STRENGTH & CONDITIONING EDUCATION

Level 4 Award in

Strength & Conditioning

Manual

CIMSPA Education Partner | Training Provider

Contents:

A word from our founder, **Brendan Chaplin**

Welcome to Strength and Conditioning Education!

Firstly, thank you very much for joining us on our Level 4 Strength and Conditioning course, we're thrilled to have you onboard.

On behalf of everyone at Strength and Conditioning Education I'd like to offer you the best of luck for the duration of this process and beyond. We'll be here to provide you with the world-class service that you need to stand out from the crowd throughout your career!

This manual is a powerful aid to the other learning opportunities you will go through on the Level 4 Award in Strength and Conditioning. We're really proud of it and we hope you will continue to refer to it in the many years to come!

Regards,

Brendan Chaplin

Needs Analysis

Before designing and implementing a training programme for an athlete or group of athletes, it is essential that a needs analysis of both the athlete and the sport are carried out.

The aim of the needs analysis is to be able to identify specific areas of fitness and training that the athlete(s) needs to focus on to improve their physical performance capabilities within their specific sport and position (specificity).

For example the physical, technical and tactical needs of an MMA fighter are very different to that of a professional football player, which should be reflected within the training programme design.

Needs Analysis of the Sport

- **What is the sport?** What fitness components are required to be able to perform the sport at an elite level? Examine time motion analysis data to find out specific demands. i.e distance covered, high speed running distance, sprint distance. Contact or non-contact in nature?
- **What is the duration of the sport?** And what are the predominant energy systems involved; aerobic, anaerobic or mixed contribution?
- **What are the major muscle groups and movement patterns involved?** I.e. sprinting, jumping, shuffling, cutting, tackling, pushing, pulling, grappling etc.… Is there a lower body, upper body or total body emphasis?
- **What are the common injuries associated with the sport?** Contact or non-contact, acute or chronic/overuse in nature?

Example

Table 1 (below)

Table 1 shows the complexity of both the physical and skill requirements of a player for a professional footballer, which will be the case for most sports. This table illustrates the key components to look for within a sport. There will be similarities between sports but there may also be major differences. Unless the S&C coach understands the specific demands of a sport then it is impossible to determine which physical qualities the athlete(s) requires to perform well within their sport.

Once the needs analysis of the sport has been completed and the physical competencies have been established the next step is to devise a fitness testing battery for the athlete which assesses the necessary qualities required for the sport.

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Example

Table 1

Sport	Football
Position	Striker
Avg. Distance Covered	10km
Avg. HSR Distance Covered	1000m
Avg. no. of Sprints / Sprint Distance Covered	300m
Time Spent Above 80% / 90% MHR (mins)	40/20
Avg. Intensity	70% VO2 Max
Predominant Energy Systems	Aerobic-alactic
Specific Physical Demands	Sprinting, turning, cutting, jumping & landing, accelerating & decelerating
Specific Technical Demands	Passing, shooting, hold up play –first touch and heading
Physical Requirements	Total body strength - hold up play Power – jumping and heading Lower body strength (eccentric) – accelerating, decelerating, landing Speed – linear sprints Agility – MD sprints Aerobic capacity (V02 max) – to last the duration of the game and recovery quickly between HI actions
Primary Movement Patterns	Lunge patterns i.e. cutting, changing direction, turning, tackling Twist pattern i.e. turning, twisting, kicking/shooting Squat pattern i.e. jumping & landing Gait patterns - running, sprinting and jogging
Common Injuries	Contact – ATFL sprains, MCL sprains, ACL ruptures, haematoma's Non-contact – Hamstring strains, groin strains, ACL ruptures

Needs Analysis of the Athlete

Once the demands of the sport have been established the next step is to begin the athlete screening and assessment process.

This is an information gathering task providing the S&C coach with as much information about the athlete as possible, in order to ensure that strengths, weaknesses and areas for improvement have been identified. By the end of the needs analysis process the S&C coach should have a clear understanding of what the athlete(s) needs to focus on (specific to their needs within the training programme).

The first part of the athlete assessment process is to have an initial consultation with the athlete, whereby a medical questionnaire should be included to ensure that the athlete is safe to participate within the training programme. The initial assessment should include the following information;

- Athlete's personal details (name, address, DOC etc...)
- Previous injuries/illnesses
- Training age/experience
- Time of season
- Athlete's goals and objective

Once the medical questionnaire and initial screening has been completed and the athlete has been medically cleared to participate, it's time to start the next step. The next step involves carrying out a physical screening and fitness testing battery that focuses on the specific demands of the sport.

Table 2 (below) shows an example of a testing protocol that could be used based on the professional footballer that was used as an example in the sport needs analysis in Table 1.

Firstly, an appropriate testing protocol needs to be established, then this needs to be administered with the athlete and finally the results need to be analysed. To analyse the results, ideally you should compare the scores of the athlete against normative data for the sport. This data could either be taken from squad and positional averages or published data within the literature.

Athlete Fitness Testing Assessment

Table 2

Fitness Component	Test	Score	Normative Score
Aerobic Capacity/V02 Max	Progressive treadmill test - lab	56 ml.kg.bw	59 ml.kg.b
Aerobic Power	MAS run (1500m)	5:38 mins	5:25 mins
Power	CMJ	66cm	61cm
Leg Strength	Back squat 3RM	140kg	130kg
Speed	10m sprint 30m sprint	1.95 secs 3.81 secs	2.01 secs 3.95 secs
Agility	T-Test	9.2 secs	9.6 secs
Anthropometry	Skinfolds (sum of 8)	76	64

From this table it is apparent that the player scores well on the anaerobic based tests such as strength, power and speed. However, the player does not score so well on the aerobic based tests and skinfold measure. These shortfalls may negatively impact on the player's physical performance; therefore, the training programme should focus on trying to improve these areas whilst maintaining the other components.

Once this information has been established, specific goals should be agreed with the athlete and the appropriate training intervention should be put into place. The training should then be reviewed and modified every 4-6 weeks.

It's also common practice to complete some form of movement screening with athletes to assess how well they can perform general movement patterns. This can be used to identify potential weaknesses and muscle imbalances. There are branded protocols on the market such as Grey Cook's FMS and Kelvin Giles's Movement Dynamics. Both of these models use a grading criteria to score how well an athlete can perform each specific movement.

Some common tests used within the screening includes the following:

- Overhead squat
- Hurdle step
- In-line lunge
- Shoulder mobility
- Rotary stability
- Active straight leg raise
- Trunk stability push up

Although these tests can be used to grade the athlete(s) movement competency, there are some limitations with this type of screening. This can be quite a time-consuming process and there is an element of learning effect which can take place between subsequent tests, especially in novice athletes. Assumptions can often be made about muscle imbalances if someone has a limitation performing a certain movement pattern.

For example, people will sometimes say that an athlete has tight hamstrings which is causing excessive forward trunk lean during the overhead squat. This may be the case, but which further tests have been carried out to validate this statement?

Therefore, it is important that any potential issues highlighted within the movement screening process are validated through the implementation of some manual muscle or joint testing. There is also limited research to validate that a poor score achieved during a movement screen corresponds with an increased risk of injury. A good S&C coach will be constantly assessing and monitoring an athlete's movement quality throughout each training session and the appropriate interventions should be implemented as necessary.

Further reading

- Movement: Functional Movement Systems: Screening, Assessment, Corrective Strategies (Cook, 2010)
- Functional Testing in Human Performance: 139 Tests for Sport, Fitness, Occupational Settings (Reimann, 2009)
- Practical Fitness Testing: Analysis in Exercise and Sport (Coulson, 2009)

Coaching Relationship

Leading by Example

As strength and conditioning practitioners, gaining respect and athlete trust is a fundamental objective that must be achieved. The resulting consequences of formulating such an effective working relationship include greater athlete and coach motivation, positivity, and athlete professionalism. All of which lead to a potential improvement in athlete performance. Therefore, coaches must lead by example, demonstrating the qualities that encompasses 'what a great coach is' consistently.
For example - If the Strength and Conditioning (S&C) Coach can't demonstrate any exercise to a component level, the resulting consequence will be an instant loss of respect between the athlete and the coach.

Therefore, if coaches are aware that the demonstration of a particular exercise isn't their strong point, then extra time must be spent practicing that particular exercise/training mode prior to any future coaching sessions. This doesn't mean coaches should be capable of lifting world-record breaking weights, or achieving Olympic level 10m sprint times. Rather, coaches need to be able to demonstrate 'competency' if they wish to gain the respect of athletes. However, before such professionalism can be achieved, it is essential that practitioners have a clear understanding of 'what makes a great coach' and 'what great looks like' and lastly, what strategies can be implemented to improve coaching practice.

Such strategies include:

- **Appropriate attire** – to gain the trust and respect of athletes, S&C Coaches must present themselves as strength and conditioning coaches. This involves being appropriately dressed, looking the part and being able to demonstrate anything that is expected of the athletes competently

- **Well-organised in advance** – 21st century coaching requires coaches to prepare programmes electronically, carrying out regular performance assessments with athletes, recording athlete performance data, setting up of strength-based and movement-based training environments etc. All of which can be time consuming and requires a good level of coach organisation. Poor organisation leads to poor practice – resulting in poor performance!

- **Clear introductions/instructions** – 21st century coaching involves the corporation between all support staff (physiologist, physiotherapists, nutritionist, technical/tactical/sport specific coaches, etc). Therefore, it is essential that all new staff members within the organisation, including oneself, are clearly and confidently introduced to the team. Likewise – any instructions given to athletes must be clear, with clear planned objectives. If a coach isn't sure on 'what they want to achieve' from a training method – then how can the athlete be expected to understand what is expected?

- **Position of coaches and performers** – as a Strength and Conditioning Coach, it is essential that coaches and athletes alike are clearly aware of their professional boundaries and what behaviours are expected of them. The result of which is a professional working environment.

- **Appropriate session** – the design and implementation of evidence-based practice, and a deep understanding of the necessary knowledge that underpins program design (volume, load, frequency, exercise mode, progressive overload, exercise sequence, etc.) is a fundamental bedrock of strength and conditioning practice. The more appropriate and specific a session is in meeting an athlete's needs, the greater the transfer of training effects will be – resulting in greater athletic performance.

- **Building good rapport and trust with athletes** – as previously highlighted, the development of good athlete rapport and trust between coaches and athletes is the foundation of an effective professional working relationship. The context of this may varying depending on the situation, for example – a team working environment differs considerably compared with the preparation of individual sport athletes. However, in either case, building a good rapport and trust in athletes is essential for optimal coaching and athletic performance.

Providing Athletes with a Problem to Solve

Strength and Conditioning Coaches can often be guilty of approaching the coaching process in a one dimensional fashion. Being over reliant on dictating rather than encouraging athletes to discover new movement for themselves. As suggested previously in literature: ***"A great teacher is also a student, who is not to dictate the answer but to stimulate his student's creativity enough so they go out and find the answers for themselves"*** - Vern Gambetta

Therefore, Strength and Conditioning Coaches need to be aware of when to dictate, when to allow athletes to problem solve, and discover correct technique and movement for themselves.

Skills of the Coach

The necessary skillset of the 21st century Strength and Conditioning Coach involves far more than merely leading training sessions, including additional skills such as:

- **Teacher** – the ability to teach new movement or correct existing movement dysfunctions is essential within strength and conditioning practice. Additionally, coaches need to be able to explain and justify the purpose behind the implementation of training modes.

- **Mentor** – the ability to mentor athletes through the development process, whether that be advise on controlling external factors which may influence the recovery process or as athlete's progress from youth, junior to senior athletes.

- **Leader** - as previously discussed, strength and conditioning coaches need to have the necessary skillset and level of professionalism to lead athletes through the development process.

- **Psychologist** – applied sports psychology is a highly-qualified skill, requiring specific psychology qualifications. However, the development of a performance driven mindset is something that can be embedded in athletes by the strength and conditioning coach, through periodic performance assessments, working within a professional environment, etc.

- **Planner/strategist** – the ability to carry out detailed athlete profiles, needs analysis, and all other preparatory stages, before designing evidenced based programmes and implementing periodisation models is the foundation of strength and conditioning practice.

- **Parent figure** – many external factors can affect athlete performance and adaptation to training, including poor sleep patterns, nutrition, and lifestyle choices. Therefore, as Strength and Conditioning Coaches, the building of effective rapport with athletes, whilst reinforcing the importance of managing external factors (e.g. sleep patterns, nutrition) is key to ensure optimal athlete development.

- **Analyst** – 21st century coaches are required to gather and analyse athlete performance data, whether it be performance assessment scores, or the evaluation of program effectiveness. Such analytic skills are essential within the modern strength and conditioning role.

- **Motivates** – Strength and Conditioning Coaches are required to not only motivate athletes, but also know when such motivation needs to be differentiated between individuals, and how to implement additional aids when applying such individualised motivation strategies (DISC profiling, etc.)

Communication

Strength and Conditioning Coaches require effective communication skills, including the ability to be able to communicate effectively both amongst athletes and peers. Such effective communication requires coaches to have a clear understanding of both verbal (tone of voice, volume) and non-verbal communication (open posture, full attention, correct attire). Additionally, coaches need to ensure that they implement basic communication skills including:

- Grab and maintain athlete attention + focus
- Be clear and concise when giving instructions
- Encourage positive work ethic, and professionalism
- Be approachable and willing to share ideas amongst both athletes and peers

In summary, great coaching is fundamentally about effective communication, professionalism, rapport building, knowing when to differentiate to meet individual athlete needs, and leading by example. Therefore, all the necessary skills and qualities that have been discussed within this module are vital to becoming a great Strength and Conditioning Coach.

Periodisation

Periodisation is defined as the "long-term cyclic structuring of training and practice to maximise performance to coincide with the athlete's competitions". It is the programme design strategy that includes planned, systematic variations in training specificity, intensity, and volume across a specific period of time.

The goal of Periodisation is to maximise the athlete's gains whilst also reducing their risk of injury and staleness or fatigue over the long term. It also addresses peak performance for competition or meets. Periodisation, if appropriately arranged, can peak the athlete multiple times over a competitive season or individual sports such as Olympic weightlifting, power lifting, track and field. Periodisation can optimise an athlete's performance over an entire competitive season for team sports, for example football, rugby and basketball well designed training year (macrocycle) should encompass smaller blocks of training (mesocycles) that each has its own goals or emphasis.

This type of overall schedule will encompass all of the aspects of the athlete's programming and should include strength training, conditioning, speed training, and sport-specific activities. The whole foundation of Periodisation is based upon the incorporation and manipulation of the basic principles of training;

Training Principles

There are a number of principles (Fig 21) that must be applied throughout the overall training plan (macrocycle) in order to enable the athlete to progress through the training programme, whilst also minimising the risk of fatigue and injury.

Specificity

Specificity is the principle of training that states that sports training should be relevant and appropriate to the sport for which the individual is training in order to produce a training effect. This does not necessarily mean that all training should involve training for the sport, but the component that is being trained is relevant to the demands of the sport, refer back to dynamic correspondence. For example during the season hypertrophy training would not be as specific to a footballer as Plyometric training. Although during the GPP less specific components should be incorporated to build a platform for more specificity during the SPP.

Progressive Overload

In order for an athlete to adapt and improve i.e. get stronger there needs to progression within the programme. Progression is normally achieved through increasing the volume or intensity or changing the stimulus i.e. moving from strength to power development. This should be gradual and progressive in nature and the athlete should not be progressed until they are clearly ready (earn the right).

Reversibility

This principle basically states that if the athlete doesn't train a specific fitness component over time, they will become detrained in that particular component "If you don't use it, you will lose it". For example; if the athlete didn't complete any strength training during the SPP that they would lose strength and therefore force production qualities. This is why during most Periodisation methods there will be a main training focus on one or two components with a secondary focus on maintaining other components so that these don't become detrained.

Tedium

Tedium refers to avoiding too much monotony through training variation within the programme from both a physical and psychological perspective. Hence the reason that it is good to start a new training cycle approximately every 4 weeks in order to prevent boredom and staleness which will cause the athlete to plateau and start to detrain. It is important to ensure that these principles are appropriately applied within the overall training programme.

FITT Principle

The FITT principle refers to the specific elements of the training programme that can be manipulated throughout the micro, meso and macrocycle in order to increase, maintain or decrease an athlete's overall workload. Table 4 identifies each of these variables that can be manipulated throughout the training programme.

Training Variables

Table 4

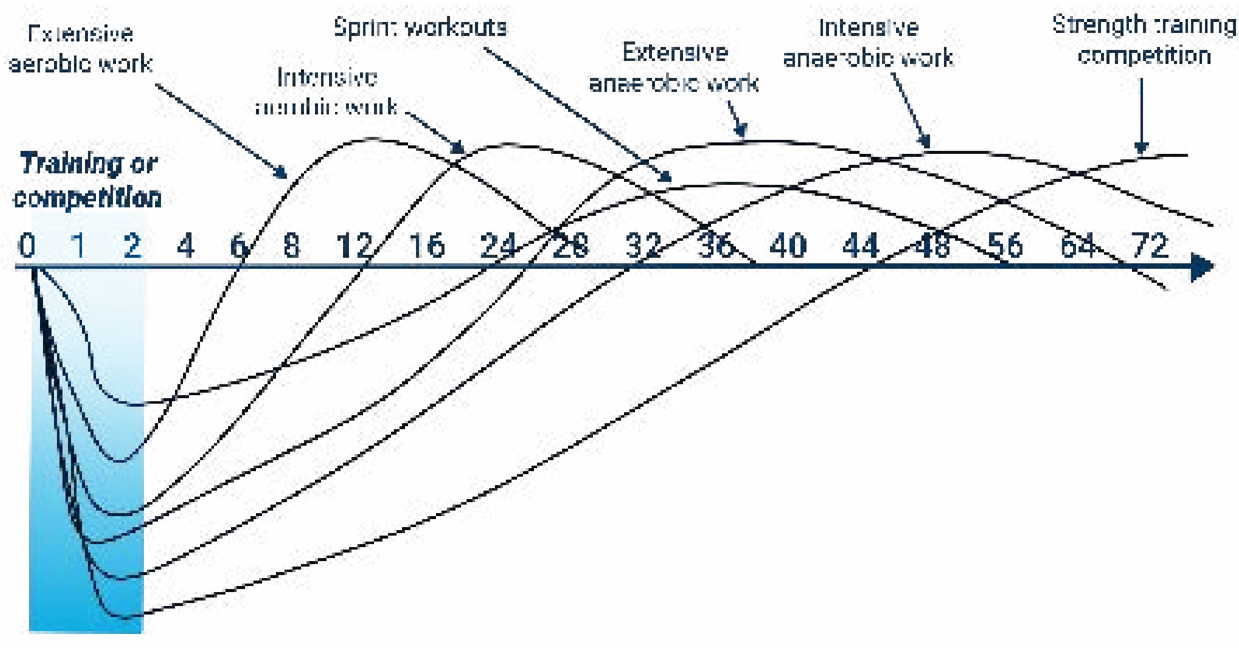
	Description	Example
Frequency	How often	No. of sessions per day, week or month
Intensity	How hard	%Load, HR zones, RPE
Time / volume	How long	Sets x reps = tonnage, mins trained, distance covered
Type	Mode of exercise	Resistance, calisthenics, met con etc.
Rest / recovery	Optimum time to allow recuperation and physical adaptation	Rest time between sets, recovery time between sessions

The frequency of training refers to how often the athlete needs to train in order to achieve a positive training adaptation. The frequency of training sessions should also allow adequate time for recovery and regeneration between sessions. For example it is recommended that an athlete performs a minimum of three strength sessions per week in order to get stronger. The training intensity relates to how hard the training session is which could refer to the load being lifted as a % of 1RM in regards to strength training. The time element refers to the volume of the session either in chronological time in which session TRIMP can be determined by multiplying the session RPE by the session time. Alternatively the session volume can be determined through calculating the overall volume loads of the session (sets x reps x load). The type of exercise refers to the modality of training being used i.e. strength, power, speed, endurance etc.. The type of exercise modality chosen should be specific to the aims of the athlete.

Supercompensation

Supercompensation is the phenomenon that all Periodisation models are built upon and relates to the time and rate at which the body adapts and responds to different training modalities.

Fig 1. The Supercompensation Curves of Different Fitness Components



Supercompensation is a four-step process;

- **Step 1** is the application of a training or loading stress and the body's subsequent reaction to this training stress, which is fatigue or tiring. There is a predictable drop-off in performance as a result of that fatigue.

- **Step 2** is the recovery phase. This can be a lighter training session, a recovery session, or active rest. As a result of the recovery period, the energy stores and performance will return to the baseline represented by the point of the application of the original training stress.

- **Step 3** is the super compensation phase. This is the adaptive rebound above the baseline; it is described as a rebound response because the body is essentially rebounding from the low point of greatest fatigue. This super compensation effect is not only a physiological response but also a psychological and technical response.

- **Step 4** is the loss of the super compensation effect. This decline is a natural result of the application of a new training stress, which should occur at the peak of super compensation. If no training stress is applied there will also be a decline, as a result detraining phenomenon (reversibility). Different physical qualities respond at different rates, therefore there is not one generalised super compensation curve, each physical quality has its own individual super compensation curve.

Fig 1. The Supercompensation Curves of Different Fitness Components

The picture illustrates the proposed super compensation curves for the different components of fitness. These differences in timing for super compensation are due to the duration of the various biological regeneration processes that take place during the recovery phase. The art is designing these curves of adaptation so that they coincide at the proper time. Working out the timing of the various components is possibly the most difficult aspect of planning; it is as much an art as it is a science.

Periodisation Models

There are many ways in which the principles of training can be manipulated and applied within the overall training programme. There are three main different Periodisation models that are commonly used with athletes which includes; linear (traditional), undulating (non-traditional) and conjugate (advanced) methods. Each of these models applies a different approach to the manipulation of these principles, although the supercompensation theory will always to be present in order to allow the athlete(s) adequate time to recover and adapt to each training stimulus. The annual training programme, referred to as the macrocycle normally consists of four distinct phases; General Preparatory Phase (GPP), Special Preparatory Phase (SPP), Competition Phase (CP), and Transition Phase (TP).

GPP - also known as the off-season phase either between seasons or competitions and can last from anywhere between 2-12 weeks dependent upon the sport. The purpose of this phase is about building a general strength and endurance base before moving into more specific and intensive training in the SPP phase. Traditionally this phase was also referred to the hypertrophy phase, although this is not a key requirement for many athletes especially athletes who need to compete within a weight category. The GPP phase normally consists of training with higher volumes at lower intensities to allow anatomical adaptations to occur. For example a repetition range between 8-12 may be used at intensities below 70% 1RM within the early strength component which could progress to heavier strength training with lower volumes (4-6 reps) across this phase. Alternatively dependent upon the length of this phase this could be broken down into 2-3 smaller blocks with a more specific objective within each block although the principle remains the same increasing the intensity, whilst reducing the volume across each of the blocks. An example for endurance training would be to begin with some LSD training, progressing to extensive interval and then intensive intervals.

SPP – more commonly known as the pre-competition phase and can range anywhere between 3-12 weeks in duration dependent upon the sport. In many team sports this period can be relatively short (4-6 weeks), which does not allow a lot of time to develop multiple qualities that are required for the sport, which is why the work completed during the GPP phase is essential for adequately preparing the sports specific training that normally occurs during this period. The aims of this phase are to develop the specific qualities that are required for the sport in order that the athlete is ready to perform i.e. power, speed & sports specific fitness. It is common in this phase that coaches try to develop multiple qualities of fitness with inadequate recovery time which can result in mixed signalling and excessive accumulation of fatigue, subsequently resulting in injury to the athlete(s).

Competition Phase – also referred to as the in season phase and can last between 6-9 months in most team sports, although can be much shorter in some individual sports. Generally this phase is recognised by maintaining the athlete's fitness (performance stabilisation). Although dependent upon the athlete's status and frequency of competition there may be windows of opportunity to develop certain components of fitness around the demands of the competition. Although it is important to remember de-load periods should be incorporated into the competition phase to avoid overtraining and injury.

Transition Phase – time between the end of the competition phase and the start of the GPP phase and is included to provide the athlete with both physical and mental recovery from the competition period. It is recommended that the athletes perform some light restorative activity during this phase such as swimming, cycling and light jogging etc, but should not consist of anything too intensive. This period can last between 2-4 weeks in duration and should not be overlooked.

The 4 Common Phases of the Macrocycle

Table 5

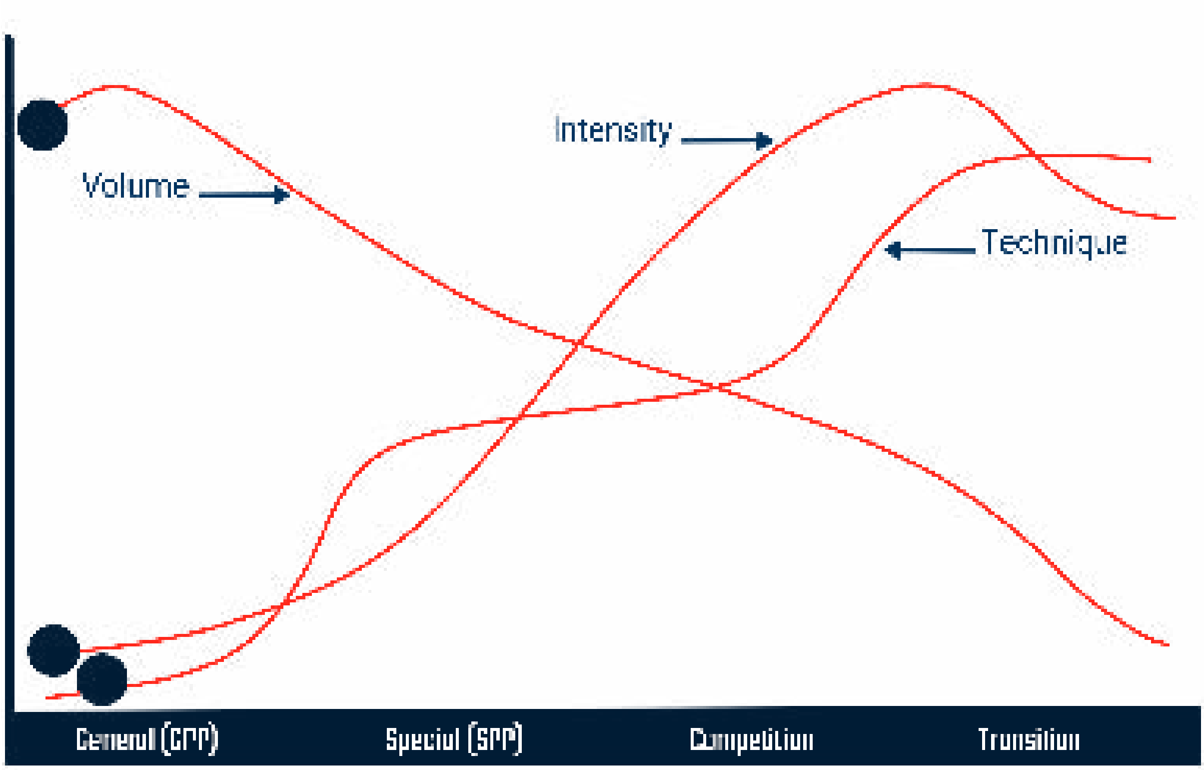
Phase	Description	Example
General preparation / off season	Training of general physical qualities to prepare for the more intensive loads during the SPP cycle	Hypertrophy / anatomical adaptation. Progressive aerobic capacity drills
Specific preparation / pre season	Training more specifically for the demands of the sport.	Strength & power, speed & agility, sports-specific drills
Competition / in season	Maintaining fitness qualities developed in earlier phases.	Strength & power, speed & agility, sports-specific drills
Transition / recovery period	Allow recovery and recuperation from the demands of training and competition	Rest, swimming, x-training

Each of these four phases will be further broken down into smaller training cycles known as mesocycles and each mesocycle will be further broken down into weekly cycles known as Microcycle, these will be discussed in further detail in module 12.

Linear Periodisation

Linear Periodisation is also termed traditional Periodisation within the literature, and is defined by simply making inverse changes in both volume and intensity across multiple mesocycles. The theory behind this model is that as intensity increases throughout the mesocycle(s) the volume is simultaneously reduced in order to minimise fatigue. Linear Periodisation is most appropriate for novice athletes or an athlete's general preparation (GPP) for sport. This model can be used to provide a unilateral development of strength, endurance, and technical abilities, and is generally characterised by longer training periods or blocks. A particular fitness component is normally trained for a specific length of time (mesocycle) i.e. 4-6 weeks before moving onto a different component. This module is normally characterised by starting with hypertrophy training during the GPP Phase then moving in to strength then into power and then into speed as the athlete moves through the SPP into the competition phases. This method is good for emphasising the development of one main fitness quality although qualities may become de-trained due to the reversibility effect of not training a specific component for a period of time.

Fig 2. Inverse relationship between training volume and training intensity
The below illustrates the inverse relationship between training volume and training intensity. Each phase should begin with high volume and low intensity, as intensity increases throughout the phase, volume is subsequently decreased to minimise accumulation of fatigue.



Undulating Periodisation

Undulating Periodisation, also referred to as non-linear or non-traditional Periodisation within the literature, has gained more interest in recent years. With the undulating method, there is enough variation in stressors to continually make progress without allowing the athlete to fully adapt to all the stressors taking place, whilst still accounting for the recovery or restoration needed. In the undulating design, the stimulus is varied either within a weekly model (WUP) or in daily undulating Periodisation (DUP) where daily changes are made to either volume or intensity. This model can be more favourable for increases in strength gains than in typical linear modelling in well-trained athletes. It is also suggested that DUP may be more beneficial for elite athletes as it helps them avoid the plateau effect that can happen in well-trained athletes. DUP modelling has also showed a favourable increase in strength gains and CNS adaptation without the added muscle mass, which could benefit athletes in groups where weight classes are of importance. There are lots of different ways that this type of method can be presented although would normally focus on three different training emphasis either on a weekly basis (WUP) or alternatively across the training week (DUP), and would normally be shown as:

1. Volume (repetition) week/session
2. Intensive (heavy) week/session
3. Dynamic (explosive) week/session

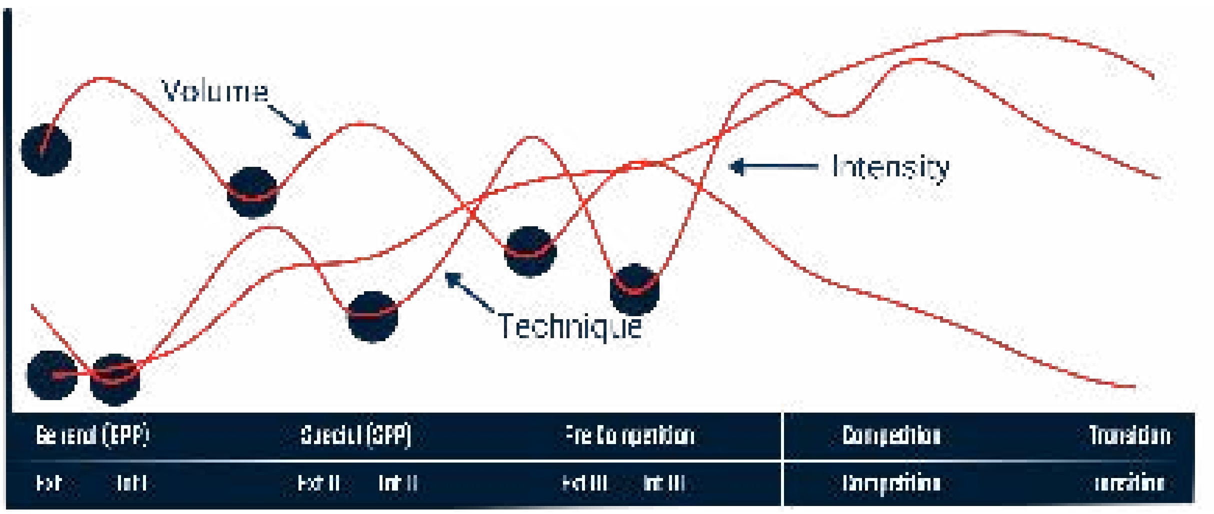
Although not necessarily in that order

WUP and DUP Training Method

Table 6

Weekly udulating		Daily udulating		Sets / reps	Load
Week 1	Repetition (hypertrophy)	**Day 1**	Repetition (hyperthophy)	4 x 8-12	70-80%
Week 2	Heavy (strength)	**Day 2**	Heavy (strength)	5 x 3-5	>80%
Week 3	Dynamic (power)	**Day 3**	Dynamic (power)	3 x 3.5	30-50%
Week 4	De-load (recovery)				

Fig 3. Wave-like pattern associated with undulating Periodisation
The below illustrates the wave-like pattern associated with undulating Periodisation. It is characterised by a constant variation and intensity throughout each mesocycle either through the use of DUP OR WUD methods.

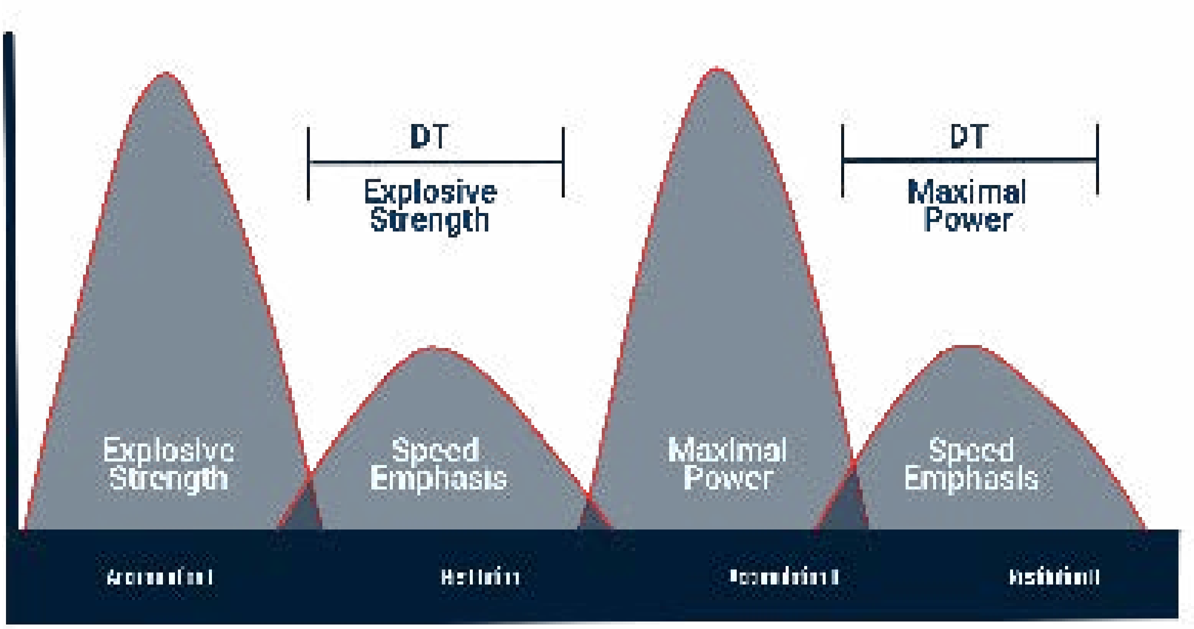


The undulating model is an effective method for training both intermediate and team sports athletes where multiple components are trained concurrently. Whereas for advanced athletes such as weightlifters and track athletes the conjugate method may be more appropriate.

Conjugated System

The conjugate model, more commonly referred to as block Periodisation, was originally developed by Verkoshansky for Olympic athletes who are very advanced. It consists of a two-block design, accumulation and restitution. During the accumulation blocks, the focus is directed toward supporting motor abilities while simultaneously developing certain strength qualities necessary for the athlete with a limited volume load. The restitution block is essentially the opposite, they support strength qualities in the athlete, while addressing the development of specific, technical motor qualities again with a limited volume load. These training loads must target different abilities i.e. max-strength, explosive strength, power and speed. Throughout the accumulation block the emphasis is on unilateral concentrated loading of strength qualities. This single emphasis increases the concentration of loading, allowing specific systems to achieve a higher level of stress which, is necessary for further adaptation to take place in elite level athletes. Although whilst they are focused on this, they are also training to keep the motor abilities necessary for their sport. During the restitution blocks the opposite applies. The focus is to support the strength qualities developed in the athlete while improving the technical motor qualities that are needed for the athlete's sport.

Fig 4. Loading patterns
The below illustrates the different loading patterns between the accumulation and restitution phases within the conjugate method.



It is important to possess a basic understanding of the different Periodisation models that can be used with athletes in order to develop specific fitness components and overall athletic ability. When it comes to writing an annual programme for an athlete it is important not to get hung up on the type of Periodisation that is being used. What is important is that the S&C coach has a clear objective of what the athlete needs to achieve within the programme and then is able to put a well-structured plan together as to how the athlete is going to achieve their goals. The macrocycle should be broken down into smaller phases or cycles of training with a specific emphasis of training, whilst maintaining other components that have previously been developed within the programme. Often there will be elements of the different models evident within the overall macrocycle. For example during the GPP there may be more of a linear approach, whereas throughout the SPP and completion phases it may look more undulating. The limitation with many traditional Periodisation models is that they were originally developed for Olympic athletes who have infrequent competition and only need to focus on training a couple of fitness qualities. Therefore this presents a number of challenges for those athletes who have to compete on a much more regular basis and have to train multiple fitness qualities to meet the demands of the sport. It is necessary to determine the key components that the athlete needs to focus on that will have the biggest impact upon their performance and then applying the principles of training when it comes to implementing the training plan. It is also essential to allow for periods of acute and chronic recovery within the programme.

