflected in the sinusoidal curve. Specifically, we will look for an angle of take off and a take off velocity that will produce a wave form of low amplitude and long period.

We can begin to create a more desirable sinusoidal pattern by effecting changes in several areas.

Mechanically, it is necessary to avoid excessive front side distance at landing. If the base of support (the foot of the performer) lands too far in front of the centre of mass, several negative consequences result. First, excessive front side distance allows the centre of mass to fall a greater distance. When the body accelerates over a longer distance, even a slightly longer one, the load at landing increases. As a result of this increased loading, the demand placed on the strength and power capacity of the performer is greater. More strength will be required to stabilize joint systems and to reverse the direction of the centre of mass.

The first step in reducing excessive front side distance and its undesirable effects is to dorsiflex the ankle during the ground preparation phase. When this is combined with greater negative foot speed, the sprinter will catch the centre of mass before it falls too far. If the centre of mass does not fall as great a distance, less strength and power will be required to reverse its direction at take off.

Moreover, during maximum velocity sprinting, some horizontal deceleration or braking of the centre of mass occurs at landing. To regain this lost speed, the sprinters must pull the track back underneath them and accelerate the hips, by calling on the strength of the hamstrings and glutes.

This new horizontal force, produced in the eccentric phase, will return the centre of mass back to the velocity achieved prior to impact. It is this capacity to re-accelerate through the support phase that most distinguishes the elite sprinters from their novice counterparts.

9 Pure acceleration

Once the development of the maximum velocity capacity has been addressed, our next training focus is pure acceleration. The objective of the acceleration phase is to reach maximum velocity as quickly and efficiently as possible.

The acceleration phase, from a mechanical point of view, must be broken down into pure acceleration and the transition phase. Pure acceleration begins after the first two steps and blends into the transition phase after the tenth or twelfth stride. The duration of the transition phase is typically 6-8 strides.

9.1 Characteristics

The primary characteristics of the pure acceleration phase are reflected in the relationship of the centre of mass and base of support. Unlike maximum velocity mechanics, in the earlier strides of acceleration the sprinter's feet land behind the centre of mass. With each additional stride, as the sprinter assumes a more upright posture, the distance between the centre of mass and base of support decreases, until the feet land directly under the hips.

In acceleration, the joint angles at the hip and knees, prior to contact, are much sharper than is the maximum velocity phase, and the direction of force is largely horizontal. Correct acceleration mechanics require maximum acceleration of the thigh over its full range of motion, which means that there must be a full and fast pick-up of the knee. The lower legs move with a piston-like action. The knee of the sprinter remains in front of the foot, both in the recovery and drive phases and the feet remain close to the ground. The angles of the lower leg and trunk should be the same in relation to the ground. The ankle is cocked in anticipation of ground contact being made with great force.

Acceleration and maximum velocity differ not only in the direction of the forces applied to the track, but also in the origin of these forces. In acceleration, much of the force comes from muscle contraction rather than elastic response. This is true in all events requiring acceleration.

Stride length, in the first two strides of block clearance and the following eight to ten strides of pure acceleration, increases at an amazingly regular rate. A range of increase of 10-15 centimetres is not uncommon. A slight decrease in stride length is found near the end of the phase. The increment of gain is directly related to the sprinter's leg length and general and specific strength and power to body weight ratio.

Surprisingly, stride frequency is extremely high for the elite sprinter during the acceleration phase. Here, too, we see an incremental increase in the stride rate of the athlete. Only in acceleration do we see stride rate and stride frequency increase in this way.

9.2 Improving acceleration

We will look to improve acceleration in three ways:

1) **Teach task specific cues** - Offering concise instructions to the athlete will help to actualize the precise body position and mechanics sought in this racing phase.
2) **Increase the general and specific strength and power capacities of the athlete** - Many different means of training will be utilized to accomplish this task.
3) **Re-programme the neuro-muscular system** -

The Speed Dynamics approach to improved acceleration is to enhance the performance capacity through neuro-physiological means. We can, in effect choreograph the precise movements of acceleration through specific training and regular rehearsal.

