Speed & Agility Training

Speed and agility are essential fitness components for most athletes, participating in many different sports. Speed can be the defining factor in determining the success of an athlete, therefore it essential that the S&C coach can effectively plan and deliver speed training programmes. The aims of this module are to provide a clearer understanding of the different components of speed and then focus on how to develop and improve speed through the appropriate training methods.

Speed

Speed is defined as “the ability to move quickly across the ground or move limbs rapidly to grab or throw”. Speed is not just about how fast an athlete can run or move, but is dependent on their acceleration, maximal speed of movement, and also speed maintenance. Movement speed requires good strength and power, but also too much body weight and air resistance can slow the athlete down. In addition to a high proportion of fast twitch muscle fibres, it is vital to have efficient mechanics of movement to optimise the muscle power for the most economical movement technique.

Agility

Agility is defined as “a rapid whole body movement with change of velocity or direction in response to a stimulus”. Agility can be influenced by strength, balance, coordination, position of the centre of gravity, as well as running speed and efficiency.

Throughout this module the term “speed” will refer to all speed components including agility, which is also known as “sports speed”. Sports speed is made up of many sub-components such as acceleration, deceleration, and reactiveness, changing direction, maximal velocity, speed maintenance, speedendurance, and repeated sprinted ability (RSA).

Acceleration

Acceleration is “the rate at which an athlete can change or increase their velocity” and it is the ability to overcome inertia through the application of force into the ground. Acceleration is a product of stride frequency, therefore requires high levels of concentric strength and force production. In many sports acceleration is more important that maximal velocity or top end speed often in sport an athlete is required to accelerate from an unpredictable position such as landing, jogging or turning therefore this should be considered when devising the training programme.

Deceleration

Deceleration is the opposite of acceleration and is therefore “the rate at which an athlete can reduce their velocity”. This is equally if not more important than being able to accelerate quickly as most sports require athlete(s) to be able decelerate and change direction at high velocities. Deceleration requires large amounts of eccentric strength especially in the quads and hamstrings, if an athlete lacks strength in these areas their risk of injury will be increased when decelerating at high speeds.

Reactiveness

Reactiveness or reactive speed refers to both the cognitive processes between the brain and the body – the ability to see, process and react to an unpredictable stimulus. It is also the physiological processes that occur within the musculo-tendon unit (MTU) in order to producereduce and reproduce force in the shortest possible time. This is a physiological mechanism that occurs during Plyometric training. It is apparent that reactiveness is an essential skill requirement in many sports, so again therefore needs consideration and inclusion in the overall training programme.

Change of Direction

Change of direction (COD) more commonly known as agility or multi-directional speed is a key speed component for many court or field based athletes. It is a combination of many of the above qualities; acceleration, reactiveness, deceleration and may also incorporate turning and/or cutting actions as well. Similarly, to accelerating and decelerating, this requires large amounts of both concentric and eccentric strength to be able to perform these actions efficiently, whilst also minimising the risk of injury.

Maximal Velocity

Maximal velocity refers to an athlete’s absolute top speed or the quickest speed at which they can run or move at. Maximum velocity is normally achieved at around 40m during a maximal sprint, therefore may not be as in important as other speed components for some athletes dependent upon the demands of the sport. Speed is a product of both stride length and stride frequency, although during to speed running stride length becomes of greater significance, which will be discussed in greater detail within the technical model.

Speed Maintenance

Speed maintenance is the ability to minimise deceleration or the ability to sustain top speed whilst sprinting. This quality is more important for track athlete’s i.e. 100-200m sprinters as opposed to court or field based athletes. This speed quality also requires some strength and power endurance capabilities in conjunction with efficient mechanics and good stride length.

Speed-Endurance

Speed-endurance is the ability to sprint or run at high intensity for an extended period of time i.e. 200-400m sprints. This type of work predominant taxes the glycolytic system therefore results in lactate and H+ accumulation and is very specific to the needs of the sport. For example, this speed quality is rarely required in many sports so careful consideration should be given before implementing this type of training into an athlete's programme.

Repeated Sprint Ability

Repeated sprint ability (RSA) is the ability to perform repeated high intensity actions interspersed with short recovery periods. RSA often gets confused with speed endurance training but in reality, they are quite different in nature, as speed endurance training requires constant sprinting whereas RSA requires intermittent sprints which predominantly taxes the ATP system whilst sprinting and the aerobic system during the recovery between sprints which is much more relevant to many team sports athletes as opposed to speed endurance training. There is research to suggest that athletes with a higher V02 max recover quicker between sprints and are therefore able to maintain a more constant sprint speed across multiple sprints compared to athletes with a lower V02 max.