Further reading

- Priodisation. Theory & Methodology of training, 5th edition, Bompa &Haff. 2009
- Periodisation training for sports. 3rd edition, Bompa & Buzzichelli. 2015
- Athletic Development. Vern Gambetta. 2007
- Essentials of Strength Training & Conditioning. 3rd Edition. Beachle & Earle. 2008

Macro, Meso & Micro-Cycles

Periodisation is the systematic planning of athletic or physical training. The aim is for the athlete to reach the best possible performance in the most important competition(s) of the season or alternatively maintain a stable high level of performance for sports that have frequent competitions or games. The macrocycle involves progressive cycling of various aspects of the training programme during a specific period. Strength and conditioning programmes use Periodisation to break up the training programme into the off-season, pre-season, in-season, and the post-season phases. The macrocycle further divides the year-round conditioning programme into smaller phases of training which focus on different goals. A periodised training programme is made up of 3 different tiers or a level which consists of the macrocycle, mesocycles and micro-cycle. The macrocycle is more commonly known as the annual plan and is the overview of the entire programme. The mesocycles are smaller blocks or periods of training with a specific aim or focus that makes up the work within the macrocycle. The micro-cycle are even smaller blocks within the training programme that make up each mesocycle and should become more detailed at each level. It is important to understand how to design each level of the programme and how much detail should be given to each level when it comes to designing the long-term training programme for an athlete.

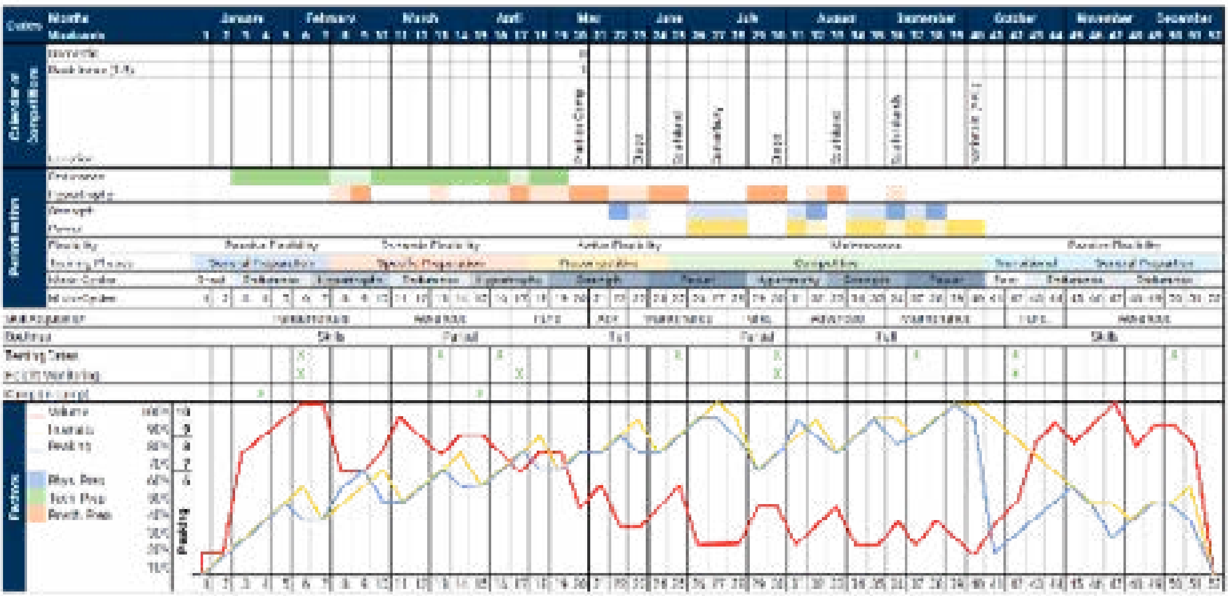
Designing the Macrocycle

The macrocycle refers to the annual training plan and should provide an overview of the different aims and emphasis of training throughout each of the different blocks or cycles that are planned within the macrocycle which is geared towards the athlete peaking for specific competitions within the year. The length of these different phases will be very dependent upon the number and frequency of competitions that there are within the macrocycle. For example, a sport such as boxing may only consist of four of five competitions within the macrocycle which allows a much longer build up for each competition. In contrast to a team a sport where the athlete is required to perform 40-50 competitions within the macrocycle where the build-up for each competition is much shorter. The macrocycle starts by breaking up the season into three separate phases; preparation, competitive, and transition. The preparation phase is further broken up into general (GPP) and specific preparation (SPP) of which the general preparation should focus on building general fitness qualities such as basic strength (anatomical adaptation) and endurance (aerobic capacity) ready to build more relevant fitness qualities such as power, speed and sports related fitness during the SPP phase that more appropriately prepares the athlete to deal with the demands of their sport.

The competition phase is the period of time between the first and last competition of the season and again the length of this will vary dependent upon the sport. The length of time between each competition will dictate how much training can be planned in and how much overload can be applied within this period. Individual sports such as athletics will enable much more time to be dedicated to developing fitness components between each competition and should allow a taper period so that the athlete peaks during completion. In contrast to team sports where the athlete may be performing every week, therefore not allowing enough time to overload and taper between competitions which limits the amount of physical development that can be achieved between competitions. It is for these reasons a linear method may be more suited to individual athletes, whereas an undulating method that focuses on multiple components may be more suited to a team sports athlete within the season. Once the length of each these phases has been planned around the competition then each of these can be further broken down into several smaller of phases (mesocycles) that normally last between four and six weeks in duration and has a specific training objective or outcome.

Fig 5. Example macrocycle template

The below provides an illustration of an example macrocycle template



As illustrated in the example above the macrocycle should provide the following information;

- **Annual dates** – this should break the annual plan up into months and weeks, similar to a calendar in order to identify the specific dates of competitions and to provide specific time periods for the length of each mesocycle and Microcycle within the macrocycle.

- **Competition schedule** – this section should outline the competition dates within the annual plan in order that the training programme can be designed around building up for these competitions.

- **Training Emphasis** – this section specifies the phase of the season is illustrated by a different colour for each different fitness component and highlights what fitness component is being emphasised and how long for which is essentially as mesocycle.

- **Training phase** – the aim of each mesocycle is specified and number of Microcycle within each mesocycle is specified.

- **Other info** – any supplementary information can be included in this section i.e. testing dates, training camps, weigh-ins & technical training objectives etc...

- **Training load** – both the volume and intensity throughout each micro and mesocycle should be represented in this section. This will be dependent upon the training emphasis and type of Periodisation that is being used.

It should be noted that this is just an example of a macrocycle template and by no means exhaustive. It is purely a representation of the type of information that should be included and how it can be presented. Once the macrocycle template has been designed then the individual mesocycles can be designed.

Designing the Mesocycle

TA mesocycle can be defined as a number of continuous weeks where the training programme emphasises the same type of physical adaptations or component of fitness, for example hypertrophy, strength or power. A mesocycle represents a phase of training with a duration of normally between two to six weeks (Microcycle), dependent upon on the sport. During the GPP phase, a mesocycle normally consists of four to six weeks, while during the competition phase it will the mesocycles will generally be shorter, usually be consisting of two to four week blocks depending on the competition schedule. The aim is to fit the mesocycles into the overall plan or timeline to make each mesocycle end on one of the phases and then to determine the workload and type of work of each cycle based on where in the overall plan the given mesocycle falls.

The aim is to make sure the athlete either peaks for the high priority competitions by improving each cycle along throughout the macrocycle. A mesocycle of four weeks in duration is generally recommended to allow enough time for a training component to be overloaded whilst avoiding excessive training monotony. This four-week training cycle should ideally consist of three weeks of progressive overload followed by a one week unload with a reduced training volume, before moving into the next phase.

Fig 6. Example 4 week mesocycle
The below illustrates the loading patterns of two traditional four week mesocycles.

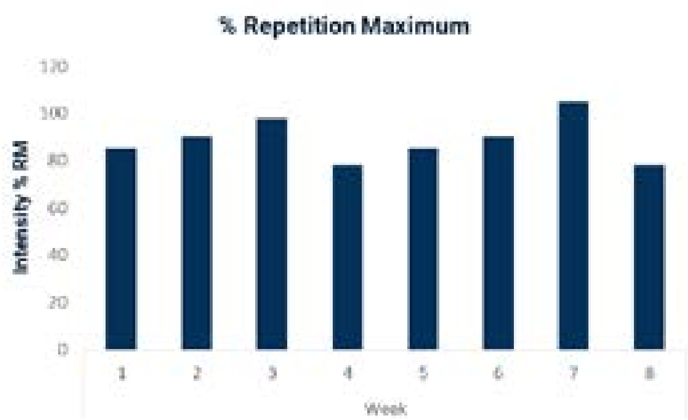
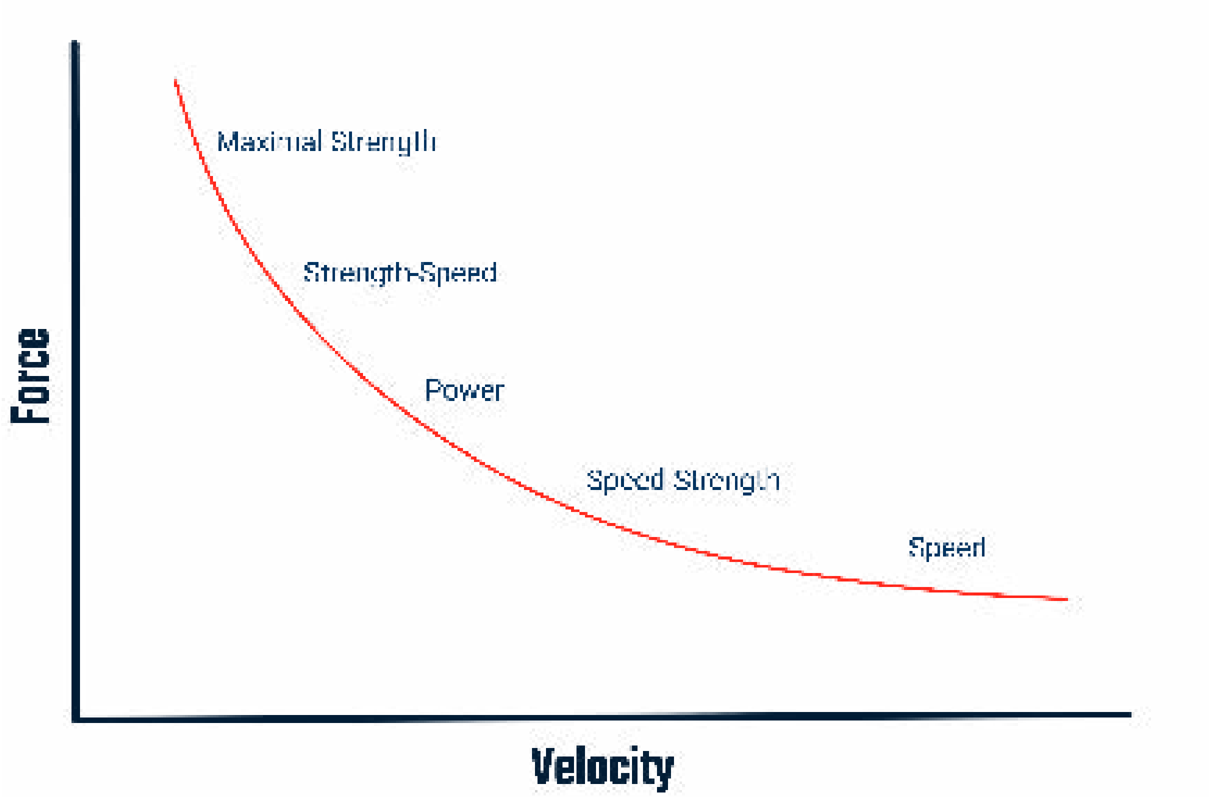


Fig 6, illustrates a three-week progressive build up followed by a week unload across two mesocycles. The unload week allows for supercompensation to occur, whilst also ensuring that accumulated fatigue is dissipated before moving onto the next cycle, which will follow the same pattern. This loading approach can be used irrespective of the type of periodisation being used (linear vs undulating) and also the component that is being trained. If the traditional linear model is being used, then the sequencing of the mesocycles can be based upon the force velocity curve (FVC) as displayed in fig 25. For example, the following sequence may be applied within the macrocycle;

- **Mesocycle 1** – anatomical adaptation (GPP)
- **Mesocycle 2** – max strength development (GPP/SPP)
- **Mesocycle 3** – power development (SP/CT)
- **Mesocycle 4** – speed (SPP/CT)

Although for many sports there is not enough time within the macrocycle to spend training these qualities independently especially within the competition phase and therefore a concurrent or undulating method is recommended whereby multiple qualities will be trained throughout each mesocycle.

Fig 7. Force velocity curve



The FVC identifies an inverse relationship between force and velocity e.g. the heavier the weight lifted (force), the slower it will be lifted (velocity). Conversely, the lighter the weight, the faster it can be lifted. Therefore, different modes of training occur on different parts of the force-velocity curve (figure 7). As the athlete goes from high force, low velocity to low force, high velocity, they work from max strength work to strength-speed to power to speed-strength to speed. The desired effect of training is to shift the force-velocity curve to the right because in most sports, speed is a greater requirement than max strength. Therefore, the Periodisation plan should travel from left to right across the force-velocity curve when using a linear model. Alternatively, when using the undulating method different elements of the FVC can be trained on different days within the Micro-cycle (DUP) or a different emphasis across each week of the mesocycle (WUP).

Designing the Micro-cycle

The Micro-cycle is the deepest layer yet the most detailed plan within the macrocycle. In terms of convenience a Micro-cycle normally consists of a 7-day period and therefore a mesocycle should be made up of four to six Micro-cycle. A Micro-cycle should provide a detailed plan of each session that is included within it including; type of session, exercises, volume and intensity, therefore the Micro-cycle should consist of a number of training sessions that make up that particular training week. It is obvious that the session plans should be in line with aim of the both the micro and mesocycles. Dependent upon the type of Periodisation being used as well as the aim of the mesocycle will dictate the type of sessions that should make up the particular training week. Table 7 identifies a linear strength Micro-cycle vs. an undulating Micro-cycle.

Micro-Cycle Comparison

Table 7

	Linear Model	Undulating Model
Day 1	Strength session 1	Strength session
Day 3	Strength session 2	Power session
Day 5	Strength session 3	Speed session

This is a very basic overview of two different Micro-cycle. The linear model consists of three sessions all focusing on strength development, although each session should have a variation in total volume load and exercise selection in order to avoid a high training monotony and fatigue. For example, session 1 may have a squat emphasis, session 2 may have a bench press emphasis and session 3 may have a dead lift emphasis. The point here is that although the training outcome is the same throughout the week, variation within the Micro-cycle must still occur. This variation in training load occurs more naturally within the undulating method due to the different training emphasis across the sessions which will cause a natural undulation in volumes and loads across the week. The table below shows an example of a weekly Micro-cycle plan for a team sports athlete during the SP phase.

Micro-Cycle Comparison

Table 8

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
AM	Speed/agility training	Anaerobic endurance training	Recovery/ technical session	Speed/ agility training	Anaerobic endurance training	Recover/ technical session	Rest day
PM	Aerobic endurance training	Power session	Rest	Aerobic endurance training	Power training	Rest	

The example given involves training multiple fitness components within the same micro and mesocycle (concurrent), therefore careful consideration must be given to the organisation of these sessions in order that they don't negatively affect each other. For example speed training, should always be planned for when the athlete is relatively fresh and endurance training should be completed before strength training. Once the macrocycle has been organised then individual session plans need to be designed which provides much greater detail in regards to the exercises, sets and reps etc. This Microcycle could be repeated for 4 weeks in total (mesocycle) therefore consideration must be given to how these training components can be progressed across each Micro-cycle (progressive overload).

Further reading

- Priodisation. Theory & Methodology of training, 5th edition, Bompa &Haff. 2009
- Periodisation training for sports. 3rd edition, Bompa & Buzzichelli. 2015
- Athletic Development. Vern Gambetta. 2007
- Essentials of Strength Training & Conditioning. 3rd Edition. Beachle & Earle. 2008

Performance Programmes

Many different nations that traditionally compete in the classic strength sports (Olympic weightlifting and powerlifting) all have varying points of view and ideologies regarding the subject of program design. However, a definite theme that is evident in all strength and sports specific programmes that have stood the test of time and produced many world champions, is that they are built on a solid foundation.

Building such structured programs based on solid foundations allows for the development of a base level of strength and robustness in athletes, which in turn, leads to greater adaptions as programmes progress, and greater injury prevention. For example – to build strength endurance in athletes, a base level of strength must be developed prior to the transfer of strength endurance. Likewise, competitive level sprint programs, regardless of the specific sprint event (100m, 200m, etc.) are normally proceeded by a base level of speed endurance training. Therefore, it is vital that as strength and conditioning practitioners, programmes are always based on a solid level of strength, conditioning, and robustness.

Their map vs our map

Before building any programs, differentiation between athletes must be taken into consideration. Such differentiation may involve a compensation between the athlete and the coach, with program adaptations being made, and therefore coming to a programming cooperation.

An example of such synergist programming and agreement between the athlete and coach would be the implementation of split squats over lunges, power snatch over full snatch, or pull ups over chin ups. Such agreement, even though not originally planned by the coach, allows for greater rapport to be built between the athlete and coach, which in turn, will lead to greater adaptations and progress.

In summary before the intricate details of programming are discussed, coaches must remember that athlete programs must be built on a solid foundation of strength, robustness, and be agreed upon between the athlete and the coach. Essentially, practitioners must ensure we don't aim to develop prefect programs that are unrealistic, but rather appropriate training interventions that work. **When designing programs, basic performance program principles must be applied. These are:**

1. **The end point**
2. **Needs analysis**
3. **Fundamental principles**
4. **Build it, and learn to endure it**
5. **Specificity and exercise selection**
6. **Write the programme**

Step 1: The end-point

Before any programme design can occur, a clear objective or 'end-point' must be established. Once such
an overall objective has been established, a reverse engineering process can occur, with specific action points throughout the programming journey, that accumulates in a final peak of performance.

For example – a competitive rugby athlete may wish to progress from a championship to premiership domestic league team, and therefore may need to progress in performance to enable the potential transfer to a premiership side. Therefore, using a reverse engineering process, the expected performance assessment data for a premiership athlete would be firstly gathered then compared, allowing for clear performance objectives to be set for the athlete in question (e.g. improve 1RM squat performance from 1.5 to 2 x bodyweight in-line with premiership level normative data).

Step 2: Needs analysis

Within strength and conditioning and sports science, the needs analysis is the key stage that all future programming will be eventually based upon, and allows for the development of evidenced based, principle guided programs. Put simply, the greater the depth of detail gathered within the needs analysis, the more effective the programs will be. To see a more detailed description of the needs analysis process, please refer to the 'needs analysis' module within this manual.

Once the needs analysis has been completed, and the performance and movement data has been gathered and evaluated, then a comparison can be made between an athlete's current performance data, and the expected performance data required to meet a particular end-point objective. Put simply, the current point and end-point objectives can be evaluated, followed by the implementation of specific training interventions to 'bridge the performance gap'. It's this evaluation and programming process that ultimately provides the fundamental objectives for all action plans and future programming.

Step 3: Programme design principles

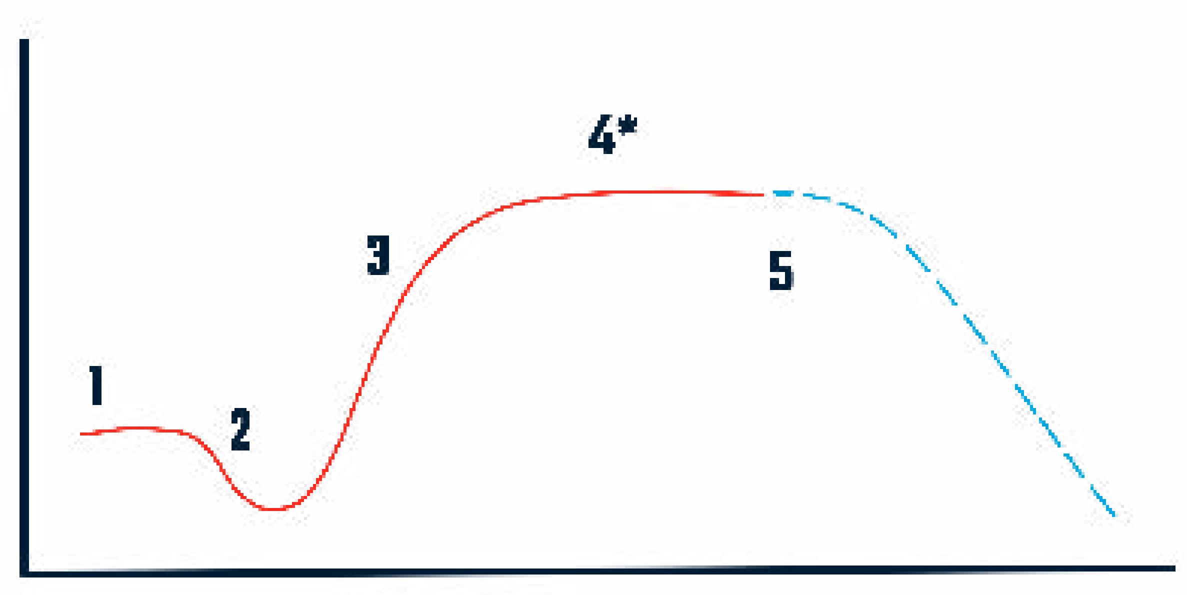
When designing any program, it is vital that the fundamental program design principles are adhered to. These fundamental program design principles are key to the development of effective and evidenced based programming with athletes, and ultimately, greater training adaptation and performance. These fundamental principles are:

- Progressive overload
- Specificity
- Reversibility
- Individualisation

Progressive overload - as first original detailed by Hans Selye (1907-1982) within the General Adaptation Syndrome model (G.A.S), the body responds to stress by following specific set stages, which ultimately leads to anatomical adaptation specific to the original training stimulus. Beyond this adaptation or supercompensation phase, the adaptations made accumulates before reaching a plateau phase.

Therefore, if further adaption is to be made, the bodily systems need to be subjected to a new training stress. Put simply, if we want the body to adapt, we need to provide it with a reason to adapt. Without a training stimulus, the body will enter a state of reversibility. This new training stress or stimulus that drives adaptation, is referred to as progressive overload.

Fig 8. Progressive overload



Progressive overload is the manipulation of training variables, resulting in the creation of a new exercise stimulus, leading to a drive in further anatomical adaptation (Stone, 2003). Applied progressive overload needs to be based on a solid foundation of athletic strength and robustness, and should be applied 'progressively'. Which training variables are manipulated is purely dependent on the desired training goal, and may involve a variety of specific variable manipulations (varying training frequency, volume, load, intra set rest, exercise selection, etc.).

Lastly, the format to which the progressive overload is applied, based on the relevant periodisation model, also needs to be considered (linear, non-linear, etc.). Once this has been selected, the progressive overload plan is to be integrated within the overall macro, meso and micro-cycle plans. Regardless of any overall progressive overload schedules, strength and conditioning coaches need to be aware that anatomical adaptations occur in a chaotic order. Therefore, practitioners need to be able to adapt to such situations, and vary progressive overload/periodisation models accordingly.

Specificity – to ensure optimal transfer of training effects, strength and conditioning coaches need to design training programs with specificity in mind. This requires programs to be specific to the sporting demands based on the information gathered previously within the needs analysis process, hence the importance of this stage. For example, when planning metabolic conditioning training, the interval type (RST, Sub MAS, etc.). the distanced to be covered, change of direction component, etc. all need to be considered to ensure optimal transfer of training effects.

Reversibility – as previously detailed within the progressive overload section, reversibility is the process whereby adaptations gained become reduced, leading to a lack in training/sport performance. This can result from the occurrence of injuries, illness, excessive training demand or additional external factors, such as poor nutrition, disrupted sleep patterns and lifestyle management. Obviously as strength and conditioning coaches, a lack in athlete performance needs to be avoided at all cost. Therefore, practitioners need to attempt to control and monitor accumulative training and competitive physical demands, whilst promoting effective external practices in athletes (nutrition advice, sleep pattern management, etc.) However, it must also be understood that such reversibility isn't always within the coaches control (injury occurrence, etc.)

Individualisation – when designing programs, coaches need to consider the individualisation of programs, rather than attempting to program all athletes training using the same format. For example, an athlete may struggle to initially perform the snatch exercise. Therefore, this would need to be replaced with an additional speed strength based exercise, such as cleans, rather than being excluded (as the need for speed strength development is still apparent).

Step 4: Build it and learn to endure it

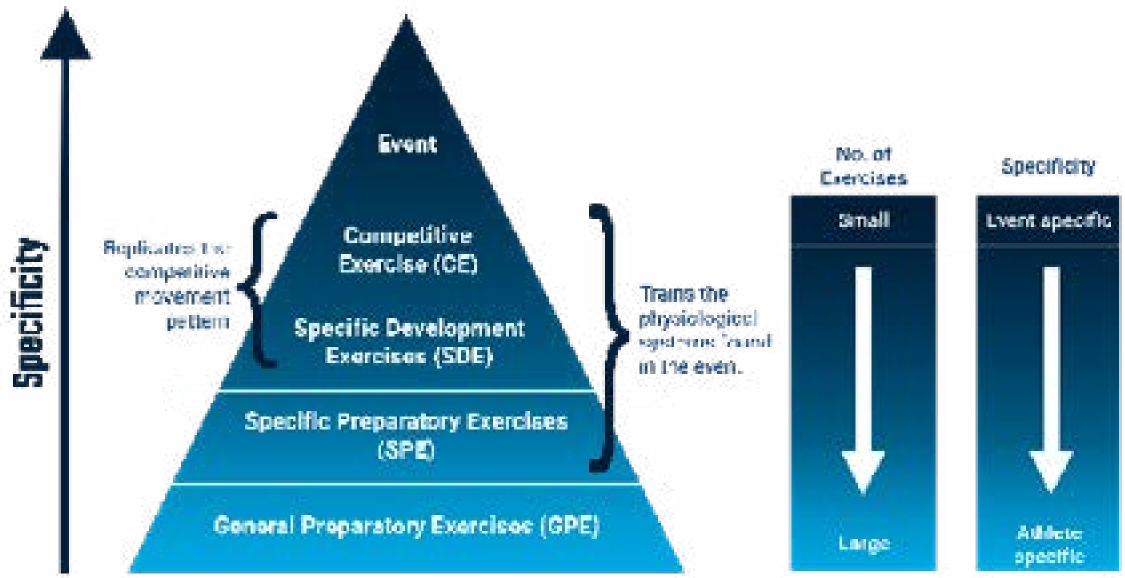
Once a program has been developed, the strength and conditioning coach needs to ensure that programs are adhered to by athletes. It is often the case that athletes and coaches alike may look to adapt or change programs before giving any adaptation to occur. As stated previously, the best athletes have built a solid foundation of strength and robustness through the development of a working capacity and the ability to tolerate high training demands.

As stated previously, once a program has been developed by the strength and conditioning coach, athletes need to learn to endure that program (Gambetta). The development of such a working capacity and the ability to tolerate large training demands can only be achieved through the completion of many hours of training. Such repetitive training stress leads to long term adaptations to the specific training demands, and cannot be achieved via short-cut training interventions.

Step 5: Specificity and exercise selection

When selecting exercises as part of training interventions, strength and conditioning coaches need to apply exercise specificity in relation to the planned competition phase. During the GPE and SPE phases of training, greater exercise variety will be implemented that doesn't necessarily replicate sporting movements, but rather develops a solid foundation as previously discussed. Additionally, during the GPE and SPE phases, greater volume of exercises will be required.

Fig 9. Specificity



However, as the athlete progresses from these initial phases into the SDE and CE phases prior to the competition or event, the volume of exercises within training will be reduced. Likewise, the specificity of the exercises selected within SDE and CE training will increase. For example, Olympic lifters will perform a variety of variations of the classic lifts early within the GPE and SPE training phases (snatch balance, hang snatch, power snatch, etc.). However, during the SDE and CE phases, the number of classic lift variations being implemented will be reduced, allowing for greater concentration on the actual competition lifts (Full snatch).

Step 6: Writing the programmes

Once all relevant factors including: training volume, frequency, load, phase within the macro/meso/micro-cycle, individual session objectives, and exercise selection have all been considered, then the program can be designed accordingly (in accordance with the relevant information detailed within this manual).

However, one final non-logistically aspect that must be considered is the 'buy in factor'. The buy in factor refers to the program inspiring athletes to 'buy' into the program, and therefore ensuring that athletes have belief in the programs being completed.

The importance of this 'belief' cannot be overstated enough. If athletes believe in the programs being completed, this will lead to a greater motivational environment and rapport between coaches and athletes – all of which result in an increase in overall training performance. Therefore, strength and conditioning coaches must attempt to educate athletes on the benefits and purpose of all programming elements, building athlete trust within the coaches and the training programs being implemented.

Resistance Training Programmes

Once the needs analysis process has been completed and the appropriate goals have been established with the athlete, the next phase is about designing the training programme. There are a number of factors that must be considered within this process and specific training principles must be applied in order to achieve the aims of the programme and enable the athlete(s) to improve and develop

Training principles

There are specific principles of training that must be applied to a successful training programme such as the SAID and FITT Principles. The SAID principle is one of the most important basic concepts in Fitness. It is an acronym which stands for Specific Adaptation to Imposed Demand. It means that when the body is placed under some form of stress, it starts to make adaptations that will allow the body to get better at withstanding that specific form of stress in the future. The adaptation process does not occur by any one mechanism, it is a general tendency of the body which is played out in several separate mechanisms.

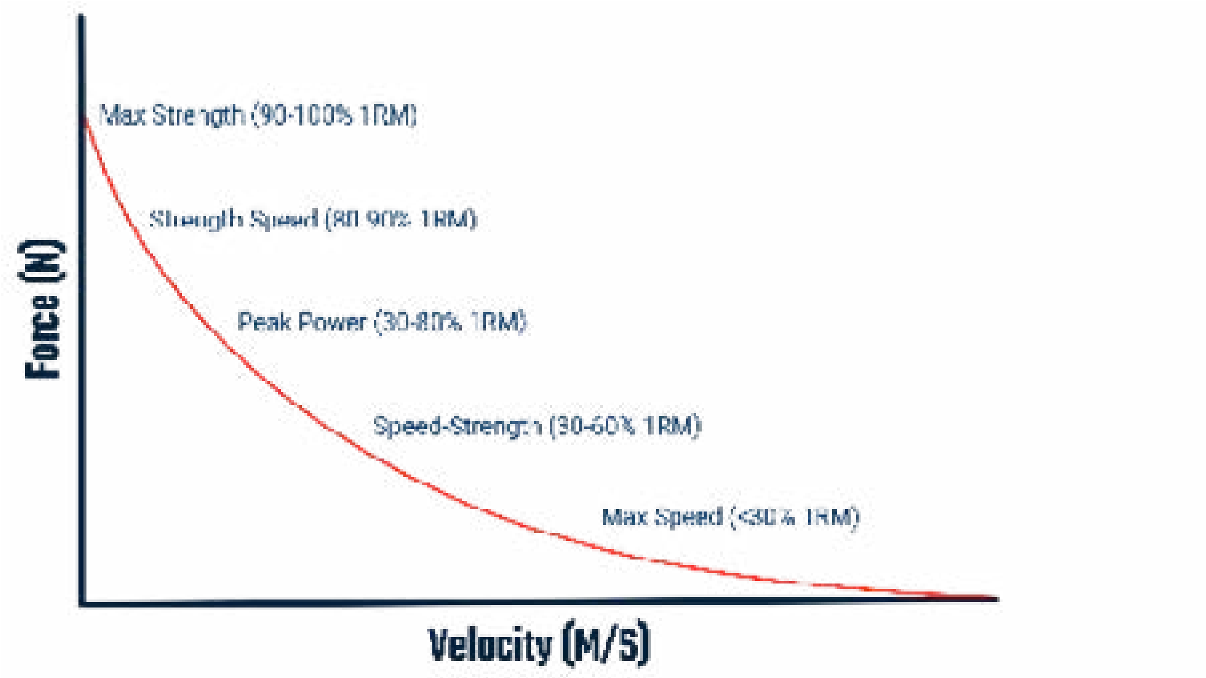
Whilst it is almost impossible to understand and account for all these separate mechanisms in devising a training programme, it is easy to remember the general SAID principle; it means that the body is always trying to get better at exactly what you practice. An example of this would be for an athlete who wants to get stronger, if they regularly lift heavy weights and apply the principle of progressive overload then in theory the contractile and non-contractile tissues will adapt and get stronger, although this will be specific to the type of stimulus applied. This is known as the dynamic correspondence theory; this concept emphasises that all exercises for specific sports be chosen to enhance the required sport motor qualities/movement patterns across several criteria which include:

- Amplitude/direction of the movement
- Accentuated region of force production
- Dynamics of effort
- Rate and time of maximum force production
- Regime of muscular work/sequencing patterns

The theory proposes that the strength displayed in the execution of a given movement be referred to only in the context of that given task. Sport movement tasks are specific and goal-directed and the enhancement in their execution should also be treated as such. Because of this, exercises should be evaluated based on the type of transfer that they may possess in relation to the degree of skill performance increase.

After this is established, exercises and/or training techniques can further be classified into categories such as general physical preparation (GPP) or special physical preparation (SPP). Evaluating the effectiveness of Dynamic Correspondence can only be decisive with the use of the force velocity curve alongside this argument. The force velocity curve shows an inverse relationship between force and velocity (e.g. the heavier the weight you lift (force), the slower you lift it (velocity); conversely, the lighter a weight, the faster you lift it). Therefore, different types of training occur on different parts of the forcevelocity curve. As you go from high force, low velocity to low force, high velocity, you go from max strength work all the way down to speed strength work on the other side of the spectrum. For most athletes' it is important that they work the curve throughout their training plan, although this will be covered in more detail in the Periodisation module. It is important that the S&C coach possesses an understanding of the FVC and are able to apply these principles within their training programmes.

Fig 10. Force-velocity curve



The next principle that the S&C coach needs to be familiar with is the FITT principle, which refers more to the practical application of the training programme as opposed to the physiological and it refers to the following components:

Frequency – refers to how often the athlete trains, therefore the overall number of training sessions within either the micro or mesocycles. Remember more is not always better as the athlete(s) needs time to recover and adapt to the previous session(s). A minimum of 2-3 sessions per week is recommended for resistance training adaptations to occur, although this must fit in with the athlete's overall training programme.

Intensity – refers to how hard or intensive the training session is, which in the instance would refer to how much weight is being lifted, normally determined as a percentage of the athletes 1RM for each exercise. The overall intensity of the session can be established by calculating total volume load (sets x reps x load) for each exercise and then the volume load for each exercise added together to give a total load for the session. Session RPE is another valid and easy method to measure the intensity of a training session.

Time – refers to the duration or length of the training session. This will be governed by the number of exercises and length of rest periods within the session. This could also be determined by actual volume of the session (exercises x set x reps). The optimal length of a resistance session should last between 45-60 mins inclusive of the warm up, although this may vary dependent upon the individual athlete(s) time of the season and also number of other training sessions throughout the week. Generally if a session runs longer than this there are either too many exercises or too much rest time. Remember minimum dose response is key when working with athletes and also maintaining their attention and focus. It is also useful to maximise your training time through the utilisation of super or compound sets, which will be covered in more detail in the advanced training programme design module.

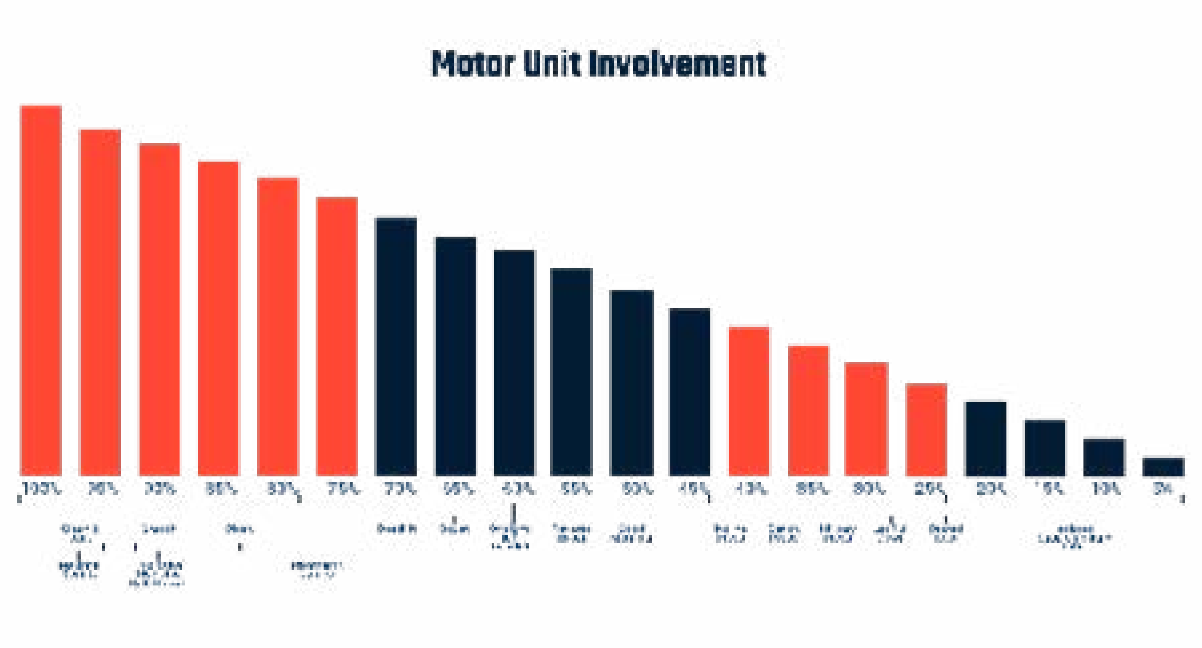
Type – this is quite self-explanatory but important part of the programme design, which refers to the mode of exercise being used within a resistance session i.e. Olympic lifts, compound exercises, isolation exercises, ballistic exercises or Plyometrics. The exercise selection used should be based upon the goals of the athlete and consideration should be given to the FVC, speed of movement and movement patterns required for the sport.

It is important to understand and be able to apply these principles when designing a resistance training programme. Based upon these principles there are a number of other factors that must be taken into consideration with regards to the content and structure of the programme such as; exercise selection, exercise order, rest period between sets and exercise tempo which should all be prescribed based upon the needs of the athlete and goals of the programme.