Significant study and preparation are required in all areas of responsibility for the coach. Yet, the coaching capacity that may influence the sprinters and their performance the most is usually the one allotted the least amount of thought or preparation. The manner in which desired results are communicated to the performer is perhaps the most important single component in the coach – athlete relationship.

The words coaches use create specific visual images. It is these images that will prompt action by the athlete. Whatever mental picture the sprinter is provided with, whether desirable or not, will be acted upon. Since the mind follows the direction of its currently most dominant thought, the coach must be exact and precise with the cues given to the sprinter.

In training and competition, the performer should be reminded of the specific motor responses desired. This reminder does not represent new information. Instead the cue will call up in the mind of the athlete the mental stimulus to be acted upon. Since each racing phase has its own inherently unique characteristics and demands, the instructions offered to the sprinter *must reflect this diversity. Each racing phase* requires its own set of specialized cues.

In contrast to the nebulous clichés common to coaching jargon, the cues offered here must describe a specific action in language that paints a universally recognized picture. The frequently used cue for acceleration of "stay low" is an example of the misdirection offered inadvertently to athletes. This cue provides the sprinter with a distorted instruction of the body position required in acceleration. Bending at the hips, as if ducking under a bar, is a common but undesirable body position found in sprinters. No doubt the 'stay low' cue has much to do with it. Instead we want the sprinter to lift the chest up, so that a power line is created from the ankle of the support leg through the torso. In this way the body lines up at about 45 degrees to the track.

Most appropriate instruction would include cues like 'stab back' or 'tear back' the track. These descriptions relate to the direction of forces and foot placements desired in acceleration. The drill sequences for acceleration, recommended in the pages that follow, also serve to emphasise the unique characteristics of this racing phase. The coach is challenged to keep on developing new cues, to facilitate the response mechanisms we seek. We can signal the high frequency desired in acceleration with cues like 'hot ground', 'fast feet', or even generic sounds that emulate the rhythm and tempo of the recurring foot-strikes, such as hand claps with an ever increasing rhythm.

In elite performers, the cue system utilized will evolve and change over time. As the athlete approaches mastery of the technical model of desired performance, the cues we use will reflect this maturity. Since many of the necessary motor responses are now automatized, cues that are more general in nature may be appropriate. Using a cue like 'explode' with the elite athlete will have a precise meaning that relates to specific movements. For the developing performer, the same word can create very different and useless visual images.

When athletes describe how their races are to be run, the words they use are very telling. If their account of the their actions of the race are general and nondescript, we can expect this to be reflected in their technical execution on the track. Athletes should be regularly questioned to determine the state of their technical awareness and understanding.

If language fails either the coach or athlete, a pencil and paper will compensate. When uncertainty exists regarding the sprinter's imagery of racing demands, ask the performer to draw examples of the variations of movement and position throughout the various racing phases. Stick figure drawings will accomplish the task. This transference of the athlete's mental image of desired performance characteristics to paper gives the coach a clear view into the mind of the sprinter.

Another way to clarify the athlete's grasp of specific technical cues and concepts is to observe carefully how the performer assists younger, inexperienced sprinters. One can only teach what one knows. Therefore, when one athlete instructs another, acquired expertise is revealed. Observing the athlete as a teacher is an effective acid test of technical awareness.

9.3 Training for general and specific strength

The ability to accelerate will improve in direct proportion to gains in strength. We can increase the general strength and power capacity of the athlete with many different means of resistance training. All of these methods are intended to increase the amount of force the athlete can apply, to stabilize the integrity of the spinal and joint systems and to limit the time spent on the ground.

Simple running is where we begin. Even a slow jog requires the performer to move against the

resistance of gravity. As a foundation of general conditioning is developed with easy running, we can increase the demand of the athlete by changing the gradient of the running surface.

Running up an incline will require the athlete to lift the recovery leg through a greater range of motion than on a flat surface. The athlete must then exert a force against the ground sufficient to lift the centre of mass somewhat higher than normal. The result is an increase in strength and power where the sprinter needs it most.

