UKA Athlete Development Model

Introduction
Many coaches have requested guidelines surrounding long-term athlete development, specifically in relation to how to progress from when they first become involved in athletics through to international success. Among the many questions UKA receives every day include ‘When should athletes begin strength training and is it dangerous before a certain age?’ and ‘Is there a best time to begin training the aerobic energy system?’

This document and its accompanying reference material have been assembled to provide insight into how young athletes develop through puberty and the implications this has on training. It is important to realise that there is significant variation both between males and females and also individuals of the same sex. Therefore, coaches will always have to make judgements regarding what is appropriate for any individual and a conservative approach should always be employed whenever there is any uncertainty.

Within this document we have included diagrams to graphically illustrate how key factors that change throughout an athlete’s development. These diagrams are not intended to be interpreted without the accompanying information in this document. Where lines donating a change from one aspect to another at a specific age are included these should not be taken as definitive cut off point because this always relates to developmental age, which varies considerably from athlete to athlete. For example, in the ‘Training and competition Requirements’ diagram there is a line at 12 years of age showing a shift in priority from Local to Regional competition. In reality this shift in priority may occur at 11 or 13 or even 14. However, it would not occur at 25 for an athlete with the potential to be an Elite level senior athlete. So while the line at 12 years of age is not definitive cut off point as a general trend the shift would occur around that age rather than 25.

Any model will always have limitations and the UKA Athlete Development Model is a growing document that will be expanded upon as new research and information is published.

In order for this document to meet your needs we need your comments and feedback so we can clarify any areas of confusion. These comments can be submitted using the feedback comment form at the bottom of this document – http://coaching.uka.org.uk/document/uka6athlete6development6model/

For more information regarding athlete development in general be sure to check out the athlete development section on uCoach:

http://coaching.uka.org.uk/coaching/athlete_development/
Assumptions of the model:
The UKA ADM assumes an athlete will move through a program from age 9 to achieving a podium finish at the Olympic/Paralympic Games or World Championships.

We assume performance improves with training age. If an athlete enters the sport in more advanced years they may have to re-visit training components before moving onto more advanced topics but it may also be possible to develop a number of training parameters in parallel.

Future Developments
At present the UKA Athlete Development Model aims to provide information and guidelines regarding four key areas fundamental to Athletics coaching:

- Biological Development
- Training Considerations
- Training and Competition Requirements
- Physical Conditioning

In the future, the model will be expanded to include other topics such as psychological development, recovery and regeneration and nutrition and lifestyle etc.

Definitions
Chronological Age
**Chronological age** refers to “the number of years and days elapsed since birth.” Chronological age is not necessarily a predictor of an individual's stages of development, as children of the same chronological age can differ by several years in their level of biological maturation.

Development Age
**Developmental age** can be multifaceted and refers to the degree of physical, mental, cognitive, and emotional maturity. Unlike chronological age, children of the same developmental age will exhibit similarities in terms of their level of physical, mental, cognitive and emotional development.

Training Age
**Training age** refers to the number of years since the athlete began formal structured training in Athletics. Peak Height Velocity (PHV) Peak height velocity (PHV) is the maximum rate of growth in stature during growth spurts.

Absolute Intensity
**Absolute Intensity** refers to the level of performance in any given task relative to the absolute limits of human performance. In running events, the quicker the time, the higher the absolute intensity. In jumping and throwing events, the greater the distance the higher the absolute intensity. In physical preparation activities the heavier the weight lifted or the
greater the power output the higher the absolute intensity. As a result male athletes tend to exhibit high absolute intensities than females and adults higher absolute intensities than children.

Relative Intensity

Relative intensity refers to the intensity of an activity relative to one's own maximum potential at any moment in time. For example, in the Shot an athlete who can throw 20m is throwing at 50% relative intensity when they launch the shot 10m. In the 100m sprint an athlete that could cover the distance in 10s is working at 50% relative intensity when they cover the distance in 20s.

Eccentric Muscular Contraction

A muscular contraction that occurs as the muscle length is increasing. Eccentric contractions produce greater forces than other types of muscular contraction.

Bone Mineral Density (BMD)

A measure of the hardness of bone, reflecting the amount of calcium present in a given area. Tests for BMD are used to evaluate bone health and fracture risk.
Biological Development

In this section we will describe the key biological changes that occur as an athlete develops. Please note that training recommendations should be based on an understanding of the interaction between developmental changes throughout the athlete’s physiology on many different levels and so it is often not appropriate to base training on a single variable seen in isolation.