Exercise Selection

This is the first step in designing the training programme and should be based upon the principles already discussed within this module and be dependent upon the sport and needs of the athlete. Ideally when training athlete(s) the exercise selection should be focused on compound movements that train multiple joints and muscles simultaneously in order to have a greater dynamic correspondence with sport and isolated muscular actions should be kept to a minimal only used to focus on specific weaknesses an athlete may have in a particular muscle group, therefore used predominantly for prehabilitative or rehabilitative prescription. Exercises that give the most “bang for their buck” should be selected based on neuromuscular recruitment. Fig. 7 illustrates the amount of motor unit recruitment during different exercises. Exercise selection should also be based upon training movement patterns that are relevant to the athlete’s sport such as pushing, pulling, squatting, bending and twisting movements. Most sports are multiplanar in nature so exercises should involve working through the frontal, sagittal and transverse planes. Consideration should also be given to the use of uni-lateral exercises as most sports will require an element of unilateral strength and stability.

Fig 11. Motor unit involvement



Exercise Order

In order to maximise the gains of the training programme, exercise order is key to ensuring a scientific flow and progression throughout a session. A well designed and structured training session will ensure the athlete(s) gets the most out of each exercise and should therefore be based upon the following principles:

- **Dynamic/explosive exercises at the beginning** - the more dynamic/explosive exercises such as Olympic lifts should be placed at the beginning of the workout whilst the athlete is fresh as this will allow maximum RFD and therefore force output, placing these types of exercises at the end of the workout when the athlete may be both mentally and physically fatigued will result in less force being produced as well as an increased risk of technique breakdown, and therefore injury.

- **Most complex to least complex** – the exercises that are more technically demanding to perform should be placed at the beginning of the session and the simpler exercises should be towards the end, similarly to the reasons above regarding fatigue and technical issues whilst performing an exercise.

- **Heaviest to lightest** – generally the heavier (compound) exercises should be placed at the beginning of a session and equally the lighter (accessory) exercises should be placed nearer the end of the session. An example of this would be that a squat would be performed earlier in the workout than a leg extension. Again, this is to ensure that the athlete(s) quads are in a fatigued state whilst performing the squat which would possibly compromise the load they can lift whilst performing the squat.

- **Bi-lateral to unilateral** – similarly to the reasons above the bi-lateral exercises should be placed before the unilateral exercises within the session. Although there is more stabilisation and proprioception required whilst performing a unilateral exercise, these feedback mechanisms will not be heavily taxed or fatigued following the completion of some heavy compound lifts. Conversely if the unilateral exercise is placed first it may result in an element of fatigue going into the bi-lateral movement, for example the Back squat should be performed before a single leg squat in the programme.

These are general guidelines and there may be circumstances where some of these principles need to be reconsidered, for an example an athlete who needs to improve their work capacity may need to perform certain exercises under fatigue or an athlete may be in a hypertrophy phase and the use of pre-exhaust sets may be a strategy that can be used to enhance the adaptations. These strategies will be discussed further in the advanced training programme design module. Table 9, highlights an appropriate exercise order for a hybrid power and strength session.

Exercise Order Example

Table 9

Number	Exercise	Rationale
1	Power Cleans	Requires maximal force production and co-ordination
2	Box Jumps	Requires maximal RFD
3	Back Squat	Heavy compound movement
4	TRX Pistol Squat	Unilateral movement
5	Glute Ham Raise	Accessory exercise – posterior chain

Exercise Volume (sets & reps)

Once the exercises have been selected and put into the appropriate order the volume must be applied through prescribing the specific number of sets and reps to each exercise - this is something that coaches get hung up on, but should be quite straight forward if the principles are understood. When it comes to deciding the required number of sets to prescribe the following guidelines can be used and is based upon the training status of the athlete(s);

- **Novice = 2-3 sets**
- **Intermediate = 3-4 sets**
- **Advanced = 4-5 sets**

Further considerations must be given to the total number of exercises and overall intensity of the session. Also the time of the season and phase of the macrocycle must also be considered. In terms of the number of repetitions being prescribed, this will be dependent upon the aim of the programme alongside the intensity of the exercise. Table 10 below gives an outline of the repetition schemes that are recommended dependent upon the desired training outcome. For strength development a low repetition scheme is required in order to enable the athlete to lift a heavy enough weight that is going to stimulate a response that is going to make them stronger (above 80% 1RM). If an athlete can comfortably lift the weight for more than five reps then they are not lifting heavy enough for this response to occur. Similarly when training for power a low repetition scheme is also recommended (1-5) as when performing an explosive exercise a maximal voluntary contraction is required at the highest rate of force development. After only a few repetitions the muscles will start to fatigue will no longer be able to function at this level, therefore continuing to train beyond this will become counterproductive as the athlete will no longer be training to improve power output. A much higher repetition scheme is required when it comes to training for either gaining muscle mass (hypertrophy) or muscular endurance. In order to change the structure and size of the muscle fibres there needs to be a significant greater time under tension (TUT) needs to occur in order to cause greater damage to the muscle fibres.

Exercise Intensity

The exercise intensity refers to the amount of load or weight used during an exercise and again is dependent upon the aim and desired outcome of the programme. For strength development, heavier loads above 80% 1RM are required in order to adequately stimulate the neuromuscular system and subsequently result in positive adaptations. In regards to training for power the optimal load to produce peak power (force) is very exercise and outcome specific. For example peak power during the jump squat occurs between 20-30% whereas during the clean it occurs at about 80% 1RM. Further consideration should be given to the FVC and the speed of movement required as it is apparent that the heavier the load being lifting the slower the movement will become. For both strength and power development there should be intent to move the weight as quickly as possible, specifically during the concentric component of the exercise. Due the higher repetition range and lower rest periods during hypertrophy training a relatively lower load should be used in order to allow the repetition range to be maintained, the literature generally suggests between 60-80%1RM for this type of training.

Recommended Training Prescriptions

Table 10

This table illustrates the recommended training prescriptions for the different training modalities.

	Sets	Reps	TUT (per set)	No. of exercises	% Load	Rest
Power	3-5	1-5	5-10s	3-5	Exercise specific	2-3m
Strength	3-5	1-6	10-30s	4-6	>80% 1RM	2-5m
Hypertrophy	4-6	6-12	45-90s	6-8	60-80% 1RM	60-90s
Muscular Endurance	2-3	>12	60-120s	6-8	40-60% 1RM	30-90s

Exercise Progressions

For the athlete(s) to continually improve and develop they will require constant challenging and stimulating from both a physical and mental perspective. One method that can be used to achieve this is to frequently change or progress the exercises prescribed within the programme. A programme should be modified and progressed every 4-6 weeks in order to reduce too much training monotony and stagnation. Table 11, shows some examples of exercise progressions for different movement patterns. Generally, these progressions are based upon changing the exercise complexity or the load potential of an exercise.

Exercise Progressions

Table 11

Bi-Lateral Squat Patterns	Unilateral Squat Patterns	Lunge Progressions	Olympic Lifts	Plyometrics
Overhead Squats	Split Squat	Reverse Lunges	Pulls From Hang	Landing (force acceptance)
Front Squats	Bulgarian Split Squat	Forward Lunges	Catch From Hang	Jumping (force production)
Back Squats	Single Leg Squats	Incline Lunge/Step up	Pulls From Floor	Reactive Jumps
Box Squats		Decline Lunge/ Step down	Catch From Floor	Unilateral

Rest Periods

This is an important yet often overlooked component of the resistance training programme and again should be prescribed dependent upon the aims of the programme. For both strength and power programmes longer rest period (2-3 mins) should be allocated in order to allow full recovery between sets. Due to the nature of this type of training, maximal intensity is required and if an athlete(s) is not given enough recovery time, it is highly likely that they will not be able to perform the following sets at the intensity required, subsequently resulting in either a reduction in force production and /or RFD which would then defeat the purpose of the programme. In contrast, for both hypertrophy and muscular endurance much shorter rest periods (30-90s) are necessary. For both of these types of training it is important that the athlete(s) train through and induce fatigue in the working muscles in order to allow lactate and H+ to accumulate in order to provoke the required adaptations in the muscles.

Exercise Tempo

The exercise tempo refers to the speed at which the exercise is performed at, which will be both exercise and goal specific based upon the athlete's needs. The tempo at which an exercise is performed along with number of repetitions performed will determine the total time under tension (TUT) for a muscle or muscle group during a particular set. Generally, the greater TUT, the more muscle damage is caused and subsequent fatigue as a result. During heavy strength training it is recommended that eccentric component of an exercise should be relatively slow and under control (2-4s), whereas the concentric phase should be performed as explosively as possible in order to recruit the highest number of type 11 fast twitch fibres. Due to the nature of power training generally being either ballistic or Plyometric in nature the concentric, eccentric and transition components need to be performed as quickly as possible in order to produce the maximal RFD. During hypertrophy training much more TUT is necessary to result in further muscle damage in order to elicit an adaptation in the muscle fibres, so generally a slow controlled contraction is recommended during both the concentric and eccentric components.

This module has identified the many considerations when it comes to designing a resistance training programme. Once you have completed the needs analysis of the athlete and understood these principles, you now need to go away and practice designing some training programmes for a variety of different athletes. Remember that when it comes to designing a programme it is both an Art and a Science, therefore scientific principles need to be applied but there should also be an element of creativity and variation within each programme. For further guidance please refer to Appendix 1 for some example resistance training programmes.

Further reading

- Practical Programming for Strength Training. Rippitoe M. 2009
- Science and Practice of Strength Training, Zatsiorsky V, 2006.
- Starting Strength. Rippitoe M, 2013

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.

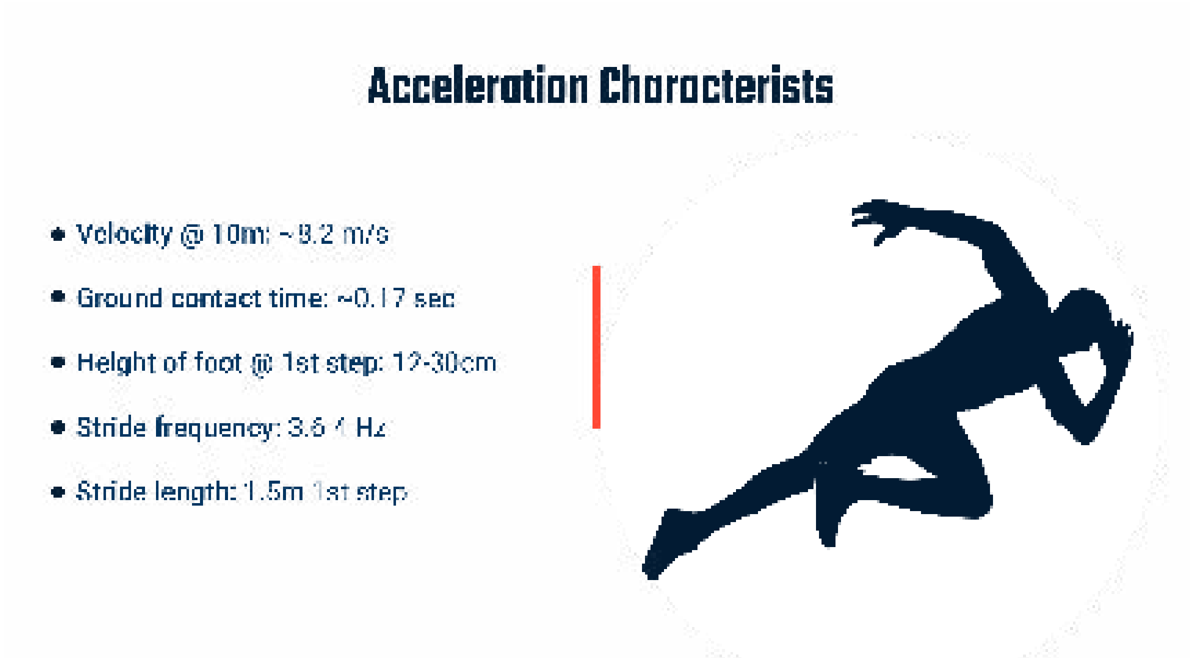
Speed Technique

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



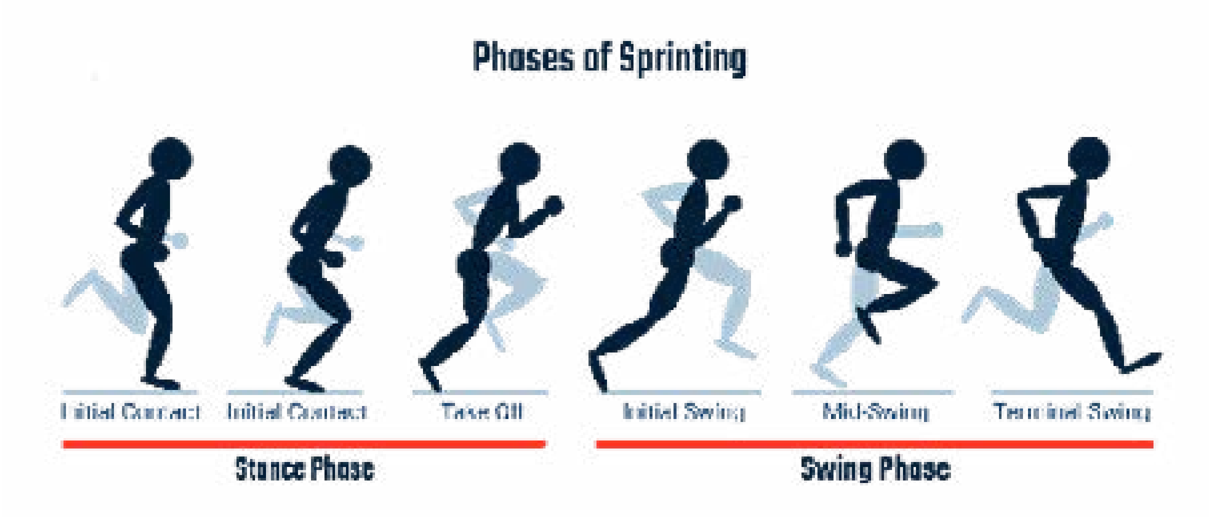
The key coaching points that should be re-enforced during the acceleration phase are as follows;

- 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 13 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)

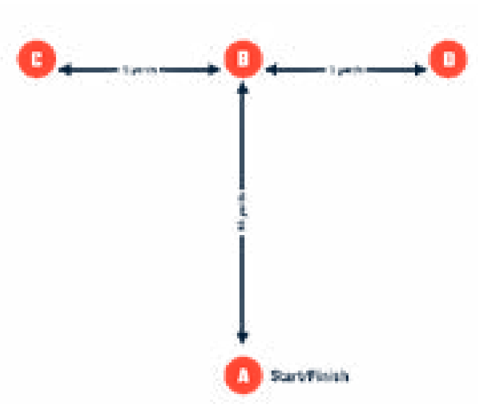
700 –500 ÷ 24 = 8.3

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

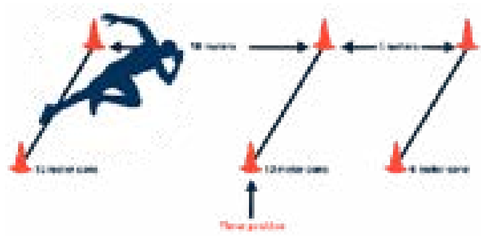
There are a number of different agility tests that can be used such as the T-Test, Arrowhead, 505 or Illinois tests. It is recommended that the one that most replicates the movement pattern of the sports is selected. Below is an example of each of these tests with a brief description;

Fig 14. T-test



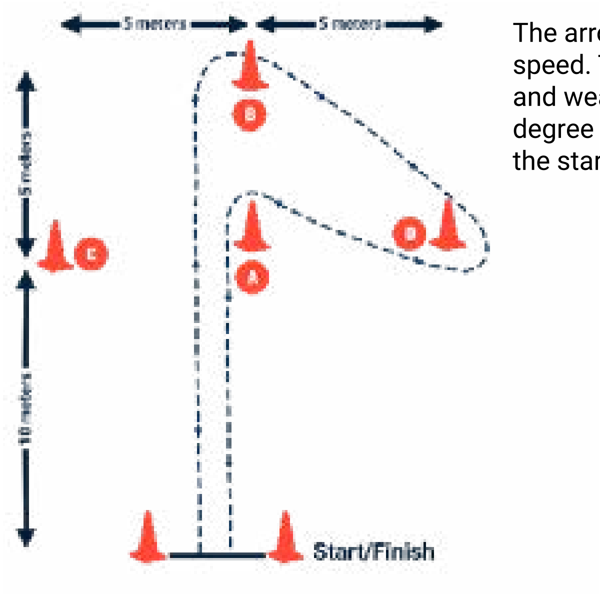
The T-test can be performed using different movement patterns depending upon the required movements for the sport. The traditional way to perform the test is to accelerate from A to B and then lateral shuffle from B to C, C to D and back to B, finishing with a backpedal from B to A. Alternatively it 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 non-specific 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

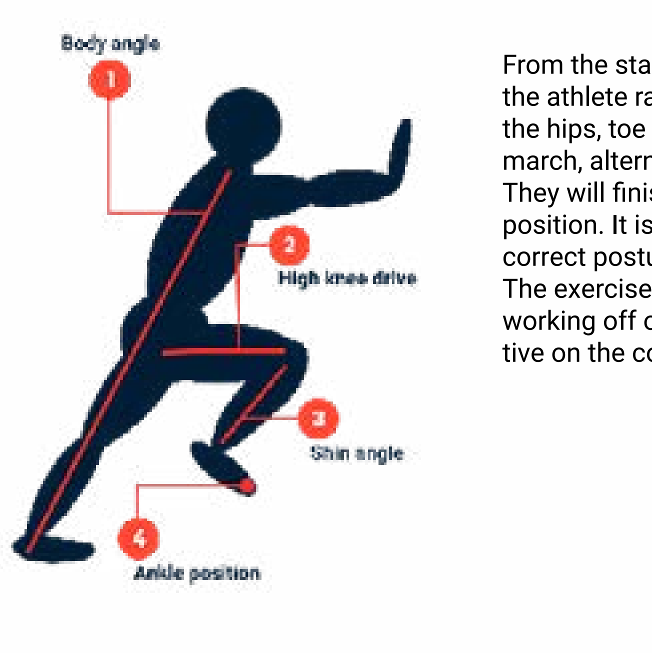
Acceleration & Deceleration	Max Velocity	RSA/Speed Endurance	Agility
Strength & power exercises (gym)	Plyometric drills (gym & field)	Strength & power endurance drills (gym)	Lateral strength & power exercises
Mechanical drills (wall)	Mechanical drills	Speed endurance sprints (100-400m)	Ladder, hurdle & 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 are 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.

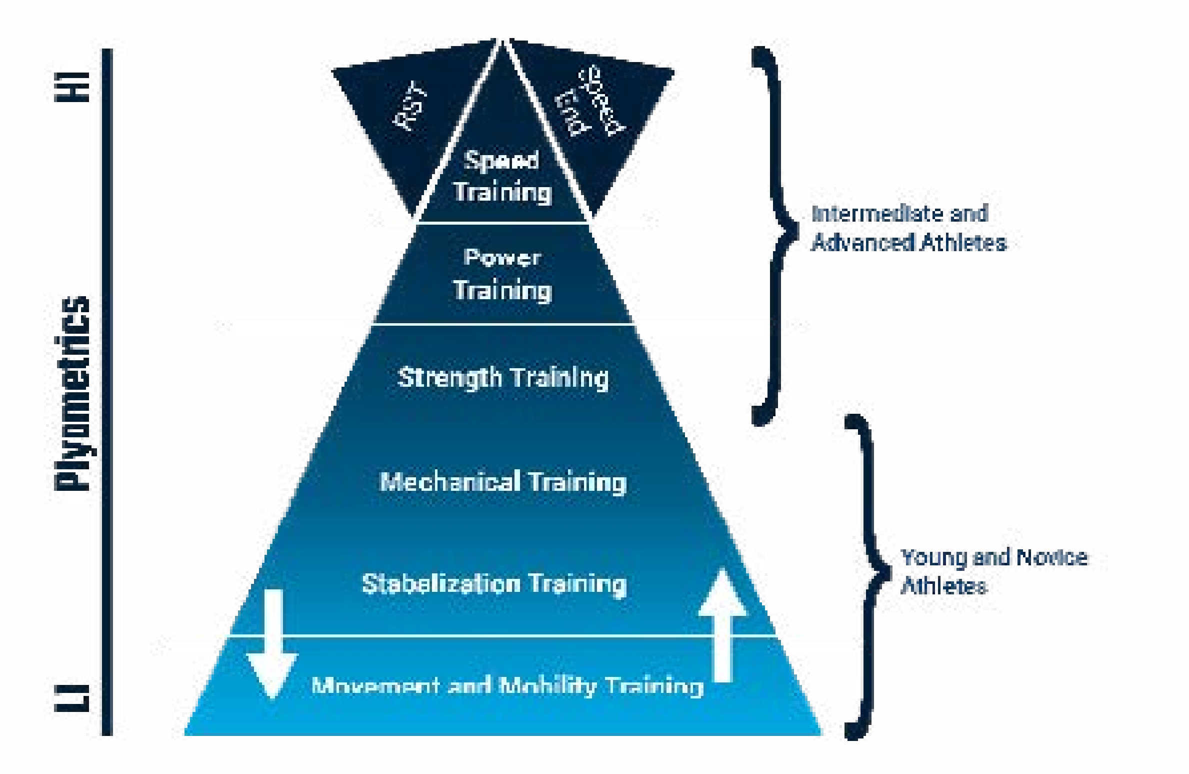
Speed Programming

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
- **Athlete'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, with more emphasis 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. 18, 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.

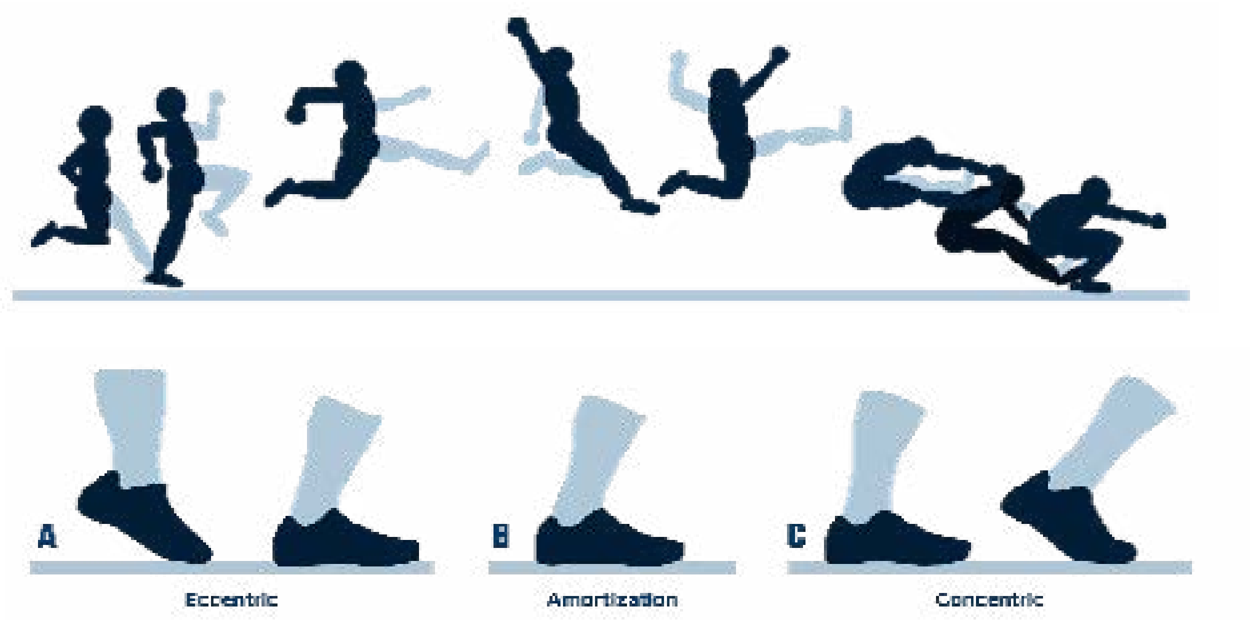
Plyometrics

Plyometrics are exercises in which the muscles exert maximum force in short periods of time, with the goal of increasing power (speed-strength). This training focuses on the athlete's ability to switch from an eccentric to a concentric contraction in a rapid or "explosive" manner, such as jumping or bounding exercises. Since its introduction in the early 1980s, two forms of Plyometrics have evolved. In the original version of Plyometrics, created by Russian scientist Yuri Verkhoshansky, it was defined as the shock method. In this, the athlete would drop down from a height and experience a "shock" upon landing. This in turn would bring about a forced eccentric contraction which was then immediately switched to a concentric contraction as the athlete jumped upward. The landing and take-off are executed in an extremely short period of time, in the range of 0.1- 0.2 seconds. The shock method was an effective method used by athletes to improve their speed, quickness, and power after development of a strong strength base. Rather than using the term Plyometrics to indicate exercises utilising the shock method, it may be preferable to use the term explosive or true Plyometrics which can be considered the same as the Plyometrics originally created by Verkhoshansky. The shock method created was the result of studying the actions that occur in running and jumping. It was found that the landings and take-offs in these two skills involved high ground reaction forces that were executed in an extremely quick and explosive manner. For example, time of execution of the landing and take-off in jumping was close to 0.20 seconds and in sprinting it was approximately 0.10 seconds. The second version of Plyometrics, relates to doing any form of jump training regardless of execution time. Such jumps cannot be considered truly Plyometric since the intensity of execution is much lower and the time required for transitioning from the eccentric to the concentric contraction is much greater, making it more ballistic in nature as opposed to Plyometric. As a result, it is important to distinguish which type of "Plyometric" exercise is used in order to determine its effectiveness and potential to receive the benefits associated with Plyometric training.

Stretch Shortening Cycle

The mechanism of the stretch shortening cycle (SCC) is the predominant factor that makes Plyometric effective and consists of three distinct phases, the lengthening (eccentric) component, the amortisation (transition) phase and the concentric component. The lengthening phase is the pre-stretch of the muscle whereby the muscle is lengthened and elastic energy is generated to provide a greater and faster contraction during the subsequent concentric contraction. The amortisation phase is the transition time between the eccentric and the concentric components; this is often referred to as the ground contact time. The amortisation phase needs to be a short as possible or the elastic energy generated will be dissipated. The concentric phases are normally referred to as the take-off or push off during a jumping or bounding movement, and the amount of force produced and rate of force development will be dependent upon how much pre stretch occurred within the muscle, and how quick the amortisation phase was performed. An example would be to use the elastic band analogy, for example if you were to flick an elastic band, the further the band was pulled back (stretched) and released the further the elastic band would travel, similarly to what happens to a muscle during a Plyometric action. In order for an exercise to be classed as a true Plyometric exercise the amortisation phase must be less than 0.2s.

Fig 19. Different Phases of the Stretch Shortening Cycle



Plyometric Assessment

Before prescribing Plyometric exercises to an athlete their ability to effectively perform a Plyometric movement needs to be assessed to ensure that they not only possess the necessary technique and physical qualities required but are also not at risk of injury through technical or strength deficiencies. The following questions need to be answered to determine how competent an athlete is and therefore what level of Plyometric training they are ready for;

- Can the athlete perform the movements well? (squatting, jumping & landing)
- Are they strong enough to absorb / reduce the impact forces? (stiffness)
- Do they possess symmetry? Left vs. Right?
- Are the reactive? (Efficiency of SSC)

Table 15

Phase 1 (Movement screen)	Phase 2 (Strength testing)	Phase 3 (jump testing)	Phase 4 (RSI testing)
Bi-lateral squat Unilateral squat Box jumps Ankle mobility (dorsi-flexion)	Squat strength (1-3rm) - 1.5 x BW SL squat or leg press strength	Squat jump CMJ EUR Single broad jumps (bi-lateral & unilateral)	30cm drop jumps (RSI) Repeated CMJ's (10 for time) Repeated broad jumps

As illustrated in Table 15, the screening process should consist of four different components; Phase 1 the movement screen should be used to assess the athlete's ability to perform basic movement patterns in a controlled environment. Phase 2 consists of assessing the athlete's lower body strength. It is recommended that an athlete can squat 1.5 x body weight before they engage in high intensity Plyometric training. If an athlete presents with poor strength levels, then it is more appropriate to spend time developing this quality before trying to improve speed. Phase 3 involves measuring an athlete's explosive qualities through the implementation of various jump tests and phase 4 examines the athlete's Plyometric ability or more specifically the reactive strength index (RSI). The RSI involves an athlete performing a drop-jump on a contact mat or force platform.

The test was developed to measure how an athlete copes and performs during Plyometric activities by measuring the muscle-tendon stress and their reactive jump capacity. It demonstrates an athlete's ability to rapidly change from an eccentric motion into a concentric muscular contraction and is an expression of their dynamic explosive vertical jump capacity. The index is a useful tool for monitoring an athlete's reactive jump capacity and comparing against normative values, in addition to monitoring training progress. It can also be used to provide recommendations for an athlete's optimal drop height for Plyometric exercises. RSI can be measured by using the either of the following methods;

- Method 1: RSI = Jump Height / Ground Contact Time
- Method 2: RSI = Flight Time / Ground Contact Time

Plyometric Training

Plyometric exercises range from simple bouncing during a warm-up to an intense series of jumps and bounds during heavy training periods. With any risk from training, coaches need to ensure the right mechanics of the exercise is done properly and the right ways to teach the movement patterns and should replicate those movement patterns closest to the sport. The following aspects must be considered when it comes to designing a Plyometric session or programme;

- **Take off and Landing** — how does the athlete take off and land, either from one foot or two? Taking off with either one or two feet may not be a clear indicator of output since many single leg actions with run ups may have a lot of forces such as bounding after a fast acceleration. Many sports require a take-off and landing from 1 leg, therefore consideration must be given to this within the training programme, although not before the athlete has mastered taking off and landing from two legs. Landing is the primary variable that classifies the Plyometric activity. Hops differ from bounds because they stay on the same foot from take-off to landing, and bounding requires an alternation of each leg and can be only one on foot at a time. Efficient landing mechanics must be developed on both two and then one leg, ensuring that ground contact times remain short enough to be classed as a Plyometric exercise.

- **Loads** — it is recommended that only body weight is used when Plyometric training. It is important to remember that Plyometrics are used to develop speed, therefore by increasing the athletes weight will conversely slow down their RFD that they can produce during an exercise. Although the use of weighted vests can be used for certain exercises such as depth jumps. Since the single leg demands of bounding and hopping are high, it is not necessary to add external load. Instead jump / hop distances or heights can be increased to apply progressive overload.

- **Force Direction** — are the predominant forces required for the athlete's sport either horizontal or vertical in nature? Plyometric exercises involve either jumping vertically (depth jumps) or horizontally (bounding). The exercises selected should be the ones that have the highest dynamic correspondence to the sport in terms of direction and amplitude of force production.

- **Volume** – plyometric training volume can be determined through both sets x reps and / or more commonly total number of foot contacts. There are some general guidelines on the recommended number of foot contacts based upon the training age of the athlete (beginners 50-100, intermediate 100-150 and advanced 150-200). Although these guidelines are much generalised and don't take into the consideration the phase of the macrocycle or the intensity of the exercises that are being used. A common-sense approach is recommended when it comes to implementing Plyometric exercises i.e. start with low volume-low intensity and progressively increase the intensity of the drills as the athlete(s) becomes more competent. Quality over quantity is key when it comes to Plyometric training.

Exercise Selections and Progressions

The exercise selection should be based upon the level and abilities of the athlete. Plyometric exercises can be placed into a continuum from low complexity – low intensity to high complexity – high intensity with novice athletes working on exercises at the beginning of the continuum and advanced athletes working on exercises towards the end of the continuum. Plyometric exercises complexity is based upon the following factors;

- Intensity - Jump height and landing height (low – high)
- Bi-lateral or unilateral take off and landings (Bi-lateral – Cyclical – Unilateral)
- Direction of movement / force (Vertical – Horizontal – Multidirectional)

Plyometric Exercise Progressions

Table 16

	Level 1	Level 2	Level 3	Level 4	Level 5
Vertical	Squat jump	Box jump	1 leg box jump	Depth jump	1 leg depth jump
Horizontal	Broad jump (double)	Linear leap	1 leg linear leap	Bounding	Resisted bounding
Lateral	Lateral jump (double)	Lateral lead	Lateral hop	Lateral leap to box	Diagonal bound-ing
Reactive 1	Pogo jumps	1 leg pop jumps	Pop-float-skip	SL pop-float-skip	MB OH pop-float-skip
Reactive 2	Tuck jumps	1 leg tuck jumps	High hurdle jumps	MD hurdle jumps	MD hurdle & box jump combos

This table gives some examples of different Plyometric exercise progressions based upon either increasing the intensity, complexity or direction of force.

Plyometric Coaching Points

It is important that Plyometric exercises are coached and executed correctly in order to optimise the force production, whilst also minimising the risk of injury. The following points are key things to be emphasised when coaching Plyometrics with an athlete;

- Maintain good posture – head and chest facing forward (athletic position)
- Land on mid-forefoot, the heels should not contact the floor
- Minimise ground contact times – landing on hot coals
- Maintain ankle dorsiflexion – Toes to shins
- Avoid knee valgus

Further reading

- High-Performance Training for Sports. Joyce D, 2014.
- Plyometrics for Athletes at All Levels: A Training Guide for Explosive Speed and Power: A Training Guide
- for Athletes at All Levels. Pire N, 2006
- High-Powered Plyometrics, Radcliffe J. 2015

Advanced Programme Design

Once an athlete has been exposed to a training stimulus for a length of time they will become conditioned and build up a tolerance to this stimulus. Advanced training involves progressing and evolving the athletes training programme in line with their development (progressive overload) for the following reasons;

- **To ensure that the athlete continues to develop and improve** – In order for the athlete to continue to develop they must be constantly challenged through the progression of exercise complexity and / or continued progression of volume loads. Once an athlete is classed as advanced these gains are much more difficult to achieve, therefore the planning of the programme becomes a lot more complex and more advanced training strategies may be required in order to ensure that the athlete gains improvements from the programme.

- **To avoid stagnation or regression in training** – Once an athlete has been training for a number of years (>2 years) they will build up a tolerance to that particular stimulus, as a result if they are not challenged or overloaded in a more advanced way not only will they stop developing (stagnate), they may even regress due to inadequate levels of overload being applied to the systems.

- **To overcome a plateau in training goals and evolve with the needs of the athlete** – The needs and goals of the athlete should be continually re-assessed and modified throughout the long term training programme. The needs analysis should consider the training age and level of the athlete and as the athlete advances through the programme; their goals should be modified and adjusted accordingly. For example, the novice athlete is going to improve and develop at a much faster rate than an advanced athlete, which must be taken into consideration when it comes to setting SMART goals.

Athletes can be classed as either novice, intermediate or advanced based upon a number of factors including; training age, movement competency and strength levels. Table 17 illustrates how athletes can be categorised based upon these factors. An athlete with a training age of less than 1 year with limited movement competency and poor strength levels would be classed as a novice athlete, whereas an athlete with a training age of between 1-3 years with moderate movement literacy and strength levels would be deemed intermediate and an athlete with over three years training history, possessing both good movement and strength levels would be classed as advanced. There are times when these components may cross over into different categories. For example, you may have a “so called” advanced athlete based upon their training age but upon assessment may possess poor movement and / or strength levels, therefore this athlete would not be deemed as advanced. They should possess all the relevant criteria before moving into the next category, therefore the athlete mentioned above should continue to train and develop both movement and strength before moving into the advanced group and therefore advanced training strategies. It is essential that athletes earn the right to progress through eeting the necessary criteria before they are advanced. It is an obvious statement but the training programme for the novice athlete will look very different to that of the advanced athlete.

Table 17

Beginner	Intermediate	Advanced
< 1 years training experience	1-3 years training experience	3+ yrs. training experience
Limited movement literacy	Competent movement literacy	Good movement literacy
Limited strength levels Squat <1 x BW	Moderate strength levels Squat 1.5x BW	High strength levels Squat > 2x BW

There are a number of ways in which the training programme can be advanced or progressed to continually challenge and stimulate the athlete in order to avoid stagnation and de-training. Advancing the training programme can be achieved by manipulation of one or more of the following training principles, dependent upon the goals and needs of the athlete.

- Training Volume (sets & reps)
- Training Intensity (Load)
- Frequency (No. of sessions)
- Exercise selection / variation
- Speed of movement (FVC)
- Periodisation Method
- Advanced Training Methods

Volume

Advanced athletes require a greater volume of training in order to elicit a positive training response compared to novice or intermediate athletes. Therefore, this must be addressed within the training programme. This will normally be achieved by either increasing the number of sets per exercise or alternatively the number of exercises included within the programme. Table 18 illustrates the optimal number of sets based upon training status. Advanced athletes are more tolerant to higher volumes of training and therefore will require a much larger training stimulus to result in an adaptation. They will also experience much less fatigue in response to a given stimulus compared to a novice athlete. For example a novice athlete may only require 2-3 sets and 3-4 exercises within a session to elicit adaptations to that stimulus; they may also experience a large amount of fatigue and muscle soreness as a result of this stimulus. In contrast an advanced athlete may require 4-5 sets and 5-6 exercises in order to overload the body enough to result in an adaptation, they also may not experience much muscle soreness following the session, although this doesn't mean that they don't need time to recover and super-compensate.

Set guidelines based on training status

Table 18

Beginner	Intermediate	Advanced
2-3 sets	3-4 sets	4-5 sets

Training Intensity

The training intensity generally refers to the amount of weight (load) being lifted during an exercise or session (volume-load). Load can either be expressed as relative (% of body weight) or absolute (% of 1RM). It is well evidenced that advanced athletes need to train at a greater intensity and more frequently than novice and intermediate athletes. For example, an advanced strength athlete may need to lift heavy (>90% 1RM) a minimum of 3 times per week in order to see gains in strength. Whereas in contrast a beginner strength athlete may only need to lift above 70% 1RM two times per week to see strength gains. Table 19 illustrates the % of absolute load required for an athlete to develop strength dependent upon training status.