Speed Technique

There are different sprinting models that can be seen, dependent upon an athlete's characteristic as well as the demands of the sport. The idea of this section is to provide a basic understanding of the different phases of sprinting as well as outline an efficient technical model during both accelerating and top speed running, including; some key coaching points that can be implemented with an athlete or group of athletes.

Acceleration Phase

This phase is characterised by an excessive forward lean position of the body, although good posture and alignment between the shoulders, hips and ankles should be maintained. The foot contact should be behind the hips in order to produce horizontal forces to propel the athlete forward. Ground contact times will be longer during this phase and strong forceful steps should be encouraged. Many acceleration models are taken from sprinters whereby they start in a low position from the blocks and accelerate out from this already low position. Although the same principles can be applied to other athlete's even if they are accelerating from a standing position. The athletes should be coached to lower their centre of mass and try and adopt the forward lean position.

Fig 12. Acceleration Model

Acceleration Characterists

- **Velocity @ 10m:** ~8.2 m/s
- **Ground contact time:** ~0.17 sec
- **Height of foot @ 1st step:** 12-30cm
- **Stride frequency:** 3.6-4 Hz
- **Stride length:** 1.5m 1st step

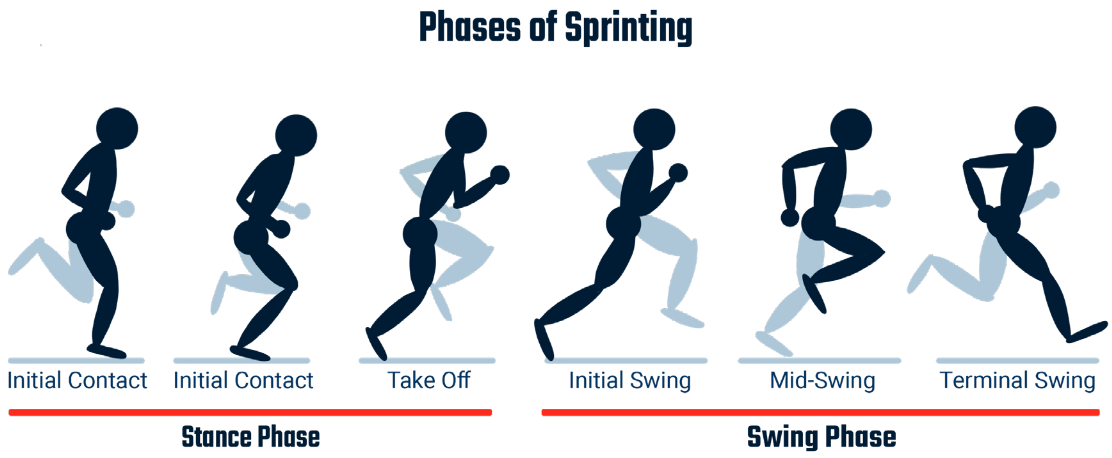
The key coaching points that should be re-enforced during the acceleration phase are as follows;

- Toes to shins – encourage the athletes to maintain ankle dorsiflexion in order to increase ground reaction forces and minimise ground contact times.
- High knee drives to increase downward force production capacity.
- Hard forceful steps on ground contact to increase ground reaction forces.
- Maintain good posture and avoid excessive trunk movement to avoid energy leaks.
- Hips to lips – good arm drive in opposition to leg action to further increase force production and propulsion

Top Speed Phase

The principles of top speed running are different to that of accelerating and therefore require slightly different physical properties. During top speed running the athlete will be in a much more upright position and the foot strike should be directly underneath the hips. There is much less emphasis on generating force compared to the acceleration phase, and more demand for maintaining speed through increasing stride length and reducing ground times. Therefore, requiring good mobility &MTU stiffness as well as high RFD qualities, this can be developed through the use of Plyometric training. Fig 12 illustrates the mechanical model of sprinting and also the different phases of the sprinting cycle.