Multi-throws training is another excellent means to improve general and specific strength and power. Multi-throws are exercises which combine movements through various ranges of motion, followed by throwing an implement (generally a shot or a medicine ball) for distance. One example of a multi-throw routine is the 'between the legs forward throw'. Holding the implement in both hands, the performer bends over and swings it back and between the legs. Then quickly changing direction, the athlete throws the implement underhanded as far forward as possible.

In this type of exercise, the body mass of the athlete is increased by the weight of the implement held. As that body moves, the stressors to the muscular system increase. Finally, when the ball is launched, great force must be applied into the ground. The athlete also must extend into the same body position required for acceleration. This combination of increased loading, greater force application and desired body position are all obvious benefits for acceleration training.

Sprinting with a weighted vest or weighted pants is also a proved method of enhancing strength and power. Once again we increase the load on the athlete's sprint systems by adding weight and thus expand the stimulus to the stretch-shortening phenomena. The result is an improvement in general and specific strength and power and a reduction in time spent on the ground.

As work is performed to improve strength and power, we must simultaneously develop the specific skills of the acceleration phase. These abilities are best introduced through the following drills and exercises. Each is designed to teach proper body position and the desired direction of forces applied to the track. Repeated rehearsal of these routines will refine the motor pattern of the athlete to adapt to the unique demands of this racing phase.

9.4 Acceleration learning progression

9.4.1 Acceleration march:

The objective of this exercise is to teach the desired body position and the piston like movement of the legs. The athlete stands approximately 1 - 1 1/2 metres from a wall or other stationary object. With the feet fixed in place, the performer leans against the wall, placing the hands flat against it. The body position achieved is now approximately at an angle of 45° to the ground.

On the coach's command, the athlete begins to march by lifting the knees alternately to a point above waist level, with the ankles kept dorsiflexed. This march should continue for a 10 second interval. The trunk should remain in line with the support leg throughout the exercise. The movement of the legs is not cyclical, as is the case in maximum speed running. Here we look for a back and forth motion, with the knees remaining in front of and above the ankle at all times.

While the exercise may test trunk strength, it is intended most to familiarize the athlete with the critically important body position unique to acceleration.

9.4.2 Wall sprints

This exercise will begin to mimic the sprinting action found in acceleration. It will improve stride frequency and refine the direction of forces applied to the track. The performers begins by assuming the same position as in the Acceleration March. He then raises one knee into the ready position. The ready stance requires that the ankle of the raised leg is dorsiflexed, the knee is up above waist height and the torso is in line with the support leg.

The coach will announce in advance of the exercise how many total steps are to be performed in succession. It is recommended to begin with sets of 3 steps. Once mastery is achieved, 5 steps then 7 steps, etc. can be utilized.

9.4.3 Continuous wall sprints

Here the athlete will assume the same ready position as in the exercises described above. On the coach's command, the performer will sprint continuously with a focus on achieving the highest possible frequency, together with a complete range of movement. The exercise begins with 5 second intervals. As competency increases, the duration can be increased up to as much as 10 seconds or more. In addition to the benefits of improved frequency and body position, these continuous sprints can also improve the energy systems.

9.4.4 Partner drills

Hip hold

Standing behind the performer, the spotter places his hands on the hips of his partner and steadies his body position at a 45° angle. On the

coach's command, the athlete begins to pump the legs in the piston like motion required for acceleration. Body position is maintained due to the support of the spotter. After 4 to 10 steps the athlete is released and continues to sprint through a distance of 30 metres.

Face to face

In this exercise, the spotter faces the athlete and supports the correct forward body lean by placing hands on the shoulders and accepting the athlete's weight. On cue, the athlete begins to sprint with proper acceleration mechanics. Arm action should be encouraged. When the spotter can no longer feel the weight of the athlete, he releases him and steps aside. At some point in the exercise, the athlete will most likely revert to old bad habits and allow the legs to become perpendicular. This action moves the supporting function from the hands of the spotter to the legs of the athlete. In this way, body position faults can be detected, when the weight of the athlete is no longer felt by the spotter.

Face and Chase

The starting position is the same as in the previous drill. After 2 to 6 seconds of action, the spotter should turn away from the athlete and sprint towards a designated finish line. The athlete's goal now is to catch the spotter before he reaches the finish line.