Training intensity guidelines based on training status

Table 19

Beginner	Intermediate	Advanced
BW - 70% 1RM	70-90% 1RM	90-100% 1RM

Training Frequency

Training frequency refers to the number of training sessions completed within a Micro-cycle. Advanced athletes require a greater number of total training sessions within each Micro-cycle compared to novice athletes in order to be exposed to enough stimulus to result in adaptations. For example 2-3 sessions per week may be adequate stimulus for a novice athlete, whereas the advanced athlete may require 4-6 sessions in order to provide adequate levels of overload. Table 20, provides an example undulating training week for a strength athlete based upon training status.

Training frequency schedule based on training status

Table 20

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Beginner	Strength		Power		Hypertrophy		
Intermediate	Strength	Power		Strength	Hypertrophy		
Advanced	Strength	Power	Hypertrophy		Strength	Power	Hypertrophy

Exercise Selection

The exercise selection within the training programme should also be dependent upon the training status of the athlete. Initially basic and relatively low level exercises should be used to develop movement literacy and relative strength. Once the athlete possesses the necessary mobility and movement competency under load then they are ready to be progressed. For example, when teaching the squat pattern to a novice athlete, they may begin with a goblet squat progressing to a front squat and then into a back squat as they become stronger and more competent at performing a particular movement pattern. Table 21 provides an example of some exercise progressions for different movement patterns.

Exercise Progressions

Table 21

Beginner	Intermediate	Advanced
Goblet squat 3x8	Front squat 4x6 @70-80%	Back squat 5x5 @ 80-90%
Press up 3x12 (BW)	DB chest press 4x6 @ 70-80%	Bench press 5x5 @ 80-90%
SL TRX squat 2x6 EL	DB split squat 3x4 EL	Barbell split squat 4x3 EL
Inverted row 2x8	Pull ups 3x6	Weighted pull ups 4x3
SL SLDL 2 x 6 EL	Hex bar SLDL 3x6	SLDL 3x4 with bands

Movement Speed

The force velocity curve represents an inverse relationship between force (load) and velocity (speed), therefore the greater the amount of external load / resistance the slower the speed of execution (muscle contraction) will be. The FVC can be broken down into different training emphasis based upon the amount of load being used and speed at which the exercise is being performed. These components can be classed as; max strength, strength-speed, speed strength and speed. The aim of the overall training programme is to shift the whole curve to the right in order that the athlete improves overall athletic performance. For a novice athlete, an appropriate way to train the curve is to break each section of the curve into separate training blocks (linear model) and train each component independently. For example, 4 weeks training strength, 4 weeks training power and then 4 weeks training speed and then repeat this 12-week cycle over again. Whereas for a more advanced athlete an undulated approach is more appropriate whereby each component of the curve is getting trained throughout each Micro-cycle and mesocycle. It is important to remember that strength is a component that underpins all other qualities, so it is important to get the athlete strong before trying to improve their power or speed.

Persiodisation Method

As mentioned above the most appropriate Periodisation model to use with an athlete will be dependent upon their training age and status as well as the competition schedule. Table 22 illustrates different loading patterns or variants across a twelve-week strength training cycle. Research has found that a programme that alternated training volumes and intensities within a week was more effective than a block method with linear intensification and no within-week variation in elite athletes (Rhea et al). Based upon this table it could be recommended that the first three methods (subtle linear, block linear and

Table 22

Week	Sets x Reps %1RM											
	1	2	3	4	5	6	7	8	9	10	11	12
Subtle linear	3x13 63%	3x12 66%	3x11 69%	3x10 72%	3x9 75%	3x8 78%	3x7 81%	3x6 84%	3x5 87%	3x4 90%	3x3 93%	3x2 96%
Block with linear intensification	4x10 60%	4x10 64%	4x10 68%	4x10 70%	4x5 78%	4x5 81%	4x5 83%	4x5 85%	3x3 88%	3x3 90%	3x3 92%	3x3 94%
Block with non-linear intensification	4x10 64%	4x10 68%	4x10 70%	4x10 66%	4x5 80%	4x5 83%	4x5 85%	4x5 75%	3x3 90%	3x3 92%	3x3 94%	3x3 80%
Undulating	4x10 64%	4x10 68%	4x6 76%	4x6 80%	4x8 72%	4x8 76%	4x4 84%	4x4 88%	3x6 82%	3x6 85%	3x3 90%	3x3 94%
Wave-like	4x10 64%	4x8 70%	4x6 76%	4x4 82%	4x9 70%	4x7 76%	4x5 82%	4x3 88%	3x8 78%	3x6 84%	3x4 90%	3x3 94%
Accumulation/ intensification*	6x3 80%	6x4 80%	6x5 80%	6x6 80%	5x5 85%	4x4 90%	3x3 95%	2x2 100%				

Note: assume the athlete increased strength by 3-5% across the 12-week period. The accumulation/intensification pattern typically follows only an 8-week cycle; however, some initial higher repetition training may precede this type of cycle. 1RM = 1 repetition maximum*

Advanced Training Strategies

Once an athlete has been guided through a well-planned and progressive long term training programme and all the above training variables have been modified accordingly based upon the progression of the athlete the next step is to consider implementing some more advanced training strategies. These can be used when the athlete has exhausted all other avenues and may need some extra variation in the training programme in order to overcome stagnation by applying a different form of overload into the programme. These advanced training strategies that can be used include:

- PAP Training
- Bands and Chains
- Cluster Sets
- Supersets, compound sets and tri-sets
- Negative (eccentric training)

PAP Training

Post activation Potentiation (PAP) is the phenomenon by which the contractile components of muscles directly affects their subsequent rate of force development (RFD) or the ability to generate force in a rapid manner. The theory behind PAP is that the acute change in contractile proteins and motor neuron activity can help induce greater explosive power performance for a 2-20 minute period following heavy loading. PAP works by training a heavy movement or lift followed by a more explosive or dynamic movement, which is interspersed with a recovery period. For PAP to be effective the movement patterns need to be similar between the exercise and appropriate rest periods must be given between the exercises (5-20 mins). An example would be doing some heavy squats followed by either box jumps or squats. Due to the nature of the rest periods required careful consideration must be given to the design of the programme to ensure the athlete has had enough recovery time between exercises. For example this could be achieved by doing some heavy squats at the beginning of the session then maybe moving into some upper body work before finishing off with some explosive jumps. Alternatively a strength session could be completed in the gym followed by a short recovery period (15 mins) before doing some sprint work on the field or track. If this method is being used then the volume of the strength session must be kept to a minimum. It must be noted that this method of training is only suited to intermediate and advanced athletes that are highly conditioned to strength training. With novice athletes strength training will actually have a dampening effect on the CNS so there subsequent outputs will be diminished following heavy strength training, therefore this type of training would not be suggested for these athletes.

Bands and Chains

Bands and chain training has become very popular in recent times and can often be seen being used (badly) in many commercial gyms - due to trainer's lack of understanding of the mechanisms and necessity of this type of training. The principle of this type of training is known as accommodating the resistance and is used to apply a greater amount of resistance during the stronger part of the movement and to reduce the load during the weaker part of the movement. For example during the squat, by attaching bands to the bar and the floor, there will be more tension / resistance at the top of the squat, as the athlete squats down the tension / resistance on the band becomes less at the bottom of the squat. This basically means the athlete can use more resistance during the squat and is not limited by their outer range strength. This method should only be implemented once an athlete is lifting near their maximal effort loads and may have reached a plateaux in their loading increments. This is certainly not an appropriate method for novice athletes who are squatting with 30kg on the bar.

Cluster Sets

Cluster training consists of breaking down a traditional set of an exercise into smaller blocks of reps interspersed with short rest periods (10-30s) between blocks. For example a set of six reps may be broken into two blocks of three reps or three blocks of two reps. The benefit of this type of training is that it allows partial restoration of ATP between clusters, therefore enabling more weight or more explosiveness to be performed on the subsequent cluster. This type of training was originally used within body building to increase growth, since which it has now become more popular for both and strength and power training as it enables the athlete to get a bit more intensity out of each total set. This method should only be implemented once all other traditional methods have been utilised and the athlete needs to overcome a plateau in their training.

Supersets and Tri-sets

Supersetting consists of training two different exercises in succession with minimal rest between them. The best way to use supersets is to use antagonistic movements i.e. a pushing movement with a pulling movement. E.G. performing a set of bench press with a set of pull ups. Another method of using supersets would be to train a lower body and upper body exercise together, for example a back squat with a pull up. The benefit of this type of training is that it increases the session density, therefore enabling the athlete to get through more volume of work in a given time. This type of training is more suited to strength and hypertrophy training as opposed to speed or power training where full recovery between sets is required. Taking this even further, tri-sets can then also be implemented which consists of training three exercises together without resting. This type of training is also quite metabolically demanding therefore a conditioning effect may also be obtained when using tri-sets. Common tri-sets include; push-pull-core or upper-lower-core although different combinations can be used careful consideration needs to be given to exercise selection to ensure that the movement and muscular action is different for each exercise. In reality this type of training can be useful for conditioned athletes when the session time is limited although isn't recommended for novice athletes.

Negative Training

Negative training is a way to add more intensity into the athletes programme and overload the muscle groups engaged in the exercises that are chosen. Negatives are performed by controlling the tempo of the repetition and slowing down the lowering phase of the lift to an approximate 3-5 seconds rep count. This type of training is also referred to as eccentric training whereby the weight is slowly being lowered under control, which furthermore increases the time under tension (TUT). It is suggested that the body can eccentrically lower and control approximately 25% more than it can concentrically lift or push therefore the athlete can and should lift heavier weights can be used for negatives (>100% 1RM). During strength training the majority of muscle fibre damage or micro trauma occurs during the eccentric phase. This damage causes the muscles to adapt, which will increase muscle mass and accelerate strength development. Negative training overloads the muscles a different way and can help an athlete push through plateaus in the gym. The difficulty with negative training is that it requires one or two spotters or training partners to help lift the bar back up following the eccentric lowering component of the exercise. Negative training can be implemented by completing a number of sets of an exercise just using negatives i.e. 3 x 5 eccentric bench press or alternatively just on the last set of a number of exercises.

It can be concluded that advanced training methods should be used selectively with intermediate to advanced athletes when they have reached a plateau and require a different type of stimulus in order to kick start their gains again. There should be an appropriate rationale for the methods selected and the traditional training variables should have been manipulated accordingly within the programme before turning to these advanced training methods.

Endurance Training & Energy System Development

Energy system development (ESD), alternatively know as metabolic conditioning is all about building the efficiency and durability of each individual energy system either individually or collectively to improve an athlete's overall physical fitness and work capacity. High levels of endurance and work capacity are required for many sports although the type of fitness required and predominant energy system utilised will be dependent upon the metabolic demands of the sport i.e. duration, intensity, work to rest ratios and muscular actions involved. The term "fitness" is often misconceived as there are many components which make up an athlete's fitness ability. For the purpose of this module the term "fitness" relates to the endurance capabilities of an athlete, more specifically the ability to be able to work continuously at a high intensity for an extended period of time and therefore the ability to resist fatigue. The energy systems need to be understood before an ESD training programme can be designed.

Energy Systems

There are three separate energy systems through which ATP can be produced. ATP production is essential to fuel muscle contractions and cellular function during exercise. Several factors determine which of these energy systems is chosen, such as exercise intensity and duration.

ATP-PC System

The ATP system can operate with or without oxygen but because it doesn't rely on the presence of oxygen it said to be anaerobic. During the first 5 seconds of exercise regardless of intensity, the ATP-PC is relied on almost exclusively. ATP concentrations last only a few seconds with Phosphocreatine (PC) buffering the drop in ATP for around another 5-10 seconds. Combined, the ATP-PC system can sustain all-out exercise for 5-15 seconds and it is during this time that the potential rate for power output is at its greatest. If activity continues beyond this immediate period, the body must rely on the glycolytic (lactate) energy system to produce ATP.

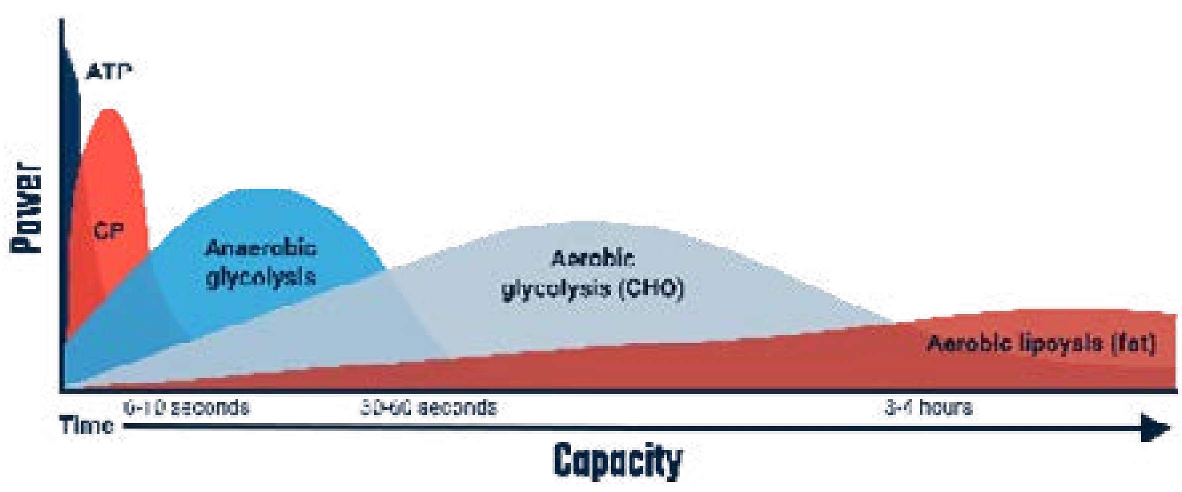
Glycolytic / Lactate System

This system mainly provides the bulk of ATP production during high-intensity, sub-maximal efforts. It may also become the dominant producer of ATP during repeated efforts which have insufficient recovery time to allow full Phosphocreatine replenishment. The glycolytic system acts as the dominant supplier of ATP in the period from around 15 seconds of maximal effort to around 60 seconds of highintensity sub-maximal effort. During glycolysis a bi product called lactate is produced and hydrogen ions begin to form in the muscles which results in, muscular contractions being inhibited during high intensity exercise. The body can tolerate increasing levels of lactate and hydrogen ion production only until their accumulation rate is greater than the body's ability to remove them at which point either exercise intensity will be significantly reduced until the aerobic energy system takes over.

Aerobic System

The aerobic system produces far more ATP than either of the other energy systems but it produces the ATP much more slowly, therefore it cannot fuel intense exercise that demands the fast production of ATP. The aerobic energy system utilises fats, carbohydrate and sometimes proteins for re-synthesising ATP for energy use. The aerobic system consists of three processes or 'stages' each of which produce ATP. These stages involve more complex chemical reactions than the other energy systems which is why ATP production is much slower. The three stages of aerobic ATP production includes; Aerobic glycolysis, Krebs cycle and Electron transport chain. The aerobic system is responsible for producing energy for sub-maximal exercise lasting from a few minutes up to a few hours. The aerobic system is also involved in resynthesising ATP during recovery between high intensity efforts. Aerobic fitness is critically important to most athletes and is also referred to as VO2max which is the maximum amount of oxygen in millilitres that can be used in one minute per kilogram of body weight. A higher VO2 max has been positively associated with exercise performance, especially in endurance based sports.

Fig 20. Energy Systems Contribution



The three energy systems do not work independently of one another. From very short, very intense exercise, to very light, prolonged activity, all three energy systems make a contribution although; one or two will usually predominate. Two factors of any activity carried out affect energy systems more than any other variable, as they are the intensity and duration of exercise. Once the predominant energy system(s) for the sport have been identified within the needs analysis a fitness testing assessment needs to be carried out to measure the athletes "fitness" levels.

Anaerobic Testing

Anaerobic tests should consist of activities that tax either the PC or glycolytic systems such as speed, speed-endurance or RSA tests, which have already been discussed in module 5 – speed training. These tests are often a marker of a specific fitness component although will have an anaerobic energy system contribution.

Aerobic Testing

There are many tests that can be administered when it comes to assessing aerobic endurance, although they are classed as aerobic many will also involve anaerobic contributions so could also be referred to as work capacity tests, a few examples include: -

- **Maximal oxygen consumption test (V02 MAX)** – this testing is often carried out on a treadmill or bike in a laboratory environment as it requires a gas analyser to measure oxygen intake and carbon dioxide expenditure. This is a very reliable way to measure aerobic capabilities although it can be quite time consuming and expensive to administer.

- **Multi-stage fitness test** - this test involves continuous running between two lines 20m apart in time to recorded beeps. For this reason the test is also often called the 'beep' or 'bleep' test. The participants stand behind one of the lines facing the second line, and begin running when instructed by the recording. The speed at the start is quite slow. The athlete continues running between the two lines, turning when signalled by the recorded beeps. After about one minute, a sound indicates an increase in speed, and the beeps will be closer together. This continues each minute (level). If the line is reached before the beep sounds, the subject must wait until the beep sounds before continuing. If the line is not reached before the beep sounds, the subject is given a warning and must continue to run to the line, then turn and try to catch up with the pace within two more 'beeps'. The test is stopped if the subject fails to reach the line (within 2 meters) for two consecutive ends after a warning.

- **Maximal aerobic speed (MAS) tests** - MAS should ideally be assessed during a running based activity. A number of simple running-based field based tests have been developed that correlate with MAS measured via the treadmill/gas analysis method(s). Some field tests are continuous, some are intermittent, some are linear running, some are shuttle-based running, some are incremental and some are steady-paced. The most common field tests of MAS include the Montreal Beep test, the Multistage Shuttle Beep test, the Yo-Yo IR1 test, time trials with set time or set distances that take the athletes between 5- to 7-minutes to complete. An example of this would be the 1500m test, whereby MAS is calculated by dividing the distance covered by the time it took to complete (seconds) i.e. if it took an athlete 320 seconds to complete the test, their MAS would equate to 4.68 m/s. This is an important measure to know when it comes to training to develop aerobic fitness.

Mixed/Intermittent Testing

There are also several intermittent tests that can be implemented to assess endurance that require utilisation of all the energy systems, including;

- **The Yo-Yo Intermittent tests** - are similar to multistage fitness tests, except in the intermittent tests the athletes have a short 10 seconds' active break in between each shuttle run. There are two versions of each Yo-Yo Intermittent test, a beginners Level 1 and advanced level 2. The test evaluates the athlete's ability to repeatedly perform intervals over a prolonged period of time, particularly for athletes from sports such as football, rugby, hockey and other similar sports.

- **30-15 Intermittent Fitness Test (30-15 IFT)** - this is an intermittent fitness test designed to more closely replicate the demands of intermittent sports compared to the standard beep test. Unlike in the beep test, where athletes run continuously with increasing speed every minute, this test involves 30 seconds of running alternated with 15 seconds of walking to assess the ability to recover and repeat intermittent activity, similar to many sporting situations.

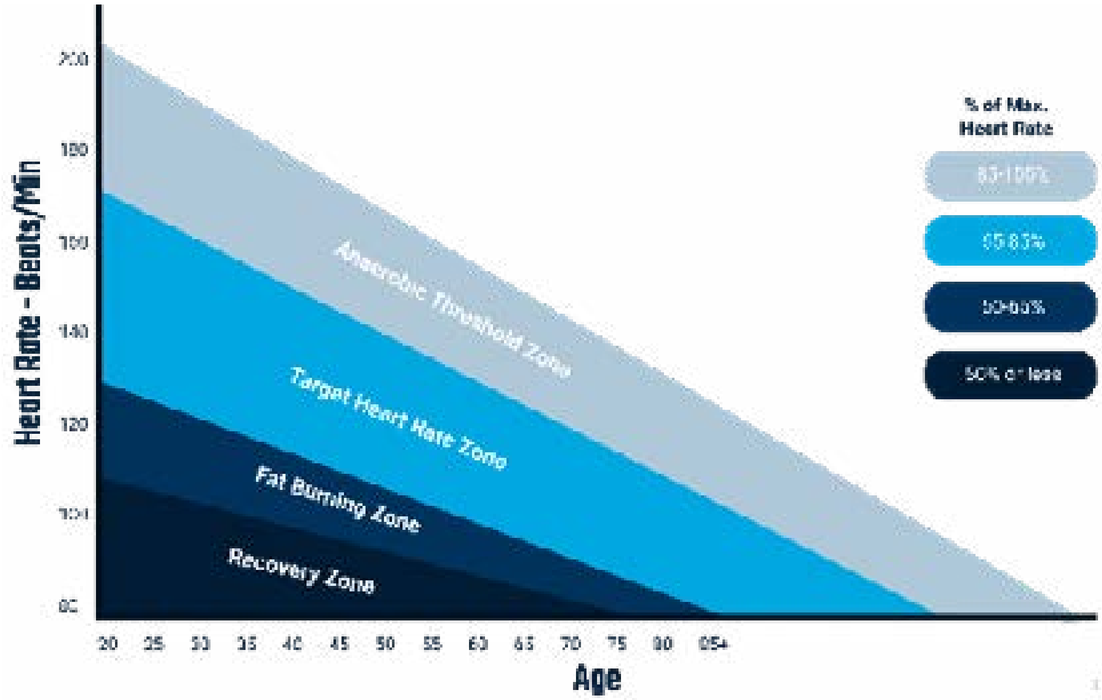
These are just a few of many possible examples when it comes to fitness testing, the tests selected should be one that most replicate the demands of the sport and needs of the athlete and also one that can determine the athletes MAS as this can then be used as a training modality.

Energy System Training

There are many ways and training methods that can be used when it comes to ESD such as continuous, fartlek, interval and MAS methods. The best method used will be dependent upon the phase of the macrocycle, demands of the sport and fitness level of the athlete. This module will mainly focus on the different training methods that aim to improve the endurance and work capacity of an athlete. These different training methods may be either predominantly aerobic or anaerobic but many will utilise all three systems. The extent of which each energy system is taxed will be dependent upon both the intensity and duration of the exercise.

In regards to measuring exercise intensity for ESD, target HR zones are commonly used and it is recommended that an athlete needs to train above 80% max HR for a positive adaption to occur (Fig 21). More frequently the MAS method has been used to determine training intensity based upon running speed.

Fig 21. Recommended Heart Rate Training Zones



It could be suggested from the HR table that an athlete should train regularly in the red zone (>90%) in order to improve fitness. Although it must be understood that this type of training can be fatiguing as there will generally be a heavy neural demand as well, and therefore requires appropriate recovery between sessions. There are different physiological adaptations that occur as a result of training at different intensities, based upon % of HR maximum. It is suggested that training at an intensity above lactate threshold, approximately 85% MHR results more greatly in central adaptations, whereas training below this intensity results in more greatly in peripheral adaptations.

Knowing this information, it is important to understand that different training intensities are required throughout the micro and mesocycles to ensure adequate recovery for an adaption to occur as well as to ensure that the athlete is achieving both central and peripheral adaptations through their training. Different training intensities may also be used during different times of the season or macrocycle. For example during the off season lower intensity continuous training and extensive interval training can be used to develop a fitness base. Whereas during the pre-season phase high intensity intervals and speed training methods could be used to more appropriately condition the athlete for the demands of their sport.

Central vs. Peripheral Adaptation to Energy System Training

Table 23

Central Adaptations	Peripheral Adaptations
Left ventricular hypertrophy (size)	Increased number of capillaries
Increased strong volume	Increased mitochondrial density
Increased cardiac output	Increased myoglobin
	Increased enzymatic activity

It is important to understand how different training intensities affect the adaptations of the body when it comes to designing the energy system training programme. The following training modalities will affect the body in different ways and it's therefore important to understand when and how these methods can be utilised to maximise the fitness of an athlete.

Continuous Training

Continuous training, also known as long slow distance training, is any type of physical training that involves activity without rest intervals. Continuous training is often performed at low to moderate intensities (60-80% MHR) for extended periods of time (30-90 mins). This type of training is more suited to endurance type athletes that compete in long distance events and is much less suited to intermittent athletes that require high intensity efforts interspersed with short periods of recovery such as team sports athletes. Although there may still be periods within the overall training programme where this method maybe beneficial to the athlete. For example during the transition period or early preparation (off season) phase of the macrocycle to minimise the de-training effect or re-introduce the athlete back into training without over stressing them too much too soon. This method may also be indicated during the late preparatory (pre-season) or competition (in season) phase as a recovery / endurance session between high intensity sessions. The adaptations associated with this type of training are more predominantly peripheral in nature as highlighted in table 7 and can therefore be used well in conjunction with HI interval training which more specifically targets the central processes. Therefore, although this type of training is not as specific as interval training for many sports its inclusion and benefits within the overall training programme should not be completely disregarding as a training modality. This will be further discussed within the Periodisation module.

Fartlek Training

Fartlek, a Swedish term that means "speed play," is a form of interval or speed training that can be effective in improving an athlete's endurance. Fartlek training involves randomly varying the pace and intensity throughout the session, alternating between fast and slow intervals. Unlike traditional interval training that involves specific timed or measured work to rest periods, fartlek is more unstructured and the work-rest intervals can be based on how the athlete feels. There are lots of different fartlek methods although a common one for team sports athletes is the Gershler method; Stride hard for 30 seconds and then jog for 90 seconds, this is then repeated with 15 second decreases in the recovery jog e.g. 30-90, 30-75, 30-60, 30-45, 30-30, 30-15 and 30-15-30. This can be an effective method to improve fitness, although it is difficult to measure the exact intensity and distances the athlete is achieving within these intervals. For this reason interval training is generally easier to administer, monitor and progress than that of fartlek training.

Extensive Interval Training

Interval training can be classified as either extensive or intensive dependent upon the intensity (speed) or duration of the interval block. Extensive intervals are often submaximal in intensity; 80-90% MHR or

90-100% MAS and are performed for longer durations than intensive interval runs, normally between 1-4 min blocks with a work to rest ratio of 1:1-1:0.5. A good example of this is the 4 x 4 interval method whereby the athlete will perform a 4 min block followed by a 2-3 min recovery period and repeated 4 times at either the specific HR zone or running speed based upon MAS. There is evidence to suggest this is an effective way to improve aerobic endurance (VO2 max). Again, this is a less specific training method for many athletes Than HIIT although is still an effective training method if used at the right times throughout the macrocycle. A good use of this type of training will be during the GPP phase throughout the off season, preparing the athlete for the HIIT that will come during the SPP or pre-competition phase. This will be covered in more detail in the Periodisation module.

Intensive Interval Training

Intensive interval training also known as high intensity interval training (HIIT) has recently become a popular and fashionable training method due to its publicised physiological benefits. HIIT is characterised by short (10-30s) near maximal intensity work periods (>90% MHR / 110-130% MAS) interspersed with short recovery periods (10-30s) which is very demanding on both the neuromuscular and metabolic systems. The adaptations that occur as a result of HIIT are more central in nature (table 7) and therefore the adaptations and improvements in fitness can be achieved relatively quickly, normally within 2-3 weeks improvements can be seen. There are different interval methods that have been developed such as the billat, tabata and MAS methods all of which have been proven to enhance an athletes fitness levels if used correctly. Intensive interval training should only be used once the athlete(s) has a basic level of conditioning and the intensity or running speed should be progressively increased over time in order to overload the athlete safely. A good time to implement HIIT would be during the early pre-competition phase (SPP) and can be used effectively in conjunction with sports specific training.

Speed-Endurance Training

Speed endurance training involves maximal intensity training (above 90% of MV) for between 30-60 seconds with longer recovery periods, a work to rest ratio of 1:3-1:5 is recommended due to the intensity of the work period. For example, a 300m run in a time of 45s would require 3-4 min recovery between reps. This method of training mainly targets the anaerobic systems, specifically the glycolytic system, therefore lactate accumulation is normally recognised with this type of training which is why longer rest periods are necessary. This type of training is very demanding on the neuromuscular system, specifically on the hamstrings due to the high running speeds, therefore training volume must be taken into consideration when implementing this type of training. Furthermore, consideration to the sport must also be given as to whether this type of training is necessary or specific for the athlete’s sport.

Repeated Sprint Training (RST)

RST is another form of maximal intensity interval training, although differs from speed endurance training. RST requires shorter bursts (5-10s) at 90-100% MV interspersed with longer recovery periods of 20-40s (1:3-1:5) between repetitions. Again, this method is very demanding therefore a good level of both aerobic and anaerobic conditioning should be achieved before implementing this type of training with athletes. This type of training will predominantly tax the anaerobic systems although the aerobic system will be heavily utilised during the recovery periods between repetitions. Normally 1-2 sets of 4-6 reps is adequate stimulus for this type of training due to its high neural demand and its recommended usage would be during the late pre-competition phase.

Sports Specific / Special Training

Consideration must be given to the energy system training an athlete will be exposed to during their sports specific or technical training for their sport especially during the pre-competition and competition phases. For many sports adequate levels of conditioning can be achieved through participating in sports specific conditioning drills such as playing small sided games in football or doing pad work in boxing. Table 24 gives an example of some different sports specific conditioning drills for a team sport athlete in relation to some non-specific conditioning drills. Sports specific conditioning drills should be used as much as possible as these will have more transfer to the competition and will also aid in improving the technical ability of the athlete(s). Therefore, general conditioning drills should be mainly used during the GPP phase and to supplement the sports specific conditioning drills during the SPP and competition phase if required.

Classification of general and specific conditioning drills for team sports athletes

Table 24

Exercise Type	General	Specific	% MAS	% MHR
Extensive endurance	8-12 min interval runs	9v9 - 10v10 LSG’s	70-80%	60-70%
Intensive endurance	4-8 min interval runs	7v7 - 8v8 MSG’s	80-90%	70-80%
Extensive intervals	1-4 min interval runs	5v5 - 6v6 SSG’s	90-100%	80-90%
Intensive intervals	15-30 sec interval runs	3v3 - 4v4 SSG’s	100-120%	90-100%
Maximal intervals (RHI)	10-30 sec interval runs	1v1 - 2v2 SSG’s	120%+60-70%	90-100%

ESD Programming

When it comes to designing an ESD training programme, consideration must be given to the phase of the season / macrocycle, athletes fitness levels and sports specific training demands. The sensible and progressive approach is to start with extensive interval training during the GPP phase to build a conditioning base before moving onto more high intensity interval training and RST during the SPP and competition periods respectively. By implementing the MAS method training intensity and volume can easily be monitored and prescribed through the time / distance spent above 100% MAS as previously mentioned. Table 25 further down is an example of an 8 weight MAS training programme

MAS Training

MAS is the maximal running speed that can be maintained aerobically for an extended period and can be used to prescribe specific training intensities based upon training at a specific % of this speed. MAS Training is a form of HIIT and there is much recent research to advocate its use in athletes. The basis of this research is that high intensity intervals of typically 15-30 seconds, interspersed with 10-30 seconds of either low intensity active recovery (e.g. <40-70% MAS) or passive rest, continued in this manner for total set times of 4-10minutes and repeated for 2 or more sets, greatly enhances aerobic power and capacity. This research emphasised that it didn’t matter if the work/rest patterns were 20 seconds’ work, 10 seconds’ recovery or 15:15, instead the key fact was that training at, or above, 100% MAS was the key intensity parameter, and how long you spent there was the driving volume parameter underpinning improvements in aerobic power. It was determined that the optimal training intensity is a 120% of MAS for the designated work time. There are different methods of MAS training that can be used such as; grid method, euro fit method, shuttle and tabata methods. These different methods can be integrated to give variation to the athlete within their programme. The benefits of the MAS method are that it is easy to measure prescribe and progressively overload especially within a group or team setting (Baker, 2011).

Week MAS Interval Training Programme

Table 25

	Day 1 (volume emphasis)	Day 2 (mixed emphasis)	Day 3 (intensity emphasis)
Week 1	Test MAS – 5min time trial LI – 3-min @ 90% MAS:2-min @40% x 4-reps x 2-sets. Rest 4-mins between sets.	LI – 2-min @ 93% MAS:2-min @40% x 5-reps x 2-sets. Rest 3-mins between sets.	LI – 90-s @ 96% MAS:90-s @ 40% x 5-reps x 2-sets. Rest 2-mins between sets.
Week 2	LI – 3-min @ 92% MAS:2-min @40% x 5-reps x 2-sets. Rest 4-mins between sets.	LI – 90-s @ 98% MAS:90-s @ 40% x 5- reps x 2-sets. Rest 2-mins between sets.	Grids 100%:70% x 15:15 x 5-mins x 4-sets. Rest 3-mins between sets.
Week 3	LI – 3-min @ 94% MAS:2-min @40% x 5-reps x 2-sets. Rest 4-mins between sets	LI – 90-s @ 100% MAS:90-s @ 40% x 5-reps x 3-sets. Rest 2-mins between sets.	Grids 102%:70% x 15:15 x 6-mins x 3-sets. Rest 3-mins between sets
Week 4	Retest MAS. Rest 5-mins, then: LI – 60-s @ 100% MAS:60-s @40% x 4-reps x 2-sets. Rest 2-mins between sets.	Grids 104%:70% x 15:15 x 6-mins x 3-sets. Rest 3-mins between sets.	EuroFit 120% MAS 15:15 x 12-reps (6-mins) x 2-sets. Rest 3-mins between sets.
Week 5	Grids 104%:70% x 15:15 x 8-mins x 2-sets. EuroFit 120% MAS 15:15 x 14-reps (7-mins) x 2-sets. Rest 3-mins between sets.	EuroFit x 1-set (7-mins) Grids x 1-set (7-mins) LI – 60-s:60-s x 4 (8-mins) Rest 3-mins between sets.	Tabata x 120% MAS x 20:10 x 10- reps x 3-sets. Rest 3-mins between sets.
Week 6	Grids 105%:70% x 15:15 x 8-mins x 2-sets. EuroFit 125% MAS 15:15 x 16-reps (8-mins) x 2-sets. Rest 3-mins between sets.	Tabata x 120% MAS x 20:10 x 8-reps x 2-sets EuroFit x 120% MAS x 20:20 x 8-reps x 2-sets Rest 3-mins between sets.	Tabata 125% 20:10 x 10 x 1-set Unpredictable Tabata 5- to 6-min set x 2-sets. Rest 3-mins between sets.
Week 7	Grids 103%:70% x 15:15 x 8-mins x 2-sets. EuroFit 125% MAS 15:15 x 16-reps (8-mins) x 2-sets. Rest 2-mins between sets.	EuroFit x 120% MAS x 20:20 x 8-reps SSG x 1 (8-mins) EuroFit x 120% MAS x 20:20 x 8-reps SSG x 1 (8-mins) Rest 2-mins between sets.	Tabata x 1 (5-mins) SSG x 1 (5-mins) Unpredictable Tabata (5-mins) SSG x 1 (5-mins) Rest 2-mins between sets.
Week 8	Retest MAS End of General Preparation		

The training programme above has an inbuilt intensity progression as athletes work from < 100% MAS in LI, to 100% MAS in the Grids method to 120 and 130% MAS in the EuroFit and Tabata methods. The other variable for difficulty progression is the choice between the active recovery (at < 40% in LI, to 60-70% MAS in the Grids method) versus the passive rest inherent in the EuroFit and Tabata methods. Furthermore, the Tabata method's work: rest ratio of 2:1 may prove even more difficult as compared to the 1:1 EuroFit method. The second Tabata method with variable interval lengths may prove more even difficult for athletes but this may be due to reasons other than just physiological reasons. Introducing turns in the Tabata, or any method, will also cause an increase in difficulty as this increases the anaerobic contribution. Training can be progressed via the systematic use of all of these different methods, starting with the 3-minute LI's and reducing LI length to 60-s, then the 100%:70% grids method, moving to the EuroFit 120% MAS method and finishing with the Japanese Tabata methods within a training cycle. Each method can be implemented for 1-3 weeks before progressing to the next method. Within each 2-3 week mini-cycle, the typical volume progressions would also occur (5-minute sets building up to 8- or even 10-minute sets and/or 2 sets building up to 3 or 4 sets).

Consequently, when a progression to the new method occurs there is a marked decrease in volume, but an increase in intensity this week serves as a “volume un-load” week (see weeks 4 & 7 in Table 9). Therefore, as intensity initially increases with the introduction of the new method, volume is lowest, but builds up over time before implementing the next intensity progression, again with a lower volume. Once an athlete has attained some training experience with these methods, weekly undulating Periodisation is also possible with one aerobic training day emphasising increasing the time spent at ~100% MAS (and possibly also the time of each repetition spent at 100% MAS) via the grids method and the other training day spent emphasising the time spent well above 100% MAS (i.e. The Eurofit or Tabata methods). This methodology is based around the Supramaximal methods developing new aerobic power and improving the ability to repeat high-intensity efforts and the Maximal method, conditioning the body to sustain the current 100% MAS for longer periods. This within-week alternation of methods allows the athlete to toggle between milder active recovery (e.g. 15 s @ 70% MAS or 90-s @ 40% MAS) and passive recovery (Baker, 2011).

Further reading

- Daker, D. Recent trends in high-intensity aerobic training for field sports. Professional Strength & Conditioning. 22 (Summer): 3-8. 2011.
- Baker, D. Cross-training workout: using high-intensity energy system conditioning for injured athletes. Professional Strength & Conditioning. 27 (Winter): 4-8. 2012.
- Baker D. Non-running, high-intensity energy-system conditioning cross-training workouts for injured athletes. Journal of Australian Strength & Conditioning 21(4)5-13. 2013.
- Baker, D. & N. Heaney. Some Normative Data for Maximal Aerobic Speed for Field Sport Athletes: A Brief Review. Journal of Australian Strength & Conditioning (in review).
- Baquet, G, Berthoin S, Gerbeaux M and Van Praagh E. High-intensity aerobic training during a 10-week one-hour physical education cycle: Effects on physical fitness of adolescents aged 11 to 16. International Journal of Sports Medicne.22:295–300. 2001.
- Berthoin S, Manteca F, Gerbeaux M and Lensel-Corbeil G. Effect of a 12-week training program on maximal aerobic speed (MAS) and running time to exhaustion at 100 percent of MAS for students aged 14 to 17 years. Journal of Sports Medicine& Physical Fitness. 35:251–256. 1995.
- Berthon, P., Fellmann, N. Bedu, M., Beaune, B., Dabonneville, M., Coudert , J., and A. Chamoux. A 5-min running field test as a measurement of maximal aerobic velocity. European journal of Applied Physiology.75: 233–238. 1997.