Fig 13. Phases of Sprinting



The key coaching points during maximal velocity sprinting are as follows:

- Maintain tall upright position and good posture
- Minimise ground contact times (running on hot coals)
- Try to reach / claw out during swing phase
- Ensure foot contact is directly beneath the hips to minimise breaking forces / deceleration
- Maintain good arm mechanics/swing to maintain momentum

As previously mentioned sprinting is both a product of stride length and stride frequency so in principle the longer an athlete's stride and the less ground contact time they can achieve will result in them being able to run quicker.

It is important to understand the different physical requirements during accelerating, sprinting and changing direction, to be able to design and effectively coach a speed programme for the athlete(s). In order to determine the speed requirements of a particular athlete, reference should be given to the needs analysis of the sport to determine the predominant speed characteristics required. For example, there would be no need to spend time training maximal velocity with a tennis player as this is not required for the sport. This time would be spent much more effectively training acceleration, deceleration and changing direction as this would be much more specific to the demands of the sport. Once this has been established the needs of the athlete should be determined through various speed tests that are specific to the requirements of the sport and the athlete.

Speed Testing

There are a number of different speed tests that can be implemented in order to assess the athlete's ability to perform a particular speed component. Table 12 illustrates some speed tests that can be used to assess the different speed qualities;

Speed Tests

Table 12

Acceleration	Max Velocity	RSA/Speed Endurance	Agility
Leg Strength (1-3RM)	RSI	Strength/power endurance	T-test
Vertical Jumps (SJ & CMJ)	30-100m sprint times	RAST	505 test
Horizontal Jumps (distance)		100-400m sprint times	Illinois test
10-30m sprint times			

Acceleration

As acceleration is a product of force production both strength and power should be assessed in order to determine if an athlete is deficient in either of these components as this could result in a limiting factor during acceleration performance. Specific tests that could be used are either a 1 or 3rm performing a power clean, squat or leg press to determine strength and either a vertical or horizontal jump to measure power. A specific test to measure acceleration speed would be to carry out a 30m sprint with 10m & 20m splits. Table 13 below displays a range of scores for the 10m, 20m & 30m sprints for athletes.

Range of sprint scores

Table 13

	Good	Average	Poor
10m	<1.95s	1.96-2.2s	>2.2s
20m	<3.0s	3.1-3.4s	>3.5s
30m	<4.0s	4.1-4.4s	>4.5s

Maximum Velocity

Maximum velocity testing should again be based upon the relevant distances covered within the sport and to determine the maximal velocity a distance of between 50-60m should be used to ensure the athlete(s) reaches their maximum. The maximal velocity can be determined by dividing the distance covered by the time it took. For example, if an athlete ran 50m in a time of 5.8s (50 ÷ 5.8) would determine that the athlete had a maximum velocity of 8.6 m/s (metres per second). An MV of above 9.0 m/s would be deemed as good, 8.4-8.9 would be reasonable and a score below 8.4 m/s for a team sport athlete, this figure would be higher in track athletes whereby speed is the only focus.

Repeated Sprint Ability (RSA)

RSA can be measured by performing a consecutive number of sprints with a short amount of recovery between each sprint. Normally this would consist of 5-6 sprints over 30-35m with 10-20s recovery between each rep. Firstly the power for each sprint needs to be calculated using the following formula (weight x distance ÷ time) and then the fatigue index can be established by using the equation (max power – minimum power ÷ total time for all 6 sprints).

For example:

Max power (W) – Min Power (W) ÷ total work time = Fatigue Index (FI)

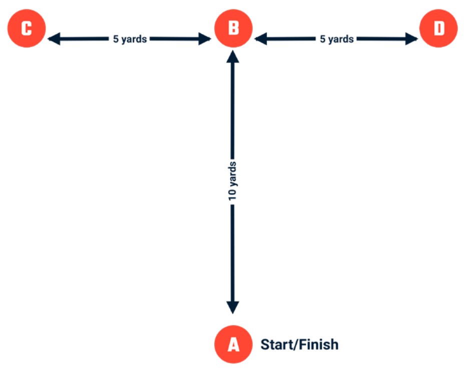
700 –500 ÷ 24 = 8.3

When assessing RSA the key indicators are both the peak power which ideally should be as high as possible alongside with a low fatigue index score which indicates that the athlete is both able to perform high sprinting outputs but is also able to maintain the outputs across multiple repetitions. For an athlete with a high-power output and high FI score this would indicate that the athlete has poor repeated sprint ability and therefore needs to train this speed component if it is a requirement of the sport.