In the next section we will describe considerations for training when all these factors are considered together.
# UKA Athlete Development Model (V1.2)

## Figure 1: Biological Development

### Developmental Age +/-

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<tr>
<td>Biological Energy System Development</td>
<td>Alactic</td>
<td>Little variation in the alactic system with age</td>
<td>Lactic</td>
<td>Anaerobic glycolytic energy system does not fully mature until after puberty</td>
<td>Aerobic</td>
<td>Aerobic system predominates before puberty</td>
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### BioMECHANICAL Energy Return is a function of STRENGTH and CO-ORDINATION

**Boys**
- Muscle CSA
- Neural Recruit.
- Tendon & Bone
- Co-ordination

**Girls**
- Muscle CSA
- Neural Recruit.
- Tendon & Bone
- Co-ordination

**PHV**
- Strength expression is primarily a function of recruitment
- Strength expression is a combination of CSA and neural recruitment
- CSA changes are minimal and improvements in strength expression comes primarily from neural recruitment
- Tendon & Bone development lags behind Muscle CSA development
- Refinement of skills
- Increased risk of tendon related injury during PHV

*These diagrams are for illustration purposes only. They can only be fully interpreted after reading the accompanying notes and audio presentations.*
Biological Development Notes:

Developmental and Chronological Age

**Developmental age** refers to the degree of physical, mental, cognitive, and emotional maturity. Physical developmental age can be determined by skeletal maturity or bone. For coaches this is best assessed in relation to the rate of growth of the individual.

**Chronological age** refers to ‘the number of years and days elapsed since birth.’ However the rates of growth, development, and maturation vary greatly between individuals and so children of the same chronological age can have very different levels of biological maturation. Since many of the social aspects of our lives, such as when we begin school, and when we are legally considered an adult (18 in the UK), are related to chronological age it is included in the UKA Athlete Development Model. However the majority of the key considerations in the coaching of developmental athletes are more appropriately addressed after assessing the developmental age of the athlete.

Stage of Development

For the purpose of simplicity UKA have divided the physical development of a child up into four key stages:

- Pre-puberty: prior to the release of sex hormones where the child is growing steadily
- Puberty: the period of rapid growth that accompanies the release of sex hormones
- Post-puberty: the period of steady decline in growth that occurs after the initial onset of puberty
- Adulthood: The period of cessation of growth where physical maturation is completed.

The variation in rates of growth that accompanies these broad stages of development are demonstrated in Figure 2 below.
UKA Athlete Development Model (V1.2)

Figure 2: Growth Rate and Stage of Development

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BioLOGICAL Energy System Development

Biological energy system development is linked to puberty and the degree to which the alactic, lactic and aerobic metabolic pathways contributes to energy production changes as the levels of hormones varies within the human body.

The anaerobic (in the absence of oxygen) energy system is the primary energy supply mechanism in short duration, high intensity activities. Unlike the aerobic, the anaerobic system can supply energy immediately on demand. However, anaerobic energy supply is expensive in terms of both the fuel stores consumed, and in terms of the fatiguing effects of the resulting waste products circulated within the body. Anaerobic energy supply systems are adapted to providing energy during short-term power events such as jumps, throws, and short sprints. As event duration increases, and peak exercise intensity decreases, then the overall contribution of the anaerobic system gradually declines, and the corresponding contribution of aerobic energy supply systems predominates.

The anaerobic energy system can be divided into 2 separate components:

- The Alactic or ATPJPC system
- The Lactic or oxygen-independent glycolytic system

Alactic (the phosphogen system)

This system is always on stand-by to provide immediate energy for very short bursts of high intensity activity. However, the stores of fuel required for alactic energy production are limited, and the amount of energy supplied through this route drops dramatically after the first few seconds of intense activity. The relative energy contribution of the alactic system does not change substantially over the course of developmental growth.

Lactic (the oxygen-independent glycolytic system)

After a few seconds of intense activity the energy contribution from alactic sources is reduced substantially. However by this time the lactic system (also referred to as the oxygen-independent glycolytic system) has been mobilised and this energy supply mechanism is capable of providing sufficient energy to sustain high intensity activity for roughly a further 15 to 20 seconds (although estimates vary widely). In this supply system energy is produced by consuming fuel that has been stored in the working muscle (in the form of glycogen). A key by-product of this chemical reaction is lactate, which is subsequently re-cycled within the body.

A key energy supply difference between developing and fully mature athletes is that the aerobic systems of young athletes switch on more quickly, and supply a higher percentage of the overall energy required for movement, regardless of duration or intensity.
While young athletes can use the lactic system to generate energy, before puberty it supplies a lower percentage of the overall energy required for movement than it will do when they are adults. As the anaerobic system matures during adolescence, energy production via the lactic metabolic pathway permits sustained high intensity activity and higher absolute intensities.

**Aerobic**
The aerobic (in the presence of oxygen) energy system is the key energy provider for activities that are moderate to long in duration, and low to medium intensity. Aerobic energy is produced when bodily stores (of carbohydrate, fat, and in some circumstances protein) are mobilised from their respective storage sites, and then consumed in the presence of oxygen to create energy and waste by-products which are then re-cycled by the body.