Transfer of Training

The overall aim of the Strength and Conditioning Programme is to improve the athlete's performance levels within their sport. In order to achieve this transfer from the training into their sport there are a number of principles and components that must be applied within the programme in order to allow this training transfer to occur.

SAID Principle

The SAID principle is one of the most important basic concepts when it comes to training. It is an acronym that stands for Specific Adaptation to Imposed Demands. This means that when the body is placed under some form of stress, it starts to make adaptations that will allow the body to get better at withstanding that specific form of stress in the future. The adaptation process does not occur by any one mechanism it is a general tendency of the body which is played out in innumerable separate mechanisms. It is almost impossible to understand and account for all these separate mechanisms when devising a training programme, although it is easy to remember the general SAID principle means that the body is always trying to get better at exactly what the athlete actually practices. The S in SAID stands for specific, meaning that the body only makes adaptations to withstand the specific stress it encounters, it has no interest wasting time making changes that don't directly address the issue. How much the athletes training programme in the gym carries over to their sport depends upon a number of factors which is also often referred to as dynamic correspondence.

Dynamic Correspondence

The theory of dynamic correspondence proposes that in order to ensure optimal training transfer based on the athlete's preparation level, it is suggested that all exercises for specific sports be chosen to enhance the required sport motor qualities/movement patterns in terms of several criterions which includes;

- The amplitude/direction of the movement
- The accentuated region of force production
- The dynamics of effort
- The rate and time of maximum force production
- The regime of muscular work

Furthermore, it is proposed that the strength displayed in the execution of a given movement be referred to only in the context of that given task. Therefore, sport movement tasks are specific and goaldirected and the enhancement in their execution should also be treated as such.

Because of this, exercises could be evaluated based on the type of transfer that they may possess in relation to the degree of skill performance increase. After this is established, exercises and/or training techniques can further be classified into categoriessuch as general physical preparation (GPP) or special physical preparation (SPP) based upon the above criteria. It has even been suggested that only special preparatory exercises will serve the motor potential and will equate to the ultimate level of physical preparation for an athlete. By understanding and emphasising the factors of dynamic correspondence in the training of athletes, strength and conditioning coaches can make training much more specific to the demands that the athletes will experience out in the athletic arena. The attainment of general physical attributes may enhance sport performance in some athletes, but training modalities focused on more specific exercises may in fact be needed for optimal transfer as athletes improve in their level of sports training mastery. In order for training to transfer into the sport at least one of the following criteria must be achieved. The more of these criteria that are achieved within an exercise the more correspondence or transfer it will have within the sport.

Amplitude / Direction of Movement

This refers to the direction of forces that are required to be applied within the sport. For example if the athlete is required to apply vertical forces against the ground such as when jumping, or horizontal forces such as when accelerating. An exercise such as squat requires the application of vertical force so would be a relevant exercises for athlete that needs to be able to jump, whereas an exercise such as stepping out of a reverse lunge requires more horizontal force production therefore would replicate the horizontal forces required when accelerating or running, therefore may have greater correspondence with running based athletes.

Accentuated Region of Force Production

This refers to the particular area or region of the body where the force or movement is produced. It is the generation of force at an appropriate/equivalent joint angle to the sport skill, specifically at the start of the movement. For instance, based upon this criterion, a partial squat may be a more appropriate exercise to incorporate based upon the typical optimal angles for vertical jumping found at approximately 90° at the hip and 120° at the knee.

Dynamic of the Effort

It is suggested that the training stimulus and exerted effort must equal or supersede the intensity of the sport movement. With the vertical jump, this criterion is easily achieved by using weighted jump squats which promote greater force production.

Rate and time of maximal force production

This relates to the available time an athlete has to generate force when performing a sports movement.

To satisfy this criterion, exercise intensities must be selected to allow the athlete to operate in an equivalent time bracket to generate power. Most sports skills permit 0.1 -0.3 seconds to generate power, with most humans capable of producing peak power readings at 0.4 seconds. To reduce the power deficit; selected exercises must stimulate rapid rate of force development. This means picking an exercise intensity which permits maximum power production (30-50% 1RM in squat jump protocols). Higher percentages will develop max strength, not desirable for vertical jump performance given the requirement for rapid force production (power). This component of DC is linked to training the Force Velocity Curve (FVC) and therefore consideration should be given to this during the athletes overall training programme.

Regime of muscular work

This principle suggests that the exercise must imitate the regime of working muscles in the sport movement. The vertical jump can be described as an explosive ballistic movement. Weighted squat jumps, Olympic cleans snatches and their derivatives address this criterion from both a ballistic and explosive perspective, with weighted speed squats in a lower percentage intensity range ticking the 'explosive' box. As a high dynamic correspondence is not always required within the training programme dependent upon the training status of the athlete and the time of the season exercise selection should be decided based upon the athletes requirements. For example during the GPP the back squat may be an appropriate exercise selection in order to increase the athlete's strength which is essential quality for further developing power and /or speed. Once the athlete has established a solid strength base during the GPP then the focus should shift to developing power and speed during the SPP so exercises such as the hang clean or weighted squat jump would be a more appropriate exercise selection as these would carry a greater DC with the sport. These exercises may further progress to Plyometric exercises such as depth jumps or multiple hurdle jumps which again would possess an even greater DC to most sporting activities. Therefore by working the athlete through the different elements of the force velocity curve during the periodised training plan should ensure that the athlete's gains will be transferable to their sport.

General Physical Preparation

The GPP is first part of the training programme and should consist of foundational training. It consists of the type of training that is rooted in the fundamental element of all sports, and that is movement. There needs to be a differentiation made between GGP cycles for the different levels of athletes. There should also be a distinction between general preparation exercises and general development exercises. Development exercises are used to improve specific physical qualities and/or skills, and are not geared to all around physical preparation. With GPP-type exercises, the objective is to strengthen the overall body and prepare the athlete for more intense training that occurs in the later periods of the process of achieving sports mastery. For the novice athlete, GPP should consist of movement-based exercises that target total physical development and should also include concentrated technique training. This will allow for total development along with improved exercise technique associated with various exercises. Technique work is done with elite-level athletes but the time spent on technique development within GPP phases is minimal, and most of the technique work is done in the specialised period. So, for higher level athletes technique improvements come in the SPP phase while novice athletes improve technique within the GPP phase and into the SPP phase.

Specific Physical Preparation

Specialised Physical Preparation (SPP) consists of training that should duplicate what occurs during the execution of a specific sport skill. This type of training is very dependent on the needs analysis performed by the strength and conditioning coach. This needs analysis will allow the coach to have a better understanding of what transpires during the execution of the sport skill, and will allow for a more accurate prescription for SPP-type training. This training also involves exercises that are based on developing the physical abilities, specific to the sport event. In turn, the physical abilities needed to perform well in the sport should be a main target within SPP-type training. As discussed above to make SPP exercises more specific, they should be tailored to duplicate the motor pathways and muscle actions seen within the sport (dynamic correspondence). This is a very specialised form of training that is done on a solid foundation of GPP training. For example, for greater strength in the same range of motion and in the same neuromuscular pathway used in the execution of a sport skill, the athlete also develops a muscular feel for the muscle actions in addition to increasing strength within that range of motion seen within the sport skill. This is why SPP-type training is important to the transfer of training to sport skill. Training programmes that incorporate such specialised exercises encompass the true meaning of the conjugate training system.

This means that as different motor abilities are trained using skill technique execution, sport skill technique is accompanied with the motor ability being trained, thus improving overall sport performance. Fig 22 illustrates the training progressions through both the GPP and SPP of the overall training programme.

Fig 22. Training Progressions through GPP and SPP

Once the appropriate training blocks (mesocycles) have been put in place around the athlete's competition schedule, then specific exercises need to be selected for each phase. The exercises selected should fit in line with the desired outcome goal of each training block and is dependent upon whether the athlete is in the GPP or SPP phase of their programme. Table 26 provides some specific examples of the different type of exercises that can be used within the different training phases in order to optimise training transfer.

Transfer of training exercise sequences

Table 26

Strength	Squats, Deadlifts, Split Squat, Step Ups, Lunges
Power	Olympic lift derivatives, Ballistic exercises (MB's, KB,s), resisted jumps, split jumps etc.
Speed	Fast Plyometrics, Sprinting and agility drills
Sports Specific	Skill or task specific exercises e.g. Sparring, SSG's etc.

Optimising Training Transfer

- Athletes should possess a good general training history before progressing to more advanced and specific tasks.
- Consider training age of athlete do not go too specific too quickly, ensure athlete earns the right to progress.
- Exercises should reinforce optimum neuromuscular efficiency and function which includes intramuscular and inter muscular coordination. This includes greater excitation of appropriate muscle agonists and synergists, decreased co-contraction of antagonists, increased motor-unit recruitment, firing rates, and synchronisation.
- Exercise selection should consider movement pattern, force application, and velocity specificity in the prescription of those exercises used during strength training for athletic preparation.
- For more experienced athletes utilise exercise that adequately challenge the CNS to ensure continual development (progressive overload).

Mobility & Stability

Mobility can be defined as the ability of a joint or series of joints to move or be moved freely and easily through a full range of movement (ROM). ROM can be affected by a joints structure as well as the compliance of the surrounding connective and contractile tissues. The term mobility is often used interchangeably with Flexibility, which is the ability of a muscle to lengthen adequately to allow the joint to work through a full ROM (muscle inhibition). For the purpose of this module, the term mobility will also include flexibility.

Importance of mobility

Athletes with poor or limited mobility around one or more joints are likely to experience performance related limitations and an increased risk of injury. Athletes are often required to move into extreme and vulnerable positions within the sport.

The question that needs to be answered within the needs analysis is what positions are the athlete(s) required to adopt within their sports and which joints require mobilisation. Although there is a fine balance between being mobile enough for the demands of the sport as opposed to being hyper mobile and having too much laxity around a joint. Table 27 illustrates the major joints that require mobility, the common restrictions that occur and ROM test that can be used for each joint.

Common joint ROM restrictions

Table 27

Joint	Common Restrictions	ROM Tests	Normal Range
Ankle (talocrural)	Dorsiflexion	Knee to wall test	8-12cm
Hip	Flexion, Extension External Rotation	Straight leg raise Thomas Test FABER’s Test	80-100 degrees 30-45 degrees
Thoracic spine	Rotation	Seated rotation (L&R)	30-45 degrees
Shoulder (gleno-humeral)	Flexion (overhead) External rotation Internal rotation	Supine lying overhead reach Underarm back scratch test Overhead back scratch test	180 degrees 90 degrees 70-90 degrees

These are some specific joint ROM tests that can be used, although they should also be used in conjunction with some global movement assessments as joints don't work in isolation when performing functional movements, but work together in sequence with other joints to allow this movement to take place. This joint sequencing and integration is also known as the kinetic chain, and any restrictions or limitations within this chain have a knock-on effect on the joints above or below the affected joint which in turn can inhibit a particular movement pattern. An example of this would be an athlete with restricted ankle dorsiflexion performing an overhead squat. This restriction would inhibit the overall movement pattern and would likely exhibit itself with the athlete moving into excessive forward lean at the trunk during the downward phase of the squat to compensate for this lack of mobility at the ankle. Another analogy would be to use a bike chain as an example, if one small segment of the chain is broken then the whole chain would be compromised and the likelihood is that the pedalling mechanism would not work properly. This is the same principle when a joint within the body is damaged or restricted. Table 12 identifies the different movement's patterns that need to be examined in relation to the demands of the sport and would be broken into 3 phases; Phase 1 – observing the athlete performing the sport of specific movement patterns that occur within the sport. Phase 2 Involves examining general movement patterns through the use of a movement screen. Finally phase 3 involves specific joint or muscle testing as shown in table 28. These specific tests should be based upon the findings of the previous two tests and should be determined before an intervention or mobility programme is prescribed.

Table 28

Performance Observation Phase 1	Movement Screening Phase 2	Specific joint/muscle testing Phase 3
How well does the athlete perform sports specific movements?	**How well does the athlete perform general athletic movements?**	**Test for isolated joint ROM or muscle length**
• Running • Jumping • Cutting • Turning • Pushing • Pulling • Kicking • Punching • Twisting	• Squat Patterns • Lunge Patterns • Hip Hinge patterns • Trunk rotations • Shoulder Rotation	• KTW Test • SLR • Thomas Test • Obers test • Hip Drop Out test • Seated Thoracic Rotation • Int & Ext Shoulder Rotation

Mobility Training

Once the movement analysis has been completed, the appropriate intervention and exercises should be included into the athletes training programme. Ideally these exercises should be placed at the beginning of a workout during the warm up and / or at the end of the workout during the cool down. There are different modes of exercise that can be used to improve mobility which could be in the form of isolated movements, targeting a specific joint or muscle. Alternatively, global movements which target multiple joints and muscles simultaneously can be used to improve the functional mobility of the kinetic chain. Commonly if an athlete has a specific restriction around a particular joint then some isolated exercise should be given in order to mobilise the joint before moving onto global movements.

Below is a description of the different training modalities that can be used to improve mobility as well as some example exercises:

Foam Rolling / Myofascial Release

It is well established that if an athlete has a tight or overactive muscle, this will restrict the ROM around the joint that the muscle acts upon. For example, if an athlete has tight hamstrings, this will restrict the amount of hip flexion that can occur during sprinting, therefore limiting sprint performance, and increasing the risk of injury. In this instance foam rolling, could be used to relax, and lengthen the hamstring prior to a training session. The deep compression from rolling helps to break up or relax tight muscles and adhesions formed between muscle layers and their surroundings. It also allows normal blood flow to return and the restoration of healthy tissue. Foam rolling would be recommended before the start of the training session to prepare the muscles for active lengthening that occurs during movement.

Static Stretching

Static stretching is used to stretch a muscle while the body is at rest. It is composed of various techniques that gradually lengthens a muscle to an elongated position (to the point of discomfort) and hold that position for a minimum of 30 seconds. Static stretching slightly lessens the sensitivity of tension receptors, which allows the muscle to relax and to be stretched to greater length.
Although static stretching performed before training and competition has been proven detrimental to performance as it reduces explosive ability. Static stretching also augments the joint and can promote instability in the joint, thus making the athlete more susceptible to injury. For these reasons, static stretching should only be used post training as part of a warm down to help improve flexibility as when performed correctly and at the right time, static stretches can help to lengthen tight muscles. A good stretching session, following exercise or as part of a recovery session can also help to relieve stress and tension.

Dynamic Stretching

Dynamic stretching is much more effective than static stretching when it comes to preparing the athlete for training session or completion and is an integral part of the RAMP warm up protocol, which will be discussed later in the module. Dynamic stretching involves working a joint or series of joints through a full ROM, whilst simultaneously actively lengthening the muscles, preparing them for more intense exercise that follows. Dynamic stretching also includes constant motion throughout the warm-up, which maintains the core body temperature, whereas static stretching causes a drop-in body temperature. Another benefit of dynamic stretching is that it prepares the muscles and joints in a more specific manner since the athlete is going through motions they will repeat in the workout. It also helps the nervous system and motor ability since dynamic motions do more to develop those areas than static stretches. Although this type of stretching is recommended before exercise its long-term effects of improving flexibility are not as effective as those of static stretching, therefore it is recommended that a combination of dynamic stretching is used to increase the mobility around the joint and prepare the athlete for training in combination with some static stretching to improve muscle length over time. Some examples of dynamic stretching sessions are shown below:

1. Hurdle Mobility – hurdles can be an effective tool in improving the lower body mobility of an athlete as it provides a set range that the athlete has to work through either by working over or under the hurdle. There a lot of different exercise that can be performed on the hurdles that focus on different movement patterns and therefore muscles. These exercises can also be used to challenge stability and co-ordination and can also be linked with other exercises and are easy to progress and / or regress.

2. Mobility Circuits – these are generally floor based and consist of a series of different exercises, dependent upon the subsequent session and needs of an athlete. These circuits should focus of working all the major joints and muscles within the body. Below is an example of a mobility circuit than can be used within a warm up for a training session;

Mobility circuit example

Table 29

Mobility Circuit	Movement Complex
A. Knee to wall touches x 5EL (Ankles) B. Fire Hydrants x 5EL (Hips) C. Thoracic Rotations x 5ES (Thoracic Spine) D. Spiderman's x5 EL (Hips) E. Inchworms x 5 (Hips / Ankles)	A. Front Squats x 6 B. Forward Lunges x 6 C. Overhead squats x 6 D. Lateral Lunges x 6 E. RDL'S x 6

PNF Stretching

PNF stretching, or proprioceptive neuromuscular facilitation stretching, consists of a number of stretching techniques to enhance both active and passive range of motion in order to improve motor performance and aid rehabilitation. PNF is considered an optimal stretching method when the aim is to increase range of motion, especially in regards short-term changes. Generally, an active PNF stretch involves a shortening contraction of the opposing muscle to place the target muscle on stretch. This is followed by an isometric contraction of the target muscle. PNF can be used to supplement daily stretching and is employed to make quick gains in range of motion to help athletes improve performance and reduce the risk of injury. There are three different types of PNF commonly used to improve ROM:

Contract Relax

Involves a passive placement of the restricted muscle into a position of stretch followed by an isotonic contraction of the restricted muscle. Most isometric contractions in PNF stretching techniques should be held for a minimum of 3 seconds at a sub maximal effort (20-50% of maximal effort) to avoid muscle fatigue and injury. After the contraction period the athlete is required to relax the restricted muscle that was just contracting and activate the opposing muscle to move the limb into a greater position of stretch.

Hold Relax

Very similar to the Contract Relax technique. This is utilised when the agonist is too weak to activate properly. The athlete's restricted muscle is put in a position of stretch followed by an isometric contraction of the restricted muscle. After the allotted time, the restricted muscle is passively moved to a position of greater stretch. Contraction times and efforts are the same as the Contract Relax technique. This technique utilises the autogenic inhibition, which relaxes a muscle after a sustained contraction has been applied to it for longer than 6 seconds.

Contract Relax Agonist(Antagonist) Contract (CRAC)

Contract Relax Agonist(Antagonist) Contract (CRAC) is usually performed by a passive or active stretch of the target muscle to move the limb into a starting position at first, followed by a submaximal isometric contraction of the target muscle and finally an active stretch is used to move the limb into a new greater position. This technique uses autogenic and reciprocal inhibition to increase the magnitude of the stretch within the target muscle.

RAMP Method

Mobility training should form an integral part of the RAMP warm up. The RAMP method has been developed to ensure that the athlete is physically ready to deal with the demands of training or competition upon completion. The RAMP method consists of the following components:

- **R**aise - This phase has the aim of elevating body temperature, heart rate, respiration rate, blood flow and joint fluid viscosity via low intensity activities.
- **A**ctivate–The aim of this phase is to "switch on" or recruit the major muscle groups required for the exercise. This can often involve exercises traditionally associated with prehab such as mini band routines, rotator cuff exercises, glute bridges, overhead squats etc. This is a time efficient method of including these exercises in the training programme, and the extent of this phase will depend upon the individual sport and the individual athlete's needs.
- **M**obilise - The achievement of the mobilisation phase of the warm-up takes a radically different approach than the traditional static stretching approach. Rather than focus on individual muscles, the approach is to work on movements as previously discussed. This has a number of key advantages. First, the dynamic nature contributes to maintaining the elevation effects of the first period. Secondly the movements are more specific to those found in the sport, and thirdly it is more time efficient.
- **P**otentiate - The term 'potentiation' refers to activities that improve effectiveness, and in the case of the warm-up involves the selection of activities that will improve the effectiveness of subsequent performance. This phase of the warm-up will see a gradual shift towards the actual sport erformance or session itself, and will normally involve sport specific activities of increasing intensity. Including these high intensity dynamic exercises can facilitate subsequent performance,

and is the essence of the potentiation phase of the warm-up. The nature of the activities will depend upon the specific nature of the activities to perform, e.g. a sprint workout will comprise of sprint drills and sprints of increasing intensity.

It is suggested that the RAMP should be used before any training session, although should be specific tailored to the needs of the athlete and the demands of the subsequent session. Using this method is an effective way to incorporate both mobility and stability components into the training session.

Stability Training

Stability can be defined as "The state or quality of being stable, especially resistance to change, deterioration, or displacement." It is the ability of the athlete to resist against external forces in all 3 planes and the ability to maintain balance even in an unstable environment. From this definition, it is apparent that due to the nature of sport, athletes will often be exposed to unstable situations and therefore require good stability to overcome these situations. To be stable an athlete requires the following attributes:

- **Balance & Proprioception** - proprioception refers to the body's ability to sense movement within joints and joint position. This ability enables athletes to know where their limbs are in space without having to look. It is important in all everyday movements but especially so in complicated sporting movements such as changing direction at speed or challenging with an opponent to win a dual.

- **Co-ordination** - coordination is the ability to repeatedly execute a sequence of movements smoothly and accurately, involving the senses, muscular contractions and joint movements.

- **Strength** – being stable involves being able to reduce and produce forces against an external resistance. It also requires good trunk strength in order to effectively resist against movement as well as to be able to efficiently transfer forces between the upper and lower body.

- **Reactiveness** – is the ability of the athlete to see or feel a change of position and be able to quickly react to overcome this change. This requires both cognitive and physical processes.

- **Technique** – being stable in an unstable situation also requires an element of technical competency i.e. the athlete lowering their COM when a tackle or interception or being able to shift their body weight efficiently when transferring weight from two legs onto one.

Due to the multifaceted nature of stability, there are different ways that this can be trained dependent upon the demands of the sport and these individual components can either be trained in isolation (GPP) or in combination through sports specific training;

General Stability Training (GPP)

- **Proprioception training** – involves trying to improve balance and kinaesthetic awareness normally through performing exercise whilst standing on one leg. There are lots of exercises whereby that athlete is required to stand on an unstable surface such as a wobble board, although there is limited evidence to suggest that this would transfer to sport. The athlete is better off spending time focusing on single leg strengthening exercises such as SL squats, SL RDL's, lunge patterns and multi-directional hoping to challenge stability and improve kinaesthetic awareness.

- **Core Stability / Trunk Training** – there is much debate about how much this type of training transfers across to sporting movements. It will mainly be dependent upon the exercises that are used, in order for core training to transfer into sport the athlete should perform the exercises in positions that are similar to that of the sport and of velocities that are similar (dynamic correspondence). This does not mean that the more remedial type of core exercises doesn't have their place in the training programme it is more about how the exercises are progressed in order to have more of a positive transfer to the sport. This will be discussed in more detail in module 9.

- **Strength / Power training** – this topic has been covered in much detail, but to improve stability, strength training exercises must be performed across all 3 planes of movement, consist of bi-lateral and unilateral exercises and also be trained with different loads at different velocities.

Specific Stability Training

In order for stability training to be effective it must be transferable to the environment where the athlete actually performs the sport. In order for this to occur there must be elements of the sport involved such as high velocities, reactiveness, multiplanar and opposed. These components can be trained through either agility training or sports specific training.

- Agility training has been discussed in detail in module 5, but it also transferable with stability training as it requires moving through multidirectional patterns and shifting bodyweight at relatively high velocities. By making these drills reactive in nature i.e. chaos training adds a further element of instability into the exercise and therefore even more sports specific.

- Sports specific training would be the final stage of the continuum and involves the athlete participating in drills where the athlete is performing a specific aspect of the sport. An example in football would be the implementation of SSG's as these involve lots of high speed movements and change of directions, reactiveness in response to the ball and / or an opponent as well as lots of physical body contacts. Therefore, this type of drill would tick a lot of boxes when it comes to improving stability.

Although stability is not a standalone component of fitness, it also encompasses many other components that are involved in the training of an athlete. The following progressions should be applied when it comes to planning a stability programme, although not necessarily in this sequence;

1. **Bi-lateral to Unilateral**
2. **Static – Dynamic – Explosive**
3. **Linear – Lateral – multidirectional**
4. **Low velocity to high velocity**
5. **Closed to reactive drills**

It is important to remember that all training will require some element of stability the extent will be dependent upon the type and nature of the exercise, therefore stability shouldn't really be trained in isolation but included through the utilisation of different strength, power, agility and sports specific drills. There may be exceptions to this where an athlete may have obvious signs of instability, which can be determined through some basic tests.

Stability Testing

Stability in its purest form is normally measured through some form of balance or hopping tests, although stability is indirectly measured through other tests such as strength, power and agility tests. The most common tests for stability are shown below in table 30, these are broken into trunk tests, lower limb stability and upper limb stability tests. Most commonly used are the star excursion test and Y balance test.

Stability Tests

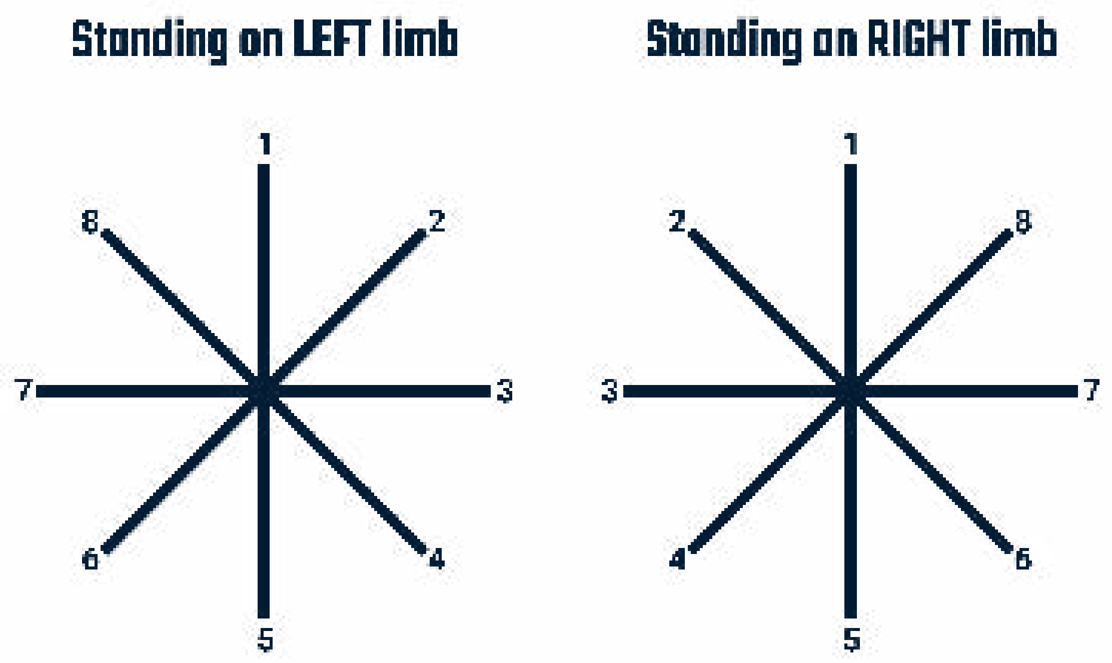
Table 30

Trunk/Core	Lower Limb	Upper Limb
• Trunk Endurance Tests • Plank • Side Plank • Back Extension • Pallof Hold	• FMS • Single Leg Squat • Single Leg SLDL's • Single Leg Hops / Jumps • Y Balance test • Star Excursion Test	• Scapular retraction • Push Up Test • Shoulder Int & Ext Rot

Star excursion test

The Star Excursion Balance Test (SEBT) is a stability test that incorporates a single-leg stance on one leg whilst trying to reach as far as possible with the opposite leg. The athlete stands in a square at the centre of the grid with 8 lines extending from the centre at 45° increments. Each of the 8 lines represents the directions which the athlete is required to reach out with the most distal part of their reach foot. A tape measure is required to measure the distance the athlete reaches from the centre of the grid to the point that they manage to reach along each diagonal line.

Fig 23. Setup of the SEBT



Y Balance Test

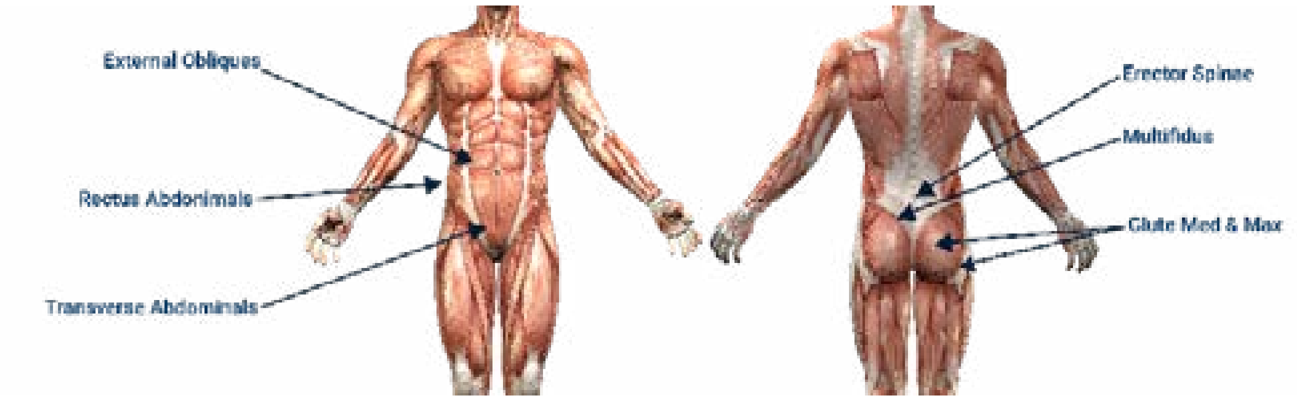
The goal of this test is to maintain single-leg balance on one leg while reaching as far as possible with the contralateral leg in three different directions. The three movement directions are anterior, posteromedial and posterolateral, performed on each leg.

These tests can be used to provide a marker for athlete's balance ability and should be used in conjunction with all other performance testing scores to determine whether the athletes balance or stability is a limiting factor within their performance.

Core Training Considerations

Core stability describes the ability to control the position and movement of the central portion of the body (Trunk). It is the ability to maintain a stable and upright position of the spine and enables the transfer of forces between the lower and upper body. Core stability training targets all of the muscles surrounding the trunk which connect to the spine, pelvis and shoulders, and also assists in the maintenance of good posture and provides the foundation for all arm and leg movements.

Fig 24. Primary Core Musculature

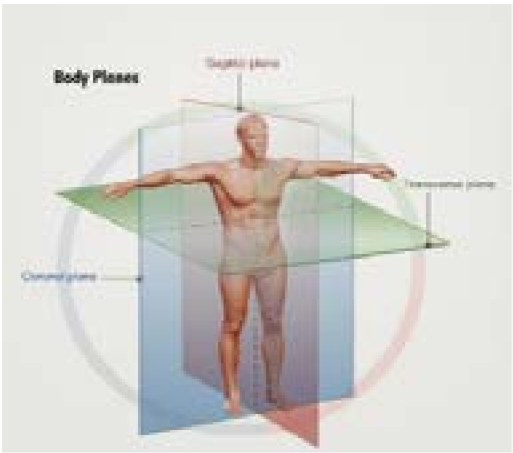


Planes of Movement

During athletic movement, the trunk is required to produce force to generate movement and also to reduce or resist against external forces (bracing) to either decelerate or prevent movement occurring at the trunk. This requires concentric, eccentric and isometric strength qualities within the trunk musculature. These forces can occur through any or all three axis and planes of movement.

- Movements in the sagittal plane involve both flexion and extension activities of the trunk.
- Movements in the frontal plane involves side flexion / bending activities of the trunk
- Movements in the transverse plane involves rotational activities of the trunk.

Fig 25. Planes of movement



These movements need to be included within the training programme, so that the athlete becomes stronger at producing these movements. It is also important that the athlete needs to be trained at resisting against these movements (bracing) in these directions using isometric trunk exercises.

Core Training

Before the core training programme can be designed consideration must be given to the demands of the sport and the needs of the athlete, specifically:

- Trunk action or movements required i.e. flexion, extension, rotation, bracing. Normally a combination of all these movements is required to some degree.
- Muscle contraction type – concentric, eccentric, isometric.
- Direction of force – what is the predominant planes of movement in which force is required?
- Body Position – What are the common positions the athlete is in when they have to produce force i.e. standing, split stance, single leg, kneeling, supine lying, prone lying etc.
- Amplitude or rate of force – Is the athlete required to produce forces more slowly against heavy loads such as grappling or more explosively against lower loads such as a tennis serve?

Table 31

Bracing	Rotation	Anti-Rotation	Flexion	Extension	Side Flexion
Ability to maintain neutral spine in various positions	Ability to rotate against an external load or resistance in a transverse plane	Ability to resist against exter-nal forces in a transverse plane	Ability to flex the spine against an external resist-ance in a sagittal plane.	Ability to extend the spine against resistance in a sagittal plane	Ability to bend laterally against an external force
Isometric action of TA and ES	Concentric & eccentric action of the oblique's	Isometric action of the oblique's	Concentric action of the rectus abdominals	Concentric action of the ES	Concentric action of the oblique's
Planks Dead bugs Superman's	Russian twists Woodchops Landmines	Side Planks Pallof Holds	Crunches Sit ups Reverse crunch	Back extensions Glute-Ham Raise Glute Bridge	Side bends Side bridge
Squatting Dead Lifting Pulling Pushing Jumping	Split stance woodchops Lunge and twist patterns MB rot throws	SL Squats SL SLDL's SA Pushes SA Pulls	Lunge & Reach	Good Mornings RDL's Olympic lifting	B clean & Press

As illustrated in the table, there are six main movements that need to be incorporated into the core training programme, these include; Bracing, rotation, anti-rotation, flexion, extension & side flexion. These movement patterns require different types of muscle concentration and can be trained through isolated core exercises or through global exercises that involve the trunk.

Isolated Core Exercises

Isolated core exercise an effective way to train the core in isolation from other body parts and include exercises that specifically train the trunk. They are a good way to train the trunk for novice and intermediate athletes that may lack good strength and stability around the trunk although as all training methods these exercises need to be progressed as the athlete gets stronger. The following progressions can be used to continuously challenge the athlete:

- Isolated to global movements
- Lying – Kneeling – Standing – Split Stance
- Bi-lateral to Unilateral
- Static (isometric) to dynamic (concentric)
- Body weight to weighted

Any one or more of these progressions can be used to advance an athlete. Table 32 below shows an example 3 phase core training programme with exercise progressions for each movement.

Table 32

Movement	Phase 1	Phase 2	Phase 3
Bracing	Iso plank	Dynamic plank	Kneeling rollout
Anti-rotation	Kneeling pallof hold	Standing pallof hold	Split stance pallof hold
Rotation	SB Russian twists	Kneeling shops	Standing landmines
Flexion (hip)	Deadbugs	Elekna’s	Reverse crunch
Extension	Glujte bridge	Glute ham raise	Good morning
Side flexion	Side plank	Side bridge	Cable pull

These are just a few exercise examples but these progressions can be applied to most exercises and the athlete should only be progressed when they are ready and possess the necessary competency to be able to progress.

Global Core Training

Due to the nature of gravity and the role of the trunk muscles in keeping an athlete upright and maintaining postural integrity. For these reasons the core muscles will be involved during all movements and exercises that are performed. The extent of this involvement will be dependent upon both the type of exercise and intensity of the exercise. There is EMG evidence to suggest that the posterior trunk muscles are more greatly engaged during traditional strength exercises such as during the squat or deadlift than compared to when performing isolated movements, although there is much less anterior trunk involvement. This suggests that there is need for supplementary isolated core training which should be used in conjunction with traditional strength and power training exercises, especially focusing on the anterior aspect of the trunk through the utilisation of bracing and anti-rotational exercises. A good way to incorporate core work into the training programme is to add a core exercise in between a strength exercise (supersets) in order to optimise the training time and tick more boxes with the training session.

Core Strength Training

A trunk strength-endurance testing protocol has been developed by Stuart McGill which requires the athlete to hold an isometric contraction for up to 2 minutes or until the athletes fail in the following position:

- Isometric plank
- Isometric side plank
- Back extension (holding neutral position whilst hanging off of the edge of a plinth)

The ability to hold a contraction for 2 minutes in each of these tests is indicative of good trunk strength.

Key Messages

- All training is core training.
- A strong core is essential for the efficient transfer of force between the upper and lower body.
- A strong core is essential for maintaining good posture.
- A strong / stable core can minimise the risk of injury especially lower back pain.
- Core training should be progressive in nature starting from basic low intensity movements to more advanced and complex movements.
- Athletes need to earn the right to progress.

Further reading

- Core Training: Evidence Translating to Better Performance and Injury Prevention, Stuart McGill, 2010.

Sports Psychology

Sports Psychology involves the study of how psychological factors can affect sports performance and how athlete participation in sport and exercise affects psychological and subsequently physical factors. The importance of psychology in sport is to help to improve the psychological skills of the athlete in order to enhance performance. There are a number of mental skills that the athlete needs to possess in order to succeed within their sport, these skills are commonly known as the 4 C's - concentration, confidence, control and commitment. These skills are required to overcome anxiety which is a natural emotion when performing. Anxiety is a form of stress and is the body's automatic response that prepares it to 'fight' or 'flight' from perceived harm or attack. It is a programmed response that ensures survival of the human species. Sporting competition promotes similar psychological and bodily responses because there is often a threat posed towards the athlete's ego or sense of selfesteem. When the demands of training or competition exceed the athlete's perceived ability, anxiety is the inevitable outcome. Training and competition places a wide variety of stressors upon the athlete which can be both psychologically and physically exhausting and if the athlete doesn't possess the necessary psychological skills to deal with anxiety then performance levels may be harmed. Directly there is nothing damaging about the stress associated with competition, and in fact stress can be a very positive influence that can improve the focus and motivation of the athlete if it is channelled in the right direction. Although, when the athlete perceives the stress to be negative, it can cause too much anxiety and therefore negatively impact upon performance. Participants in individual sports have been shown generally to suffer more anxiety before, during and after competition than participants in team sports because the sense of isolation and exposure is much greater in sports such as athletics, tennis and snooker than in comparison to team sports. For athletes in high contact sports such as boxing and martial arts, the possibility of getting hurt can also be a source of anxiety. Typically, this anxiety causes some critical changes in technique. For example, anxious boxers will often lean too far forward, be clumsy in their foot movements or fight defensively, any of which may result in them getting knocked out. The inverted U theory illustrates the relationship between anxiety / arousal and performance levels. It shows that up to a certain level of anxiety performance will be enhanced although once this arousal reaches a certain point there will then be a drop off in performance as a result.

