SECTION 4.

PLANNING AN EFFECTIVE STRENGTH AND CONDITIONING PROGRAMME

CONTENTS

4.1 INTRODUCTION

The aim of the S&C Trainer qualification is to enable you to become competent in designing a 12-week programme and individual sessions that will effectively satisfy the required training adaptations and satisfy the objectives set in the goal-setting process. Within a single session there may be a number of discrete training factors included (see Table 1). These are distinct blocks of time (typically 15–30 minutes) allocated to targeting a specific training adaptation within the session (eg, warm-up, maximum strength, stretch shortening cycle ability). Units are logically sequenced and constructed within the session to make sure training is optimised throughout the session.

DOMINANT/PRIMARY TRAINING EMPHASIS	COMPATIBLE TRAINING FACTORS
Aerobic endurance	Strength endurance training Maximal strength training Anaerobic endurance training Technical and tactical training (if done first)
Anaerobic endurance	Strength endurance training Aerobic-anaerobic mixed endurance training Sprint/change of direction training Strength training Technical and tactical training (if done first)
Sprint ability	Maximum strength training Plyometric training Rate of force development (RFD) training Change of direction training Technical and tactical training (if done first)
Maximum strength	Sprint training Change of direction training RFD training Anaerobic endurance training Technical and tactical training (if done first)
Rate of force development	Sprint training Change of direction training Maximal strength training Plyometric training Technical and tactical training (if done first)
Technical training	Any emphasis as long as it is performed after the technical work (often done in a state of fatigue in team sports to mimic game exposure)
Tactical training	Any emphasis as long as it is performed after the tactical work (often done in a state of fatigue in team sports to mimic game exposure)

Table 1. Compatible training factors

The S&C Trainer should also be able to logically sequence the session within a training day and across the microcycle, mesocycle and 12-week programme (see Table 2), but competency in planning over longer periods should be further developed as the S&C Trainer progresses towards full accreditation as a UKSCA Accredited S&C Coach. In practice, in higher level sports teams and environments, the S&C Trainer is likely either to be working alongside fully UKSCA Accredited S&C Coaches, or being supervised directly by one through their role as an intern or assistant coach. The S&C Trainer is encouraged to seek guidance with an accredited mentor/coach regarding the individual session objectives to make sure that they fit with the level of athlete and the position within the periodised plan. Section 2 of this manual also provides information that will assist the S&C Trainer in their understanding of how to progressively develop movement competency and the training of basic fitness abilities. Planning all-encompassing strength and conditioning programmes for individuals and teams is a complex and time-consuming process that requires a broad and detailed theoretical knowledge of the discipline as well as practical experience of programme delivery. Training variation is acknowledged as being an essential component of successful training prescription, with periodisation[27,30] being regarded as providing an effective framework for the planning and implementation of variation. Haff defined periodisation as: 'the logical integration and sequencing of training factors into mutually dependent periods of time designed to optimise specific physiological and performance outcomes at predetermined end-points'.[30] With this definition in mind, there are a number of training factors that must be considered during the planning process including:

- The manipulation and integration of volume (ie, managing how much work is done by the athlete)
- Intensity (how hard the athlete trains)
- Frequency of training
- Density (ie, amount of work completed per session or per day)
- Training foci (eg, maximum strength, maximal speed etc)
- Exercise selection
- Mode of training (eg, type of exercise such as change of direction, plyometrics, strength-based training and aerobic endurance)

This list of inter-related factors not only provides an opportunity for a large degree of training variation, but also shows how complex and intricate the planning process can become.

Often the challenge with planning is to get the balance right between too much and too little variation – training adaptations rely on a consistent 'dose' of training to elicit the desired training adaptations and too much variation can be counterproductive to the training process. When variation is well managed, the goals of periodisation are:

- To optimise an athlete's or a team's performance at specific, identified time points. This will involve peaking or maintaining performance at key times throughout the course of the competitive season, brought about by creative variation of a combination of training methods
- To maximise the specific physiological qualities identified in the needs analysis that underpin sport-specific development
- To reduce overtraining potential – this involves appropriate management of total training load to optimise performance and avoidance of excessive fatigue (see 3.2.3 GAS principle)
- To provide for long-term athlete development:

i) The adaptations gained from one block or phase of training should have a positive influence on adaptations gained in subsequent training blocks or phases. This requires a knowledge of how to sequence training blocks over extensive periods of time to optimise physiological adaptations, leading to improved performance

ii) An understanding of common injury patterns associated with the sport, the mechanisms of injury and a knowledge of how to plan a programme to successfully reduce the risk factors associated with these injuries is required. In instances where an injury has already occurred, knowledge of rehabilitation practices is needed in order to help an athlete return to fitness, but it should also be acknowledged that overall rehabilitation is actually the medical team's responsibility, as the athlete is still injured.

Put simply, periodisation is the process of dividing a long-term plan (multi-year or annual training plan) into specific time blocks, where each block has particular goals. This provides the body with complementary combinations of training types and training stresses at different times in order to develop the necessary physiological abilities required for sporting success. The inclusion of harder and easier training periods facilitates recovery, so that the athlete is able to commit to training while mitigating the risk of overtraining and injury.

The process for devising a periodised training plan involves multiple layers of planning, typically made up of seven levels. These levels are ordered from the longest to the shortest time and are described in Table 2.

LEVEL	NAME	DESCRIPTION
1	Multi-year training plan	Comprised of several consecutive annual plans – typically two (eg, linking two World Championships) or four years of training (eg, linking two consecutive Olympic Games), but may be longer for development athletes
2	Annual training plan	An entire year of training
3	Macrocycle	Describes a season of training – between 1 and 3 macrocycles make up an annual training plan. Some sports have multiple seasons within the training year, eg, field hockey can have both an indoor and outdoor season. Each macrocycle is comprised of three different phases which divide the training goals across the macrocycle: 1. Preparation: aims to improve work capacity and develop basic biomotor abilities 2. Specific preparation: development of basic biomotor abilities into specific physiological profile required to fit the sporting profile and/or position 3. Transition periods: linkage period between two phases (eg, between the end of the competition period and the start of the preparation period) with the aim of promoting the athlete's physiological and psychological recovery
4	Mesocycle	A block of training, usually between two and six weeks, aiming to develop one or two key physical capacities, while maintaining other capacities
5	Microcycle	Typically one to two weeks of training – seven days is the most commonly used duration, although competitive schedules and the sport (eg, multi-sport events such as triathlon or decathlon/heptathlon) may require longer microcycles
6	Training day	The actual structure of the training day, including the number of training sessions included (ie, density of training)
7	Training session	Single training session that will include a number of training units which are distinct blocks of time allocated to targeting a specific training adaptation within the session (eg, warm-up, plyometrics and strength-based activity) Units are logically sequenced and constructed within the session to make sure training is optimised throughout

Table 2. Periodised training programme[30,78]

The exact nature and content prescribed in the periodised training programme is determined by the sport and level of ability of the athlete. The make-up of the competition structure is different for every sport and is determined by the sport's national governing body. In relation to the ability of the athlete, the longer the training history and the more advanced the athlete, the more variation they need in their programme to achieve the desired goals. Several different types and hybrids of traditional periodisation models have been proposed within the literature to accommodate the differing needs of athletes and sports, but it is beyond the scope of this manual to explore periodisation in greater depth. A fully accredited UKSCA S&C Coach is required to have an extensive working knowledge of periodisation; it is also a compulsory element within the case study aspect of the of the UKSCA Accredited S&C Coach assessment (see uksca.org.uk/assessments).

To develop a greater understanding of the concept of periodisation, the S&C Trainer is signposted to review articles for further reading.[13,30,31,38,40,56,61,78] The topic is also an integral part of the UKSCA 'Planning Effective Programmes' workshop, which could be considered a worthwhile professional development option for S&C Trainers.

4.2 THE PLANNING PROCESS

While developing short, medium and long-term strength and conditioning plans, the trainer should seek to marry individual needs and outcomes with underpinning theory and delivery. A fundamental part of this process centres around the importance of objective goals that serve to keep an overall programme on track.

4.2.1 PLAN-DO-REVIEW

Planning: Many factors impact the planning stage and developing an individual plan should be centred around joint goal setting, adherence and motivation from all parties. Planning is a constantly evolving process that is often impacted by multiple variables.

Doing: Following the planning process there is a period of delivery where agreed physical qualities can be developed.

Reviewing: The review stage will allow trainers to assess the status and effectiveness of the training plan and implement any changes based on this.

The skill of reflection allows a programme to be constantly adapted to ensure success. Participants should be involved in this process as well as any other key stakeholders, eg, a sports coach or parent if working with a young athlete.

Figure 1. The Plan-Do-Review process

For the S&C Trainer, the process of Plan-Do-Review can be aided by asking some key questions:

1. **WHO** am I coaching?
2. **WHAT** am I coaching?
3. **WHERE** am I coaching?
4. **HOW** am I coaching?

There are no hard and fast rules on building a framework for S&C session design,[77] but the process shown in Table 3 provides a guideline and summarises the key steps that the S&C Trainer will need to complete in order to design an effective training session.

4.2.2 RECOMMENDED PROCESS FOR PLANNING A S&C PROGRAMME

There is no hard and fast methodology which must be followed in order to plan a S&C session or programme. Trainers and participants will both have personal preferences on how to collect data and design training programmes. These preferences will develop over time and with experience. The table below shows one such process for planning a S&C programme, which could form a useful template to a trainer developing their skills and knowledge.

1. Initial consultation and analysis	Physical activity readiness questionnaire and ACSM Exercise participation health screening recommendations (see 4.3.1 Pre-participation health screening)
2. Sport and participant needs analysis	Sport needs analysis: metabolic and biomechanic demands, injury analysis (see 3.3 Sports/activity needs analysis) Participant needs analysis: training preferences, lifestyle, age, sex (see 4.4 Participant/athlete needs analysis) Complete informed consent (see 4.3.3 Informed consent)
3. Evaluate overall physical status	Risk stratification (see 4.5.1 Risk stratification) Carry out appropriate battery of fitness tests based on needs analysis (see 4.5.4 Physical capacity testing) Complete a movement screen (see 4.5.5 Movement screening)
4. Set goals	Complete a comparative analysis by comparing needs analysis information with fitness/movement screen data (see 3.3.4 Comparative analysis) Establish SMART training goals for the mesocycle (see 4.6.1 SMART goals)
5. Establish training content (see 4.7 Establish training content)	Determine number/duration of weekly training sessions Break down sessions into a number of training units per week and allocate these to each specific training objective identified in the goal-setting process Establish a typical week of training to include date, time, factoring in other commitments (eg, work, social life etc), competition schedule (travel days/ recovery time) etc Consider location of training, equipment available and group size if relevant
6. Design the training programme	Design the training programme based on guidlelines provided in this manual
7. Review of the training programme	Consider how the content and programme have been delivered so that improvements can be made to future planning (see 4.8 Review of planning and effective S&C programme).

Table 3. Guidelines for planning a S&C programme

Note that in planning training sessions:

i) Although the S&C Trainer may coach S&C sessions that last for up to 75 minutes and include several training units, they may also be asked to lead warm-ups that last between 10-20 minutes in duration and therefore will only be made up of one to two training units (eg, enhancement of foundation movement ability and maximal speed). The warm-up is an essential component of any session, but it will happen at the start of every training session – if the S&C Trainer can plan content and deliver several warm-ups for the technical coaches throughout the microcycle, then this can significantly increase both the consistency and overall volume of S&C input to the participant/team. This will also negate the need for additional training sessions/time which may not be feasible or realistic for the participant.

ii) Some participants may complete more than one training session per day (ie, increased density of training) and for more advanced athletes, this may be necessary to achieve the overload required to promote the desired training effects. Although the timing of training sessions may not be under the control of the S&C Trainer, where possible, it is important to allow as much recovery as possible between sessions to enable the participant to maximise the benefits of each session. Those sessions that are most fatiguing (ie, high volume and/or high intensity) will require longer recovery periods.[30]

iii) The goal-setting process may identify several different training qualities that the participant may need to develop. Especially in more advanced athletes, it is important to recognise that not all types of training within the microcycle are compatible and that more training units will need to be directed towards a specific training quality (eg, maximal strength, maximal speed, etc) to continue to see fitness improvements (see Table 2).

Compatible training factors provide the S&C Trainer with some direction on which training qualities are compatible across a microcycle.

iv) Competitive demands (the number and timing of these) across the microcycle require consideration. This will typically provide the most intense training and impose the greatest amount of fatigue for the participant across the training week. The S&C Trainer will need, therefore, to consider what training precedes the competition to ensure that the participant can perform throughout the competitive event, as well as to allow sufficient recovery post-event. Usually, at least one day a week would be a rest day, although it should be noted that some advanced models will differ from this, eg, 10 days of training, two days of recovery etc.

v) As a general rule, training sessions should be scheduled such that the athlete will experience heavy and light days across the week – this should also be evident with repeated, consecutive microcycles to effectively manage physiological and psychological recovery.

4.3 INITIAL CONSULTATION AND ANALYSIS

Initiate the process through collecting information from the participant. The purpose of this is to identify personal goals, lifestyle factors and training/injury history that will influence training decisions. (See 3.5.2 In-person consultations).

4.3.1 PRE-PARTICIPATION HEALTH SCREENING

Many benefits are associated with regular exercise, and completion of a Physical Activity Readiness Questionnaire (PAR-Q) and an understanding of the ACSM Exercise Participation Health Screening Recommendations, is a sensible first step to take if you are planning to increase the amount of physical activity for any participant.