Agility

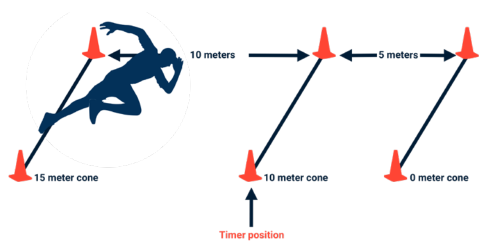
There are a number of different agility tests that can be used such as the T-Test, Arrowhead, 505 or Illinois tests. It is recommended that one that most replicates the movement pattern of the sports is selected. Below is an example of each of these tests with a brief description;

Fig 14. T-test



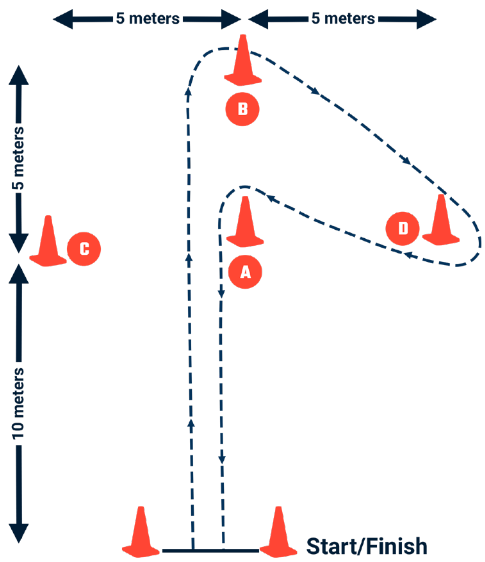
The T-test can be performed using different movement patterns depending upon the required movements for the sport. The traditional way to perform the test is to accelerate from A to B and then lateral shuffle from B to C, C to D and back to B, finishing with a backpedal from B to A. Alternatively it can be carried out by running forwards, then cutting left or right around B, then running out to C or D back into B and then finishing back to A.

Fig 15. 505 agility test



The aim of this test is to measure 180 degree turning ability and comparing bi-laterally. The test is completed by sprinting out (15m) to the turn line, turning and then sprinting back, the time is recorded between the 5m zone.

Fig 16. Arrowhead agility test



The arrowhead test is an overall test of multidirectional speed. The athlete sprints to cone A, makes a right cut and weaves around D, sprints out to cone B where a 180 degree left hand turn is made and then sprints back to the start line. This is then repeated on the opposite side.

Once the appropriate speed and agility tests have been administered and the athlete's needs have been established the Strength and Conditioning Coach can then go about designing and implementing a speed development programme.

Speed Training Methods

When it comes to speed training there are a number of modalities and methods that can be used in order to develop a particular component of speed. These methods can be classified as either general physical preparation (GPP) or specific physical preparation (SPP). GPP would generally refer to nonspecific running drills that can indirectly improve acceleration or speed; this would include both traditional strength and power exercises that would be performed within the gym. SPP for speed development generally refers to sprinting specific drills that act to transfer the strength qualities gained in the gym onto the field or track (dynamic correspondence). When it comes to speed to development emphasis should be given to both the technical and physical components to get the best adaptations possible is response to a particular drill or programme. The exercises prescribed should again be relevant to the sport requirements and needs of the athlete. Table 14 illustrates the different training modalities that can be used for each speed component.

Speed Training Modalities

Table 14

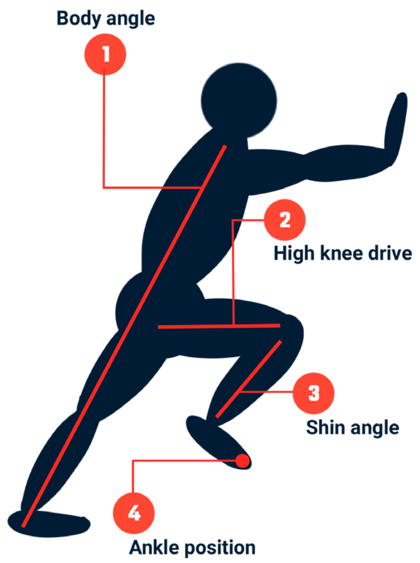
Acceleration & Deceleration	Max Velocity	RSA/Speed Endurance	Agility
Strength & power exercises (gym)	Plyometric drills (gym & field)	Strength & power endurance drills (gym)	Lateral strength & power exercises
Mechanical drills (wall)	Mechanical drills	Speed endurance sprints (100-400m)	Ladder, hurdle & pole drills (SAQ)
Resisted sprints (0.30m)	Overspeed drills	Repeated sprint drills (0-50)	Cutting/turning drills (COD)
Hill sprints	Downhill running	Stride-hollow-stride	Linear & lateral decelaration drills
Starting/reaction drills	Flying starts		
Ballistic exercises			