Anxiety can be recognised on three levels:

- On the cognitive level – i.e. by thought processes;
- On the somatic level (bodily) – i.e. by physical responses;
- On the behavioural level – i.e. by certain patterns of behaviour

It is believed that it is the ability to control the environment and themselves that determines the athlete's anxiety response. For example, if they believe they can cope in a particular sporting situation, they will tend to strive to achieve their goals with positive expectations of success. Having positive expectations will invariably mean that they will be more confident and therefore more likely to perform close to their best. Conversely the feeling that they can't control a particular stressor such as a competing against a difficult opponent or a carrying a niggling injury will mean that the symptoms of anxiety are exacerbated possibly resulting in performance impairment. In order to overcome the negative effects associated with anxiety the athlete needs to possess the 4 C's.

Confidence

When athletes feel confident, they are more readily able to turn sporting potential into superior performance. Conversely, when they feel unsure of themselves, the slightest setback or smallest hurdle can have a hugely detrimental effect on their performance. Self-confidence is commonly defined as the sureness of feeling that they are equal to the task at hand. This sureness is characterised by absolute belief in their ability. Confidence results from the comparison an athlete makes between the goal and their ability. The athlete will have self-confidence if they believe they can achieve their goal. When an athlete has self-confidence they will tend to persevere even when things are not going to plan, show enthusiasm, be positive in their approach and take their share of the responsibility in success and fail. Confidence is a positive state of mind and a belief that the athlete can meet the challenge ahead and a feeling of being in control. It is not the situation that directly affects confidence; thoughts, assumptions and expectations can build or destroy confidence. There are different emotional and physical symptoms associated with either high or low self-confidence:

High self confidence

- Thoughts - Positive thoughts of success
- Feelings - Excited, anticipation, calm, elation and prepared
- Focus - On self, on the task
- Behaviour - Maximum effort and commitment, willing to take chances, positive reaction to set backs, open to learning, take responsibility for outcomes

Low self confidence

- Thoughts - Negative, defeat or failure, doubt
- Feelings - Tense, dread, fear, not wanting to take part
- Focus - On others, on less relevant factors (coach, umpire, conditions)
- Behaviour - Lack of effort, likely to give up, unwilling to take risks (rather play safe), blame others or conditions for outcome

Control

Self-control is the ability of an athlete to keep their emotions in check and focus on the task at hand. Identifying when an athlete feels a particular emotion and understanding the reason for the feelings is an important stage of helping an athlete gain emotional control. An athlete's ability to maintain control of their emotions in the face of adversity and remain positive is essential to successful performance. Two emotions that are often associated with poor performance are anxiety and anger. Anxiety comes in two forms; physical (butterflies, sweating, nausea etc...) and mental (worry, negative thoughts, confusion, lack of concentration etc.…). When an athlete becomes angry, the cause of the anger often becomes the focus of attention. This then leads to a lack of concentration on the task, performance deteriorates and confidence in ability is lost which further fuels the anger which is a progressive route to failure. It is important that an athlete is able to keep their emotions in check and maintain their focus when going into competition in order to ensure a stable performance. If an athlete is unable to control their emotions, their focus and attention can be easily distracted and performance inhibited.

Concentration

This is the mental quality to focus on the task in hand. If the athlete lacks concentration, then their athletic abilities will not be effectively or efficiently applied to the task. Research has identified the following types of attention focus:

- **Broad Narrow continuum** - the athlete focuses on a large or small number of stimuli
- **Internal External continuum** - the athlete focuses on internal stimuli (feelings) or external stimuli (ball)

The demand for concentration varies with the sport:

- **Sustained concentration** - distance running, cycling, tennis, squash
- **Short bursts of concentration** - cricket, golf, shooting, athletic field events
- **Intense concentration** - sprinting events, bobsleigh, skiing

Common distractions that can affect concentration are: anxiety, mistakes, fatigue, weather, public announcements, coach, manager, opponent, negative thoughts etc. Strategies to improve concentration are very personal. One way to maintain focus is to set process goals for each session or competition. The athlete will have an overall goal for which the athlete will identify a number of process goals that help focus on specific aspects of the task. For each of these goals the athlete can use a trigger word (a word which instantly refocuses the athlete's concentration to the goal) e.g. sprinting technique requires the athlete to focus on being tall, relaxed, smooth and to drive with the elbows - trigger word could be "technique". Athletes will develop a routine for competition that may include the night before, the morning, pre-competition, competition and post competition routines. If these routines are appropriately structured, then they can prove a useful aid to concentration.

Commitment

Sports performance depends on the athlete being fully committed to numerous goals over many years. In competition with these goals the athlete will have many aspects of daily life to manage. The many competing interests and commitments include work, studies, family/partner, friends, social life and other hobbies/sports. Within the athlete's sport, commitment can be undermined by:

- Perceived lack of progress or improvement
- Not being sufficiently involved in developing the training programme
- Not understanding the objectives of the training programme
- Injury
- Lack of enjoyment
- Anxiety about performance - competition
- Becoming bored (Training Monotony)
- Coach athlete not working as a team
- Lack of commitment by other athletes

Setting goals with the athlete will raise their feelings of value, give them joint ownership of the goals and therefore become more committed to achieving them. All goals should be SMARTER. Many people (coach, medical support team, manager, friends, etc.) can contribute to an athlete's levels of commitment with appropriate levels of support and positive feedback, especially during times of injury, illness and poor performance.

Signs & Symptoms of Anxiety

Table 33

Cognitive	Somatic	Behavioural
• Indecision • Sense of confusion • Feeling heavy • Negative thoughts • Poor concentration • Irritability • Fear • Forgetfulness • Loss of confidence • Images of failure • Defeatist self-talk • Feeling rushed • Feeling weak • Constant dissatisfaction • Unable to take instruc-tions • Thoughts of avoidance	• Increased blood pressure • Pounding heart • Increased respiration rate • Sweating • Clammy hands and feet • Butterflies in the stomach • Adrenaline surge • Dry mouth • Need to urinate • Muscular tension • Tightness in neck and • shoulders • Trembling • Incessant talking • Blushing • Pacing up and down • Distorted vision • Twitching • Yawning • Voice distortion • Nausea • Vomiting	• Biting fingernails • Lethargic movements • Inhibited posture • Playing safe • Going through the • motions • Introversion • Uncharacteristic • displays of extroversion • Fidgeting • Avoidance of eye contact • Covering face with hand

Psychological Strategies

There are several psychological strategies that can be used in order improve an athlete's confidence, control, commitment and concentration levels. These strategies include; Imagery, relaxation techniques, self-talk and goal setting.

Imagery

Imagery has been described as "an experience that mimics real experience, and involves using a combination of different sensory modalities in the absence of actual perception". Imagery is a psychological technique which has demonstrated its effectiveness in sport through positively affecting psychological states, such as decreasing anxiety and enhancing self-confidence, self-efficacy, and concentration. It is also beneficial for use as a coping strategy, maintaining existing skills, and reviewing past performances.

Imagery is built upon the link between physical and imagined movements and it is proposed that there are certain shared areas in the brain that are activated during both physical and imagined movements. This is defined as "functional equivalence" and is hypothesised as the means by which imagery can improve performance. It is suggested that if there is a greater similarity between the image and the physical movement (i.e. a greater degree of functional equivalence), it may help to add more detail to the image and enhance the vividness of the image. PETTLEP is an acronym which stands for 7 key elements to include during imagery to create the most functionally equivalent image possible. Using the example of a footballer, the specific details to include would be:

- **Physical** – image the relevant physical characteristics. For example, a footballer would image dressed in their kit with the football at their feet.
- **Environment** – if possible, image in the environment where the performance takes place e.g. football pitch.
- **Task** – try to image details relevant to the task (e.g. intentional demands) and image at the appropriate level of expertise for the performer (i.e. a novice footballer should avoid imagining an elite level player as it is not as functionally equivalent).
- **Timing** – the most functionally equivalent approach is to image in 'real time', but 'slow motion' imagery can be used to emphasise and perfect more difficult aspects of a skill. For example, a footballer may wish to 'slow motion' image a particularly tricky piece of footwork.
- **Learning** – the imagery should be continually adapted and reviewed over time to match changing task demands and the experience level of the athlete. For example, as a novice footballer progresses and masters a skill, they should adapt the imagery to reflect their improvement in performance.
- **Emotion** – include the same images that would be felt in the physical situation. However, try to avoid debilitative emotions (e.g. fear, panic). For example, a player imaging taking a penalty would include feelings of confidence and adrenaline rushes.
- **Perspective** – the imagery perspective can be first person (through their own eyes) or third person (like watching themselves on video). However, one perspective may be more advantageous

depending on the task characteristics. A first-person perspective (or internal visual imagery) may be more beneficial for tasks including open skills and with a focus on timing (e.g. tackling). On the other hand, a third person perspective (or external visual imagery) is preferred for tasks where form and positioning is important, such as heading the ball or kicking technique.

Relaxation Techniques

When preparing for competition, very few athletes actually take the time to sit back and take a breath and relax. The simple acts of inhaling, exhaling and relaxing for just a few moments can have a significant impact on sporting performance. This ability to relax and focus on the skill to be executed is not something that can be implemented instantaneously but rather it is developed over time and with practise. Practising 'relaxing' is something that requires dedication, time and effort through the use of breathing techniques and one of the most popular techniques that is used by athletes is Progressive Muscle Relaxation (PMR). This technique involves the athlete tensing and relaxing muscle groups for 20 minutes a day, in a quiet location where they can 'let go' and clear their mind of stress. PMR has been shown to have hugely significant long-term effects in sport, particularly with helping to reduce general anxiety and stress, while also helping to increase concentration. By practising PMR, athletes will have a better understanding of their breathing and they can then implement shorter, concentrated breathing exercises around competition. Many athletes struggle with 'over arousal', where they are overly anxious and stressed or even over-motivated, before matches and this can have a debilitating effect on their performance. The use of PMR and concentrated breathing techniques can help overcome these negative effects by decreasing arousal to a level that is more suitable for the match situation, thus ensuring that performance is not adversely affected.

Breathing techniques are arguably most relevant in sports involving a 'closed skill', where there are fewer 'outside distractions' during the competition and there is the time available to take a moment to relax. For example, sports such as athletics, tennis and boxing would appear to be more suited to using relaxation techniques as an athlete may find themselves becoming 'over aroused' but by breathing deeply and allowing themselves to relax, they can ensure they perform their next movement at the level they expect and require. Even in team sports, there will be times when deep breathing techniques can give an athlete a vital few seconds to ensure they are in the right state of mind to execute a skill effectively, for example before taking a free kick.

Self-talk

All athletes have an inner voice which can be either be positive (helpful) or negative (unhelpful). It is an important skill for the athlete to learn to re-structure their thoughts whenever a negative one creeps into their mind. It is apparent that the athlete's thoughts are linked with their emotions and therefore actions and / or outcomes. For example, if the athlete's thoughts are negative they will feel negative emotionally and consequently their actions/behaviour/performance will suffer. If they can replace the negatives with positivesthoughts the opposite will be true, leading to good performance. It is important that the athlete getsinto the habit of changing bad thoughts into good ones. As with all the interventions they should use them as often as possible in all different situations in order for them to become automatic during competition. Table 34. Highlights some different examples of negative and positive self-talk.

Negative & Positive Self-talk

Table 34

Negative self-talk	Positive self-talk
• Too much pressure • Want a quick finish • Things aren't going to plan • Feeling fatigued • The coach isn't going to be happy	• Be patient, focus on the training • Be patient, don't rush • Focus on a new plan • Believe in fitness levels • I am going to make the coach happy

Goals Setting

Setting goals creates a path for athletes to follow. It is an effective motivational technique that boosts skill learning as well as competitive performance. Athletes tend to be more focused and committed to training when goals are clearly established and they know exactly when they have achieved them.

There are three commonly accepted types of goals coaches can set:

- **Outcome goals** - are those that compare the performances of athletes with those of other athletes. For example, "Winning a competition" means that the athlete's outcome depends on the performances of others.

- **Performance goals** - are used to improve an athlete's individual performance. For example a sprinter may want to run the 100m in under 10s. The athlete has much better control over performance goals.

- **Process goals** - are used to improve the execution of a skill. For example, the athlete may strive to increase stride length during sprinting to help them achieve their performance goals.

When goal setting with athletes all three of these types of goals should be used and should be in the form of the SMART analogy; Specific, measurable, achievable, realistic, time-based. Fig 26 illustrates the SMART process.

Fig 26. SMART Goals

Specific Goals

The athlete's goals must be clear and well defined, they must understand what they are required to achieve. Vague or generalised goals are not achievable because they don't provide sufficient direction. The goals should be linked with the design of the training programme.

Measurable Goals

The goals must be measurable in order to determine the degree of success. Without a way to measure their progress they will not know whether they have actually achieved their goals or not. A good to way to set measurable goals is through the use of specific fitness tests and then repeat these tests after a period of training to monitor the improvements made.

Achievable Goals

Make sure that it's possible for the athlete to actually achieve the goals that are set. If the coach sets a goal that the athlete has no hope of achieving, they will become demoralised and lose confidence, although do not set goals that are too easy. By setting realistic yet challenging goals the athlete will be motivated and focused towards achieving these goals. These types of goals require the athlete to "raise the bar" and bring the great personal satisfaction once achieved.

Relevant Goals

Goals should be relevant to both the sport and needs of the athlete. By keeping goals aligned with the athlete it will develop the focus they need to achieve their goals. For example, setting goals based upon the areas for improvement determined through the needs analysis will ensure that the goals are specific to the athlete.

Time based goals

All goals must have a deadline so that the athlete knows when they have achieved their goals. When working on a deadline, their sense of urgency will increase and achievement will come that much quicker. Short medium and long term goals should be set in order to keep the athlete on track with their goals. Short term goals are normally set over a time period of 1-3 months, medium term goals 3-6 months and long term 6-12 months. These goals should be identified within the annual training programme and the programme should be adjusted accordingly to keep the athletes on track with their goals.

Performance Profiling

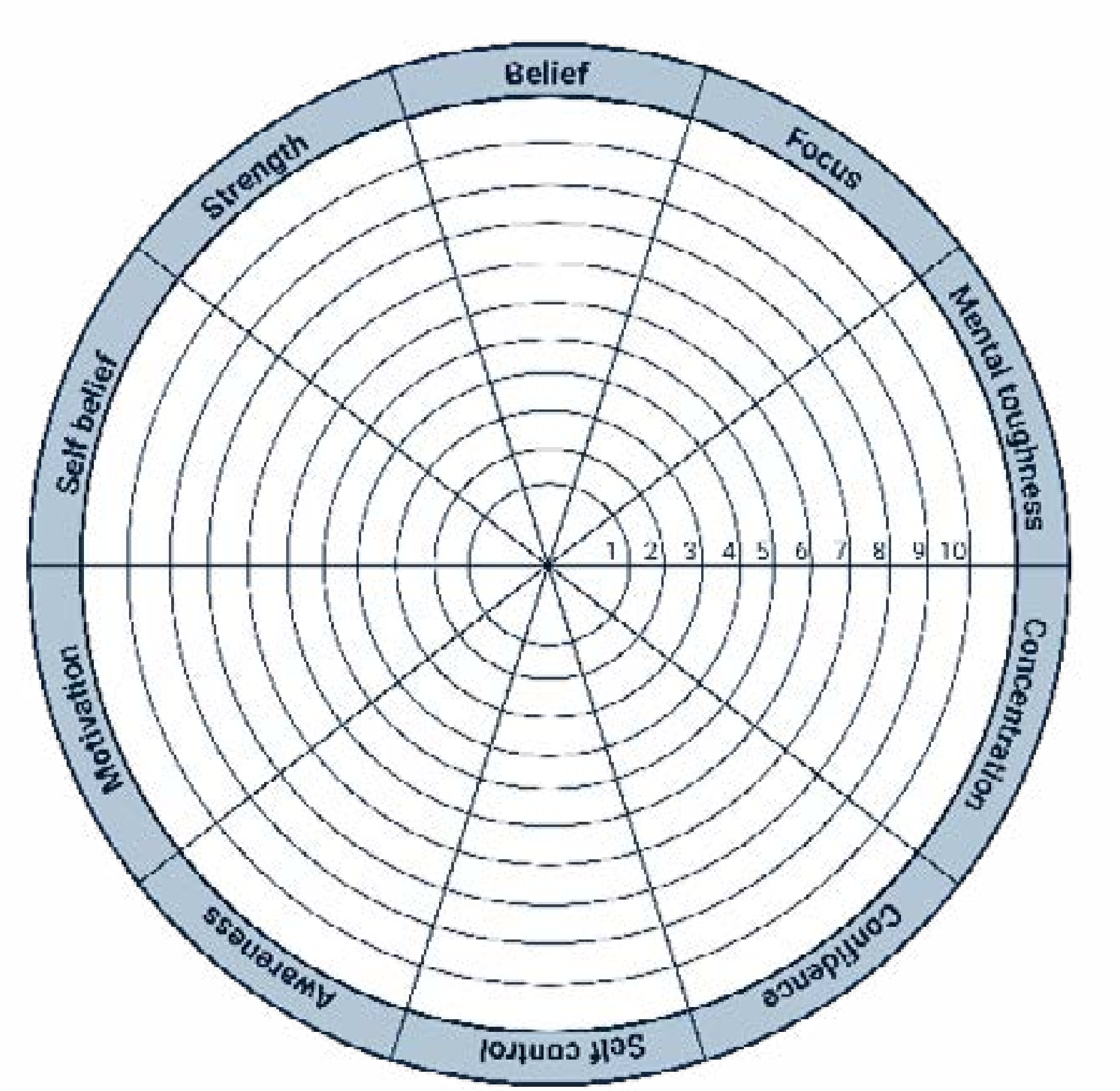
Performance profiling is a technique used to identify and organise training, preparation and the development of an athlete. This assessment can provide important information on athletes, which can be used to implement realistic goal setting strategies and help maximise their intrinsic motivation. If applied correctly, these interventions can help focus the athlete on the key aspects of their performance and help direct their training to the areas of perceived need. The premise underlying the coach-athlete relationship is the ability to help the athlete reach their full potential. There has been a rapid spread of performance profiling across a number of sports because coaches have now recognised the potential in enhancing their understanding of an athlete. Performance profiling allows the athlete to have a more active role in evaluating their own performances. Sports psychology includes undertaking a subjective analysis of the athlete and their chosen sport, individual assessments of the athlete, implementation of appropriate training techniques and the evaluation of the effectiveness of the programme. Performance profiling can be an effective tool in raising the athlete self-awareness of their current ability and enhancing adherence to the overall training programme. The flexibility of the performance profile has previously helped coaches gain a better understanding of their athlete's visions and perceptions as well as monitoring the athlete's progress.

The first stages of performance profiling involve the coach and athlete selecting a number of personal performance factors for which to base the performance profile around. These factors can be broken down into 4 performance components; Tactical, Technical, Physical and Mental. For example performance factors could include; Shot Accuracy, tackle completion, Sprint Speed or communication. The athlete is required to complete a self-rating assessment of their current level on a 1-10 scale before rating the selected performance factors due to their importance (1 – not at all important, 10 – crucial). The athlete must decide a performance rating (1-10 scale) for their 'Ideal' or 'optimum' performer in their chosen sport. More effective performance profiling has taken place when the athletes' 'ideal' performer competes at a similar level, therefore providing a more realistic target to aim for. The performance profile serves to provide the athlete with a developmental agenda and training focus in order to improve their performance.

After analysing an athletes' performance profiling results, the next stage of the process would be planning and implementing an effective goal setting strategy. This should be done using the SMART principle of goal setting and it is suggested that the most effective goals are set by the athletes themselves. However, although performance profiling does encourage accurate self-assessment by the athlete they may not always set appropriate goals, and may need guidance from the coach to steer them towards more suitable ones. The outcome of performance profiling is to motivate athletes to improve factors of their performance, therefore enhancing their overall ability.

Performance profiling has been demonstrated to be a useful tool for any athlete in order to analyse their own performance effectively. Through motivation and determination, carrying out performance profiling and implementing a subsequent goal-setting programme, the athletes' performance in training and competition can improve. A separate performance profile can be carried out for each of the four pillars of performance (technical, tactical, physical, and psychological) if a more detailed breakdown and understanding of the athlete is required. For the purpose of this module the following example is a performance profiling template that could be used to solely assess the athlete's psychological status (strengths & weaknesses).

Fig 27. Psychological Profile Template



This profile should be completed as part of the athlete assessment process and make up part of the needs analysis. Specific psychological strategies should then be implemented as part of the training programme based around their weaknesses and needs.

Injury Reduction Programmes

An injury can be defined as damage or dysfunction of a tissue or structure due to the body being unable to deal with a certain stress placed upon it. There are several different classifications of injuries dependent upon the mechanism of the injury as well as the affected structures. Injuries are often multifactorial in nature, meaning there are many different factors that may lead to or increase the likelihood of an athlete getting injured. The different mechanisms of injury are known as either intrinsic or extrinsic dependant if they occur from forces within the body i.e. a muscle tear or from outside of the body such as a dead leg from a tackle. Table 35 highlights some different intrinsic vs extrinsic injuries.

Intrinsic/extrinsic injury risk factors

Table 35

Intrinsic	Extrinsic
Internal or not contact injuries	External or contact Injuries
Overuse injuries e.g. tendinopathy, stress fractures etc..	Haematoma's / contusions
Muscle / tendon Injuries (Strains)	Ligament injuries (sprains)
	Bone / joint injuries (fractures / dislocations)

It is important that the S&C coach possess a good knowledge of the different types and mechanisms of injury that the athlete(s) may be exposed to. It is difficult to minimise the risk of extrinsic type injuries but all intrinsic type injuries should be deemed as preventable. Table 36 below illustrates some common injuries associated with different sports. This information can be used when devising the needs analysis and risk assessment for the athlete(s) sport. In order that the appropriate strategy or intervention can be implemented to minimise the risks identified.

Injury analysis sport examples

Table 36

Football	Rugby
• Hamstring, groin & calf strains • Ankle inversion sprains • ACL Tears • Meniscus tears • Dead leg / Haematoma's	• External or con ontact Injuries (contusions, concussions, shoulder dislocations) • ACL & Meniscus Tears • Ankle Inversion sprains • Hamstring & Groin Strains tact Injuries
Athletics (sprinting)	**MMA**
• Hamstring, quad & calf strains • Achilles tendinopathy	• Head & neck Injuries • Hand & wrist fractures • MCL & LCL elbow sprains • R cuff tear and impingements • Shoulder subluxations / dislocations
Tennis	**Cycling**
• Rotator cuff impingement / tears • Lower back pain / dysfunction • Patella tendinopathy • Ankle Inversion Sprains	• Quad & Calf strains • Patella tendonitis • ITB Syndrome • Lower back pain

Once the common injuries are understood the possible risk factors that result in a particular injury also need to be determined. Similarly, to injuries these are termed either intrinsic or extrinsic dependent upon whether the risk is an internal or external factor.

Intrinsic Risk Factors

An intrinsic risk factor is something that normally occurs from within the athlete and is to more to do with the physiological functioning of the different systems within the body and includes the following:

- **Biomechanics** – athletes with poor mechanics or movement patterns may be at greater risk of injury due to abnormal loading patterns and transfer of weight. This could either occur from a structural problem such as a length discrepancy which may require some sort of external intervention i.e. orthotics to be worn. Alternatively this may just come from poor technique due to not be taught correctly or lacking the necessary attributes to perform the activity competently. Therefore the athlete may need stripping back and re-educating through basic movement and technical training exercises within the programme.

- **Age –** age is not something that can be controlled by the athlete or coach but is something that should be taken into consideration when designing the training programme. Older athletes tend to take longer to recover between sessions and are at an increased risk of injury if the overall training load is too high. Similarly, younger athletes that may not be fully developed and used to the physical demands of full time training are also at a greater risk of injury, particularly growth and overuse type injuries.

- **Training age** – athletes with a low training age are at a greater risk of injury compared to those with a higher training age due to more experienced athletes having built up more tolerance and resilience to deal with training loads. Therefore, novice athletes should have a more progressive training programme with less overall volume and intensity or load.

- **Previous injury** – it is well known that athletes with a previous history of injuries are at greater risk of injury either at the same site or away from the site. It is important that an appropriate rehab programme and S&C programme is put into place for the athlete when returning to training. Specific attention should be given to the mechanism of injury and the appropriate interventions need to be put into place to minimise the risk.

- **Fitness levels** – athletes with lower fitness levels are at greater risk of injury due to the earlier onset of fatigue and therefore risk of picking up a fatigue related injury. This risk can be minimised by ensuring that the athletes are adequately conditioned to deal with the demands of the sport.

- **Strength levels** – stronger athletes are generally more robust than weaker athletes and are therefore at a lower risk of injury. Therefore by implementing a good strength programme to improve the athlete(s) strength will help to minimise injury occurrence. For example poor eccentric strength of the hamstrings is a predictor of hamstring injuries during sprinting.

- **Flexibility / ROM** – there is mixed evidence as to whether poor flexibility actually results in injury incidence. Although it is known that poor mobility around a joint inhibits movement and function, therefore leading to poor technique. Therefore, it is likely that poor mobility can result in poor movement and subsequently increases the risk of injury.

Extrinsic Risk Factors

An extrinsic risk factor is something that occurs from outside of the body, some of which can be influenced by the athlete or coach and others which can't. It is important that the S&C coach performs a comprehensive risk assessment to determine which risk factors can be controlled in order that these risks are addressed within the overall training programme. Extrinsic risk factors include;

- **Environment** – there are certain aspects of the environment that can be controlled such as ensuring that there are no hazards in or around the facility where the athlete is training or competing. There are also other factors that can't be affected such as the weather i.e. is it hot, cold, wet, dry etc... Although there are interventions that can be ensured to make sure the athlete is adequately prepared to deal with these factors, such as wearing the correct kit/footwear and ensuring the athlete is adequately hydrated if training or competing in a hot environment.

- **Gender** – generally females are at greater risk of certain types of injury than males due to biomechanical and structural differences between them. Further consideration should be given to addressing these issues and modification of training loads when training females.

- **Training load exposure** – this an obvious one for the S&C coach to manage, athletes should follow a well-planned and structured programme that allows for periods of unload and recovery. It is evident that athletes without a structured plan will be at a greater risk of injury possibly due to accumulative fatigue. This is a key area when it comes to minimising the risk of injury and the information gained from the other modules should enable the Strength and Conditioning Coach to plan and deliver a safe and effective Periodisation programme.

- **Lifestyle factors** – it is well known that sleep and nutrition are the two key areas that promote recovery and help the athlete positively adapt to the demands of training imposed upon them. There is evidence to show that inadequate sleep on a regular basis, increases risk of injury due to inadequate recovery. Other risk factors could include regularly consuming alcohol as this can cause dehydration and effect concentration and co-ordination. It is important that the Strength and Conditioning Coach educates the athlete(s) about these risks.

- **Contact / Impact –** these types of injuries are quite a common occurrence within contact sports and there is not much that can be done to prevent them except by ensuring that the athlete is wearing the necessary protective equipment.

The risk assessment of both the sport and the athlete should be carried out within the needs analysis and subsequently any risk factors that are found should be addressed where possible. For example, if the athlete has a previous history of hamstring injuries firstly further investigation is required as to why i.e.is there a muscle imbalance? Are there biomechanical issues etc... and then the appropriate intervention needs to be incorporated into their programme to minimise the risk of the injury reoccurring. Following the intervention period normally 4-6 weeks the athlete should be re-assessed to see if the risk has reduced as a result of the intervention. There are a number of different intrinsic and extrinsic factors that may put an athlete at risk of sustaining an injury. Most commonly; too much load/stress coupled with inadequate recovery resulting in accumulated fatigue and or poor movement competency combined with inadequate strength levels to deal with the forces they are exposed to within the sport. Ultimately the key for S&C coaches to minimising injuries involves effective load monitoring and management strategies combined with a well-planned, organised and progressive strength and conditioning programme.

Load Monitoring and Management

Training for sport or competition reflects a balance between the minimum training load required to elicit an improvement in fitness and the maximum training load tolerable before sustaining marked increases in injury. Studies of team sport athletes have reported a positive relationship between training loads and training injury rates, suggesting that the harder these athletes train the more injuries they will sustain. Consequently, the prevention of training-load related soft-tissue injuries in team sports has been relatively simple: if training loads exceeded a planned ‘threshold’, athletes were ‘managed away’ from potential injury. There is also evidence to suggest that insufficient training may lead to increased injury risk. While injury prediction models may have sufficient predictive accuracy to warrant systematic use in an elite sport programme, a fine balance exists between training, detraining and overtraining. These injury prediction frameworks constrain the amount of physical adaptation permitted through training, by limiting the amount of physical work that can be performed. While allowing athletes to exert themselves above and beyond the planned training loads could identify those athletes likely to tolerate the intensity and fatigue of competition, the available evidence suggests that soft tissue injury is also likely to occur. Ensuring athletes reach minimum physical fitness standards, coupled with scientific monitoring of training loads to avoid overtraining and excessive fatigue, offers coaches a 'best practice' approach to minimise the risk of injuries. In this day and age there are a number of different monitoring tools and systems that the S&C coach should be familiar with in order to help them manage the overall training loads of the athlete(s). These methods can range from relatively simple and inexpensive methods such as RPE and heart rate monitoring through to much more detailed and accurate monitoring devices such as GPS. Measuring training load is just about being able to put a quantifiable measure on the work that is being done and then being able to measure or track this over time. A recent system that has been devised to measure this is known as the training stress balance (TSB) which looks at monitoring the acute (1 week) vs chronic (4 week) training loads. This is determined by dividing the 7 day average TL with the previous 4 week average TL. A negative TSB which would be shown as a sudden spike in the athletes overall TL has been shown to significantly increase the risk of injury. This model can be used with any form of athlete monitoring system that is available to the Strength and Conditioning Coach.

Designing the Programme

There is no magic programme when it comes to reducing injuries or making the athlete bulletproof, although there are several ways the Strength and Conditioning Coach can make the athlete more robust and reduce the risk of injury, specifically through the implementation of well-designed and evidence based training programme which applies the principles of progressive overload to avoid sudden spikes in the acute training load. The athlete needs to develop good mobility and movement and gradually build good levels of strength in order to make the athlete more robust. The training programme should also include individual exercises to target areas of risk or weakness based upon the findings of the needs analysis. It is also essential to ensure athlete is adequately conditioned for demands of the sport through the addition of specific fitness and conditioning drills within the programme. Adequate recovery and deloads should be built into the programme to allow sufficient recovery for adaptations to the training programme to occur as well as to avoid the build-up of accumulative fatigue. The athletes progress should be continuously monitored throughout the programme and should be modified and adapted where necessary to fit the requirements and status of the athlete, this could be a case of increasing the intensity if an athlete is progressing quickly to improve fitness or alternatively to reduce the load or intensity if an athlete is regressing or showing signs of fatigue. Fig 19 illustrates a safe and effective model for developing fitness and athleticism in a progressive manner, therefore reducing the risk of injury by accelerating an athlete too quickly through this continuum. It is suggested that the athlete begins by developing good movement quality and literacy skills as a foundation before moving onto more complex training involving the energy systems and the progressively working through the force velocity curve starting with strength development into power and finally speed development.

Nutrtion for Sports Performance

Optimum nutrition is essential for athletes when it comes to performance and also for optimising recovery after training or competition. Good nutritional intake comes from the athlete consuming a nutritious and well balanced diet containing all of the essential nutrients they require in order to:

- Provide energy
- Preserve and build muscle
- Maintain healthy bones
- Maximise oxygen transport and usage
- Repair existing cells and create new tissue
- Maintain optimal fluid and electrolyte balance

Individual nutrients all have a different part to play in optimising bodily functions and these nutrients are classified as either macronutrients or micronutrients.

Macronutrients

Macronutrients are nutrients that are required in large amounts as they provide the energy needed to maintain body functions and ultimately fuel performance. There are 3 macronutrients carbohydrates, proteins and fats.

Carbohydrates

Carbohydrates are one of the most important nutrients needed in an athlete's diet. Carbohydrates are vital to help them reach peak performance during physical activity because they provide energy. When carbohydrates are consumed they are eventually digested and broken down into smaller sugar molecules called glucose. These glucose molecules are stored in the liver and muscles to be used for fuel, especially during physical activity. Carbohydrates improve athletic performance by delaying fatigue and allowing an athlete to compete at higher levels for longer. Carbohydrates also have a role to play in gaining or maintaining muscle mass. Without an adequate amount of stored glucose in the body, other nutrients, such as fat or muscle protein, are utilised to make energy. With the correct amount of carbohydrates available for the muscles to use as fuel, protein can be free to do its main job of repairing and rebuilding muscle tissue, which maximises muscle gain. As exercise increases, muscle glycogen (stored carbohydrate) becomes used up, which causes a greater need for carbohydrates. For athletes involved in high intensity training or competition, eating the right amount of carbohydrates before, during, and after an event is essential. Often athletes have the misconception that a low-carb and high protein diet will help them gain significant muscle mass. This is not true as a diet low in carbs will not only decrease muscle potential but will also inhibit overall athletic performance. Furthermore when these carbohydrate stores are inadequate to meet the fuel needs of an athlete's training programme, this results in fatigue, reduced ability to train hard, impaired competition performance, and a reduction in immune system function. For these reasons, athletes are encouraged to plan carbohydrate intake around key training sessions and over the whole day according to their carbohydrate requirements as an exercise fuel. Carbohydrate requirements are dependent on the fuel needs of the athlete's training and competition programme. Exactly how much is required is dependent on the frequency, duration and intensity of the activity. Since activity levels change from day to day, carbohydrate intake should fluctuate to reflect this. On high activity days, carbohydrate intake should be increased to match the increase in activity. This will help to maximise the outcomes from the training sessions and promote recovery between sessions. Alternatively, on low or non-training days, carbohydrate intake should be reduced to reflect the decreased training load. A good way to adjust the athletes carbohydrate intake from day to day is to schedule carbohydrate-rich food choices at meals or snacks around the important training sessions. As the sessions increase in their carbohydrate demands, so should the athlete increase their carbohydrate intake before, during or after exercise? Table 37 provides an example of a weekly undulating nutrition plan based upon training intensity and subsequent energy expenditure.

Weekly undulating nutrtion plan example

Table 37

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Training load	**Low**	**High**	**Low**	**Med**	**Med**	**High**	**Med**
Carbs (g)	316	632	316	474	474	632	474
Protein (g)	120	160	120	140	140	160	140
Fats (g)	90-110 (80% un-sat)	90-110 (80% un-sat)	90-110 (80% un-sat)	90-110 (80% un-sat)	90-110 (80% un-sat)	90-110 (80% unsat)	90-110 (80% un-sat)
Calories	2554-2644	6506-6596	2554-2644	4214-4304	4214-4304	6505-6596	4214-4303

A general recommendation for carbohydrate intake for endurance or team sports athletes is anywhere between 6-10g per kg of body weight. For example for a 75kg athlete this would equate to 450 – 750g of carbohydrate per day, therefore the lower amount being consumed on a lighter training day and the higher amount being used on a heavier training day when energy expenditure is going to be higher. It should also be noted that 1g of carbohydrates provides 4kcal of energy, for example if an athlete consumed 400g of carbohydrate in a day this would equate to 2000kcal of energy consumption. There are also a number of different types of carbohydrates that the athlete can consume (sucrose, glucose, fructose, maltodextrin & starch) which will all have different effect on the body and blood sugar levels. These different carbohydrate types can be classified by the Glycaemic Index (GI) which is a ranking of how quickly carbohydrate foods raise blood glucose levels in the body following ingestion

(See fig 28). High GI foods are rapidly digested and absorbed by the body and raise BGLs quickly. Low GI foods, on the other hand, are much slower to be digested and absorbed and result in more gradual rise in blood glucose levels. For athletes, it is important to consider their immediate requirements and what a whole food or snack can provide (such as protein, vitamins and minerals) rather than looking at only one component of any food. For example, higher GI foods can be useful immediately after exercise to promote a faster recovery of muscle glycogen stores. Daily requirements, based on anthropometrics and performance goals should also be considered when making these food choices. Furthermore, an athlete's carbohydrate requirements before, during and after training or competition will depend on a number of factors including:

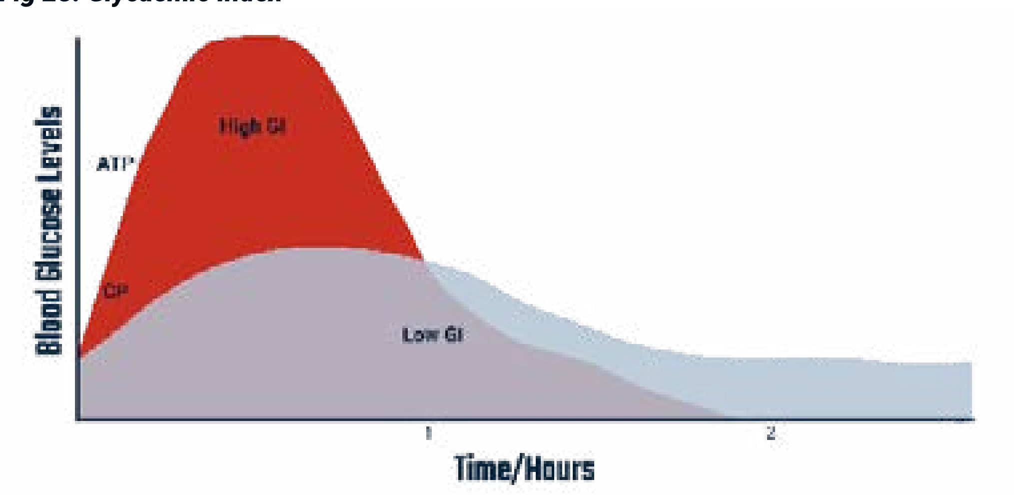
- Type, intensity, duration of exercise
- Frequency of exercise or time available for recovery between sessions
- Body composition goals
- Environmental conditions
- Training background
- Performance goals for the session

While these recommendations provide, the overall carbohydrate needs of the athlete, it is also important to consider the timing of carbohydrate around training and competition. Carbohydrate ingestion before exercise should assist in topping up blood glucose levels as well as glycogen stores in the muscle and liver. This is especially important if the competition or training is undertaken first thing in the morning or if the event is high intensity or will continue beyond 90 mins in duration.