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

A PAR-Q or Physical Activity Readiness Questionnaire uses simple, effective questions that allow the trainer to assess both a participant's readiness to train and also any contraindications to starting training. Pre-existing medical issues or physical contraindications can be highlighted and where appropriate referred to a medical professional. Typically, questions will cover the following subjects:

- Pregnancy or childbirth in the previous 3 months
- Recent surgery or illness
- Pain in bones or joints while performing exercise
- Chest pain when performing exercise
- Other medical limitations – eg, diabetes,high blood pressure/cholesterol, arthritis, etc.

In the case of youth participants, the PAR-Q will also screen for growth-related conditions and obtain parent/guardian consent.

The PAR-Q will be guided by the health and safety processes of the trainer's organisation and should clearly lay out the correct course of action prior to commencing any exercise. Referral to a GP or physiotherapist may be required (see 4.5.1 Risk stratification) and standard referral letters can be drafted with prior consent.


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PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

CONTACT DETAILS

NAME: .... AGE: .... GENDER: ....

CONTACT NUMBER: .... EMAIL: ....

NEXT OF KIN: .... CONTACT NUMBER: ....

Many benefits are associated with regular exercise, and completion of the PAR-Q form is a sensible first step to take if you are planning to increase the amount of physical activity you do. For most people, doing so, should not pose a problem or a hazard.

The PAR-Q has been designed to identify rare cases where increased exercise might be inappropriate or for those who should seek medical advice concerning the type of activity most suitable for them. Common sense should guide your answers.

MEDICAL HISTORY

HAS YOUR DOCTOR EVER SAID THAT YOU HAVE A HEART CONDITION AND THAT YOU SHOULD ONLY DO PHYSICAL ACTIVITY RECOMMENDED BY A DOCTOR? YES/NO

DO YOU FEEL PAIN IN YOUR CHEST WHEN YOU DO PHYSICAL ACTIVITY? YES/NO

IN THE PAST MONTH, HAVE YOU HAD CHEST PAIN WHEN YOU WERE NOT DOING PHYSICAL ACTIVITY? YES/NO

DO YOU LOSE YOUR BALANCE BECAUSE OF DIZZINESS, OR DO YOU EVER LOSE CONSCIOUSNESS? YES/NO

DO YOU HAVE A BONE OR JOINT PROBLEM (FOR EXAMPLE BACK, KNEE OR HIP) THAT COULD BE MADE WORSE BY A CHANGE IN YOUR PHYSICAL ACTIVITY? YES/NO

IS YOUR DOCTOR CURRENTLY PRESCRIBING DRUGS FOR YOUR BLOOD PRESSURE OR HEART CONDITION? YES/NO

ARE YOU OR COULD YOU BE PREGNANT OR HAVE YOU HAD A BABY WITHIN THE LAST 3 MONTHS? YES/NO

DO YOU KNOW OF ANY OTHER REASON WHY YOU SHOULD NOT DO PHYSICAL ACTIVITY? YES/NO

If you have answered yes to any of these questions:
Then you are required to gain consent from your doctor before participating in the S&C training programme.

If you have answered no to all of the previous questions:
Then there is reasonable assurance of your suitability for a gym-based exercise programme – which will include exercises designed around your needs and goals. The programme will work all components of physical fitness and use the principles of training to ensure it is a gradual, periodised programme of exercise and physical activity.

You are advised to postpone entry into the programme if you feel unwell or have a temporary illness. You must inform your trainer of any changes to your health status whilst engaged in your training programme.

DECLARATION

CLIENT NAME: .... DATE: ....

WITNESS NAME .... DATE: ....

UKSCA PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Figure 2. Example of PAR-Q form (see Appendix 3)

The UKSCA PAR-Q can be found in Appendix 3

ACSM EXERCISE SCREENING PRE-PARTICIPATION

The purpose of the American College of Sports Medicine's (ACSM) exercise pre-participation health screening process is to identify individuals who may be at elevated risk for exercise-related sudden cardiac death and/or other life-threatening conditions.

Public health officials have long encouraged physical activity to realise the many health benefits associated with regular exercise. At the same time, S&C Trainers are taught that pre-participation health screening is necessary to identify those individuals with certain known risk factors for an unexpected event during or immediately after exercise. To accomplish this, exercise pre-participation screenings were developed. Through such classification protocols, at-risk individuals would be referred to a physician for medical testing and clearance before starting an exercise program.

As public health efforts encouraging regular physical activity have increased over the past few decades, there has also been an associated effort to identify barriers keeping people from starting exercise. One area thought to be a substantial limiting factor in these efforts to increase physical activity

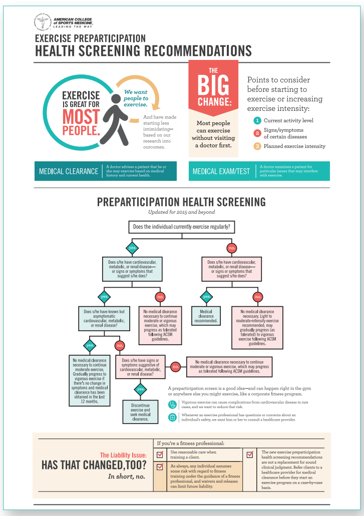

Figure 3. ACSM Exercise screening pre-participation (see Appendix 4)

participation was an over-prescription for medical clearance prior to participation.

Consequently, ACSM updated recommendations to consider the following:

- Current exercise participation
- History and symptoms of cardiovascular, metabolic or renal disease
- The desired exercise intensity for the person who wants to participate in a physical activity programmme.

As well as completing the PAR-Q, and considering the ACSM Exercise Pre-participation Health Screening Recommendations, the S&C Trainer and participant should work together to establish the participant's current lifestyle trends (see 4.4 Participant/athlete needs analysis). The following factors will have a significant impact on the effectiveness of a strength and conditioning programme: sleep, hydration, nutrition, general physical activity, family life and professional or education commitments.

4.3.2 S&C CONSULTATION RECORD AND INITIAL PLANNING TOOL (SCRIPT)

How to collect data for use in designing a training session is a matter of personal preference. The UKSCA's SCRIPT provides a useful resource, although further preferences for this process will likely be developed over time and with experience as a S&C Trainer.

The purpose of the SCRIPT is to identify personal goals, lifestyle factors and a training/injury history that will influence training decisions. This participants' needs analysis along with a specific sports needs analysis where relevant, (see 3.3 Sports/activity needs analysis) can be considered with the overall physical status to allow comparisons to be drawn and training goals set. The results of this data analysis, along with the physical capacity testing, are used to design the training programme.

As previously suggested, the UKSCA's PAR-Q, ACSM Exercise pre-participation health screening recommendations, SCRIPT and additional forms are available and recommended tools for S&C Trainers to make use of in order to ensure the participants' consultation and analysis process is complete and effective. Other organisations and Accredited S&C Trainers will have preferred methods for this data collection.

4.3.3 INFORMED CONSENT

Informed consent is the process for getting permission before undertaking any training, assessment, treatment or intervention on a participant, or for disclosing personal information.

As a trainer, it is your responsibility to educate the participant about what they are taking part in, including any risks, benefits, procedures and possible alternatives in the training or assessment they are about to undergo. You must obtain their consent before they get involved and you must keep them informed throughout.

Informed consent is fundamental in both ethics and law, and participants have the right to receive information and ask questions so that they can make well-considered decisions. An informed consent can be said to have been given based on the participant being considered competent, being in possession of all the relevant facts and having given their consent voluntarily.

There are common reasons why a participant may not give informed consent which usually fall into one of the following categories:

- Children under the age of 18
- People with an intellectual disability
- People with a mental health condition
- People with dementia.

In these cases another person is generally authorised to give consent on behalf of the participant, eg, a parent, carer or legal guardian.

Implied consent is consent that is not expressly granted by a person, but implicitly granted by their actions or the facts and circumstances of a particular situation, eg, where an unconscious person would die without immediate medical treatment.

4.4 PARTICIPANT/ATHLETE NEEDS ANALYSIS

In addition to objective information gathering through the sports needs analysis (see 3.3 Sports/activity needs analysis), there is significant benefit to be gained in understanding those lifestyle factors which are specific to the individual, and how they may impact on training. Questionnaires such as the UKSCA's SCRIPT (see 4.3.2 SCRIPT) and an initial consultation can help with this and may determine lifestyle factors such as diet and nutrition, occupation/ stage of education, medical conditions and so on.

A needs analysis and initial physical testing battery are vitally important in determining an individual's strengths and deficiencies. This enables the S&C Trainer to develop an appropriate set of training goals to improve performance and build robustness and consequently reduce injury potential.

4.4.1 TRAINING PREFERENCES

Participants often have training preferences that may influence exercise selection. Trainers should use their knowledge and understanding of training prescription to educate participants and adapt delivery to achieve optimal results. This may mean at times that there is a need to compromise and agree a method of training delivery that is optimal rather than 'perfect' for all parties. A pragmatic approach is sometimes needed and trainers should recognise that there may be more than one method to use. Trainers should also employ a range of motivational approaches and aim to create a good rapport with participants. Effective trainers learn which methods work best.

4.4.2 LIFESTYLE

Lifestyle factors such as sleep, nutrition, school and work commitments should be considered in the planning stage. Successful training plans are adaptable and flexible to the needs of each participant.

4.4.3 MULTI-SPORT PARTICIPATION

Multi-sport athletes gain different kinds of skills that they can apply from one sport to the next. These skills enhance hand-eye coordination, balance, endurance, explosion, communication and athletic agility – all of which are desirable outcomes in S&C and of particular importance in the developing child/adolescent athletes and their long-term relationship with sport.

Greater overall athleticism
Improved foundational motor skills and transferable skills
Lower chance of drop out
Increased fun and enjoyment
Wider circle of social relationships
Reduced chance of overuse injuries
Longer sport career and involvement
Promotion of lifelong physical activity skills
Greater intrinsic motivation
Opportunity to learn new sports

Table 4. The top 10 benefits of multi-sport participation

Trainers, educators and researchers/scientists have been addressing the trend toward 'single sport specialisation' at a young age, particularly over the past decade, as coaches or parents look to maximise the potential of their children becoming elite athletes. As a result of this, various governing bodies of sport now publish recommended guidelines for time spent practising a specific sport or other activities – for example, rugby union offers very detailed information on 'Age Grade Rugby', which includes general advice on a multi-sport/active lifestyle approach, as well as recommended minutes of play per week, between matches and so on.[19]

4.4.4 AVAILABILITY AND KEY EVENTS

Time constraints can affect programme priorities. More time available means a greater window of opportunity for development. Trainers should prioritise specific training goals and deliver in the most efficient way possible. For example, when contact time is limited, a trainer may supplement one-to-one delivery with self-directed sessions increasing volume and frequency accordingly. Key events like holidays and periods away from home should be accounted for in the planning process. Trainers should be able to adapt their schedules around these events.

4.4.5 WORK ETHIC

Although often not considered, individuals can have differing motivations, work ethics and capacities to train (physically). The 'principle of awareness' requires the participant to know themselves and develop an understanding of both their physiological and psychological capacities and tolerances for work. There is no 'one size fits all' solution here and trainers should engage and communicate with participants in order to develop these areas. It is important that realistic goals are agreed between the S&C Trainer and the participant to ensure the participant commits to and engages in the actions required to understand themselves and develop to the best of their ability.

4.4.6 CONSIDERATIONS FOR YOUTH S&C

The S&C Trainer should understand that there is a difference between training an adult participant with a fully mature musculoskeletal system, and training a youth participant whose body is undergoing continuous natural change.

The S&C Trainer should be aware of how growth and development factors interact with health and physical performance and be diligent in keeping up-to-date with ongoing research in paediatric strength and conditioning if working with youth participants

> **'Children and young people should engage in a variety of types and intensities of physical activity across the week to develop movement skills, muscular fitness, and bone strength'**
>
> UK Chief Medical Officer's Physical Activity Guidelines, 2019[15]

KEY TERMS FOR CONSIDERING YOUTH

Growth: The progression in the size and shape of the body and organs through an increase in cell number and size, and cellular material.

Maturation: Process by which humans progress to adulthood. There are differences between individuals with regard to the timing (when it occurs relative to chronological age) and tempo (rate of change) of maturation of different systems such as the skeletal and reproductive systems. This means that individuals of the same chronological age can be physically very different.

Development: A broader concept than growth and maturation and refers to both biological and behavioural factors. An effective coaching programme will not only consider how training impacts physiological mechanisms, but also how it can provide a positive educational experience.

CHRONOLOGICAL AGE

Chronological age is the time frame indicated at a single point and relative to date of birth. This measure of age is used to classify groups such as children's school year groups and sports age groups (youth and senior).

In the UK, a school year group will be based on the child's chronological age (in years only) for the year running from September 1 to August 31. Many sports then use this same classification to categorise the sporting age group.

DATE OF BIRTH	SCHOOL YEAR	AGE ON 31/08/2020	SCHOOL YEAR GROUP	SPORT AGE EG, FOOTBALL	AGE ON 01/01/2021
Child A 12th Sept 2008	1st Sept 2020 – 31st Aug 2021	11 years, 353 days	7	U12	12 years, 111 days
Child B 4th March 2009	1st Sept 2020 – 31st Aug 2021	11 years, 180 days	7	U12	11 years, 303 days
Child C 7th August 2009	1st Sept 2020 – 31st Aug 2021	11 years, 24 days	7	U12	11 years, 147 days

Table 5. Chronological age

When working with youth participants, the S&C Trainer should review the age-group structure of the sports the young person is involved with as a part of the sport and individual needs analysis. Chronological age may give broad hints to the S&C Trainer concerning what a child/adolescent athlete should be able to cope with both physically and mentally. However, it will not provide the detailed picture (that biological age can provide), required to train children efficiently and safely, as it does not account for how quickly children develop.

BIOLOGICAL AGE

The biological age of an individual is a more complex factor than chronological age. As a consequence of the variables associated with growth and maturation, there can be large individual differences between young people of the same chronological age which are difficult to assess, and not easily predicted.