This exercise incorporates a game-like structure, while addressing several crucial training objectives. When the spotter turns and runs away from the athlete, the resistance which the performer was working against ends, as does the artificial support of the body position. Neurologically, the sprint systems respond to the contrasting demands of the early resistance provided by the spotter and then the full final sprint without impedance. Add to the mix the competition factor between the partners and the result is a superior training session for each participant.

Face, Chase and Race

This final progression in the partner drills adds another element to the Face and Chase routine. The distance from start to finish should be about 25-40 metres. The starting position is the same as in the previous drills. The spotter supports the athlete with hands on the shoulders. The performer drives against the resistance aggressively. Between 2 to 6 seconds after the exercise begins, the spotter turns away from the partner and attempts to sprint to the finish without being caught.

The new element in this exercise is that, if the spotter is caught with a touch of the performer's hand, both partners will stop, turn 180° and race back to the start. If the spotter is not caught before reaching the finish, they will turn around after crossing the finish line and then race back to the start line.

Many benefits are derived from this exercise. Firstly, the game-like conditions charge the competitive instincts of the participants, thus improving intensity. Secondly, the sprint systems respond to the contrasting demands of resistance, braking, change of direction and re-acceleration. Gains in strength and elastic response result.

9.4.5 Hill training

Once thought only appropriate for general conditioning, hill training can increase both stride frequency and stride length simultaneously. Earlier we learned how these mechanical components have an inverse relationship, when related to maximum speed sprinting. In acceleration, however, both stride frequency and stride length increase at an amazingly regular rate. This mechanical characteristic should be reflected in training.

We can creatively use hill running to improve both stride length and stride frequency in a single training session. Ideally, a hill with a slope of 20-35° should be used. The athletes are instructed to stand at the base of the hill, with a small marker (a pencil, nail spike, etc.) held in their hands. The markers will be used to identify the distance covered in the exercise.

Once the coach gives the start command, the athletes sprint up the hill with maximum effort. After just 8 seconds, the coach signals them to stop and the athletes place the markers into the ground to identify the distance covered during the run. The markers can be personalised for each athlete, by fixing a piece of adhesive tape to the top of them with the athlete's initials on it.

Once the distance is marked, the athlete reports the number of strides taken during the 8 second interval. This data is recorded by the coach. The objective of the trial runs that follow are to improve effective stride length by increasing the distance covered up the incline. At the same time, the athlete is attempting to cover the distance while taking a greater number of strides, i.e. increasing stride frequency.

Of course, the challenge to the performer is to optimize both stride length and stride frequency simultaneously. Typically, one can expect the performer to improve just one of these mechanical components in the next few trial sprints. However, initially, the stride frequency will tend to increase and both stride length and distance covered decrease.

Since proper body position is maintained largely due to the slope of the incline, the athletes can

focus their complete attention on maximizing force application and reducing time spent on the ground. Over time, measurable gains in both stride rate and stride length will be visible. With continued improvement, the time interval of these efforts should be increased from 8 seconds to 10 and then 12.

If steep inclines are unavailable, stadium steps can be an effective substitute. However, since stride length is pre-defined by the depth and width of the stairs, the session must be modified accordingly. The following work-outs are appropriate:

- Single steps against time. Sprint up the stairs, one step at a time, for a designated time. Record the total number of steps covered in the effort. In subsequent reps., the objective is to cover more steps in the same time. When successful, the duration of the exercise is increased.
- Double steps against time. A greater application of force will be required to displace the centre of mass over this longer distance. The objective is also the same as above; more steps covered in the same time.
- Single, single, double sprint - for the first two strides the athlete takes the steps one at a time and then two at a time. This action continues so that each leg will be challenged to cover the two steps distance. The cadence is single, single, double, single, single, double ... and so on.

9.4.6 Towing

We can improve an athlete's acceleration capacity with the use of towing exercises. Many athletes have difficulty appreciating the importance of horizontal drive during the acceleration phase. The quadriceps muscles, responsible for vertical movement, are so dominant that they will often override the hip flexion/ extension needed in acceleration. Towing drills will focus the athlete's attention on the horizontal movement we seek.