The replacement of carbohydrate during prolonged exercise can benefit sports performance, both through effects on the muscle (reducing/delaying the decline in exercise intensity with time) and the brain/central nervous system (reducing/delaying the decline in concentration and mental skills, as well as reducing/delaying the decline in pacing strategies with time). Using specific training sessions to practice consuming specific carbohydrate foods is also important if it is intended to be consumed during a competition.

Carbohydrate intake after exercise is essential for optimum recovery of glycogen stores. Often athletic performance is dependent upon the ability to recover from one session and do it all again in the next session. Incomplete or slow restoration of muscle glycogen stores between training sessions can lead to a reduced ability to train well and a general feeling of fatigue. In competition, it may also reduce subsequent performances where efforts are repeated within or across days.

Fig 28. Glycaemic Index



Protein

Protein is an essential nutrient in the athlete's diet, being used to manufacture body proteins that have important structural and functional roles. Structural proteins are needed to build connective tissue, cell membranes and muscle cells. Regulatory proteins act as enzymes or transport vehicles. Proteins are made up of about 20 different amino acids. Eight of these amino acids are essential and must come from the diet. Some amino acids are also used as a minor fuel source during exercise. Athletes involved in heavy training require extra protein to cover a small proportion of the energy costs of their training and to assist in the repair and recovery process after exercise. Strength athletes, who are interested in gaining muscle size and function, require more protein in the early stages of very intensive resistance exercise. However, strength athlete's muscles seem to adapt to the stress of resistance exercise, so that the protein requirements to maintain protein balance in very well-trained athletes are only marginally greater than those of generally active people. Athletes, who are growing, such as adolescents, have additional protein requirements. The table below summarises protein requirements for different types of athletes or exercise activities. Since athletes come in various shapes and sizes, it is easier to keep track of these requirements by relating them to the size (body mass or BM) of the athlete.

Protein requirments for athletes based on per kg of body weight

Table 38

Sedentary men and women	08-1.0
Elite male endurance athleres	1.6
Moderate-intensity endurance athletes (a)	1.2
Recreational endurance athletes (b)	0.8-1.0
Football power sports	1.4-1.7
Resistance athletes (early training)	1.5-1.7
Resistance athletes (steady state)	1.0-1.2
Female athletes	~15% lower than male athletes

For example, an 80kg resistance training athlete would require between 120-136g of protein per day. Similarly, to carbohydrates, 1g of protein provides 4Kcal of energy. In this instance this protein intake would provide the athlete with 480-544Kcal of energy per day.

Recovery after a workout or competition is a very important consideration for the athlete. Recovery processes are complex and include refuelling, rehydrating and repairing. Muscle and body protein metabolism is a constant balance between protein breakdown and protein rebuilding. During exercise the balance shifts towards protein breakdown, while during the recovery period after exercise the balance tips in the opposite direction. By consuming protein immediately after exercise it enhances muscle uptake and retention of amino acids, and promotes a more positive protein balance. This heightened state of protein metabolism seems to last for up to 24 hours and it is important for athletes to look at their protein spread throughout the rest of the day as well as immediately after exercise. The most important consideration is that the effect of post-exercise protein intake is best seen when the protein is combined with carbohydrate. Carbohydrate intake stimulates an increase in the hormone insulin, which in turn, stimulates the muscle to take up the amino acids. A protein-carbohydrate snack or drink after a workout is key, not only for muscle repair and adaptation to training, but to provide carbohydrate fuel to restore muscle glycogen levels prior to the next training session or competition.

Fat

Fat is an essential component of the athlete's diet as it helps the body to absorb nutrients as well as providing a great source of energy which provides the body with essential fatty acids that it is unable to manufacture on its own. Although fats are an important part of the diet they should be consumed in moderation, as large amounts could lead to excess weight gain and could subsequently result in an increased risk of serious health concerns such as heart disease and high blood pressure. All fat contains both saturated and unsaturated fatty acids though are usually referred to as either 'saturated' or 'unsaturated' depending on the percentage of fatty acids present. Saturated fats are commonly found in animal products and processed foods such as meat, dairy and chips, and the unsaturated fats are found in foods such as avocados, olives, nuts and oily fish. The structure of saturated and unsaturated fat is very different. Saturated fat is not considered to be healthy for the heart and is known to raise LDL (bad) cholesterol levels.

Consuming too much saturated fat is also associated with weight gain, which is undesirable for athletes. Conversely unsaturated fats are considered to be healthy, and can actually work to lower LDL cholesterol levels as well as raising the HDL (good) cholesterol levels. Unsaturated fats should make up over 80% of the athletes fat intake. It must also be noted that all fats have a higher energy value than either carbohydrates and protein as 1g of fat provides 9kcal of energy. For example, if the athlete consumed 100g of fat this would equate to 900Kcal of energy consumed. Recommended total fat intake for athletes should be in the region of 60-90g dependent upon their size and training goals and should make up approximately 25-30% of the athlete's daily macronutrient intake.

Micronutrients

Micronutrients play an important role in energy production, haemoglobin synthesis, maintenance of bone health, adequate immune function, and protection of the body against oxidative damage. They assist with synthesis and repair of muscle tissue during recovery from exercise and injury. Exercise stresses many of the metabolic pathways where micronutrients are required, and intensive training may result in muscle biochemical adaptations that increase micronutrient needs. Exercise may also increase the turnover and loss of these micronutrients from the body. As a result, greater intakes of micronutrients may be required by athletes to cover increased needs for building, repair, and maintenance of lean body mass.

Vitamins

Vitamins do not provide energy, but they are crucial for turning food into energy. High activity levels of athletes may increase their vitamin needs although, vitamins will not directly enhance their performance, a shortage is likely to reduce or impact performance and health negatively. The essential vitamins required and their role includes the following:

- **Vitamin B1 (Thiamine)** - Thiamine helps break down carbohydrates and proteins for energy. However, taking more than the DRI does not appear to enhance performance. Good food sources includes; whole and enriched grains and fortified cereals.

- **Vitamin B2 (Riboflavin)** - Riboflavin is integral to energy production. It also plays a role in red blood cell formation and athletes need the DRI of this vitamin. Good food sources include almonds, milk, yogurt, wheat germ, fortified breads and cereals.

- **Niacin** - Niacin supports both anaerobic and aerobic performance. Too much or too little niacin can shift the body's use of energy from fat to carbohydrates or vice versa which might affect performance. A good food source includes; meat, fish, poultry, peanuts, peanut butter and enriched grain products.

- **Vitamin B6** - Vitamin B6 is involved in over 100 metabolic reactions in the body, including the production of energy and haemoglobin, a protein in red blood cells. Intakes below the DRI can inhibit performance. A good food source includes; meat, fish, poultry, eggs, beans whole grains, seeds and oysters.

- **Vitamin B12** - Because of its role in red blood cell formation, B12 is crucial for getting oxygen to tissues. B12 is only found in animal products, putting vegan and vegetarian athletes at risk for anaemia. Such groups should try to get as much B12 from food as possible. Taking a B12 supplement or eating B12-fortified foods also may be needed. Good food sources include; seafood, meats, milk and cheese, eggs and fortified breakfast cereals.

- **Folate** - Folate is important for cell production, heart health and protection against birth defects. The DRI appears to be enough to support the energy demands of athletes. It is recommended that female athletes of childbearing age should include folate in their diet every day. Good food sources include; enriched grains, dark leafy greens, whole-grain breads and cereals and citrus fruits.

- **Vitamin C** – This is the most commonly known antioxidant, vitamin C offers a wide variety of health benefits, including protecting from infection and damage to body cells, helping produce collagen (the connective tissue that holds bones and muscles together), protecting the body from bruising by keeping capillary walls and blood vessels firm, and helping in the absorption of iron and folate. Good food sources include; citrus fruits (oranges, grapefruits and tangerines), strawberries, sweet peppers, tomatoes, broccoli and potatoes.

- **Pantothenic Acid** - This vitamin is needed for the breakdown of fats, proteins and carbohydrates into usable energy. It is found in almost all plant and animal foods, good food sources include poultry, seafood, nuts, seeds, avocados and whole grains.

- **Vitamin D** - Vitamin D is actually a hormone, not a vitamin. The body can make its own vitamin D through sunlight exposure. Vitamin D is important for bone health as well as muscle function. Athletes in weight sensitive sports such as gymnastics, running or cycling should take care to get enough. An athlete who is deficient in vitamin D should be prescribed Vitamin D and/or calcium supplements to increase their levels. Good food sources include; fortified milk and cereals, cod-liver oil, seafood and eggs.

Minerals

The primary minerals lows in the diets of athletes, especially female athletes, are calcium, iron, zinc, and magnesium. Low intakes of these minerals are often due to energy restriction or avoidance of animal products and in these instances supplementary mineral intake is recommended.

- **Calcium** is especially important for growth, maintenance and repair of bone tissue, maintenance of blood calcium levels, regulation of muscle contraction, nerve conduction, and normal blood clotting. Inadequate dietary calcium and vitamin D increase the risk of low bone mineral density and stress fractures. Female athletes are at greatest risk for low bone mineral density if energy intakes are low, dairy products and other calcium-rich foods are inadequate or eliminated from the diet, and menstrual dysfunction is present.

- **Iron** is required for the formation of oxygen-carrying proteins, haemoglobin and myoglobin, and for enzymes involved in energy production. Oxygen-carrying capacity is essential for endurance athletes as well as normal function of the nervous, behavioural, and immune systems. Iron depletion is one of the most prevalent nutrient deficiencies observed among athletes, especially females. Iron deficiency, with or without anaemia, can impair muscle function and limit work capacity. Iron requirements for endurance athletes, especially distance runners, are increased by approximately 70%.

- **Zinc** plays a role in growth, building and repair of muscle tissue, energy production, and immune status. Diets low in animal protein, high in fibre and vegetarian diets are associated with decreased zinc intake. Zinc status has been shown to directly affect thyroid hormone levels, BMR, and protein use, which in turn can negatively affect the health and performance levels of athletes.

- **Magnesium** plays a variety of roles in cellular metabolism (glycolysis, fat, and protein metabolism) and regulates membrane stability and neuromuscular, cardiovascular, immune, and hormonal functions. Magnesium deficiency impairs endurance performance by increasing oxygen equirements to complete submaximal exercise. Athletes in weight-class and bodyconscious sports, such as wrestling, ballet, gymnastics, and tennis, have been reported to consume inadequate dietary magnesium. Athletes should be educated about good food sources of magnesium. In athletes with low magnesium status, supplementation is recommended.

- **Sodium, Chloride, and Potassium** - Sodium is a critical electrolyte, particularly for athletes with high sweat losses. Many endurance athletes will require much more sodium than is normally recommended. Sports drinks containing sodium and potassium, as well as carbohydrate, are recommended for athletes especially in endurance events. Potassium is important for fluid and electrolyte balance, nerve transmission, and active transport mechanisms. During intense exercise, plasma potassium concentrations tend to decline to a lesser degree than sodium. A diet rich in a variety of fresh vegetables, fruits, nuts/seeds, dairy foods, lean meats, and whole grains is usually considered adequate for maintaining normal potassium status among athletes.

Hydration

Being well hydrated is an important consideration for optimal exercise performance. Because dehydration increases the risk of potentially life-threatening heat injury such as heat stroke, athletes should strive for hydration before, during, and after exercise. Dehydration (loss of >2% body weight) can compromise aerobic exercise performance, particularly in hot weather, and may impair mental/cognitive performance. Therefore appropriate hydration strategies should be implemented pre, during and post training and competition.

Pre training

At least 4 hours before exercise athletes should consume approximately 5-7 ml·kg body weight of water, this would allow enough time to optimise hydration status and for excretion of any excess fluid as urine. Approximately 1 hour before exercise the athletes should consume another 300-500ml of fluid, preferably in the form of an isotonic drink in order to top up muscle glycogen stores as well as to provide the body with essential electrolytes that will be lost through sweat during exercise.

During Exercise

The purpose of drinking during exercise is to avert a water deficit in excess of 2% of body weight. The amount and rate of fluid replacement is dependent on the individual athlete's sweat rate, exercise duration, and opportunities to drink. Consumption of drinks containing electrolytes and carbohydrates can help sustain fluid and electrolyte balance and endurance exercise performance. The type, intensity, and duration of exercise and environmental conditions will alter the need for fluids and electrolytes. Fluids containing sodium and potassium help replace sweat electrolyte losses, whereas sodium stimulates thirst and fluid retention and carbohydrates provides energy. Drinks containing 6-8% carbohydrate are recommended for exercise events lasting longer than 1 hour.

Post Exercise

Because many athletes do not consume enough fluids during exercise to balance fluid losses, they complete their exercise session dehydrated to some extent. Given adequate time, intake of normal meals and beverages will restore hydration status by replacing fluids and electrolytes lost during exercise. Rapid and complete recovery from excessive dehydration can be accomplished by drinking approximately 500ml of fluid for every pound (0.5 kg) of body weight lost during exercise. Consuming rehydration beverages and salty foods at meals/snacks will help replace fluid and electrolyte losses. Carbohydrate and protein ingestion should also be considered in order to replenish glycogen stores as well as stimulating protein synthesis. Therefore, recovery shakes containing 50-60g of carbohydrates and 20-30g of protein as well as containing added electrolytes is recommended within the first half an hour following exercise.

Long Term Athletic Development

LTAD is a process or model that allows for optimal physical, psychological, emotional, cognitive and bio motor development of a child or adolescent. It is achieved through the delivery a well-planned long term training programme which should take into consideration the different stages of development and maturation of each individual athlete. The LTAD programme should be based around the following principles:

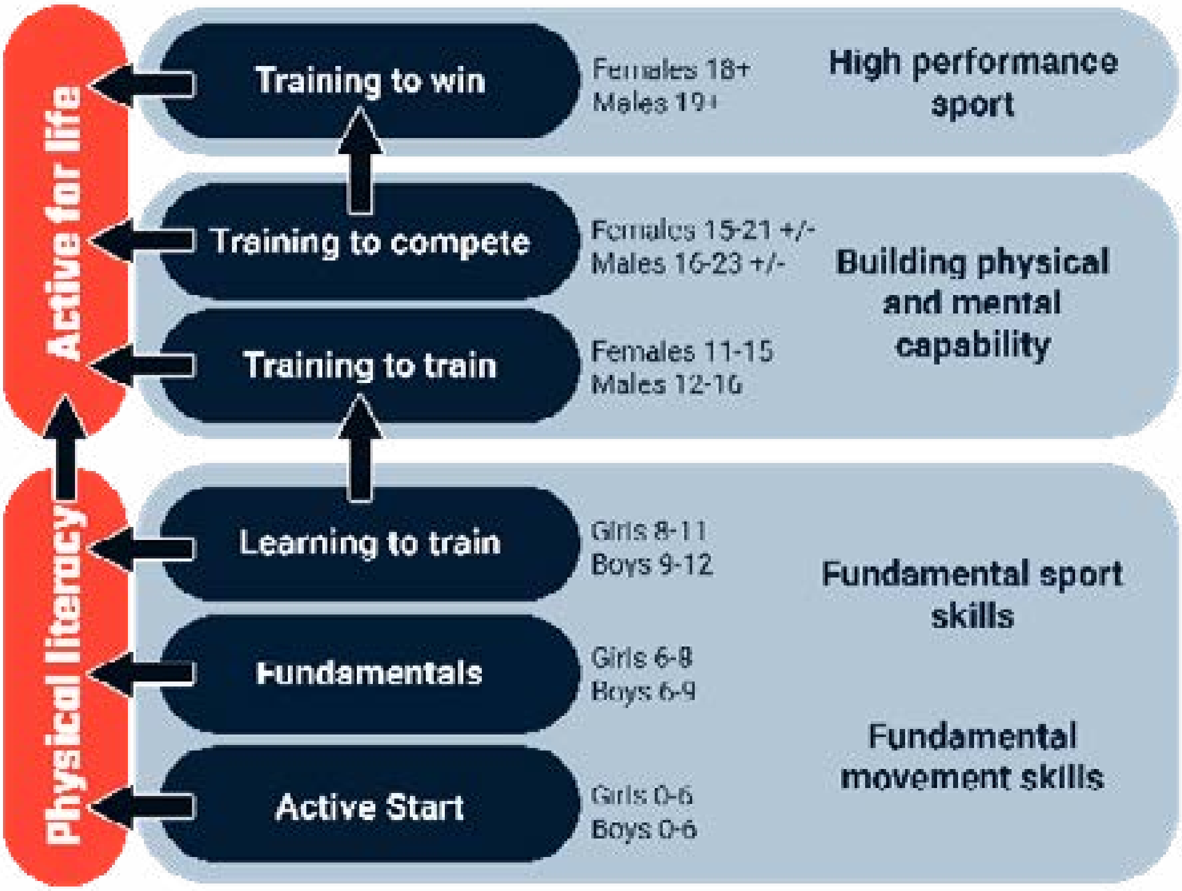
- Focus on developing the appropriate movement or fitness qualities, throughout the different stages of the development or maturation process.
- Avoidance of early specialisation through just playing one sport.
- Clear, precise and logical progressions throughout the training process in line with the maturation process.
- Continuous monitoring and assessment of both general and athletic development through appropriate screening and testing methods.
- Improve movement qualities and patterns before applying overload to young immature athletes.
- Minimise / Reduce the risk of training and growth related injuries through effective monitoring and training load management.
- Long term not short term, overall improvement of athletic capabilities.

The LTAD model can be split into five or six distinct phases in line with a child's maturation & development. These phases are identified in Fig 29. and includes:

1. Active Start
2. Fundamentals
3. Learning to train
4. Training to train
5. Training to compete
6. Training / competing to win

Each of these phases clearly has different goals and therefore the type of training within each phase will be different as the training should be clearly directed to desired outcomes and training goals of each particular phase.

Fig 29. LTAD Framework



Active Start Stage

From ages 0-6 years, children need to be introduced to unstructured active play that incorporates a variety of body movements. Children this age need to develop the ABCs of movement; Agility, Balance, Coordination and Speed. The ABCs are essential for developing fundamental movement skills, which will later provide the foundation for fundamental sport skills. Together fundamental movement skills and fundamental sport skills form the basis of physical literacy. An early active start enhances development of brain function, physical coordination, gross motor skills, posture and balance. An active start also helps children to build confidence, social skills, emotional control, and imagination. Children in the active start stage should see physical activity as a fun and exciting part of everyday life. Young children need regular physical activity (active play) to develop and grow properly. A physically active lifestyle is crucial for life-long health and physical and emotional wellbeing.

Physical activity means taking part in active play that uses the body's large muscles. Children should get outside when possible and should experience a range of activities and games.

This activity doesn't always have to be structured, but it should be vigorous. Physical activity should begin during the infancy stage, using toys to prompt movement. It is recommended that children under six shouldn't be inactive for more than 60 minutes at a time (unless sleeping). Reducing screen time will help keep this schedule intact. Because children need to develop a range of body control, locomotors and sending and receiving skills, it's imperative that they experience a variety of different activities throughout this stage.

Fundamentals Stage

The Fundamental stage is the second of the three LTAD stages that are critical to the development of physical literacy and takes place between the ages of 6-9 in boys and 6-8 in girls. If children fail to develop physical literacy prior to the growth spurt in puberty, they will have limited ability to develop sport-specific skills at older ages and stages of training and development. Obviously, this will significantly impact their desire to continue in lifelong physical activity and limit their opportunities to develop as an athlete. Children in the Fundamental stage are motivated primarily by the desire to have FUN. While they may participate in competitive sports where points are scored, they should be far less concerned with competitive results than they are with having fun, being with friends and developing a strong selfesteem. Children in the Fundamental stage should improve their fundamental movement skills through well-structured programmes and Skill development should happen through a combination of unstructured play in safe and challenging environments and quality instruction from knowledgeable teachers and coaches in structured programmes at their schools or external sports clubs. Children this age should not specialise in a single sport, unless they are participating in one of the few recognised early-specialisation sports (e.g. gymnastics).If they have a preferred sport, they should take part in it two or three times a week, but they should also participate in other sports and physical activities at least three to four times per week. Children this age should develop a strong sense of what is fair and should be introduced to the simple rules and ethics of different sports. Basic rules, tactics, decision making and ethics of sport can also be introduced throughout this phase. Table 39 highlights the different physiological changes that occur during this phase and how to plan the training programme based around these changes.

Principles of the Fundamentals stage

Table 39

Growth & Maturation	Training
The child is more skilful in gross movements involving large muscle groups than in precise co-ordinated movements involving the interaction of many smaller muscles.	General basic skill should be developed during this phase
The size of the heart is increasing in relation to the rest of the body. The cardiovascular system is still developing	Short duration anaerobic activities (alactic) must be planned; Endurance must be developed through play and games
Ligamentous structures are becoming stronger; Both ends of the long bones are still cartilaginous and continue to ossify.	Slow progression in hopping, jumping, own bodyweight and medicine ball exercises. Volumes and intensity kept low.
Basic motor patterns become more refined towards the end of this stage. The balance mechanism of the inner ear gradually matures.	Specific activities and games should emphasise coordination. Kinaesthetic sense emphasised in gymnastics, diving, athletics field events.
During this stage girls develop coordination skills faster than boys but generally there is little difference between the two sexes.	Training and playing together should be emphasised at this stage.

Key considerations during the Fundamentals stage include:

- Hand and foot speed can be developed especially well by boys and girls during this stage. If this sensitive period of accelerated adaptation to develop speed is missed, body speed later in life may be significantly compromised.
- This is a great age for children to take part in a wide range of sports. They should be encouraged to take part in as many different types of activities as possible.
- It is important that all children master fundamental movement skills before sport specific skills are introduced.
- Strength, endurance and flexibility need to be developed, but through games and fun activities rather than a training regimen.
- Children need to learn to read the movements going on around them and make sound decisions during games.

Learn to Train Stage

During the learning to train stage which occurs between the ages 8-11 in girls and 9-12 in boys, children should be converting their fundamental movement skills into fundamental sport skills. This stage is defined as the golden age of learning for specific sport skills. The Learn to train stage of LTAD is the most important stage for the development of sport-specific skills. This stage represents a sensitive period of accelerated adaptation to skills training and fine motor control. It is also a time when they should enjoy practicing their skills and seeing their own improvement. The learn to train stage ends when the growth spurt begins. The growth spurt disrupts coordination and motor control, making it more difficult to pick up and develop new sport skills. It is still too early for specialisation in many sports, although many children at this age may have developed a preference for one sport. To maximise the long-term development of their athletic capabilities, they need to engage in a broad range of activities, playing at least 2-3 different sports through the year. While most children naturally enjoy healthy competition, skills training and practice should be the focus at Learn to train (not on winning). It is recommended that approximately 70% of time in the sport should be spent in practice, and no more than 30% of time spent competing in formal games and competitions. (Competitive training activities count as part of the 70% training time). This is the time to develop and refine all fundamental movement skills and learn overall sport skills. The brain is approaching adult size and complexity, and refined skill performance is easier to develop. During this stage children will develop at their own rate and some much faster than others. Children that hit puberty at a slower rate than expected are generally termed as “late developers”. Late developers do have an advantage when it comes to learning skills, as the learn to train stage lasts longer for them. They can often become better sport performers in the long term because of the longer period of skill development that they enjoy. Although conversely, early developers often get selected over the late developers because of the emphasis that coaches and parents often put on competition outcomes at youth level. It is important that schools and clubs provide the late developers with an equal opportunity to train and develop within the sport, so that they do not get overlooked or excluded in the development of the larger pool of future athlete talent.

By this stage, children have developed clear ideas about the sports they like. Their enthusiasm and personal sense of success should be encouraged. The focus should be on playing at least 2-3 sports in different seasons through the year. Children should not focus only on one sport for an entire year. This is also an important time to start to work on training mobility, endurance and strength mainly through the use of specific games, relays, and own-body weight exercises as opposed to more formalised physical training, although for the more physically and technically developed children early strength training can begin to be implemented.

Key considerations during the learn to train stage include:

- Training should provide positive experiences with a deal of enjoyment and fun which should be informal and without regimentation.
- Agility, balance, co-ordination, speed and general strength & stability should be trained through simple bodyweight exercises (movement education, basic gymnastics), games and relays.
- Early speed and agility windows are available for female's 6-8years and males 7-9 years old.
- Develop running, jumping, throwing, catching, passing and kicking skills
- Training intensity & volumes should be kept relatively low to avoid growth related overuse injuries.
- Young athletes must be carefully monitored throughout this period to detect early changes in growth and maturation.

Train to Train Stage

During the train to train stage (females 11-15, males 12-16), young athletes need to build an aerobic base and consolidate their sport- specific skills. Towards the end of the stage, they need to focus on both strength development and the anaerobic alactic energy system. Increased training hours are needed at this stage to develop each athlete's long-term potential. The ages that define the train to train stage are based on the approximate onset and end of the adolescent growth spurt. This period is generally defined as ages 11 to 15 years for females and 12 to 16 years for males. At this stage, athletes are ready to consolidate their basic sport-specific skills and tactics. It is also a major fitness development stage and it is suggested that the train to train stage makes or breaks the developing athlete. Youth athletes may exhibit special talent and want to play to win and to do their best, but they still need to allocate more time to training skills and physical capacities than competing in formal settings. To maximise their long-term potential, winning should remain a secondary emphasis. This approach is critical to the long-term development of top performers and lifelong participants by ensuring their programme is following the correct training-to-competition ratio, along with other guidelines that describe training design and competition objectives at each LTAD stage, coaches should also refer the sport-specific LTAD plan from their sport's national organisation.

It must be considered that during the train to train stage of LTAD, physical changes take place faster in the athlete than at younger ages. Training programmes need to be designed to account for these rapid changes and the various advantages and disadvantages that they create for the athlete's development. Therefore, young athletes must be constantly monitored in order to understand how their growth and maturation is affecting their training and vice versa. During the train to train stage, athletes are entering their growth spurt and passing through puberty. As they do so, their growth can be measured and plotted to calculate the time when they reach peak height velocity (PHV). PHV is an important marker for determining which physical capacities can be trained effectively and safely during this stage. For example, aerobic training should be a priority after reaching PHV.

During the growth spurt, especially if the growth spurt happens quickly, athlete skills and movement abilities may be significantly impeded. Coaches may need to explain to the athletes why their motor skills and movement abilities have been negatively affected, so the athletes can understand that this is a natural event that will pass with time. The training programme should include both flexibility and mobility training to accommodate the rapid growth of bones, tendons, ligaments, and muscles. It should also address the sensitive periods of accelerated adaptation to strength training. For boys, the sensitive period for strength begins 12 to 18 months after PHV.

For girls, the sensitive period begins with whichever of the following occurs first in the individual: menarche or the onset of Peak Weight Velocity (PWV). Some girls will experience PWV prior to menarche, while others will experience menarche prior to PWV. Both aerobic and strength trainability are dependent on the maturation of the athlete. For this reason, the timing of training emphasis may differ between athletes depending on whether they are early, average, or late developers.

Athletes also need to learn to cope with the physical and mental challenges of competition during this stage. Optimal training and competition ratios follow a 60:40 percent training to competition ratio as still too much competition wastes valuable training time; too little competition reduces the practical application and development of technique, tactics, and decision-making skills under realistic competition conditions. Table 40 illustrates the physical changes that occur during this stage and the training considerations that should be applied to maximise the adaptations, whilst minimising the risk of injury.

Table 40

Growth & Maturation	Training
Significant proportional changes occur in bone, muscle and fat tissue.	Monitor training carefully and individualise the content of training to ensure adaptation whilst minimising the risk of overuse injuries such as fractures and growth plate injuries.
Girls begin their growth spurt between 11-14 years, boys between 12-15 years. Girls achieve a maximum rate of grow that an average age of 11, boys at an average of 14 years.	Early in this phase girls maybe faster and stronger than boys; later in the phase boys begin to get the upper hand in these qualities. Chronological age may not be the most appropriate way to group young athletes.
Smaller muscle groups are becoming more developed. Speed, agility and coordination are still improving rapidly at this stage.	With the improvement of fine motor movement all basic technical skills should be mastered. Athletes must learn how to train during this period including physical, technical, tactical and ancillary capacities.
A significant increase in red blood cells occurs during this stage, especially in boys due testosterone. The oxygen transport system is still developing and aerobic endurance continues to increase.	The increase in body mass requires more structured aerobic training. Only short duration of anaerobic activities are recommended.

Key considerations during the train to train stage include:

- A long training period (6-9 months) and short competition period (2-3months) is recommended during this stage.
- A greater emphasis on sport specific skills, although should still be fun and enjoyable. Also team sport position specific skills are introduced without specialisation.
- Skill trainability gradually declines after 11 and 12 years of age. It is suggested that the female window is between 8 – 11 years old and the male window is between 9 – 12 years old.
- During this stage there is a second window for speed & agility development.
- There should be a greater emphasis on strength and endurance training during this stage, especially after PHV has been achieved.
- Emphasis should be on learning how to train, on the process, not on the outcome.
- A sound screening of the athlete can now take place to ensure accuracy in exercise selection.
- During training competitive situations in the form of practice matches or competitive games and drills should be included.
- A key reason why many athletes hit a plateau during later stages of their development has to do with too much competition and not enough training during this stage.
- Competition is most valuable when it is used to develop strategic and tactical understanding. The focus must be on the learning process and not the outcome.

Train to Compete Stage

During the train to compete stage (females 15-21, males 16-23), athletes will focus on one sport in which they will train to excel. Athletes will train to re-enforce their sport-specific and position-specific skills as well as all of their physical qualities. During the train to compete stage of LTAD, this is where the competition often becomes serious. Athletes enter this stage if they have chosen to specialise in one sport and excel at the highest level of competition possible and therefore need to commit to highvolume and high-intensity training throughout the year. Nutrition, sport psychology, recovery and regeneration, injury prevention, and injury management also become an important component of the athletes programme. Competition becomes more prominent in the annual training plan. Train to compete athletes are generally not the average community sport programme participant; they are committed athletes with recognised talent who have chosen an elite pathway which requires huge amounts of dedication and training. The training to compete stage should aim to maximise all of the physical, mental, cognitive, and emotional capacities of the athlete. It also teaches the athlete how to handle the distractions of elite sport, such as travel, weather, different competition venues, media, spectators, and difficult opponents. Winning becomes a major focus during train to compete. However, coaches should help their athletes to select specific competitions that support strategic athlete development. The learning and development that occurs during these competitive events will prepare athletes for the next stage in their sporting progress, train to win. From a training perspective the athletes training potential is huge during this period, therefore an appropriate periodised annual training programme should be implemented in order to develop the appropriate fitness qualities throughout the year in order to optimise athletic development. Table 40 identifies the main physiological adaptations the athlete will go through during this stage and how to optimise their training around these adaptation.

Table 41

Growth & Maturation	Training
The circulatory and respiratory systems reach maturity. These systems are generally able to deliver maximum output.	Aerobic and anaerobic systems can be trained for maximum output. Full sports specific energy system training can be implemented.
Muscles have grown to their mature size but muscular strength continues to increase reaching its peak in the late twenties.	Strength training can be maximised to improve overall strength development. Neuromuscular training should be optimised during this stage.
Skeletal maturation continues in males and females. Connective tissues are still strengthening.	Progressive overload in training should be continued.
By age 17 girls have generally reached adult proportions whereas boys may reach these proportions several years later.	Aerobic training for girls should be optimised. Coaches must be aware of how to deal with weight gain and the personal and social effects. Athletes must learn how to compete under differing circumstances

Key considerations during the train to compete stage include:

- Provide year-round, high intensity, individual event and position-specific training.
- Have the athletes perform their skills under a variety of competitive conditions during training.
- Place special emphasis on optimum preparation by modelling high-level competition in training.
- Continue to tailor and refine individual training programmes, recovery strategies, psychological preparation, and technical development.
- Emphasise individual preparation that addresses each athlete's individual strengths and weaknesses.
- Athletes must strive to deliver consistent high performance results in both training and competition.
- Coaches should consistently use Periodisation plans as the optimal framework of preparation according on the Periodisation recommendations of their sport's LTAD plan.
- Coaches and athletes must plan for tapering and peaking for competition, to accommodate the large increase in training volume.
- Tapering means reducing both intensity and volume in training as athletes approach the date of major competition events. Tapering allows athletes to peak for major competitions, ensuring that they will perform at their best.

Train to Win Stage

This is the final stage of athletic preparation. All of the athlete's physical, technical, tactical and mental capacities are now fully established and the focus of the training should be shifted to the optimisation of performance whereby the athlete(s) is trained to peak for major competitions. Training is characterised by high intensity and relatively high volume. Frequent unloads should be planned into the training programme to help to prevent physical and mental burnouts. Training and competition-specific training/ competition ratios are 25:75. By the time the athlete reaches this stage of their development they will be considered an intermediate to advanced athlete and therefore their training programme should replicate this and therefore a more advanced Periodisation model may be required to continue their physical development. Table 42 illustrates both the physiological and training considerations during the train to win stage.

Table 42

Growth & Maturation	Training
Both males and females skeletal system should be fully developed.	Athlete can handle greater increases in training volume especially in weight bearing activities.
Both aerobic and anaerobic energy systems fully developed.	Supplementary anaerobic conditioning can be integrated (Speed End. & RSA).
Skeletal muscle mass should be at its peak due to increase hormone production especially testosterone in males.	Athlete can manage greater volume and loads in regards to resistance / strength training.
Should be physically and emotionally mature to handle the pressure of competition.	Training should be sports specific and replicate both the physical and emotional demands of the sport.

Key considerations during the train to win stage include:

- Towards competition specific training must be tempered with a commitment towards long term development.
- During this stage training approaches consistently high intensity and specificity all year round.
- Strength is developed through the more advanced external loading strategies (undulating) and more complex exercises.
- Training the lactic energy system should be maintained.
- More emphasis on sports specific and individual specific work.
- Simulation of all competition conditions including competition specific training can slowly be introduced over several years and tapering techniques become more advanced.

Youth Periodisation

When it comes to designing the long-term Periodisation model for youth athletes the following model (Fig 30) can be used to provide a framework for the coach to work within. This model splits the programme into four separate phases; initiation (6-10 years old), Athletic formation (11-14 years old), specialisation (15-20 years old) and High performance (20+ years old). The training programme begins a lot more general in nature with a lower training volume (2-6 hours per week) as the athlete works through the phases training becomes more specific to the demands of the sport and training volume gradually increases across the phases as the athletes tolerance to training load increases. This model should only be used as a guideline as it doesn't allow for individual differences such as gender, biological age, sport etc.… and the training intensity and emphasis should be specific to the stage of development that the athlete is in.