Paediatric science differentiates between – and seeks to measure and monitor – the following systems in order to try and build a more accurate picture of an individual's biological age:

Skeletal age: radiography of the skeleton – with a focus on hand-wrist development – provides the most accurate assessment of biological age. This has limitations in its use due to requiring an X-ray and expert assessment to interpret images.

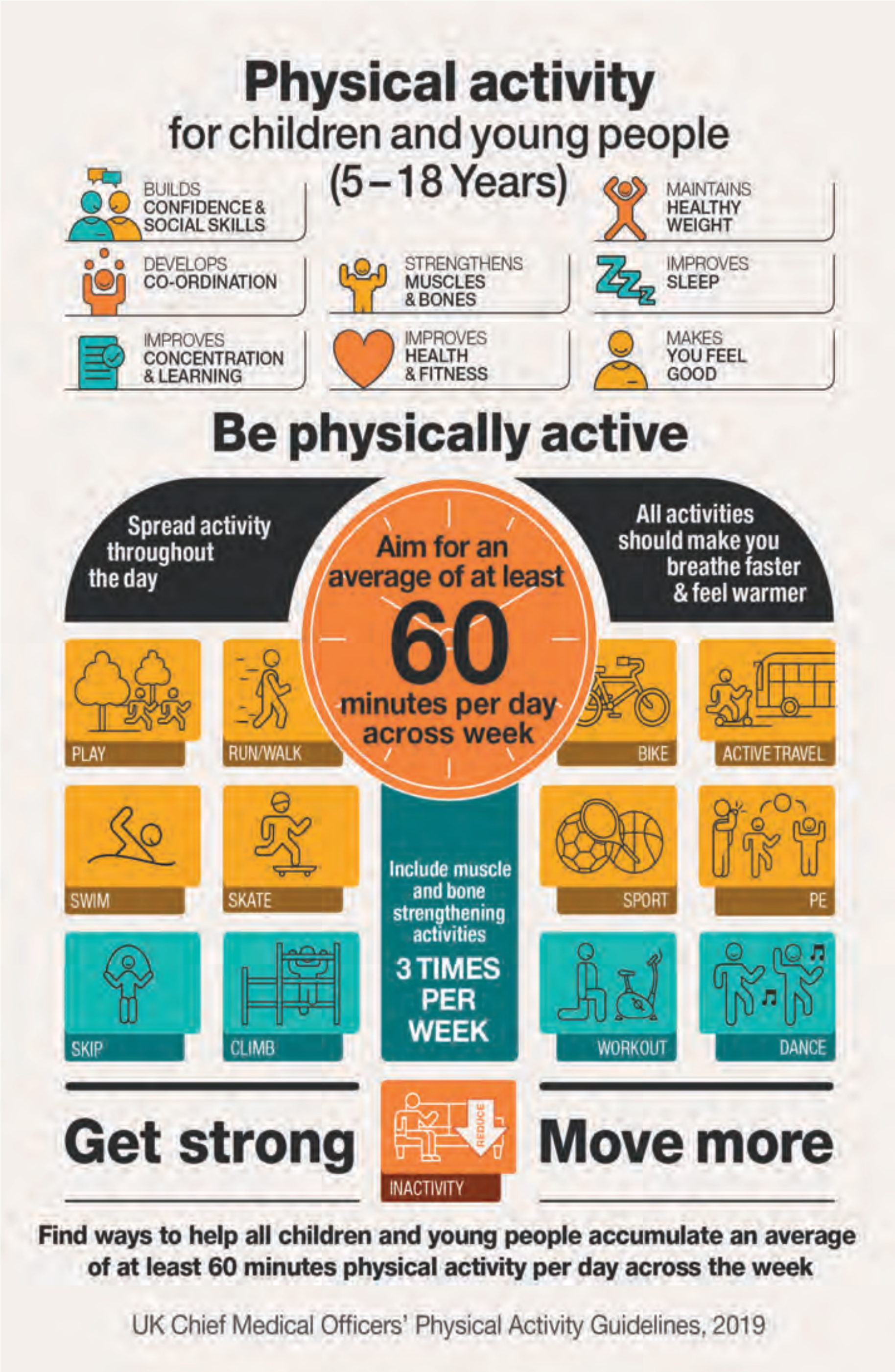

Figure 4. UK Chief Medical Officer's Physical Activity Guidelines[15]

Sexual age: can be assessed based on the development of secondary sexual characteristics: eg, breast development, age of menarche, pubic hair development, and penis/testes development. Accurate assessment requires trained health professionals. It is possible for young people to self-assess, based on knowledge of their own bodies in comparison with normative data, but it is not appropriate for a S&C Trainer to try to use sexual development to ascertain maturation.

Somatic age: detailed anthropometric data (measures of the body) can be accurate predictors of somatic age if undertaken by skilled assessors. However, more accessible measures of body stature and mass in the form of peak height velocity (PHV) can be used as a useful guideline for stage of maturation.

PEAK HEIGHT VELOCITY (PHV)

PHV is the maximum rate of growth that occurs in young people during adolescence. Having an understanding of when this occurs for an individual (Age of Peak Height Velocity – APHV) will help the S&C Trainer to select appropriate training objectives and strength and conditioning protocols using the Youth Physical Development Model as a guide. See review by Lloyd & Oliver.[48]

PHV is of particular interest from a strength and conditioning perspective because it is a period associated with potential sensorimotor challenges ('adolescent awkwardness') and increases in conditions like Osgood-Schlatter disease. It is important that the S&C Trainer communicates effectively with parents or guardians, technical coaches and medical professionals if the screening process identifies any growth-related conditions.

PHV occurs earlier in girls (age 10 to 15, with 12 as an average) than in boys (age 12 to 16, with 14 as an average).[47]

Predicting APHV is now more accessible through online calculators, with most based on the formula developed by Mirwald et al.[53] The formula requires participant height, seated height, body mass, date of birth and date of measurement and is available at: **https://www.usask.ca/kin-growthutility/phv_ui.php**

PEAK WEIGHT VELOCITY (PWV)

PWV is the maximum rate of change in body mass. In boys, PWV typically coincides with PHV with an average increase of 9kg/year. In girls, PWV typically lags behind PHV by 6-12 months with an average increase of 8.3kg/year.[64] These rapid changes in body mass can significantly increase load for jumping, landing and change of direction tasks and contribute to 'adolescent awkwardness' which may result in a plateau in performance outcomes (strength, explosive skills, speed). This is especially important to keep in mind when working with females, as PWV is associated with natural increases in fat mass that are more likely to attenuate performance improvements.

PRACTICAL IMPLICATIONS OF GROWTH AND MATURATION

Growth and maturational changes evident in youth populations mean that they cannot merely be treated as 'miniature adults' and, for a S&C Trainer, programming should reflect this. It is important that an effective monitoring process is in place to track changes in growth. If the S&C Trainer is working in an environment with large groups of young participants, then quarterly measurements of height and body mass are sufficient to keep informed of the individuals' growth for girls aged 10-15 years and boys aged 12-16 years.[48]

The measuring process should include protocols that support confidentiality and the S&C Trainer should be sympathetic to any potential concerns from young people regarding measurements. It is important that conversations take place with young people, with their primary carers and also with their coaches, to ensure that everyone is educated about the purpose and meaning of the measurement process. It is also important to note that accelerated periods of growth, triggered by puberty, significantly increase nutritional intake of both macro and micronutrients;[68] therefore, a youth's 'readiness' to train can be impacted heavily by their nutritional status.

Effective S&C Trainer-participant relationships are essential in identifying just how growing is affecting the participant's ability to train. Monitoring fatigue, whether through one-to-one communication with the coach, or through wellness diaries[32] can help the S&C Trainer make appropriate decisions on the amount of work that a youth can tolerate as they progress into adulthood. The S&C Trainer should also be extra vigilant during sessions with respect to observation of the participant's movement quality – growth spurts can affect the participant's motor control and coordination abilities, plus growth of the long bones can compromise mobility. Prioritising movement quality is even more crucial during periods of growth and maturation and the S&C Trainer should make sure that during group sessions they are in the right position to be able to effectively observe participants in or around PHV.

BIO-BANDING

Bio-banding is a relatively new concept aimed at better management of the issues that arise in youth sport caused by the complex relationship between chronological age grouping, the relative age effect, and inter-individual differences in the timing and tempo of growth and maturation.

Simplistically, bio-banding is the process of grouping youth athletes according to maturational status rather than chronological age-group bands. Although accurate assessment methods of skeletal and sexual maturity are currently too invasive and/or impractical to allow for widespread implementation, simpler anthropometric measures to determine percentage of adult height and peak height velocity have been used in a number of test cases, notably in some football academies.

Proponents of bio-banding claim that test cases have benefitted both early- and late-maturers. The former train and compete in an environment where they cannot rely on physical dominance, and thereby develop their technical and tactical skills. The late-maturers are no longer physically overwhelmed, and have the opportunity to use and develop their physical and technical skills.12

Bio-banding is an area of ongoing research and development, and the S&C Trainer should be diligent in keeping up to date with research and applied models of this concept. However, it should be recognised that physical and mental development may not run in parallel: for example, you may have a child who is physically very mature, but mentally quite immature (or vice versa).

THE YOUTH PHYSICAL DEVELOPMENT MODEL (YPD)

In terms of programming, the Youth Physical Development (YPD) model proposed by Lloyd and Oliver[48] offers the S&C Trainer an evidence-based framework for the physical development of both male and female youth athletes. Analysis indicates that – throughout childhood – most fitness qualities are trainable, provided the S&C Trainer is responsive to individual variation in the rate and timing of maturation and that monitoring and observational data is a consideration.[24,48]

The Long-Term Athletic Development (LTAD) model proposed by Baker (see Tables 6 and 7) builds on Lloyd and Oliver's YPD model. This provides specific detail and guidance on what methods of training are appropriate within the key training areas identified for athletes at different ages, training ages and stages of maturity within a 3-phase system.[39]

RELATIVE AGE EFFECT

The relative age effect (RAE) refers to the consequences of difference in age between individuals grouped within the same cohort. The bias occurs because youth participants born in the first quarter of the year are likely to be more physically, emotionally and cognitively developed than participants born in the last quarter. This can give them an advantage in academic and sporting endeavours.

In Table 5 on chronological age, Child A is almost a year older than Child C, but based on the September 1 to August 31 grouping of the UK academic (and sporting) year they are in the same cohort. The younger the children, the more obvious this age gap and it can remain an issue until the late teens. If this is not managed well by coaches, it can lead to the younger participants in a cohort being overlooked or becoming demotivated, reducing the quality and potential benefits of their sporting experience. By being aware of RAE, S&C Trainers can offer a more rounded perspective on inter-individual differences in the physical ability of youth participants.

TRAINING, BIOLOGICAL AND CHRONOLOGICAL AGE

There are often big differences between training age (the number of years of exposure to training) and chronological age (years from birth). It is not uncommon to programme for participants who, although they have a greater chronological age, have no training history. Conversely, trainers may often work with younger populations who have already amassed significant 'training years' through exposure in their sport and at school.

Participants may also differ in biological age but not chronological age, eg, two 14-year-olds may be very different biologically. One may well be much further developed physically impacting on the training they can cope with physically and mentally.

	FOUNDATION	DEVELOPMENT	PERFORMANCE
CHRONOLOGICAL AGE	8–11 years	12–14 years	15–19 years
TRAINING AGE	0–2 years	2–4 years	4+ years
STRUCTURE	Low structure | High gamification | Lesson plan	Mod. structure | Mod. gamification | Programmed	High structure | Low gamification | Periodisation
MATURATION STATUS	← PRE-PHV → ← PRE-PWV →	← Circa-PHV → ← Circa-PWV →	← POST-PHV → ← POST-PWV →
ADAPTATION	← PREDOMINANTLY NEURAL (AGE-RELATED) →	← COMBINED NEURAL AND HORMONAL (MATURITY-RELATED) →	
FMS*	FOUNDATION MOVEMENT SKILLS	FOUNDATION MOVEMENT SKILLS	FOUNDATION MOVEMENT SKILLS
SSS*	SPORT SPECIFIC SKILLS	SPORT SPECIFIC SKILLS	SPORT SPECIFIC SKILLS
STRENGTH-BASED TRAINING	Enhance strength using foundation movement skills, bodyweight exercises, low load resistance training (eg, wooden dowels, sandbags, medicine balls, technique bars)	Develop confidence and competence in a resistance training environment with progression of external load (eg, dumb-bells and barbells) and bodyweight exercises. Ensure that balanced, whole body relative strength is achieved by rounded programming	Optimise strength development utilising more advanced training systems and progressive, periodised programming. Manipulate strength-based training to achieve specific adaptations (eg, hypertrophy, strength endurance, maximum strength)
EXPLOSIVE SKILLS	Develop explosive skills using (gamified) jumping, landing, and medicine ball throws. Plyometric ability can be developed indirectly using low intensity (gamified) jumps, skips, hops, bounds. Gradually build complexity and eccentric load	Continue to refine jumping, landing and throwing technique. Continue development of plyometric ability using low to moderate intensity jumps, skips, hops, bounds. Gradually build complexity and eccentric load. Allow time for the participant to adapt to performing plyometrics with increased body mass and stature. Introduce resistance techniques with velocity-based objectives	Maximise explosive skill development utilising a range of methods that span the force-velocity curve: weightlifting derivatives, loaded jumps, throws, basic jumping and landing. Maximise plyometric ability using a full spectrum of low to high intensity jumps. Establish jump volume using low to moderate plyometrics early in the season, to lay the foundations for high intensity plyometrics training later in the year
SPEED	Provide frequent opportunities for participants to sprint fast using games, relays and chasing activities that allow the development of acceleration and maximal velocity sprinting	Continue to sprint frequently using a variety of speed games (eg, racing and chasing), technical drills and appropriately sequenced sprint training methods for developing acceleration and maximal velocity sprinting. Refine and recalibrate sprinting technique in response to PHV and PWV	Optimise sprinting technique now growth has stabilised and the required underpinning strength and power is developing. Maximise speed using a short to long periodised programme that enhances the skill of sprinting and speed through appropriately sequenced sprint training methods
AGILITY	Allow for COD and agility development through evasion and chase games. Provide context by linking movements to specific sports and recreating game scenarios during agility training components	Continue to progress COD and agility movements using a combination of evasion and chase games along with specific deceleration, COD and re-acceleration drills to refine and recalibrate technique in response to PHV and PWV	Develop sport-specific agility according to the needs analysis. Revisit technical competency in COD and agility movements based on frequent re-evaluaıon of the individual needs of the participant
ENERGY SYSTEMS TRAINING	Develop energy systems fitness through playing sport and being physically active. Specific energy systems training and assessment is a low priority in this phase	Continue to develop energy systems fitness through playing sport and being physically active. Introduce occasional assessments of energy systems fitness to identify potential limiting factors to health and performance	Identify energy systems demands for the specific sport and/or position. Ensure those demands can be met by the participant using structured energy systems training
FLEXIBILITY AND MOBILITY	Challenge full ranges of movement through movement challenges, playing games and foundation movement skill competency	Increase focus on flexibility and mobility, addressing growth-related limitations in range of movement and emphasis on technical quality through full ranges of movement in strength-based training	Utilise as required for the participant's individual needs. Developmental objectives of warm ups and cool downs should address these needs