Acceleration Drills

The following exercises are a few examples of some SPP drills that can be used to help improve acceleration;

Wall Drills – the purpose of the wall drill is to focus on developing good acceleration mechanics and force production without actually running. If these drills are performed properly they are great for developing explosive power in the posterior chain and therefore increasing the ground reaction forces that are required when accelerating. These drills can be progressed or regressed very easily and straight forward to coach; they generally work well in the warm up prior to a speed session.

Fig 17. Wall drills: The Power Line



From the start position implement a marching action. Have the athlete raise the right leg so that the ankle is beneath the hips, toe dorsiflexed. On a command, the athlete will march, alternating legs, for a given number of repetitions. They will finish with their leg in the original starting position. It is important that the athlete can maintain correct posture and maximal force is applied into the floor. The exercise can be progressed by speeding it up and working off of prescribed repetitions and then made reactive on the coach's cue.

Resistend Sprinting – can be used to overload the athlete during the acceleration phase of sprinting. Different modalities can be used such as; pulling sleds, pushing sleds, resistance bands or partner resistance. Caution must be taken when prescribing the optimal load as it is suggested that once an athlete goes above 10% of body weight that sprinting mechanics may be altered. For this reason sleds are a preferable tool to use at it is easier to control the load and amount of resistance that is being applied, although this method can be quite time consuming especially if working with a team of group of athletes. This can be a good method to encourage athletes to apply force behind their COM. An example of a resisted speed session would consist of 4 x 20m sprints with a 10kg sled followed by 2 x 20m sprints with no resistance as a contrast. Full recovery 2-3 mins between reps is recommended to ensure maximal outputs during each repetition.

Hill Sprints - during hill sprinting, the athlete is using their body weight as a resistance to push against, so the driving muscles from which their leg power is derived have to work harder. They should aim to drive hard, pushing upwards with their toes, flexing their ankle as much as possible, landing on the front part of the foot and then letting the heel come down below the level of the toes as the weight is taken. This stretches the calf muscles upwards and downwards as much as possible and applies resistance which overtime will improve their power and elasticity. Hill work results in the calf muscles learning to contract more quickly and thereby generating work at a higher rate, they become more powerful. The calf muscle achieves this by recruiting more muscle fibres, around two or three times as many when compared to running on the flat. Hills also help to improve the power of the quads as they provide the high knee lift that is required. It is recommended to optimum angle of the incline should be between 10-20 degrees. Hill training offers the following benefits:

- Develops power and muscle elasticity
- Improves stride frequency and length
- Develops co-ordination, encouraging the proper use of arm action during the driving phase and feet in the support phase
- Develops maximum speed and strength

An example hill session would consist of 4-6 x 30m hill sprints with full recovery between repetitions.

Maximum Velocity Drills

These drills should only be implemented once the athlete has a good strength and conditioning base and ideally should have spent some time working on acceleration drills before trying to improve maximum speed. There are some specific modalities than can be used such as Plyometric drills and over speed running to improve stride frequency although consideration must be given to safety issues with this type of training. Fundamentally MV training is about getting the athlete running quickly over increased distances (short to long), therefore is more about the programming as opposed to the implementation of training modalities. It is important to remember that these types of drill are highly taxing and fatiguing and therefore should be used in moderation. Examples of some MV drills are as follows;

- **Flying Starts** – the aim of these drills is for the athlete to gradually build up to maximum speed and then be able to maintain this speed over a set distance. For example, you may begin with a 30m acceleration zone followed by a 20m maintenance zone. The maintenance zone can be gradually increased over time as the athlete(s) gets more conditioned to the drill and will then be able to maintain top speed for longer.

- **Downhill / over speed running** – the purpose of downhill running is to improve stride length, frequency and co-ordination by the athlete running quicker than they could do when running on a flat surface. There is mixed evidence as to the effectiveness of this type of training and it is classed as an advanced strategy, so definitely should not be used in novice athletes. The optimal gradient of the hill is between 5-15 degrees when using downhill running. Another method would be to use a tow or bungee to apply an over speed force although this method is more risky and difficult to measure.