Fig 30. Periodisation of the youth athlete

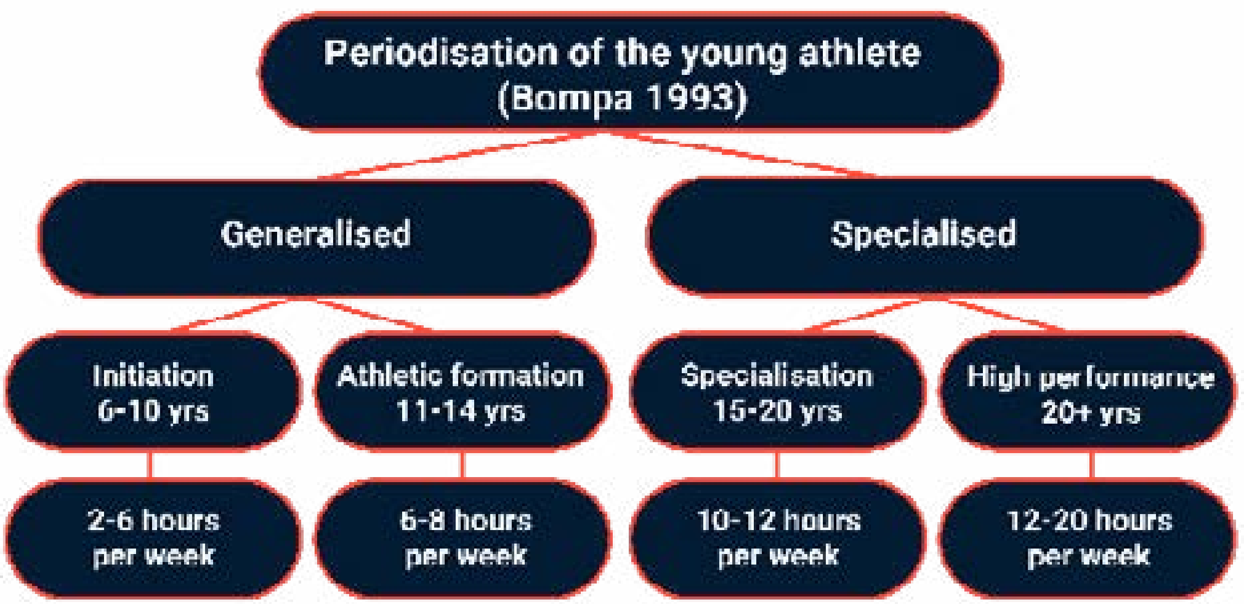
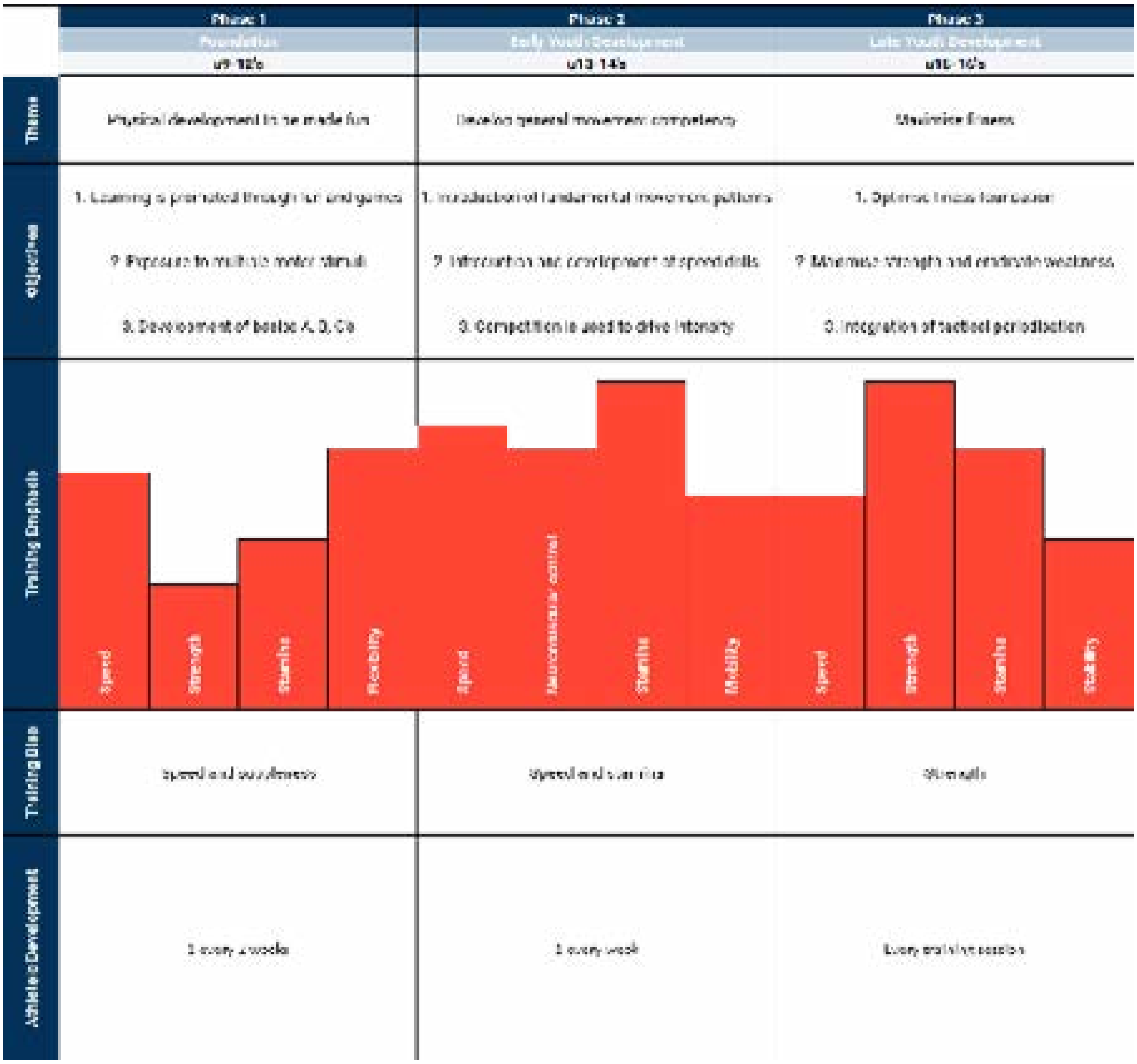


Fig 31. Below illustrates the different training emphasis, frequency and volumes of during different stages of the LTAD model from a professional football academy. This model is broken into the foundation (phase 1), early youth development (phase 2) and late youth development. During phase 1 the main training emphasis is on speed and suppleness whereas in phase 2 the main training emphasis is on speed and stamina (endurance) and in phase 3 the main training emphasis is on strength development. There is also an increase in the number of strength and conditioning training sessions per week that the athletes are exposed to throughout the programme as they develop.

Fig 31. Example LTAD model from a professional football academy



Training emphasis and progressions should be based upon both the physical development and the competency of the individual athlete. Although the traditional LTAD model categorises training structure and outcomes into age specific groups, consideration should also be given to individual differences within a group. For example athletes that are early developers and competent movers should be progressed to further challenge them in order to maximise their development. In contrast late developers or young athletes with poor movement competency should be halted or regressed in order to ensure that they are not progressing to more complex tasks before they are ready to do so. Athletes need to earn the right to progress by demonstrating that they are competent during each training phase.

Fig 32. LTAD training progressions

As illustrated all athletes should begin by developing basic movement skills with specific emphasis on co-ordination and balance whilst also starting to develop suppleness and flexibility. Once athletes possess good movement literacy and mobility the training emphasis should then focus on strength and energy system development.

Chronological vs. Biological Age

It is apparent that physical transformation happens at different rates in different children. Any coach who works with young athletes knows the large and sometimes unbelievable differences between two youth athletes of the same age. The chronological age refers to the child's actual age based upon their date of birth whereas the biological age refers to their physical maturation age. Ideally young athletes should progressed through the LTAD programme based upon their biological age as opposed to their chronological age. A child's biological age can be determined through measuring peak height velocity (PHV). PHV is the time in a child's life in which they attain the most rapid height growth and tends to coincide with sexual maturation and rapid changes in bone structure. In girls, this typically happens at around twelve years of age, and in boys at age fourteen, although it can occur more than a year before or after these estimates. PHV is calculated by regularly taking height (sitting & standing) and weight measurements and then using a regression equation (http://www.pponline.co.uk/phv-calculator) to predict when an athlete will reach PHV. This information can be important to identify when young athletes will reach their window of opportunity for different training components.

It is apparent from this predicted model that females normally reach PHV before males. Before, during, and after PHV there appears to be certain periods in time in which young athletes are more sensitive to particular types of training (e.g. strength, speed, and hypertrophy). These time periods are often referred to as "windows of opportunity", which also implies that these opportunities can be missed if the appropriate training stimulus is not applied and therefore athletes may miss a vital opportunity to maximise their athletic potential. It is also believed that there is a ceiling for athletic potential, and if these windows are missed, then that ceiling may be lower than if they were to train throughout that time. In contrast it is believed that athletes who exploit these “windows of opportunity” have a higher ceiling for their athletic potential than those who do not. This has led to the development of the term “periods of accelerated adaptation”, which are simply time periods of opportunity for athletes’ to make greater improvements in athleticism than otherwise possible. These periods of accelerated adaptation have many implications for training programme design, including: training content, intensity, volume, frequency, Periodisation, coaching style, and training group segregation. Therefore, it is believed that by calculating a child’s onset of PHV it can enable the coaches to tailor the training programme in relation to the athlete’s biological age as opposed to their chronological age in order to develop a better suited and more effective training programme. It is suggested that preadolescents benefit more from training methods which require higher levels of neural activation (sprint training and Plyometrics), whereas adolescents responded better to training types which target both neural and structural development (strength training and Plyometrics). It is also well known that adolescents respond more favourably to hypertrophy training than preadolescents due to the higher concentrations of certain hormones such as testosterone and growth hormone. Also, during the onset of the adolescent growth spurt, boys typically experience greater maturational improvements in all aspect of fitness than girls (e.g. strength and power), except for flexibility.

Key messages:

- Children and adolescents are not little adults and therefore should not be trained like them.
- Closely monitor for rapid changes in growth and maturation (PHV).
- Avoid early specialisation.
- Develop good general and all round movement competencies.
- Respect and adhere to training the correct components of fitness during the specific phases of growth and development.
- Ensure that training is fun and enjoyable with specific aims and objectives.
- Have a well-planned and designed approach for each development stage

Further reading

- http://www.pgedf.ufpr.br/Referencias08/Peak%20high%20velocity2006%20RO.pdf
- http://www.oxspa.co.uk/uploads/long-term-athlete-development-article.pdf

Recovery & Regeneration

Recovery from exercise and training is a vital component of the athletes overall training programmes, and is critical for performance and continued improvement. If the rate of recovery is appropriate, higher training volumes and intensities are possible without the detrimental effects of overtraining. Therefore, an understanding of the physiological concept of recovery is essential for designing effective training programmes. Individual variability exists within the recovery process due to training status (trained vs. untrained), factors of fatigue and an athlete's ability to deal with physical, emotional and psychological stressors. The process by which an athlete recovers from a training session or competition is known as supercompensation. Supercompensation is the time frame in which the athlete's body recovers and adapts to the stimulus that has been applied. The timeframe of this super compensation will be dependent upon a number of factors such as the volume and intensity of the training session as well as the training age and lifestyle factors of the athlete. The aim of implementing recovery strategies is both to reduce the time of the super compensation to occur, in order that more frequent training or competition can be scheduled. It is also to ensure that the athlete fully compensates and adapts (improves) to the training stress that has been applied. If inadequate recovery takes place over an extended period of time the athletes fatigue levels will accumulate and they will be at risk of overtraining which can result in both underperformance and injury.

Overtraining

Overtraining, in its early forms is often unrecognisable as a medical condition as no symptoms may appear. The only signs may be slight decreases in performance, injuries that never seem to heal, or a cold that won't go away. It's the accumulation of all the stress of work and training that contribute to these factors. The body goes through three stages of stress adaptation:

- **Stress Adaptation Stage 1** - Diagnosing the early stages of overtraining can be difficult. Things may appear as slight back pain in a cyclist, a touch of ankle or foot problems in a runner, or as shoulder pain in a lifter. Usually during this time blood tests will still come back showing normal ranges, which can lead to further frustration as injuries continue or performances start to decline further. It is important to be aware when athletes start reporting feeling a little run down that this may be down to overtraining. During the first stage of overtraining big gains in performance can be made afterwards if used correctly. Commonly this is referred to as overreaching, and it is not uncommon for athletes to deliberately be pushed into the red zone so that after an appropriate recovery period they have adapted better and return faster and stronger. The problem here lies in the excitement of heightened performance. The athlete and coach usually pushing more and more until the athlete burns out and often breaks down with injury.

- **Stress Adaptation Stage 2** – During this stage the athlete's metabolism and therefore fat burning reduces and increases in fat storage can occur. This stage is most often seen by athletes who perform high volumes of anaerobic or strength work, particularly those who have high lifestyle stress. Conversely, a feeling of increased energy will be felt as the adrenal system kicks into high gear to cope with the extra demands. This will be shown in a restless, over excited state and a feeling of not needing any sleep and of being able to train harder. The resulting high cortisol levels can lead to increased insulin the carbs being stored as fat, not as potential energy, further increasing the problem. Although even during this stage the entire downward spiral can still be reversed through changing diet and training and implementing appropriate recovery strategies.

- **Stress Adaptation Stage 3** - Chronic overtraining can lead to serious brain, muscle, and metabolic imbalances as well as chronic adrenal dysfunction and aerobic deficiency. Eventually the athlete becomes exhausted and many hormones are significantly reduced. The most notable side effect of stage three is severe exhaustion. Performance at this stage is likely at an all-time low and many athletes give up at this point. Athletes in this third stage can become seriously unwell, with high risk of developing chronic diseases of the heart, blood vessels, and other areas. The body has an intricate system of checks and balances in place to help manage stress. The adrenal glands prepare the muscles for physical activity, thyroxine is secreted by the thyroid gland, which increases the rate at which cells burn glucose for energy. Growth hormone is produced by the pituitary gland and plays an essential role in the elevation of blood glucose. Insulin, secreted by the pancreas, is concerned with glucose metabolism. With so many systems interdependent on one another for proper function, one small change to any of them can create massive problems for an athlete.

The systems of the body are affected differently by overtraining and these will manifest themselves in different ways dependent upon the type of training and main systems affected. These systems include the adrenal system (hormones), metabolic systems, nervous system or psychological in nature. Table 43 provides an example of the signs and symptoms of fatigue within these system.

Table 43

System	Signs and Symptoms
Adrenal	• Increase cortisol levels • Higher levels of CK • Reduced testosterone levels • Reduced GH levels • Compromised immune function
Metabolic	• Exercise outstrips the rate of ATP replacement. • Accumulation of metabolic byproducts (H+, and lactate) • Glycogen depletion within the muscles. • Interference with actin-myosin interaction (cross bridging).
Neural	Central and peripheral • Inhibition of neurotransmitters • Reduced motor unit recruitment • Reduced firing rate • Reduced muscle function • Reduction in force production
Psychological	• Anxiety • Stress • Low confidence / self esteem • Social inhibition • Can impact upon physiological fatigue

Although overtraining is considered to be as a result of too much training intensity and / or volume it is also exacerbated by under recovering through inadequate nutritional intake or poor sleep patterns as these two factors are essential for optimising recovery from training and competition and are often referred to as macro strategies. There are also a number of smaller less impactful recovery systems that can be used in order to help accelerate the recovery process in order to enhance the training effect such as massage, cryotherapy, compression, electro muscle stimulation and active recovery training. These are often referred to as micro strategies.

Macro Strategies

- **Sleep** - Getting enough quality and quantity of sleep is at the top of the list for athlete recovery strategies. Minimal sleep (six hours or less) for four days has been shown to affect cognitive (thinking) function and mood. All sport requires the ability to process information very quickly and react; athletes also need to have high levels of focus and motivation. These functions will be impaired without adequate sleep. Minimal sleep can also decrease glucose metabolism which fuels the brain and the body for mental and physical performance. Immune function can also be impaired which puts athletes at a greater risk for sickness. If an athlete's sleep is inhibited speed, power and endurance capacities can all decrease. When an athlete fails to sleep enough (less than 8 hours per night), the body fails to produce the adequate amount of testosterone. Testosterone is responsible for building muscle and gaining a training effect from training. This gain in muscle, also known as the training effect, is decreased without the testosterone to recover from intense physical activity. Physical stress decreases the body's ability to recover, especially as an athlete. For every two hours of time an athlete spends awake and stressed, it takes one hour of sleep to recover. This means that if an athlete is awake and under stress 16 hours a day, at least 8 hours of sleep are required for the CNS to recover from the overload. It is essential that the athlete gets adequate sleep in order to optimise recovery between sessions. If the athlete is regularly lacking in sleep their performance levels will quickly diminish and signs of fatigue will be apparent.

- **Nutrition** - Recovery nutrition involves the athlete consuming the adequate amount of carbohydrates, proteins, fluids, and an electrolyte to ensure the body is refuelled, re-hydrated, and has the nutrients necessary to support repair and rebuild muscle tissue. It's not a one-size fits-all solution, the amount and ratio of nutrients varies with the athlete, and recommendations should take into consideration age, gender, body size, physical condition, duration, nature of events. Although it's essential to consider all these variables, there are simple guidelines that you can be applied to the athletes training and competition in order to optimise recovery. The three essential requirements for successful short-term recovery are: resynthesise of the body's carbohydrate stores, rehydration and rest. Carbohydrates provide the muscles with the fuel needed to perform. The body stores carbohydrates as glycogen to be used during activity. Glycogen recovery is most important for those athletes, who are training multiple times per day, have back-to-back events, and for those athletes who may not be getting the carbohydrates they need throughout the day. An athlete who is glycogen deficient will show early signs of fatigue. Ensuring adequate protein intake helps the athlete recover following training sessions and competition by aiding the synthesis of muscle protein, a key process for building muscle. Rehydration is also essential when it comes to optimising recovery post training or competition. Fluids consumed should also contain electrolytes (sodium and potassium) as these are lost through sweat during exercise.

Micro Strategies

- **Cryotherapy –** Cold therapy is a common strategy used by athletes to help them recover quicker from intense training sessions or competition, commonly in the form of ice baths although more recently cryotherapy chambers have become more readily available to athletes. Cryotherapy works by constricting the blood vessels and decreasing metabolic activity, which reduces swelling and tissue breakdown. Once the athlete is no longer in contact with the cold source, the underlying tissues warm up, causing a return of faster blood flow, which helps return the by-products of cellular breakdown to the lymph system for efficient recycling by the body. It is believed that cryotherapy suppresses inflammation, and helps to flush harmful metabolic debris out of the muscles. There is mixed research regarding the physiological benefits of cryotherapy, although there is much anecdotal evidence from athletes who testify that cryotherapy makes them feel better recovered following intensive exercise.

- **Massage –** Soft tissue treatment can be an important part of the recovery process for many athletes. Massage is used to speed recovery following heavy single workouts, competitions, or during high-intensity cycles. Massage can also play a part in the prevention of injury, especially those that might arise due to overuse and overload. The physical effects of massage therapy can greatly improve an athlete's health and lifestyle by alleviating pain and reducing potential for injury. The main effect of sports massage therapy is to increase the health of the athlete's internal tissues by improving circulation of blood and nutrients, while simultaneously removing toxins. Deep massages help to regulate the pores in the fibrous tissues, which increases permeability. This allows for more fluids and nutrients to flow through the tissue. Waste products are removed and new oxygen and nutrients are supplied. During massage stretching of the tissues during a massage helps muscle fibre's release tension and pressure build up. Massage works in the recovery process by increasing circulation, removing waste products, stretching and re-aligning the muscle fibres and also helping the athlete relax, which can further help to increase sleep quality.

- **Active recovery** – low intensity exercise or training can be prescribed following an intensive training session to enhance recovery and reduce muscle soreness. Low intensity training increases the circulation and blood flow around the body which helps to provide the muscles with oxygen and nutrients that they require as well as assisting with the removal of waste produces. Specific exercises can also be used to help re-align the muscle fibres to reduce stiffness and increase joint ROM. It is believed that an active recovery session is more beneficial than total rest in enhancing recovery time. A typical recovery session would consist of some low intensity aerobic exercise (swimming, cycling, jogging etc..) followed by some mobility and flexibility exercises.

- **Electro muscle stimulation** – EMS devices work by transmitting an electrical current to the muscles which causes them to contract and relax, in turn acting as a pump that can increase blood flow around the body and more specifically within the muscles. Similarly to active recovery this increased blood flow brings a fresh supply of oxygen and nutrients that the muscle needs to repair and recover. The benefit with this type of system compared to active recovery is that it allows the athlete to offload therefore further reducing any other stress that may occur during low intensity exercise. Although the research is still limited in regards to the effectiveness of these systems.

- **Compression** –It is claimed that compression socks and tights can help to increase oxygen delivery, decrease lactic acid, prevent cramps, and minimise muscle fatigue, which in turns helps promote recovery following a training session. The use of compression garments in athletes stemmed from the usage in hospitals on patients following an operation in order to promote circulation and minimise the risk of blood pooling and the development of clots. Although there is limited research on the effect on recovery for athletes, but these still remain a popular modality for athletes.

In order for the athlete to improve and develop physically they must be exposed to a training stress or load which subsequently resultsin a certain amount of fatigue. To recover from this fatigue the athlete must have the appropriate recovery strategies in place to promote the physiological processes that are responsible for appropriate adaptation. The fundamental strategies that must be in place throughout the athletes training programme include nutrition and sleep. If either of these are compromised then the athlete's recovery will be inhibited and their training and performance will be negatively affected.

In regards the micro strategies these should be used selectively during periods when the athlete is going through heavy training sessions or days and should not make up part of their daily routine as they will become less effective if they are used on a regularly basis. Consideration should also be given as to whether it is necessary to accelerate the athlete's recovery or whether it is more important to let them recover and adapt naturally, for example during the off season and pre-season periods. The overall aim of recovery and regeneration is to promote the following:

- Minimise muscle damage and breakdown.
- Enhance protein synthesis and muscle repair.
- Replenishment of muscle and liver glycogen stores.
- Restoration & Regeneration of the CNS.
- Enable immune function to return to normal levels.
- Promote mental relaxation.
- Removal of waste and by products.
- Minimise oxidative damage at a cellular level.
- Increase testosterone to cortisol ratios.

Brilliant Coach - Brilliant Business

It could be suggested that many practitioners have a great level of knowledge, but struggle to convert such knowledge into business success. Therefore, an external observer's evaluation of this maybe 'Why are you watching trainers who are nowhere near as good as you taking all the credit and making all the money? A solution to such lack of business development is simple – develop your business knowledge, and therefore progress the success of your business. The purpose of this module and corresponding video tutorial is to provide strength and conditioning coaches with a clear business model. Thus, allowing knowledgeable and experienced practitioners the opportunity to develop a successful business.

6 Steps to Success

As a systematic guide to help strength and conditioning coaches develop brilliant business, strength and conditioning education have developed the following '6 steps to success' development model:

1. Become a great coach - An obvious first place to concentrate on when developing a strength and conditioning business is the practitioners actual level of coaching ability. It's vital as coaches that we firstly evaluate our practice, and identify what areas need improvement. A great formula to help guide practitioners through such an evaluation process is as follows:

K x A + E = S

This success formula states: Knowledge x Action + Experience = Success

Knowledge – As strength and conditioning practitioners, a key responsibility on behalf of practitioners is a solid foundation of strength and conditioning knowledge, including knowledge on all training modes, periodisation templates, program design, resistance progressions, effective coaching, etc. However, other key areas within strength and conditioning practice may require extra development including: excel knowledge, marketing and social media advertising knowledge, networking, etc.

Action - Therefore, as strength and conditioning coaches, its vital that such areas of needed development are firstly identified via a self-evaluation process, then addressed with set action plan to develop any needed areas for improvement.

Experience – Reflecting on gained experiences as strength and conditioning practitioners is a process of great importance, as it allows coaches to learn from such experiences through an evaluation process, and therefore, constantly improve as practitioners.

The correct application of each of these phases will result in a great level of success for practitioners. Therefore, it is essential that each phase is carried out correctly and honestly. Remember, as coaches – we never stop learning.

2. Find clarity – When developing a strength and conditioning business, its important practitioners self-reflect and ask:

Who I am I? – are you a personal trainer attempting to break into the strength and conditioning profession or an experienced practitioner who aims to create their own strength and conditioning consulting company?

What do I want? – would you like to work in elite sport? Would you like to work within a particular sport or any sport? Would you like to open your own facility, work with youth athletes within sporting academies?

Who do I want to work with? – identify who you would like to work with as a practitioner, and what networking strategy could I apply to get connected with these individuals?

How do I close the gap from where I am now, to where I want to be? – what action points need to be put in place to ensure these goals are met? Do you need to gain more knowledge, qualifications, experience, practice a certain training mode more, gain internship experience, etc.

What is the end point? – what is your final goal? What would measure as career success?

When attempting to find clarity as a practitioner, this set of questions provides a great framework to address all the required information necessary to become successful in your field:

Seven killer questions:

a. What is your definition of success?
b. What is your perfect day?
c. Who is your ideal client?
d. What are you doing to attract this ideal client?
e. What things are holding you back from achieving your success?
f. How can you overcome these challenges?
g. What can you do in the next 30 days to move forward?

3. Marketing – Build your marketing machine

A lack of knowledge in 'how to market yourself and your services/products is common amongst strength and conditioning practitioners. Many coaches have a great level of industry knowledge, but lack in self-promotional skills. Therefore, if marketing isn't an area of one's expertise, then knowledge must be gained in this vital area. This may involve building a catalogue of resources specifically about marketing (books, podcast, articles, video tutorials, etc.) or being honest with oneself, and employing somebody who specialises in this area. Remember – marketing is an investment – not a cost!

4. Authority – Build your authority (with integrity)

When attempting to build any strength and conditioning business, coaches must aim to establish themselves as an authority within their fields. However, it is essential that the building of such authority is done so with integrity. This requires that any work is referenced correctly, no plagiarism is committed, and one portrays themselves as a professional practitioner that is respectful of their peers. When attempting to build one's authority, rather than selecting a broad area of interest, coaches should choose a specific area of interest, and review/contribute towards this field. For example – certain industry respected practitioners are well established as being leading figures within their particular fields. Therefore, coaches should select a research area that is of particular interest, and build their authority around this subject.

5. Team – Build your team

When developing a strength and conditioning business, many individuals make the fatal mistake of attempting to do all areas of the business for themselves (e.g. marketing, sales, admin, etc.). Attempting such a variety of individual roles only leads to each set of objectives not being carried out effectively. A strength and conditioning coach's strengths is …. strength and conditioning! Therefore, practitioners need to be honest with themselves, and know when to admit that a particular area of business isn't a personal strength, and when to seek external assistance instead. Seeking such assistance isn't a sign of weakness, but rather an identification of good delegation, by employing individuals who specialise in the required areas.

What are your values, stick to them! – Whether practitioners are independent self-traders, or a CEO of a large strength and conditioning company, having a clear set of company values ensures all team members, including the athletes being coached, are all aware of what is expected. Such clarity ensures that all set values are adhered to by all those involved.

6. Re-evaluate, re-assess, and become great again

A key principle that all great practitioners understand, implement, and admire to, is that one never stops learning and that there is always an opportunity to improve. This process can be simplified into the three key areas that form the 'the three pillars of development':

1. Coach development
2. Personal development
3. Business development

This process of re-evaluation and reassessment is a continuous process, and allows strengths and areas for development to be highlighted, and future action plans to be put in place.

Course Round Up and Assessment Procedure

In this chapter, we will give you a brief overview of what you will cover and the assessment procedure. During your case study and on completion you will be expected to know and deliver the following:

Needs Analysis and Target Setting

- The different types of sport classification, the positional demands or event specifics and the associated physical quality requirements
- How the rules of the sport affect the demands placed on the athlete
- How to research, analyse and determine the unique attributes and demands of any sport or performance activity
- How to identify measurable physical qualities for the performance activity
- How physical/physiological requirements relate to specific performance factors
- The methodology associated with gathering information
- How to identify measurable physical qualities for the athlete
- How to create performance targets that are specific, measurable, achievable, realistic and time bound, and why this is important
- The methods of presenting agreed performance targets to the athlete and support team
- Which tools can be used to evaluate progression towards a target and why they need to be aligned with the previous evaluation status of the athlete
- How to revise performance targets in line with regular review processes
- The frequency of evaluating and reviewing performance necessary to support achievement of targets
- How to present performance targets in a clear format suitable for the athlete, technical coach and support team
- How to employ different methods of communication tailored for different audiences

Programme Design

- Why it is important to plan a structured and sequential strength and conditioning programme to support progression of performance
- Why it is important for the athlete and support team to understand and agree the programme
- The structure of the competitive cycle and performance goals set
- Common strategies for planning and systems of training
- The implications of the performance calendar on the planning of training
- The implications of the athlete's training and injury history on the planning of training

Evidence Informed Practice

- The role of evidence in underpinning the coaching process
- How to find and interpret evidence relating to training practice
- How to collect and interpret accurate and appropriate information/data
- How to access and interpret different forms of peer reviewed evidence
- The relative merits of different forms of evidence
- The information needed to be collected and included in an athlete's profile and/or that of athletes within a team
- The strengths and weaknesses of the various methods of collecting information for different types of athletes, to include but not limited to aspects of validity and reliability; importance of control during data collection; relative merits of testing, monitoring and predictive screening• appropriate formats for recording information
- How to organise information in a way which will help you to interpret and analyse it
- How to analyse and interpret collected information so that you can identify athlete performance targets
- How to analyse data to clearly demonstrate strengths and weaknesses based on testing results
- How to respond to information available from assessment of an athlete's status
- What constitutes meaningful change in performance on tests or in monitoring data
- The legal and ethical implications of collecting information about athletes including consent, storage and distribution

Effective communication and collaboration

- How to communicate effectively with the athlete, technical coach and support team
- How to communicate effectively to come to agreement on the interpretation of available evidence
- The importance of and how to communicate with athletes and/or teams as well as coaches and other support practitioners to elicit an effective and productive environment
- How to communicate effectively to foster agreement and engagement with the programme
- How to collaborate, and who with, to ensure appropriate information is provided from outside the strength and conditioning skill domain including but not limited to:
- Injury information and related screening from a physiotherapist
- Health information
- Why it is important to work together with the athlete, coaches and the wider support team to agree performance targets and activities
- The importance of sharing and agreeing roles and responsibilities of the athlete and wider support team
- Establish a rapport and agree and identify the roles and responsibilities with the athlete and support team.

Session delivery

- The aims, content and rationale of the of the training plan from which a session is drawn, including the knowledge base utilised to design the programme
- Why the manner of delivery is important to outcomes of the strength and conditioning programme
- The importance of and how to give effective explanations, demonstrations or instructions

- The importance of and how to evaluate understanding from the athlete
- How to foster development of a motivated athlete engaged in the strength and conditioning
- programme
- Accepted principles of coaching
- How to modify behaviour to support achievement of aims of the training unit
- How to manage delivery of training unit to minimise risk of injury
- Strategies for evaluating athlete status and readiness to train
- How to manage and maintain engagement of individuals and groups taking into account group dynamics, individual motivations and training partner/group selection
- Potential benefits offered by a warm-up
- Warm-up activities and structure to best capitalise on potential benefits
- Models of competent movement for training activities used in strength and conditioning
- Modifications to movement models based on aims/objectives of the training unit or limitations of the athlete
- How to observe and analyse existing competence of the athlete
- Skill acquisition principles and current evidence to support best practice in design and management of session activities with a view to skill development and learning. This includes but is not limited to;
- Organisation of practices
- Modification of constraints upon, and aims of, practices
- Delivery of feedback
- How to effectively observe, give feedback and evaluate progress when working with athletes and athletes within groups
- How to progress and regress exercises according to the needs of an athlete or athletes within a group
- Best practice guidelines and evidence relating to session management variables such as activity/ exercise selection and order, movement tempo, intensity, volume, work distribution/division and recovery periods
- Strategies for monitoring outcomes from training unit which might include but not be limited to; volume-load; rating of perceived exertion; heart rate; time
- How to effectively record session outcomes and modifications
- The potential benefits of session-end cool-down activities and prescription to best capitalise on potential benefits
- First aid attained through a recognised first-aid education provider
- How to evaluate and manage risk

Level 4 Strength & Conditioning Specialist – Assessment details

Case Study Assessment

A pass mark of 70% is required

- You are required to plan, deliver and evaluate a periodised strength and conditioning programme for an athlete of your choice.
- It may include one or more, but not all, of the following phases of training: preparation, first transition, competition or second transition (active rest).
- The periodised programme must cover an 8-week period.
- After eight weeks, you must undertake a critical review of the programme and make recommendations for the final four weeks.
- You will only deliver the first eight weeks.
- You will not deliver the final four weeks.

The following sections must be included, supported by the evidence-based research and referenced using the Harvard referencing system:

- A detailed sport analysis including position specific details (if appropriate)
- A detailed athlete analysis including, but not limited to, a performance profile, appropriate performance measures and results. You must also provide evidence that you have communicated and collaborated with a technical coach and/or members of the athlete's support team. These should be included within the appendices and must be referred to in the case study
- An evidence-based rationale for the periodised training programme
- An evidence-based rationale for the training methods prescribed
- A critical evaluation of the first eight weeks of training, including performance measures, and adaptations/modifications/recommendations for the final four weeks
- Session plans with notes should be included in the appendices and referred to as a part of the critical evaluation. You should consider the use of tables, charts, pictures and diagrams when relevant and ensure you label these appropriately.

Case Study Marking Criteria

Table 44

Criteria	100-90%	89-70%	69-60%	59-40%	<40%
Quality and depth of sport analysis, performance measures and performance profile (25%)	Exceptional and professional sport analysis, performance profile and performer analysis	Excellent sport analysis, performance profile and performer analysis	Thorough sport analysis, performance profile and performer analysis	Limited sport analysis, performance profile and performer analysis	Poor sport analysis, performance profile and performer analysis
Inclusion of appropriate and Harvard referenced conditioning research, and relevance of evidence-based periodised programme and training methods (25%)	Exceptional, professional and advanced interpretation of evidence-based research and excellent referencing throughout	An excellent and sustained use of evidence-based research, critical evaluation and referenced throughout	Thorough and consistent critical use of evidence-based research and referencing but inconsistencies	Limited and appropriate evidence-based research and referencing	Indequate evidence-based research and/or inaccurate referencing
Critical evaluation of an appropriate training programme and recommendations for next four weeks (25%)	Exceptional and professional analysis clearly expressed; excellent detail with extensive referencing to the training session notes	An excellent analysis and well referenced to the training session notes	Thorough critical analysis clearly expressed and referenced to the training session notes	Tendency to be vague and descriptive; minimal reference to the training session notes	Not addressed, no depth to the evaluation and limited
Quality, range, detail and appropriateness of sample session plans with notes (25%)	Professional and exceptional session plans with notes, all aspects included in detail; an excellent range	Excellent and detailed session plans with notes; extensive range	Very good quality and range of session plans with notes, all areas included	Limited and lacking sufficient depth of information	Poor quality, inappropriate and lacking detail

Practical Assessment

You are required to coach and evaluate an athlete in 1) an Olympic lift or variant of AND 2) a conditioning drill. Both will be drawn at random on the day of the assessment from the lists below. The conditioning drill ONLY must be tailored to one of the sports listed below that will also be drawn at random on the day. You will be provided with the relevant equipment.

You must clearly identify the specific aim of the Olympic lift and conditioning drill, this will inform your choice of repetition range, sets, tempo and any recovery times.

1. Olympic lifts (one from two)
- Snatch
- Clean

2. Conditioning drills (one from two)
- Agility drill
- Plyometric drill

3.Sport (one from two)
- Rugby Union
- Field Hockey

Practical Assessment Marking Criteria

Table 45

Criteria	Olympic Lift	Conditioning Drill
Introduction - yourself, the lift/ drill, the facility and relevant health and safety information	P / R	P / R
Coaching and demonstrations - gave technically detailed and appropriate demonstrations (when appropriate) and coaching points throughout, enhancing the client's performance	P / R	P / R
Progression and regression – gave technically detailed information to allow the athlete to progress and regress in a safe and effective manner	P / R	P / R
Observation and motivation – observed and motivated from a range of positions to ensure the athlete completed the task in a safe and effective manner	P / R	P / R
End the session – evaluated the session and provided the athlete with some technically detailed feedback relevant to their performance and allowed the athlete the opportunity to ask any questions	P / R	P / R

Overall result: PASS or **REFER** (please circle)

Feedback and/or action plan for the resit:

Theory Assessment

A pass mark of 70% is required

The Level 4 Strength and Conditioning theory assessment consists of 30 multiple choice questions and two short answer questions from the information contained below:

You will be required to sit a supervised exam under exam conditions.

Fundamental aspects of sport science...

- Physiology
- Biomechanics
- Psychology
- Injursy epidemiology

Below are a few exam question examples that you will be questioned on:

1. Which one of the following statements best describes “athlete training status”?

A. The athletes current level of preparedness for training
B. A decrease in available time to spend in the conditioning centre
C. An analysis of the athlete’s performance measures
D. The summary of the functional movement analysis results
E. Consideration of the demands of the sport and position

2. Hans Selye’s proposed model regarding the body’s response to stress, the General Adaptation Syndrome (GAS), is best described by which one of the following statements?

A. Alarm, resistance, compliance and exhaustion
B. Alarm, resistance and exhaustion
C. Compliance, resistance and recovery
D. Resistance, acceptance, exhaustion and recovery
E. Exhaustion, resistance and recovery

3. Which one of the following statements best describes non-linear or undulating periodisation?

A. The linear structuring and training of individual physical characteristics within the peaking phase of training
B. The large manipulation of volume and load on a daily basis, often within a microcycle
C. The organisation of training blocks according to an athlete’s physiological responses measured on a session by session basis
D. The manipulation of volume based upon the athlete’s verbal feedback
E. None of the above

Meet the Authors

Brendan Chaplin

Founder and CEO

Brendan is a performance enhancement specialist and Strength and Conditioning Coach who has worked with a wide variety of athletic populations including professional athletes, Olympians, aspiring athletes and everything in between! He is the founder and managing director for Strength and Conditioning Education, the UK's #1 provider of education, resources and mentoring for strength and conditioning professionals.

Outside of his education role Brendan is a sought-after consultant, coach educator, and speaker. He works with a number of governing bodies and performance athletes including golfers, champion mixed martial artists, cyclists, snowboarders, and many others.

Previous to his current role he has worked for Leeds Beckett University, Huddersfield Giants Rugby League, British Tennis, and the English Institute of Sport, Durham University and many other organisations and teams as a coach, coach educator and consultant.

As the founder of Strength and Conditioning Education Brendan designs qualifications and courses for fitness professionals which are recognised by number of governing bodies and institutions as the standard in coaching and technical knowledge. Academically he has master's degree in Strength and Conditioning, and is accredited through the UKSCA and the NSCA.

Lawrence Bloom

Strength and Conditioning Coach

Laurence Bloom a certified Strength and Conditioning Coach specialising in the physical and athletic development of elite football players.

Laurence was head of Sports Science at Charlton Athletic Football Club, a position held for over 3 years. Primary role within the club is to deliver both general (gym) and sports specific (field) strength and conditioning programmes in order to optimise the players' physical performance levels. Prior to this worked within a similar role at South end United Football Club for 6 years, also overseeing the physical development of the academy players.

Laurence has worked part time as a sports science tutor and provided strength and conditioning services to a number of teams and individual athletes from a range of sports including; rugby, hockey, tennis, athletics, boxing and MMA.

Graduated in 2004 from Middlesex University with a degree in Sports Rehabilitation & Injury Prevention. Since then he has completed an MSc in Strength & Conditioning from Salford University and gained a number of professional qualifications, including; UKSCA, NSCA (CSCS), BWLA tutor award & the FA Fitness Trainers Award.

ELITE COACH NETWORK

As part of your enrolment onto the course, you have 12 months free membership to our Elite Coach Network, more affectionately known as the ECN! The ECN includes hours of Strength and Conditioning presentations and previous 'live' business coaching and mentoring from our founder, Brendan Chaplin and Lead Mentor, Ste Gordon. It also includes access to our thriving and supportive coaches' community! You should have received an email with a link to join the ECN Facebook group, however the link is below for you too.

Join this group and benefit from a thriving and supportive coaches' community ready to help you, drive you and support your journey. Why not reach out in the group and introduce yourself today! Share your reasons for joining the course and what you want to get out of it and reach out to the group with any questions you have! The community and our coaches are always on hand to respond and support how they can, it really is an extremely valuable tool for your studies, development, and your business!

JOIN THE ECN FACEBOOK GROUP