Table 6. LTAD Network Youth Physical Development Model for Males. Baker, J. LTAD Network. Available at http://www.ltadnetwork.com

* Larger font size indicates increased level of emphasis on FMS / SSS at different stages of the participant's developmental journey

	FOUNDATION	DEVELOPMENT	PERFORMANCE
CHRONOLOGICAL AGE	8–11 years	12–14 years	15–19 years
TRAINING AGE	0–2 years	2–4 years	4+ years
STRUCTURE	Low structure | High gamification | Lesson plan	Mod. structure | Mod. gamification | Programmed	High structure | Low gamification | Periodisation
MATURATION STATUS	← PRE-PHV →	← Circa-PHV →	← POST-PHV →
	← PRE-PWV →	← Circa-PWV →	← POST-PWV →
MENARCHE		← MENARCHE →	
ADAPTATION	← PREDOMINANTLY NEURAL (AGE-RELATED) →	← COMBINED NEURAL AND HORMONAL (MATURITY-RELATED) →	
FMS*	FOUNDATION MOVEMENT SKILLS	FOUNDATION MOVEMENT SKILLS	FOUNDATION MOVEMENT SKILLS
SSS*	SPORT SPECIFIC SKILLS	SPORT SPECIFIC SKILLS	SPORT SPECIFIC SKILLS
STRENGTH-BASE TRAINING	Enhance strength using foundation movement skills, bodyweight exercises, low load resistance training (eg, wooden dowels, sandbags, medicine balls, technique bars)	Develop confidence and competence in a resistance training environment with progression of external load (eg, dumbbells and barbells) and bodyweight exercises. Ensure single leg strength and stability is emphasised to mitigate ACL-injury risk. Raise awareness that increased fat mass may effect relative strength levels	Optimise strength development utilising more advanced training systems and progressive, periodised programming giving consideration to the individual's menstrual cycle. Manipulate strength-based training to achieve specific adaptations (eg, hypertrophy, strength endurance, maximum strength)
EXPLOSIVE SKILLS	Develop explosive skills using (gamified) jumping, landing, and medicine ball throws. Plyometric ability can be developed indirectly using low intensity (gamified) jumps, skips, hops, bounds. Gradually build complexity and eccentric load	Increase focus on appropriate jumping and landing mechanics to mitigate ACL-injury risk. Raise awareness that natural increases in fat mass at PWV may attenuate improvements in explosive skills. Continue development of plyometric ability using low to moderate intensity jumps, skips, hops, bounds. Gradually build complexity and eccentric load, allowing time for the participant to adapt to increases in stature and body mass. Introduce resistance techniques with velocity based objectives	Maximise explosive skill development utilising a range of methods that span the force-velocity curve: weightlifting derivatives, loaded jumps, throws, basic jumping and landing. Maximise plyometric ability using a full spectrum of low to high intensity jumps. Establish jump volume using low to moderate plyometrics early in the season, to lay the foundations for high intensity plyometrics later in the training year
SPEED	Provide frequent opportunities for participants to sprint fast using games, relays and chasing activities that allow the development of acceleration and maximal velocity sprinting	Continue to sprint frequently using a variety of speed games (eg, racing and chasing), technical drills and appropriately sequenced sprint training methods for developing acceleration and maximal velocity sprinting. Refine and recalibrate sprinting technique in response to PHV and PWV	Optimise sprinting technique now growth has stabilised and the required underpinning strength and power is developing. Maximise speed using a short to long periodised programme that enhances the skill of sprinting and speed through appropriately sequenced sprint training methods
AGILITY	Allow for COD and agility development through evasion and chase games. Provide context by linking movements to specific sports and recreating game scenarios during agility training components	Continue to progress COD and agility movements using a combination of evasion and chase games along with specific deceleration, COD and re-acceleration drills to refine and recalibrate technique in response to PHV and PWV	Develop sport-specific agility according to the needs analysis. Revisit technical competency in COD and agility movements based on frequent re-evaluation of the individual needs of the participant
ENERGY SYSTEMS TRAINING	Develop energy systems fitness through playing sport and being physically active. Specific energy systems training and assessment is a low priority in this phase	Continue to develop energy systems fitness through playing sport and being physically active. Introduce occasional assessments of energy systems fitness to identify potential limiting factors to health and performance	Identify energy systems demands for the specific sport and/or position. Ensure those demands can be met by the participant using structured energy systems training
FLEXIBILITY AND MOBILITY	Challenge full ranges of movement through movement challenges, playing games and foundation movement skill competency	Increase focus on flexibility and mobility, addressing growth-related limitations in range of movement and emphasis on technical quality through full ranges of movement in strength-based training	Utilise as required for the participant's individual needs. Developmental objectives of warm ups and cool downs should address these needs

Table 7. LTAD Network Youth Physical Development Model for Females. Baker, J. LTAD Network. Available at http://www.ltadnetwork.com

* Larger font size indicates increased level of emphasis on FMS / SSS at different stages of the participant's developmental journey

4.4.7 SEX CONSIDERATIONS FOR S&C (INCLUDING ANTE- AND POST-NATAL ADAPTATIONS)

PHYSICAL DEVELOPMENT CONSIDERATIONS

It is important to note that females will experience puberty and peak height velocity on average two years earlier than males. ‘Adolescence’ is the term used to describe the transition period from childhood to adulthood (12-18 years in females; 14-18 years in males), with ‘puberty’ defining the time when secondary sex characteristics become evident.[48] At some point during adolescence, individuals will experience their greatest rate of change in both stature (peak height velocity; PHV) and body mass (peak weight velocity; PWV), with differences evident between the sexes in the timing of these events. The onset of the adolescent growth spurt and PHV typically occurs two years earlier in females (~ 10 and 12 years respectively), when compared to males (~ 12 and 14 years respectively). In addition, the magnitude of the growth spurt is greater[14,48] in males, with PWV coinciding with PHV. In females, PWV lags behind PHV by approximately 6 months.[14]

PUBERTY

At the onset of puberty, changes to the following body’s hormones are reported to influence growth:

1. Growth hormone, thyroxine, insulin, and corticosteroids – growth rate
2. Leptin – alters body composition
3. Parathyroid hormone,1,20 – dihydroxy-vitamin D, and calcitonin – alters skeletal mineralisation

Other factors also contribute to growth rate, including nutrition, genetics, environmental factors, physical activity levels, cultural background and socioeconomic status.[60]

All factors considered, there is considerable variation in the extent, timing and rate of change in growth and maturation rates between individuals of both sexes (early versus late maturing). These differences subsequently affect the physiological ‘readiness’ of the body to tolerate different types of training. Regular measures of PHV & PWV (every three to four months) are recommended to be able to track and assess the biological age of youth athletes. This information will allow intelligent interpretation and application of long-term athletic development models[29,48] in youth athletes. For example, an early maturing athlete may be able to tolerate a more advanced training prescription, ie, leftward shift in the long-term athletic development model; (see 4.4.6 Considerations for youth S&C), if the necessary adaptations from the early development stages have already been realised (eg, mastery of foundation movement patterns).

STRENGTH CONSIDERATIONS

It is important to note that adolescent females do not have the same level of strength-related hormones as adolescent males and therefore strength training is perhaps even more important for female participants. At the time of PWV, rapid gains in muscle mass occur in both males and females due to an increase in circulating androgens (including testosterone, growth hormones and IGF-1) which are synthesised in the testes, the ovaries, the pituitary and adrenal glands. Males demonstrate a rapid increase in muscle mass and strength at the onset of puberty, whereas in females these changes are much more linear in nature.[48] Evidence highlights the fact that, as males enter adulthood, they consistently surpass females in strength measures.[24,48]

It is recognised that the strength capabilities of an individual are not only determined by the architecture, fibre type and cross-sectional area of the muscle, but also by the ability of the nervous system to optimally recruit and activate the relevant motor units. Although neural factors do change during childhood and adolescence as the neural system develops and matures,[22,46,48] sex-related differences in post-pubertal strength are primarily attributed to the differences in muscle growth resulting from sex differences in circulating androgen concentrations.

In adulthood, males show a 20-30% larger muscle cross-sectional area compared to females.[16,26,33,36] Females typically display a lower proportion of their muscle mass in the upper body (~ 60 to 70–75% of male values) when compared to males, even when adjustments are made for lean muscle mass or body mass.[70]

Consequently, females are typically weaker than males in the upper body. Comparisons of lower body strength values, however, correlate more closely between the sexes (~80–100% male values).

Despite the reported role of androgens in explaining post-puberty differences in muscle mass between the sexes, recent evidence exploring post-exercise hypertrophic adaptations to resistance training in adults has questioned the role of the 'hormone hypothesis', which suggests that muscle size increases are mediated by post-exercise hormone release.[66]

There is evidence to suggest that despite the sex differences in anabolic hormone concentrations, post-exercise muscle protein synthesis rates are increased equally in both males (52%) and females (47%) after high intensity resistance training; furthermore, this can remain elevated for up to two hours. In addition, the rate of gain in cross-sectional area per day between males and females who have followed the same training programme is similar, with increases of 0.13% and 0.14% respectively.[37,80]

Given the importance of muscular strength in enhancing sports performance and reducing injury potential,[71] strength qualities should be a focus at all stages of development in youth. However, given the absolute differences in muscle mass observed in adult males and females, strength training should be a particular priority for females, especially with regards to strength development in the upper body. Also, given the fact that oestrogen, the predominant female sex-specific hormone, increases levels of body fat, resistance training is important for maintaining a favourable body composition,[34,69] as well as optimising strength to weight ratios and relative strength (ie, strength relative to body weight) levels.

> **'Female participants are at a greater risk of ACL injury in multi-directional physical activity due to the anatomical differences identified by the Q angle, plus a lack of strength in the pelvic girdle'**

ACL INJURY

Females have a 2–10 times greater risk of anterior cruciate ligament (ACL) injury compared to their male counterparts[35,55,67,73] and it is worth noting that an initial ACL injury not only increases the risk of a secondary ACL injury,[41] but also increases the risk of chronic patella-femoral pain, as well as increasing the chances of developing osteoarthritis in later years.[25]

Four common motor performance components have been identified that are correlated to increased ACL injury risk, particularly in female athletes:

1. Knee valgus (ligament dominance): muscles do not adequately absorb the ground reaction forces, leading to excessive amounts of force being absorbed by the joint and the ligaments over a very short period of time which can lead to ligament rupture
2. Relatively straight leg on injured side: females tend preferentially to recruit the quadriceps to stabilise the knee joint (ie, quadriceps dominance). Contraction of the quadriceps extends the knee and causes an anterior shear stress to the tibia and ACL which increases injury risk
3. A large proportion of the weight, if not all, is on the landing leg: females tend to be more one-leg dominant (ie, display asymmetry) compared to males, which means the ability to cope with landing forces can be compromised, particularly on the weaker side
4. The trunk is likely to be tilted laterally, meaning that the centre of mass is outside the base of foot support. This is likely to lead to excessive motion of the trunk during jumping and landing manoeuvres which increases injury risk.

The above neuromuscular imbalances are reported to underpin the mechanisms that increase ACL injury risk in females compared to males.[35,63] Furthermore, high oestrogen levels have been shown to increase joint laxity, which further increases risk of ACL injury[81] at certain time points across the menstrual cycle (ie, at or near ovulation).

Exercise prescriptions to successfully improve strength development and neuromuscular control to reduce these types of injuries (eg, FIFA 11+, Sportsmetric programme) are available and have been shown to be effective, provided sufficient compliance is achieved.[72] The following points highlight some key recommendations for S&C Trainers to assist with programming decisions:

1. Training emphasis on developing full range of movement
2. Ensuring good alignment of hip, knee and ankle according to exercise technical models
3. Encouraging good whole-body alignment, including trunk position in all exercises
4. Developing strength in athletes through lifting skills and implementing progressive overload strategies as a fundamental part of exercise
5. Incorporating a variety of movement types in training programmes, such as controlled strength-based exercises under load and more explosive activities such as jumping and landing, acceleration, deceleration and change of direction

SOCIALISATION FACTORS INHIBITING FEMALE PARTICIPATION

Although evidence suggests that females respond and adapt to resistance training programmes in the same way as males,[4,43,80] females often demonstrate lower participation rates in constructive strength-based training. The reasons for this may include a misunderstanding of the physical effects of the activity (muscle bulking), a perception that resistance training is a masculine activity and/or a lack of confidence that prevents them from attending and adhering to strength-based sessions.