Reaction Drills

As most sports require a reactive element to either an object or an opponent it is important that this is also trained within the speed component. There are many ways in which this can be achieved and quite often it's about being creative within the context of the sport. Some examples of different ways to do this include;

- **Ball reaction drills** – this is a simple way to include some reactiveness to a drill, just by dropping or throwing a ball that the athletes need to react to, these drills can also start to become sport or even positional specific.

- **Partner reaction / mirror drills** – these are good drills to use to get the athletes to better respond to the movement of an opponent. An example of this would be to put two athletes facing each other into a 5 x 5 grid with a 10m sprint zone either side. Athlete A needs to move around in the grid and Athlete B needs to mirror their movements. When athlete A feels that have lost athlete B, they need to sprint out to one of the 10m cones, Athlete B must again react and try and catch them. These are good drills for team sports athletes, where man to man marking is required.

- **Cone drills** – these are as simple as putting down a few different coloured or numbered cones in a particular shape (square, circle, star etc...). The athlete starts in the centre of the shape and the coach calls a number or colour that the athlete has to move to as quickly as possible.

- **Coaching cue drills** – these are whereby the coach just calls out different instructions that the athlete has to respond to i.e. up, down, left, right & turn. This can be performed into a grid and can be followed by a sprint. To make this more difficult the coach could get the athlete to perform the opposite movement to the instruction given. For example, if the coach calls up, the athlete must go down.

- **Reaction speed drills** - can be quite fun and enjoyable but care and attention must be given to the quality and intensity of the session in order that the appropriate overload is achieved within the session.

Agility Drills

There is an endless list of agility drills that could be provided including those ones shown in the testing section. When training agility it is important to refer to the necessary movement patterns required within the sport and to design drills that specifically replicate these movements. There are a number of different patterns that can be trained under the term of “agility” including;

- **Cutting** – ss the ability to accelerate, decelerate and then accelerate at a different angle (10-90 degrees). This requires good strength in both the frontal and sagittal planes and is an important quality required for many sports. An example cutting exercise would be the zigzag drill over 20-30m. The athlete should be encouraged to lower their COM and explosively drive off the outside leg when pushing off.

- **Turning and twisting** – requires the athlete to manoeuvre or turn around an object or person. The mechanics are slightly different to that of cutting and an example would be the Illinois agility drill.

- **Lateral movements / shuffling** – requires the athlete to be able to move laterally or side to side as quickly as possible, which could be in the form of shuffling or by using the cross step to move. An example of this type of drill would be the T-Drill.

- **Backwards movements / backpedalling** – this is often a movement that is overlooked when it comes to training. Athletes often spend time training on speed running forwards but often neglect backwards running. Backwards running can be used as a good conditioning tool for the hamstrings and should be trained if it is a necessary requirement for the sport. Backwards running can be trained in isolation or integrated within a multi-directional agility drill.

Speed Programming

Similarly, to strength training the key to developing speed with an athlete is not necessarily the exercise selection but more importantly the overall programme design. When designing the speed programme consideration must be given to the following:

- **Needs of the sport and the athlete** – as has already been discussed in the needs analysis module

- **Aethlete's status** - the training age and experience of the athlete must be considered before exercise choice and exercise volume can be programmed. A novice athlete will require much less volume load than a more experienced or advanced athlete.

- **Time / stage of season & aims of session or cycle** – this will dictate the speed emphasis that is required during a particular stage of the season or competition and to with more emphasis is given to GPP or SPP. For example, during the off season more emphasis may be given to strength and power development (GPP), whereas during the pre-season this focus may shift to acceleration and max velocity development and then shift into speed maintenance phase during the in season or competition phase.

- **Training volume (distance x reps x sets)** – this will be dependent upon the athletes status and time of season, although the minimum dose rule should be applied in order not to overcook the athlete(s). This is also a good way to measure and plan specific loads for a speed session.

- **Rest time between reps, sets & sessions** – full recovery is required between repetitions when it comes to speed training. A work to rest ratio of 1:10-1:20 is recommended to allow for this. Therefore, if a sprint repetition took approx. 5s then a rest time of 50-100s should be given. This is why speed training can be quite consuming. There are ways in which this recovery time can be utilised such as by practising some low intensity technical skills. It is also recommended that 48-72 hours recovery is given between sessions in order that the athlete is fresh and not fatigued when performing speed work.