Running with an opposing force from behind the athlete can improve the general and specific strength and power necessary for acceleration. A variety of options are available for this type of training. Manual resistance from a coach or team-mate, sledges, tyres and other weighted objects can meet the task demand.

Partner drills are a simple form of towing. Either with hands on hips or with the use of reins attached to the athlete, manual resistance can be applied to stress the capacities of the performer. Moving pulley systems, with the load controlled by the coach, are also available for this type of training.

Perhaps the best overall option is to utilize a sledge or automobile tyre. In towing, the athlete sprints, from a standing or falling start, over a distance of 10-40 metres, while attached to a weighted object. The lines that connect the athlete to the sledge or tyre should be fastened to the shoulders of the performer, not the waist. If the resistance is towed from the waist, the desired body position of a straight line at 45° will be compromised. Shoulder harnesses are available for this purpose.

The load in acceleration training can be significantly greater than that used for maximum velocity training. However, the resistance offered should never overwhelm the athlete or destroy proper mechanics. If a sledge or automobile tyre is used, begin the training with a minimum of weight. Since the increased load will impact negatively on ground time and stride frequency, the coach should actively cue these characteristics during the exercise. Maintenance of proper body position is paramount.

Since the first two strides are greatly influenced by the task of overcoming inertia, it is wise to reduce the frictional drag of the opposing force. The use of a tube, like the kind used to ship maps or posters, placed under the sledge, will lessen the initial drag sufficiently and allow the performer to "set up" proper mechanics, before dealing with the full force of the resistance.

As progress continues, additional weight can be added to the sledge or placed in the tyre. Always remember that 'harder' is not always 'better'. Protecting body position and stride length and stride frequency characteristics is always the first focus.

9.5 The Acceleration Ladder™

Only in acceleration do we see stride frequency and stride length increase incrementally. We can improve the acceleration capacity of an athlete by carefully choreographing the precise movements of this racing phase. The best means to address this neuro-physiological challenge is with a training concept called the Acceleration Ladder.

Acceleration Ladder™ is a collection of 10 rungs attached by cords which identify the approximate spacing of each foot placement throughout the acceleration phase. Sprinting with this training tool will allow for an exact programming of the neuromuscular system. The rungs or "sticks" used in the exercise improve the kinaesthetic awareness of the athletes, by allowing them to feel the proper foot placement as it occurs behind the athletes' centre of mass.

This adjustable tool offers two different settings. The most common setting for the young or developing athlete is the 40:10 ratio. The second

rung or stick is positioned 40cm from the first. Each additional rung is placed at a point that is 10 additional cm away.

The second setting is appropriate for the taller or more advanced performer. The setting of 50:15 ratio follows the same pattern as before. The second rung is positioned 50cm from the first and each additional rung is positioned a further 15cm away.

The exercise begins with the use of 5 to 6 rungs. The performers place their 'power' foot (the foot that is forward in the starting blocks) just in front of the first rung. It is important to note that at no time do the athletes step on top of the sticks. Rather they will drive back into the face of these rungs, as a method of determining exact foot placement. With the power foot in position, point the shin towards the finish line. The torso is in line with the shin. The knee should line up in front of the spike plate. The arms hang loosely from the shoulders.

To begin the routine, execute a falling start. Before balance is lost, quickly recover the dominant leg (the back leg in the blocks), while simultaneously extending at the hip on the power side to move the centre of mass forward. The emphasis on horizontal motion is critically important. When recovery of the dominant leg is complete, the hips will be positioned past the second rung. The second step requires the recovered leg to be driven back down into the track surface, as was rehearsed in each of the preceding drills. The athlete should be able to feel or sense the second stick or rung just behind the spike plate as ground contact is made.

With each stride, the athlete should drive the legs back into the running surface, resulting in a horizontal displacement. As competency increases, additional rungs can be added to the exercise. Repeated rehearsal of this routine will automatize the precise movements desired in the acceleration racing phase. Even though the actual stride length of the performer may not exactly match the pattern rehearsed, the benefits of the gradually increasing steps will translate directly to competition.