It is therefore essential that the coaching environment created encourages female participation and promotes long-term adherence to resistance training programmes. This will usually require a process of education to include: the benefits of resistance training to performance, reduction of injury potential and promotion of psychological and physiological health and wellbeing. Female athletes respond particularly well to a climate of cooperation, so time taken to facilitate coach-athlete relationships and promote positive group dynamics is time well spent.[65]

OLDER FEMALE PARTICIPANTS

Oestrogen has a significant, positive effect on musculoskeletal function including the anabolic response to exercise,[9] and bone health.[42,44,54] As a consequence, in female populations of advancing age who are experiencing a chronic decline in oestrogen concentration (ie, at menopause), the three most commonly reported musculoskeletal disorders are osteoporosis, osteoarthritis and sarcopenia.[75,76] Although the use of hormone replacement therapy (HRT) can offset some of these noted detrimental effects,[51,82] the importance of resistance training throughout a lifetime is essential for maintaining muscle and bone mass, encouraging lifelong activity/optimal performance and injury prevention at all ages.[28,57]

ANTENATAL CONSIDERATIONS

Women who continue to exercise into pregnancy can gain considerable physiological and psychological health benefits;[21] they are also more likely to exercise during the postpartum (postnatal) period, promoting lifelong exercise participation and a quicker return to fitness after the birth. The benefits of maintaining an active lifestyle in pregnancy include:

1. Reduced likelihood of excessive gestational weight gain, gestational diabetes, pre-eclampsia, and pre-term birth
2. Prevention of urinary incontinence, low back pain, varicose veins and deep vein thrombosis
3. Reduction of risk of delivery complications and length of labour
4. Improved well-being associated with reduced fatigue, stress, anxiety, and depression.

For healthy women who take part in low intensity exercise, or none at all, pregnancy exercise recommendations are consistent with the UK physical activity guidelines, except that depending on previous training history and potential pregnancy-related contraindications (see Table 8), extra precautions may be necessary and/or medical advice sought prior to initiating or continuing with activity during pregnancy.

For women who exercise at a moderate to vigorous intensity, they may continue to do so when pregnant provided they remain healthy. Evidence suggests that maintaining an active lifestyle through pregnancy is well tolerated and it is not associated with risks to the newborn.[8,74] In general, however, exercise intensity should not exceed pre-pregnancy levels and certain activities should be avoided (see Table 9).

ABSOLUTE CONTRAINDICATIONS TO AEROBIC EXERCISE DURING PREGNANCY
Severe respiratory diseases (eg, chronic obstructive pulmonary disease, restrictive lung disease and cystic fibrosis) Severe acquired or congenital heart disease with exercise intolerance Uncontrolled or severe arryhthmia Placental abruption Vasa previa Uncontrolled type 1 diabetes Intrauterine growth restriction Active preterm labour Severe pre-eclampsia Cervical insufficiency
RELATIVE CONTRAINDICATIONS TO AEROBIC EXERCISE DURING PREGNANCY
Mild respiratory disorders Mild congenital or acquired heart disease Well-controlled type 1 diabetes Mild pre-eclampsia Preterm premature rupture of membranes Placenta previa after 28 weeks Untreated thyroid disease Symptomatic, severe eating disorder Multiple nutrient deficiencies and/or chronic undernutrition Moderate-heavy smoking (>20 cigarettes per day) in the presence of co-morbidities
BMI: Body mass index

Table 8. Contraindications to aerobic exercise during pregnancy[50]

SECTION 4. PLANNING AN EFFECTIVE STRENGTH AND CONDITIONING PROGRAMME

EXAMPLES OF SAFE AND UNSAFE PHYSICAL ACTIVITIES DURING PREGNANCY **The following activities are safe to initiate or continue***
Walking Swimming Stationary cycling Low impact aerobics Yoga, modified** Pilates, modified Running or jogging*** Racquet sports**** Strength training*** Pelvic floor muscle training (Kegel)
The following activities should be avoided:
Contact sports (eg, ice hockey, boxing, football and basketball) Activities with a high risk of falling or otherwise hitting the abdomen against a hard surface (eg, downhill snow skiing, water skiing, surfing, off-road cycling, gymnastics and horseback riding) Scuba diving Sky diving 'Hot yoga' or 'hot Pilates'
* In women with uncomplicated pregnancies in consultation with an obstetric care provider ** Yoga positions that result in decreased venous return and hypertension should be avoided as much as possible *** In consultation with an obstetric care provider, running or jogging, racquet sports and strength training may be safe for pregnant women who participated in these activities regularly before pregnancy. Moderate intensity is optimal (eg, ≤80% age predicted maximum heart rate, rate of perceived exertion 13 or 14 on the Borg scale, or ability to converse while exercising). High intensity strenuous exercise should be avoided (>90% age predicted maximum heart rate) **** Racquet sports where a pregnant woman's changing balance may affect rapid movements and increase the risk of falling should be avoided as much as possible.

Table 9. Safe and unsafe recreational exercises in pregnancy[1]

Compared to pre-pregnancy, a number of physiological responses to exercise are all exaggerated during pregnancy and are likely to become greater as a pregnancy progresses. These include changes in heart rate, cardiac output, ventilation, and energy expenditure. In addition, increases in joint laxity also occur that could increase a woman's risk of injury. Therefore, for the S&C Trainer, the training prescription will need to be adaptable and flexible to accommodate these physiological changes and medical expert advice should be sought whenever necessary.[21]

POSTNATAL CONSIDERATIONS

A gradual return to exercise after childbirth can take place as soon as it is medically safe to do so and should occur when bleeding has stopped. This could be as little as a few days after birth, or it could be a number of weeks – depending on the type of birth (vaginal or caesarean) and whether or not this is complicated by other medical and/or surgical interventions. Following caesarean section, commencement of exercise should occur only when the surgical incision is fully healed. Consultation with an appropriate medical expert (eg, doctor or midwife) will guide the participant and the S&C Trainer as to when it is safe for the post-partum participant to return to exercise. Once medical clearance is gained, light activity will help recovery and well-being as long as it is in the context of the participant's history of exercise and current post-partum condition.

Benefits of postnatal S&C include:

1. Reduced anxiety and stress
2. Enhanced cardiovascular fitness and muscle conditioning. In lactating women this will not affect milk production or composition
3. Improved strength of the pelvic and abdominal muscles
4. Better sleep
5. Prevention of post-partum depression
6. Helping the participant lose the extra weight that they may have gained during pregnancy.[1]

Women returning to exercise after childbirth should aim to gradually increase activity to about 20–30 minutes per day and over time start to incorporate moderate to vigorous intensity exercise. As with all participants, if pain is experienced during exercise, the S&C Trainer should stop the session and encourage the participant to seek medical advice before further exercise sessions are scheduled.

During pregnancy and childbirth, the pelvic floor muscles will become weakened and the abdominal muscles will lengthen. In addition, some women may develop 'diastasis recti', a condition characterised by a separation of the two outermost parts of the abdominal wall formed by the rectus abdominis muscle. This typically occurs during the third trimester of pregnancy and can take up to six to eight weeks or longer to close.[65] The effects of pregnancy and childbirth on the abdominal and pelvic structures will vary between individuals and must be taken into consideration when prescribing exercises and intensities for the participant. Although the trunk musculature needs to be challenged in order to regain strength, exercises that significantly stress the abdominal wall, preventing the gap from closing (eg, abdominal exercises, including push-ups) should be avoided until the abdominal wall has fully healed. Sub-maximal bracing movements requiring isometric muscle actions can be developed progressively as part of the whole-body strengthening routine. High impact activities – such as running and jumping – should be avoided until the pelvic floor and associated muscles have regained some of their strength and stability following childbirth.

Other relevant physiological changes that occur during pregnancy and that continue postpartum, including the hormonal changes, can result in an increased ligament and joint laxity. The hormone that has this effect is relaxin and it can continue to be produced three to six months after the baby is born. For this reason, it is important that participants do not perform ballistic movements and/or stretching routines that require the participant to go into extreme ranges of movement until joint and ligament stability have recovered.

Some questions that the S&C Trainer should ask their participant in preparation for a return to exercise are:

1. What type of training or exercise did you perform throughout your pregnancy?
2. When did you give birth?
3. Did you experience any complications during pregnancy or birth?
4. What advice have you received from medical experts regarding your return to exercise?

In order to make the participant's return to exercise a positive experience, the S&C Trainer can offer the following advice to prepare them for the session:

1. If you are breastfeeding, feed your baby or express your milk before your workout to avoid discomfort
2. Wear loose-fitting clothing that will help keep you cool
3. Wear a bra that fits well and gives plenty of support to protect your breasts
4. Have a bottle of water handy and take several sips during your workout.[1]

EXERCISE	DESCRIPTION	SETS/REPS
Isometric holds	Either sitting or standing with knees slightly apart, squeeze the pelvic floor as if trying not to pass wind and squeeze the muscles as if trying not to pass urine. Then squeeze both together and hold for as long as possible. Initially the duration of hold may just be 2–3 seconds, but this should gradually be increased as the participant gets stronger and can be taken up to ~10 second holds. Rest for ~10 seconds between each squeeze	Work up to 10 repetitions
On-off contractions	Use the same techniques as described for the isometric holds, but rather than continuing to hold, release the tension immediately then repeat the squeezing action	Work up to 3 x 10 repetitions
*Kegel exercises	Squeeze and hold the vaginal muscles for 10 seconds and then slowly release. Squeeze again and release quickly.	Work up to 10–20 repetitions

*Kegel exercises aim to prevent or control urinary incontinence and other pelvic floor problems

Table 10. Pelvic floor exercise routine examples[65]

4.5 EVALUATE PARTICIPANT/ATHLETE PHYSICAL STATUS

This section considers the 'level' of the person or people you are working with. Although you may have considered their goals, sport-specific requirements, and run through pre-participation health screening as well as gaining consent to work with them, the level at which you need to prescribe the session or programme can be best assessed through a number of measures discussed here.

4.5.1 RISK STRATIFICATION (PRE-PARTICIPATION EXERCISE SCREENING)

The process of separating participants into high-risk, low-risk, and the ever-important rising-risk groups, is called risk stratification. Having a platform to stratify participants according to risk is key to the success of any S&C programme.

Health conditions (eg, diabetes, asthma), the medications associated with their management and/or the physiological effects of the illness can affect the participant's ability to tolerate prescribed training. The type and severity of the illness must be understood if the S&C Trainer is to programme an appropriate training load. Consultation and clearance to begin training with relevant medical/support staff is likely to be necessary to avoid the S&C Trainer overstepping their professional boundaries – the PAR-Q and the consultation process should highlight areas for further exploration and/or referral.

Trainers should be aware of any impairment that a participant may have. Disabled people benefit from S&C just as much as the non-disabled: although there may be accessibility issues in many places, discrimination is unlawful. Most professional organisations and bodies have disability awareness policies and many also offer programmes and information to help support disabled people to get into sport and training. (see UKSCA Equality and Diversity Policy available at www.uksca.org.uk)

Table 11 shows a brief overview of when a trainer may need to seek medical referral; Table 12 (the Irwin and Morgan Risk Stratification Tool) gives more specific guidelines for the S&C Trainer.

NEED FOR INSTANT REFERRAL	Previous diagnosis of disease • Cardiovascular • Metabolic • Pulmonary Suspected symptoms of any of the above
SPECIAL ATTENTION OR TEMPORARY DEFERRAL OF TRAINING	Any minor musculoskeletal injury contraindications including • High blood pressure • Alcohol/prohibited substance use • Smoker • Family history of coronary heart disease
UNCERTAINTY	If you have any doubt or concerns over any aspect, err on the side of caution and refer
CLIENT PREFERENCE	If the participant has any concerns or doubts, err on the side of caution and refer

Table 11. Medical referral

The Irwin and Morgan Risk Stratification Tool Takes the form of a simple traffic light system, the categories of risk are demonstrated in Table 12.