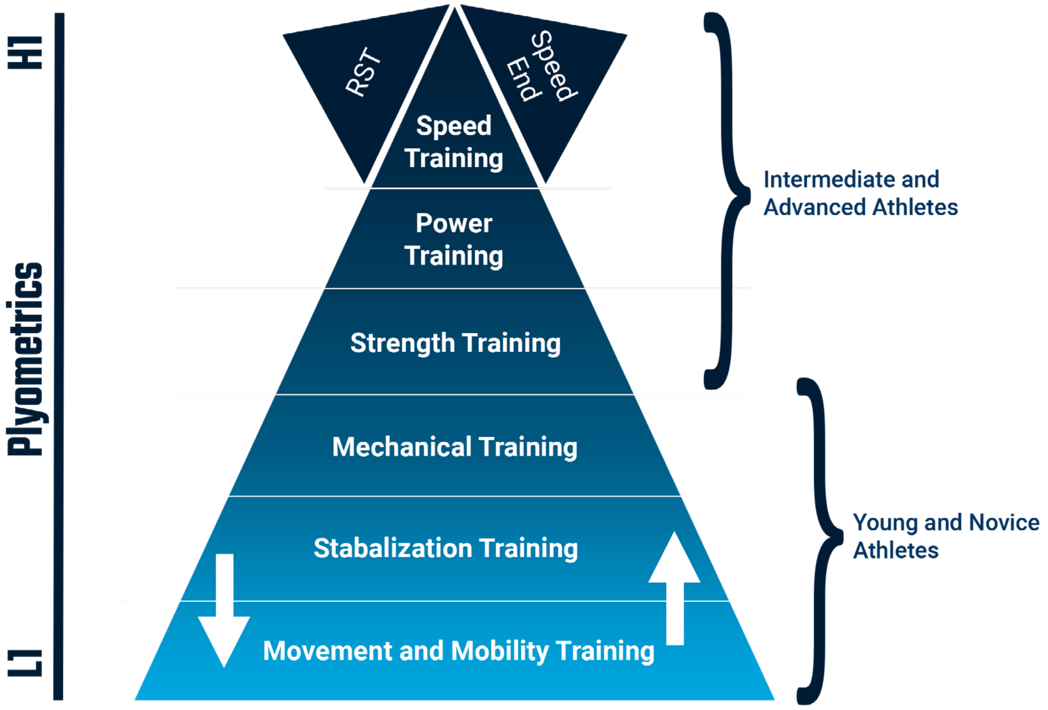
- **No of sessions per micro & mesocycle** – a minimum of 2-3 sessions per week is recommended for speed development, although during the season 1 session per week may be enough to maintain speed.

- **Exercise selection and order** – all speed sessions should begin with a RAMP warm up, leading into some mechanical drills. Either the intensity or distances of the sprints should be progressive. For example, 2 x 20m, 2 x 40m, 2 x 60m sprints in order that the athlete is adequately prepared for the intensity of the longer sprints.

- **Progressive overload principle** – as all fitness components progressive overload must be applied, which can be achieved through increasing the total sprint volume across a mesocycle.

The speed pyramid shown in Fig. 17, illustrates how to build a long-term speed programme and should be based upon developing good mobility, movement literacy and running mechanics as well as developing a good strength base before beginning actual sprint training. These are the essential foundations to build speed upon as an athlete with poor movement, technique or strength levels will always be limited in their speed development and will never fully reach their maximum potential.

Fig 18. Speed pyramid



When it comes to developing a speed programme the short to long approach is recommended. This method was developed by the legendary sprint coach Charlie Francis. This approach is based upon the premise that an athlete needs to develop a quality before they can learn to endure it. For example an athlete needs to develop good levels of speed before they can improve their speed-endurance. This is also known as reverse Periodisation whereby you start with a relatively high intensity training block and progressively increase the volume across that particular phase or cycle. This is a very popular model in the world of sprinting and can be very effective if it is implemented correctly. An example of this for a team sport athlete may be during the 1st phase to focus on acceleration and COD qualities over shorter distances, progressing to MV work in the second phase and moving onto RSA drills during phase 3. Appendix 2 shows an example of 6 week speed training programme for a football player and Appendix 3 shows an example of a speed training session for the same player.

Further reading

- Developing Speed (Sport Performance Series), Jeffrey's I, 2013.
- Training for Sports Speed and Agility: An Evidence-Based Approach. Gamble P, 2011.
- Training for Speed, Agility, and Quickness, Brown L, 2014.