LOW RISK	
Overweight	No complications
High/normal blood pressure	(130–139/85–89) not medication-controlled
Deconditioned	Due to age or inactive lifestyle
Type 2 diabetes	Controlled by diet
Older people aged >65	No more than two CHD risk factors and not at risk of falls
Antenatal	No symptoms of pre-eclampsia/no history of miscarriage
Postnatal	Provided 6/52 check complete and no complications
Osteoarthritis	Mild where physical activity will provide symptomatic relief
Mild bone density changes	BMD>1SD and <2.5 SD below young adult mean
Exercise-induced asthma	Without other symptoms
Smoker	One other CHD risk factor and no known impairment or respiratory function
Stress/mild anxiety	Asymptomatic
Seropositive HIV	
MEDIUM RISK	
Hypertension Stage 1	(140–159/90–99) Medication-controlled
Type 1 diabetes	With adequate instructions regarding modification of insulin dosage depending on timing of exercise and warning signs
Type 2 diabetes	Medication-controlled
Physical disabilities	No other risk factors
Moderate OA/RA	With intermittent mobility problems
Clinical diagnosis of osteoporosis	BMD -2.5 at spine, hip or forearm or ->4 on fracture index, with no history of previous low trauma fracture
Surgery – pre and post	General or orthopaedic, NOT cardiac
Intermittent claudication	No symptoms of cardiac dysfunction
Stroke/TIA	> 1 year ago. Stable CV symptoms. Mobile and no assistance required
Asthma	Mild (ventilator limitation does not refrain submaximal exercise)
COPD (Chronic Obstructive Pulmonary Disease)	Without ventilator limitation but would benefit from optimisation of respiratory
Neurological conditions	System mechanics and corrections of physical deconditioning – eg, young onset of Parkinson's disease (stable); multiple sclerosis
Early symptomatic HIV	Moderately diminished CD4 cells, intermittent or persistent signs and symptoms – eg, fatigue, weight loss
Chronic fatigue syndrome	Significantly deconditioned due to longstanding symptoms
Depression	Mild to moderate
Fibromyalgia	Associated impaired functional ability, poor physical fitness, social isolation, neuroendocrine and automatic system regulation in disorders
HIGH RISK	
Older people >65 at risk of falls	REFER DIRECT TO FALLS SERVICE
Frail older people with osteoporosis and history of fracture	(BMD) >-2.5 at spine, hip of forearm in the presence one or more documented low trauma or fragility fractures REFER DIRECT TO FALLS SERVICE
Unstable and uncontrolled cardiac dysfunction	
Claudication with cardiac dysfunction	
Orthostatic hypotension	Fall SBP - 20mg/Hg within 3 mins of standing
Stroke / TIA	Recent (>3 months ago)
Severe OA/RA	With associated mobility
Type 1 or Type 2 diabetes (advanced)	With associated mobility
Moderate to severe arthritis	With accompanying autonomic neuropathy, advanced retinopathy
COPD/emphysema	With true ventilator limitation
AIDS	With accompanying neuromuscular complications severe depletion of CD4 cells, malignancy or opportunistic infection
Psychiatric illness/cognitive	AMT score<8

CHD = coronary heart disease OA = osteoarthritis RA = rheumatoid arthritis BMD = bone mineral density TIA = transient ischaemic attack (mini stroke) COPD - chronic obstructive pulmonary disease

Table 12. Irwin and Morgan Risk Stratification Tool

4.5.2 PHYSICAL TESTING

Physical assessment (when supported by other information gathering) presents an opportunity to collect information that will help with planning and reflecting on the success of a training intervention. Assessment – whether anthropometric (height, mass, BMI, body composition) or performance (strength, speed etc) – should be performed objectively and intervention programmes based on the result.

Avoid collecting information that will not be used as it is time-consuming, inefficient and may negatively affect participant engagement. For example, recording a 5km time trial can be replaced by a maximum aerobic speed test (MAS test) to prescribe training loads far more easily than a 5km time trial.

There must be 'informed consent' from participants whereby they have been made aware of all the potential benefits, as well as risks, of starting training. This consent stage should coincide with the initial consultation and completion of the Physical Activity Readiness Questionnaire (PAR-Q) (see 4.3.1 Pre-participation health screening). Trainers should be aware that any exercise can be used as an assessment tool for movement quality, technique, posture and ability.

WHAT MAKES AN EFFECTIVE PHYSICAL TEST?

Specific: Specific tests replicate the biomechanical and energy system demands of a particular physical activity or sporting action. Tests should measure only one variable, with no interference from other factors in order to remain purely specific and therefore valid.

Accurate: Assessment should be repeatable (ie, reliable) and accurate (valid). The same protocol and conditions should always be used and the same consistency should apply to the equipment used. For example, if a maximal test was carried out on two pieces of cardiovascular equipment from different manufacturers, the test results would be neither accurate or repeatable owing to potential differences between the two machines. A good habit is to keep a record of any key information about the testing process in order to be able to refer back to it in the future.

Validity: A test is only valid if there is good evidence to support the claim that it does measure the target physical quality you are trying to measure. For example, how closely a field-based measure of aerobic capacity eg, YoYo test relates to a direct measure of actual oxygen upteake in a laboratory setting (see 4.5.2 Physical testing). A bank of 'normative data' should be available for each chosen test as it is important to be able to compare and contrast an individual's test outcomes to this, enabling training objectives to be set. It should be noted that although normative data may be essential, its validity is linked to how the data was collected. If methods differ from the trainers test validity is questionable.

Timing: Assessments should be agreed by all parties and conducted at appropriate times (eg, after a set number of blocks or training cycles). Dates and times should be fixed on the initial communication and then adhered to. For example, a participant engaging in sport may have formalised assessment 'windows' pre-season, mid-season and post-season, as well as having ongoing weekly assessment through observation and coaching.

Education and reporting of results: Trainers should educate any relevant parties as to the method of assessment, the rationale, the timing and the agreed action plan. Results should be kept confidential and only shared with those who have given prior consent.

SOME METHODS OF DATA COLLECTION:

Monitoring: Ongoing tracking of training loads and performances on a session by session basis

Assessment: Measurement of specific qualities or variables normally within a training phase to identify any changes/adaptations

Testing: Normal administration of a battery of several tests before and after an intervention.

4.5.3 ANTHROPOMETRIC MEASURES

Anthropometric measurements are used to assess the size, shape and composition of the human body. Simply knowing how much someone weighs does not reveal much about their overall condition, but a small person with a low percentage of body fat will be more successful as a jockey than they would be as a forward in rugby union. S&C Trainers can also use these measurements to monitor a participant's body to ensure they stay in physical shape.

Measurements of weight, BMI and physical shape can cause anxiety or embarrassment with individual participants. This is the case for all sexes and not exclusive to females. S&C Trainers should consider the negative impact of taking such measurements in someone who is under- or over-weight, and that doing this could easily outweigh any benefit in knowing this information. In this case, the S&C Trainer could encourage the participant to measure themselves and keep these as part of a way of assessing their progress towards their goals, albeit privately.

Height: Standing height should be measured using the stretch stature method. Stretch stature is measured by recording the maximum distance from the floor to the vertex of the head (the highest point of the skull).

- Measurements should be taken with shoes removed, using a stadiometer
- The participant's feet should be together and flat, with the buttocks, back and head in contact with the stadiometer
- Place the hands along the line of the jaw and instruct the participant to take a deep breath keeping the head upright and eyes looking forward
- Place the head board firmly down on the head and gently lift the head upright
- Record the measurement at the end of the participant's deep inward breath.

Bodyweight: Participants should be measured in bare feet, without excess clothing and on calibrated scales with their hands by their sides. To aid reliability, measurements should be consistently taken at the same time of day, in the same clothing and with an empty bladder. When practical, use the same set of scales.

Body Mass Index: The Body Mass Index (BMI) is a formula used to calculate if a participant is within acceptable bodyweight ranges in relation to their height. Although useful across general populations, BMI is less reliable for the following groups:

1. Athletes - BMI does not differentiate between fat mass and muscle mass, so the result for a muscular athlete may actually put them in the overweight category
2. Older people
3. Some ethnic groups
4. Pregnant women

The calculation is worked out by:

$$\text{BMI (kg/m}^2) = \frac{\text{Weight (kg)}}{\text{Height}^2\ (\text{m}^2)}$$

For example, a man who weighs 88kg and is 179cm tall:

$$\text{BMI} = \frac{88}{1.79^2} = \frac{88}{3.20}$$

$$\text{BMI} = 27.7\ \text{kg/m}^2$$

Waist:Hip Ratio: This is the ratio of waist circumference to the hip circumference. The higher the ratio, the more fat is stored around the waist or abdomen – in other words, an 'apple shape'. This shape poses a greater health risk than fat stored elsewhere in the body - a 'pear shape'.

- Measurements should be taken with a tape measure
- Measure the circumference of the hips at the widest point of the buttocks
- Measure the waist at the narrowest point between the bottom of the ribs and the top of the hips
- Use any unit of measurement - waist measurement is divided by hip measurement
- Fat around the abdomen is linked to higher risk of diabetes, heart and circulatory disease and cancer
- High risk is defined as a waist:hip ratio above 0.90 for males and 0.85 for females

The calculation is worked out by:

$$\text{Ratio} = \frac{\text{Waist measurement}}{\text{Hip measurement}}$$

For example, a woman has a waist measurement of 78cm and a hip measurement of 100cm:

$$\text{Waist:hip} = \frac{78}{100} = 0.78$$

	CLASS	BMI
Underweight		< 18.5
Normal Acceptable		18.5 – 24.9
Overweight Special Attention		25 – 29.9
Obesity Medical Referral	I	30–34.9
	II	35 – 39.9
Extreme obesity	III	>40

Table 13. BMI classifications

4.5.4 PHYSICAL CAPACITY TESTING

A fitness test or assessment comprises a series of exercises that help evaluate overall health and physical capacity. There are a wide range of tests that can be used for general health and fitness evaluation; these tests contribute to the starting point for designing an appropriate S&C programme.

- Aerobic Capacity Tests (ACT) measure how efficiently the heart and lungs work to supply oxygen and energy to the body during physical activity
- Muscular capacity exercises measure the maximal amount of force a muscle group can exert at one time
- Muscle endurance testing measures the length of time a muscle group can contract and relax before it fatigues
- Measuring the flexibility of your joints is vital in determining postural imbalances, foot instability or limitations in range of motion.

Basic movement competency can be assessed across all training and all movements and every opportunity should be used to gather information on participants. Assessment can provide valuable information regarding a participant's ability to move and tolerate load.

TEST	PHYSICAL QUALITY	EQUIPMENT NEEDED
Shuttle run (4 or 5 min)	Maximal ACT	Recording sheet Cones Stopwatch
Cooper test	Maximal ACT	Recording sheet 400m track (preferably) Stopwatch
Bleep test	Maximal ACT	Recording sheet Cones Stopwatch Audio recording
Yo-Yo recovery test Level 1	Maximal ACT	Recording sheet Cones Stopwatch Audio Recording
Adapted cardiovascular tests (treadmill, rower, bike, 'Airbike', upright bicycle, cross trainer, elyptical trainer, stepper)	Maximal ACT	Recording sheet Relevant piece of CV equipment
Muscular capacity push-up test	Muscular endurance	Recording sheet Stopwatch Metronome
Muscular capacity horizontal row/ pull-up test	Muscular endurance	Recording sheet Stopwatch Metronome
Muscular capacity lateral hold test	Muscular endurance	Recording sheet Stopwatch
Sargent jump	Explosive leg strength	Smartphone app (eg, my jump 2)
Lying active leg raise	Hamstring flexibility	Smartphone app (eg, iHandy level)

Table 14. Fitness testing. Table shows suggested methods for assessment for differing physical qualities

ASSESSMENT PROTOCOLS

SHUTTLE RUN (4/5 MINUTES)

- Set up a 20m (measured) shuttle marked out with cones allowing adequate space for the group size
- Warm-up allowing participants the opportunity to practise turning prior to starting the test
- The test can be conducted over 4 or 5 minutes and is a maximal 'best effort' test
- Participants run continuously and upon completion record their total number of complete shuttles. In larger groups, participants can work in pairs with partners recording each other's results.

The results for each participant can be used to calculate their maximal aerobic speed (MAS), giving the metres covered per second for individual (m/s).

Example using a four-minute shuttle:
Number of shuttles 42
Shuttle length = 20m
Time = 240s
MAS = distance/time = (42x20m)/240s =3.5 m/s

This figure can then be used to prescribe individual distances in a shuttle-based drill

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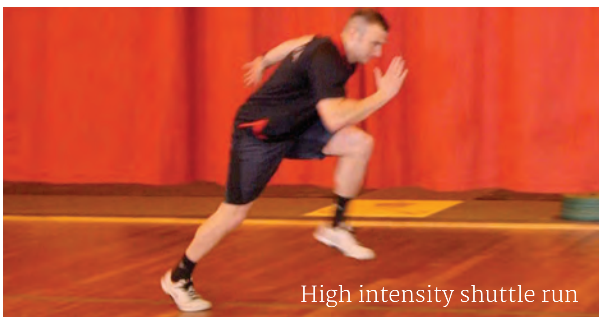
For example, using a work:rest ratio of
30s:15s for 6 reps at 100% MAS

- MAS = 3.5m/s • (Work) time = 30s
- Distance = MAS x time = 3.5m/s x 30s = 105m
- The participant must cover 105m in 30s. Rest for 15s.
- Repeat 6 times.
- Each repetition will contain 5 x 20m shuttles plus a final partial shuttle of 5m
- Trainers can use different colour marker cones for the individual distances when working with a group.


High intensity shuttle run

COOPER TEST

- Warm up the participants
- Participants run continuously around a 400m track for 12 minutes. If a track is not available, a pitch can be used with straight linear shuttles. Trainers must accurately measure the distance prior to the start of the Cooper run to account for differences in dimensions of pitches
- Participants can be given a 'running time' at the end of each lap
- The score is the total number of metres covered in the 12 minutes
- MAS can also be calculated from results.

BLEEP TEST

The test should be carried out using the relevant bleep audio track. Ensure the audio track is complete and a suitable speaker system is used.

- Set up a 20m (measured) shuttle marked out with cones allowing adequate space for the group size
- Warm-up, allowing participants the opportunity to practise turning prior to starting the test
- Participants should 'pace' themselves in early levels to arrive at the end of each shuttle 'on the bleep'
- Participants who fail to reach the end of a shuttle before a bleep are allowed two further attempts to make the line at the required pace before being withdrawn
- The last completed level is recorded as the result
- Using the results a maximum oxygen uptake ($vo_2{}^{max}$) can be estimated.

YO-YO RECOVERY TEST LEVEL 1

The test should be carried out using the relevant bleep audio track. Ensure the audio track is complete and a suitable speaker system is used.

- Set up a 20m (measured) shuttle marked out with cones allowing adequate space for the group size. There should also be a further 5m line laid out as the 'recovery line'
- Warm-up, allowing participants the opportunity to practise turning prior to starting the test

- Participants start at the middle line and begin running when signalled by the beep. Turn at the top cone and run back to the starting point when signalled by the beep
- There is 'active recovery' of 10s between every 40m shuttle. Participants must walk/jog around the 5m cone in this 10s period and return back to the start
- Participants who do not complete a full shuttle are given two warnings before being removed
- A warning is also given for participants who 'false start' or fail to cross the 20m line with their foot
- The last completed shuttle is used as the result.

ADAPTED CARDIOVASCULAR TESTS

Trainers can adapt the MAS principle on a range of cardiovascular machines, such as a rower, bike, arm-bike or airdyne bike.

- The test can be conducted over 4 or 5 minutes and is a maximal 'best effort' test
- Participants work maximally for the set time, recording a 'best effort' distance upon completion
- The results for each participant can be used to calculate MAS, (m/s), giving the metres covered per second per individual (m/s)
- Trainers should be aware that results are only relevant and specific to the piece of equipment on which the test was performed.

MUSCULAR CAPACITY PUSH-UP TEST

The test is done accurately using a metronome app set at 60hz.

- Participants lie in a press-up position with hands by their sides. A partner places a clenched fist on the floor under the sternum
- In time with the metronome, participants complete full repetitions until failure
- Participants must touch the tester's hand in the bottom position and fully extend at the top position
- Technical faults include failing to extend fully, loss of trunk position and failure to keep to time.

MUSCULAR CAPACITY HORIZONTAL ROW/ PULL-UP TEST

The test is done accurately using a metronome app at 60hz.

Horizontal row

- Securely attach a bar in a squat rack or squat stand, at a height where the participant can grab the bar with their shoulders flexed to 90°
- Lying down with the bar in line with the shoulders, grip the bar with a closed overhand grip. Participants extend their hips so the pelvis and lower back are off the floor
- In time with the metronome, participants complete full repetitions until failure
- Participants must fully extend their elbow at the start position and their sternum should touch the bar when ascending
- Technical faults include not extending the elbows fully, the sternum not touching the bar, a loss of trunk position and failure to keep time.

Pull-up

- Participants 'dead hang' from a pull-up bar with the body fully extended and still
- Using a closed overhand grip, pull up vertically until the chin clears the bar
- The repetitions are completed in time with the metronome
- There should be no excessive movement through the body
- The test finishes when the participant can no longer clear the bar with their chin
- Technical faults include not fully extending to a 'dead hang' position, excessive movement/ swaying and failure to keep to time.

MUSCULAR CAPACITY LATERAL HOLD TEST

Lateral hold

- The test can be done either individually on a glute-ham bench, or using a normal bench and the assistance of a partner to fix the legs
- The body should be aligned through the shoulders, hips and feet parallel to the floor
- The shoulders and hips should be aligned vertically with the floor

- Participants are to hold the position until a point of failure or when the shoulders drop below 3cm from the starting position
- The test result is the total time the position is held.


Lateral hold

Prone hold

- The test can be done either individually on a Glute-Ham bench, or using a normal bench and the assistance of a partner to fix the legs
- The body should be aligned through the shoulders, hips and feet perpendicular to the floor
- Participants are to hold the position until a point of failure or when the shoulders drop below 3cm from the starting position
- The test result is the total time the position is held.

SARGENT JUMP

The Sargent jump is a 'jump-and-reach test' which is included in this section because it requires minimal equipment (ie, a wall and chalk). If the S&C Trainer has access to a device that measures jump height (eg, Just Jump system, Optojump etc), a more reliable alternative test would be a counter movement jump with the hands placed on the hips. The Sargent jump involves a coordinated upper and lower body movement – this may enable the participant to jump higher, but the reliability of the test may be reduced depending on the coordination abilities of the participant.

- **Start position:** Stand with the right side of the body next to the wall. Extend the right arm over the head and make a chalk mark on the wall. The left arm can remain by the sides of the body. Stand with the feet hip-width apart, and parallel or slightly turned out, with the weight distributed over the midfoot
- **Countermovement:** Perform the countermovement by simultaneously flexing at the hip, knee and ankle, allowing the arms to swing behind the body. This allows the participant to drop into a quarter squat position – this is typically known as the 'jump' position
- **Jump:** Explosively 'jump' by extending through the hips, knees, and ankles, moving the arms forward and upwards at the same time. Place a chalk mark with the right hand on the wall at the highest part of the jump. Body alignment in flight should reach full triple extension, with arms overhead
- **Landing:** The participant should be instructed to land in the same point as take-off, with feet wide enough (typically shoulder-width) apart to faciliate a stable landing
- The jump height is determined by subtracting standing reach height from the jumping height reached
- Common technical faults include a failure to maintain hip, knee, and ankle alignment (ie, valgus or varus present) and inadequate flexion of the hip (ie, countermovement predominantly achieved through knee and ankle flexion only) which will likely reduce jump height.

LYING ACTIVE LEG RAISE

The purpose of the active leg raise test is to assess hamstring muscle-tendinous unit (MTU) flexibility. Hamstring strain injuries are prevalent in participants involved in running-based sports[7,18] and occur more frequently in participants with an inadequate range of motion and strength (particularly in eccentric actions) in the hamstring MTU.[6]

- Lie supine, with the testing leg at 90° hip flexion and 90° knee flexion. Instruct the participant to hold their lower leg and then extend the knee until they achieve their full range of motion
- Common faults or compensations include a posterior tilt of the pelvis or hip extension
- A normal range of motion is 70° of knee extension from start to finish position of the test.[16]

4.5.5 MOVEMENT SCREENING

A pre-participation movement screening tool is designed to identify compensatory movement patterns that might indicate sub-optimal movement strategies that could reduce performance and increase injury risk.[3] Although there are various published screening protocols, evidence supporting their ability to predict injury risk is not well established, with some authors showing no link to injury[5,49,59] and others making claims that such tools are valuable in predicting injury risk throughout a season.[10,17,62,79] The reality is that factors that predispose an individual to injury are multifactorial[63] (see Figure 5) and some authors suggest that screening tools are unlikely ever to be able to predict injury risk with sufficient accuracy.[2]

Similarly, the ability of movement screening tools to predict athletic performance has also been questioned.[58] The reason for this could be down to a number of factors, including:

- Screening protocols typically do not assess movement quality under load or at high velocity and as such lack specificity to sporting actions
- Movements that require fast velocity will shift the focus of attention from internal (ie, what the body is supposed to be doing) to an external focus (ie, speed of the movement)
- Loading will alter the participant's movement strategy. Screening movements are often unloaded, although sport requires load tolerance from collisions, jump landings, changes of direction etc.

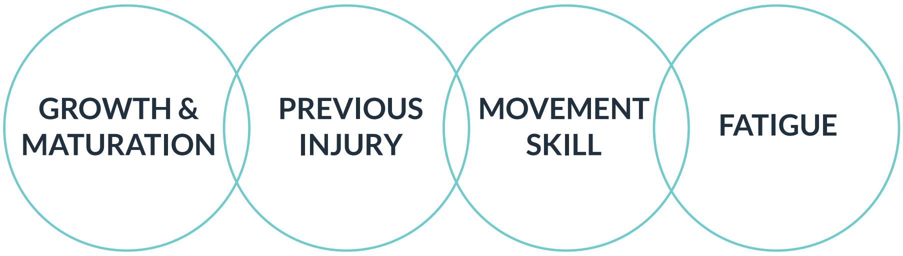


Figure 5. Factors predisposing an individual to injury

Despite these findings, the rationale behind the concept of a 'movement screen' is logical – the body is designed to tolerate and dissipate load, but if the joints are out of alignment they are unable to do this effectively. Compensatory movements, that remain uncorrected, could lead to the development of chronic overuse injuries later on in life.

In order to identify 'compensatory' movement patterns, the kinematic sequence observed in the participant during the screening test will need to be compared to an 'ideal technical model'.

This represents the least injurious way of performing the movement. The technical models (see Section 6 Technical models: Foundation movements and Section 7 Technical models: Strength-based training) will give you a good starting point for assessing good quality movement; in addition, the repertoire of movements will also enable you to target specific movements relevant to the individual and the sport identified in the needs analysis (see 3.3 Sports/activity needs analysis and 4.4 Participant/athlete needs analysis).

A practical scoring system is shown below:

SCORE	CRITERIA
5	Excellent form with little or no deviation from the technical model
4	Good technique with a minor fault. The participant is safe to load
3	One or more significant technical faults. Unsafe to load until movements are mastered
2	Multiple technical faults
1	Exercise cannot be completed or pain is reported

Table 15. Scoring system

Example of jump and stick (bilateral and unilateral) movement competency:

Jump and stick (bilateral and unilateral)

- Tape markers are set at a distance equal to one third of the participant's height. Participants should use these individual markers each time they jump
- Clarify the technical points to the participant and how the criteria will be scored (see 6.4.2 Squat jump and stick)
- For the bilateral test, stand with feet hip-width apart and for the unilateral test, ensure left foot and right foot start position is assessed; participant in an upright posture
- Jump forward and 'stick' the landing on two feet in the bilateral test or one foot in the unilateral test, (ensure participant jumps from the same leg they land on); landing in a stable position
- Complete five repetitions
- Trainers should video and assess from a front and side position to see any deviation from the technical model.

As a S&C Trainer, you should be encouraged to develop your own philosophies on movement screening's relevance to your participants. Regardless of whether this tool is able to predict injury risk or indeed athletic performance, there are some additional benefits to conducting a movement screen that relate to the trainer-participant relationship. These include:

- Educating the participant about the importance of good movement quality and the benefits of supervision
- Raising the participant's awareness of their own movement capabilities – sometimes actual and perceived movement competencies are different things
- Accelerating the S&C Trainer's technical knowledge, observation skills and understanding of technical models
- Providing benchmark values for current movement competencies, which can be part of a testing battery or monitoring strategy to assess training programme effectiveness. Obvious improvements in this will help motivate your participant to continue to adhere to their training protocols
- If you are working with a group of 'new' athletes, this is a great way to assess their programme requirements, as well as to develop trainer-participant relationships.

4.6 GOAL SETTING

Together with a comprehensive assessment of the participant, the trainer should discuss and develop appropriate goals for the programme. Goals may follow an 'outcome', 'performance' or 'process' path. An **'outcome' goal** involves winning and describes the aspirational long-term goal that the participant is working towards. For example, winning the league at the end of the season, finishing in the top 8 at the World Championships or achieving a personal best time. Whilst it is important to set outcome goals, it is also important to remember that the participant will have little control over this type of goal as it is determined by how other competitors perform.

In contrast a **'performance' goal** describes what the participant will need to deliver to likely achieve the outcome goal. For example, a male 100m sprinter, based on previous World Championship times, would need to run faster than 10.08 seconds to achieve a top 8 place. The ability for the participant to focus upon specific aspects of the performance means that they are in control of this type of goal outcome.

Finally, **'process' goals** centre around how to develop longer term skills and qualities that will contribute to future success and the achievement of the performance goals eg, the development of wide-ranging movement and skill competency in young developing athletes.

It is not uncommon for S&C programmes to have all three types of goal, however, S&C Trainers should prioritise details relating to performance and process goals in the planning process since these are within the participant's and S&C Trainer's control. The assumption is that an outcome goal, which centres around a specific performance-related outcome, will only be possible by developing process goals such as consistent training, overall education and associated areas such as nutrition and recovery strategies. To positively affect an outcome, there will always need to be a plan as well as an excellently delivered process.

4.6.1 SMART GOALS (SPECIFIC, MEASURABLE, ACHIEVABLE, RELEVANT, TIME-BOUND)

Specific: Set precise and specific goals and avoid being too general. It is difficult to measure success with general goals such as 'get stronger' or 'get fitter'.

For example:
General goal (weak): 'get stronger'
Specific process goal: Complete two x 20-minute foundation movement skills sessions weekly for four weeks
Specific performance goal: Improve 5RM deadlift by 15kg in 12 weeks

General goal (weak): 'get fitter'
Specific process goal: Complete two shuttle run energy systems training sessions each week for six weeks
Specific performance goal: Improve bleep test score from 11.2 to 12.5 in 12 weeks

Measurable: Trainers must use standardised measures that are accurate, repeatable and valid. Used on an individual basis, they will allow comparison to previous tests, or normative results from similar populations.

Achievable: There is a fine balance between setting a goal that is unachievable and one that does not create enough challenge. Both can potentially result in a loss of motivation and monotony: trainers should seek to challenge while remaining realistic. Effective communication with participants will aid this process and they should be involved throughout the process.

Relevant: The participant should agree that the goal is worthwhile and they are motivated to reach it. Creating a goal with a motivation attached to it will give relevancy. Pinpoint why a goal is important to the participant.

Time-bound: Scheduling fixed dates and times for review will be more effective than vague dates in the future.

Further individual analysis of participants' needs should add context to the goals, bearing in mind that there will always also be some generic training considerations.

4.7 ESTABLISH TRAINING CONTENT

The structure of the S&C session should be given adequate thought and preparation. Training sessions will not develop desired physical qualities when selected in a random manner and should be purposeful and planned. Sessions should fit into a long-term plan and be goal-specific, based on that overall plan. Reflect on the ability of a session's structure to meet the needs of the participant and progress/regress content where necessary. There may be instances where multiple objectives are targeted in one session, eg, when a participant requires strength development and energy system development in the same session.

4.7.1 WARM UP (RAMP)

Warm-ups should follow a **RAMP** protocol and the content should be guided by the session eg, gym-based versus field-based. RAMP warm-ups should seek to:

- **Raise** (increase) body temperature, blood flow, heart rate, joint fluidity and psychological arousal
- **Activate** key muscle groups
- **Mobilise** key joint sites through their full range of motion
- **Potentiate:** finish with high intensity activities relevant to the main training session.

All elements of a RAMP warm-up can be developed simultaneously and should not be delivered separately. Increase warm-up intensity from low to high, with general activities becoming more specific.

Specific session content should be underpinned by the 'principles of training' (see 3.2 The principles of training), but it is the 'acute variables of training' that allow flexibility in delivery. By manipulating the variables of training, the body's systems and fuel stores can be progressively overloaded resulting in improvements. Variables of training include the following: frequency, intensity, volume, exercise order and group dynamics.

4.7.2 FREQUENCY

Frequency relates to how often training takes place. Training multiple physical qualities simultaneously will impact on results. There is an inverse relationship between frequency and both intensity and volume. For example, without sufficient recovery, participants will be unable to maintain a high frequency of training if it is both high volume and high intensity.

Some factors to consider:

- As the training age of youth participants increases, so too will their ability to recover and thus higher frequency of sessions may be possible
- In older participants there will be a decreased ability to recover
- The genetic profile of individuals can impact recovery
- Be mindful of the psychological as well as physical demands when programming a high frequency of sessions. High frequency of training can lead to overtraining and monotony if not planned correctly.

4.7.3 INTENSITY

Intensity relates to 'how hard', or how close to maximal load, velocity or effort the training is and this is inversely related to volume, ie, is volume-dependent. The relationship between the intensity of exercise and its duration are central to developing adaptations in physical qualities. The higher the intensity of a session or exercise, the greater the need for lower volume and longer recovery periods. It is important to remember, however, that there is a 'threshold' of intensity that is required to elicit any required training adaption. For example, to improve VO_2max in well-trained distance runners, training intensities that achieve near or maximal VO_2max values are necessary.[52] For training to be effective, it is important that the S&C Trainer understands what the 'threshold intensities' are that participants need to achieve. Training below this level will not only be ineffective in achieving the targeted training adaptation, but will induce greater fatigue that may compromise training of other fitness qualities, perhaps leading to overtraining. Psychologically, this can have detrimental effects on motivation, particularly if the participant is training hard and not showing improvements in test results.

4.7.4 VOLUME (SETS, REPETITIONS, DENSITY)

Volume relates to the amount of training prescribed and can relate to per session/day/week/month/year. It is measured in distance, time, repetitions, sets and load. The more exercise participants complete across multiple variables, the greater the cumulative fatigue will be and thus the need for increased recovery time.

Sets

The number of sets of any given exercise will be driven by the intended physical outcome, phase of training, available time and individual responses to training.

A set contains multiple repetitions interspersed with periods of recovery. There is an inverse relationship to repetitions – meaning the lower the number of repetitions, the greater the need for multiple sets and vice versa.

For example:

- Eight sets of two repetitions
- Four sets of ten repetitions

Repetitions

A repetition is one complete movement of an exercise.[23] Repetition selection is prescribed based on load and the intended outcome of the session. High repetitions, low intensity generally improves muscular endurance; low repetitions, high intensity generally improves muscular strength. Trainers should be aware that these are broad guidelines and there may be instances where they are not relevant, eg, with beginners, where there will be strength adaptations at higher repetition ranges.

Density

Training density can be manipulated within a session by pairing or grouping exercises together through 'super sets' or 'tri sets'. This will allow a greater volume of work to be completed in a shorter period of time. Exercises are typically paired together in two ways: agonist/antagonist pairs (eg, a set of bench press followed by a set of pull-ups which can then be repeated for multiple sets); or multiple exercises for the same muscle group(s) which are performed consecutively (eg, a set of shoulder presses, followed by a set of lateral raises and then a set of bench presses and then repeated for multiple sets).

4.7.5 EXERCISE ORDER

Exercise order should follow a structure that ensures priority is given to large muscle groups and the most technically demanding exercises first following a warm-up, as illustrated below:

1. Technique, mobility and foundation movement quality
2. Explosive exercise
3. Speed and agility
4. Strength-based training
5. Energy-systems training

4.7.6 GROUP DYNAMICS

Working with a group rather than an individual can present challenges specifically relating to the time available to coach on an individual level. Group sessions can dilute the coaching impact but may enhance work ethic and enjoyment through appropriate competition. When working with greater numbers, trainers may divide participants into groups and appoint more experienced individuals to act as leaders in delivery.

When working with both groups and individuals, it is important to remember that the exercise programme prescribed (ie, exercise selection, equipment used, etc) by the S&C Trainer should be tailored to the sport-specific and individual needs/goals of the participants (see 3.3 Sports/activity needs analysis and 4.4 Participant/athelete needs analysis); it should also be appropriate for the facility/space where the training will take place. Management of large groups – especially when relatively large participant-to-S&C Trainer ratios are involved – is key to running an effective S&C session and should be considered during the planning process. Key areas for deliberation include:

Grouping of participants: Levels of ability, psychological maturity and readiness to engage with S&C training can be very variable in group sessions, particularly when working with young athletes. Therefore, participants should be 'buddied up' with compatible training partners that enable all individuals to learn and develop within the session. More mature participants with a higher trainer age might be budding S&C Trainers and through a process of education, can be encouraged to help coach more junior and/or potentially younger members of the group. This allows for more coaching to take place within the session overall and enables participants to focus their attention on the important aspects of the programme (ie, correct movement techniques, safety within the space, training with intent, and so on).

Personalities can also be organised within training groups, and participants with a greater understanding of the rules and etiquette expected during S&C sessions can be paired with those who have less knowledge and/or who are less willing to conform to the expected standards of behaviour. Managing participants' personalities can have a positive effect on others' behaviour in order to help maintain a safe and positive training environment; it can also provide a healthy level of competition and/or encouragement to optimise training effectiveness.

With regards to young athletes, although they will benefit from S&C training from a very young age,[22,45] youths must first demonstrate the psychological maturity to be able to train effectively in the S&C environment. This means that, firstly, they must not present a risk or a distraction to others participating in the session and secondly, they must not present a risk to themselves. The S&C Trainer needs to feel confident in being able to make a judgement about when a youth should be enrolled in S&C.

S&C Trainer positioning: The S&C Trainer should position themselves within the training space to ensure that maximum visibility of the group is guaranteed at all stages and that individuals within the group performing potentially higher risk activities (eg, those learning new skills/movements or those lifting heavy loads) receive the appropriate amount of supervision. The use of non-verbal communication methods is necessary to maintain contact with the whole group, including those not in immediate proximity to the S&C Trainer, especially in a noisy environment (eg, when music is being played). The S&C Trainer should circulate around the space throughout the session to ensure that all individuals have equal access to their time.

The S&C Trainer-to-participant ratio: This will determine the amount of feedback and instruction participants will receive during the session. Depending on the age, maturity and competency of the group members, consideration should be given to the appropriate number of trainers to participants. In general, a ratio of 1:up to 12 is recommended.

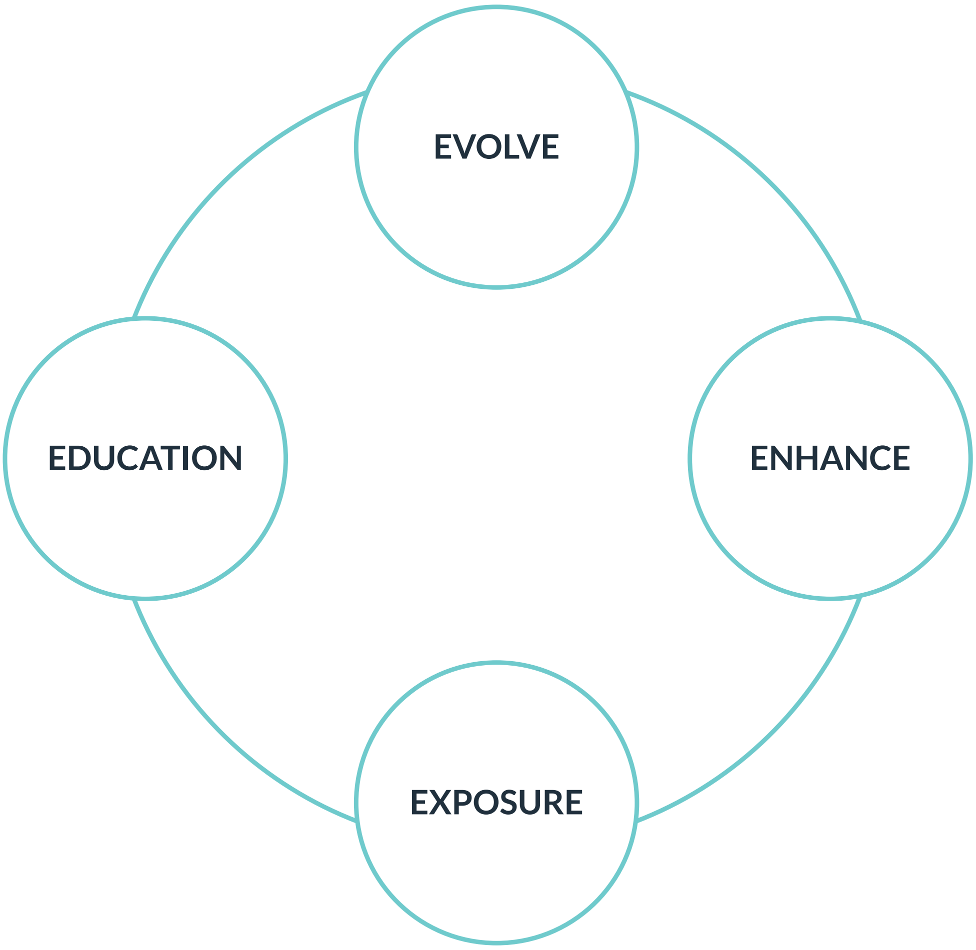


Figure 6. Evolve-Enhance-Exposure-Education

Figure 6. Evolve-Enhance-Exposure-Education outlines a process for developing individuals and groups. Education is central to achieving both 'buy-in' and commitment. There is no endpoint to the education process and it will be present throughout the training life-cycle, helping to develop 'self-sufficient' participants who fully understand the training process. Exposure and enhancement occur simultaneously as participants move through the long-term training plan over weeks and months. Development will occur through effective coaching, challenge and progression. Finally, the plan must evolve to challenge further and to cater for developing specific goals/position.

4.8 REVIEW OF PLANNING AN EFFECTIVE S&C PROGRAMME

Once designed, the S&C Trainer can deliver and coach the training session(s) to the athlete/participant, ie, carry out the 'Do' part of the Plan-Do-Review process (see 4.2 The planning process). The microcycle can be repeated for a number of consecutive weeks, ie, to form a mesocycle (see 4.1 Introduction) and progressive loading each week can take place provided that the athlete/participant can tolerate the amount of training included in the programme and that sufficient recovery is provided through the inclusion of 'lighter' training weeks. It is important to understand that it is these lighter training weeks that will allow athletes/participants to recover from and adapt to the training loads applied to them; they should therefore see an improvement in performance of the specific capacities the training programme was designed to address.

The final part of the coaching process is to review the programme that has been delivered – both the content and how the programme has been delivered (eg, management of environment, coaching and communication style, effectiveness of feedback etc) so that improvements can be made to future planning. Monitoring and testing will provide valuable information on the success of the programme. For example, attendance monitoring will provide some indication of whether the athlete/participant is enjoying the programme and whether or not they are motivated to continue training. Fitness testing data will also allow the S&C Trainer to make an objective judgement about whether the athlete/participant has adapted to the programme and achieved the session objectives set in the goal-setting process.

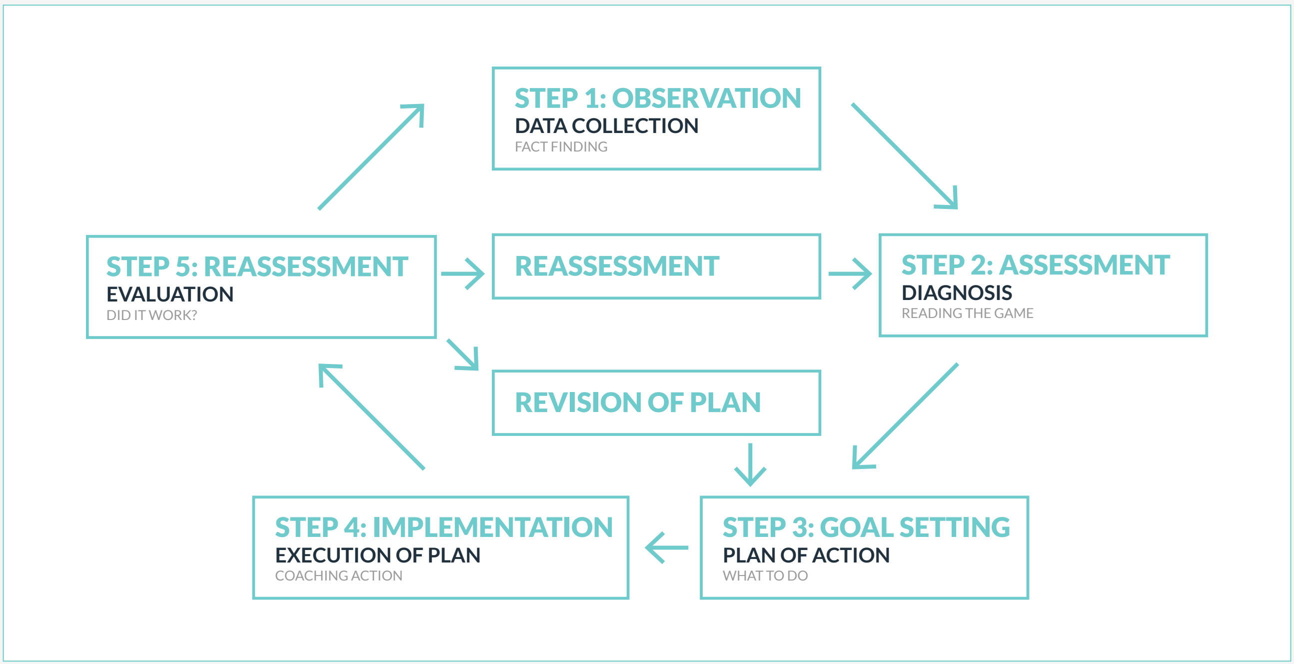


Figure 7. Coaching process – five-stage model (Fairs, 1987)

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