As the aerobic system requires that a number of steps are completed before energy production is fully turned on (for example, an increase in breathing rates, increases in blood flow, mobilisation of energy stores and so on). There is a lag time between the start of exercise and the time when aerobic processes can provide sufficient energy to fuel athletic movement. This lag time depends on various factors, such as training status, but it is estimated to normally take a couple of minutes before aerobic systems are fully engaged.

A key energy supply difference between developing and fully mature athletes is that the aerobic systems of young athletes switch on more quickly, and supply a higher percentage of the overall energy required for movement, regardless of duration or intensity.

It should be noted that while in children the aerobic metabolic system predominates permitting them to sustain long periods of low (absolute) intensity activity this does NOT mean that they should be trained purely for aerobic endurance as it is also at this time that the ability to rapidly learn skills predominates — see the following section on ‘Training Principles’.

**BioMECHANICAL Energy Return**
While the biological energy systems (alactic, lactic and aerobic) generate energy for muscular contraction, ultimate human performance in athletics events is also a matter of biomechanical energy return.

Biomechanical energy return describes the body’s ability to function as a series of spring-like structures capable of re-cycling energy stored during athletic movement. This energy is stored predominantly within the tendons and muscles and is responsible for supplying an estimated 30\% to 50\% of the energy required for normal running. Biomechanical energy return contributes most obviously to run and jump activities through the spring-like function of the legs, but is also a key contributor to throwing activities as elastic energy is also stored throughout the structures of the hips, back, and shoulders. The key factors which contribute to biomechanical energy return are; movement skill and coordination, muscle strength, and the healthy functioning of tendons.
Strength
The amount of force an athlete is able to generate is essentially the result of two key interacting factors, firstly, the structural characteristics of the body (most importantly the muscle size, quality, and functional health, but also the load bearing capabilities of the skeleton and supporting tissues). Secondly, the ability of the brain to optimally activate and coordinate the actions of the specific muscles required for movement.

Key trainable aspects of strength in growing athletes are:
- Cross-sectional area (CSA) of the muscle
- Neural recruitment
- Tendon structure
- Bone

CSA
During normal growth processes there is a natural growth in the cross sectional area (CSA) of muscle and hence an increase in muscle size. This increase in muscle size is accompanied by a corresponding increase in strength. However, prior to puberty, strength training has little impact upon muscle growth. Strength levels typically increase, but not necessarily through the mechanism of muscle growth (see neural recruitment below). During and after puberty there are dramatic changes in the biology of the young athlete. A key relevant change is a modified hormonal profile (hormones are a family of chemical messengers within the body that control basic aspects of health such as growth and repair). Over the course of puberty there is an increase in the levels of various hormones essential for muscle growth (the most important of which is testosterone). While testosterone levels naturally increase in both males and females, this increase is not equal between the genders, and following puberty males typically have circulating testosterone levels that are 10 to 20 times that of females.

Neural Recruitment
Neural recruitment is the term used to describe the central nervous systems (in other words, the brain and spinal cord) ability to send commands to, and therefore to activate, the various muscles of the body. Neural recruitment is responsive to training and in the absence of muscle growth, is the primary mechanism for increasing the muscles ability to generate force.

- Neural factors are responsible for the vast majority of strength increases in children prior to puberty, and in both males and females in the absence of muscle growth.
- While during puberty muscle CSA does contribute greatly to strength expression so too do improvements in neural recruitment.
- After puberty, once muscle CSA has stabilised further increases in strength expression come primarily from improvements in neural recruitment.

Tendon
The various muscles of the body are connected to the skeleton by way of the tendons. Therefore for movement to occur firstly the appropriate muscles must activate, hence pulling on their attached tendons, which in turn pull on the bone to which they are attached resulting in movement around a particular joint.

Tendons are therefore designed, and constantly required, to transfer force. As a result tendons are a common injury site in athletes. The cross section and load bearing qualities of tendons develop to meet the needs of the muscles to which they are attached. Therefore, as an athlete enters puberty and the CSA of muscle increases so too will the cross section of the tendons. However, as tendons are slower to develop than muscles, there is a period of time between an increase in muscle CSA and the respective adaptations within the tendons. During this lag period there is an increased risk of tendon related injury as the muscle is often capable of generating more force than the tendon can withstand.

**Bone**
Like tendon, bone develops slower than muscle. Therefore, its development lags behind muscle cross-sectional area and this predisposes athletes to bone related injury during sudden growth spurts.

**Co-ordination**
While the individual has low body mass and relatively short limb length they are ideally suited to develop skills because it is easier to control the movement of their centre of mass. As body mass increases during puberty the potential for rapid skill development of new skills diminishes although the learning of new skills is always possible. As body mass and limb lengths increase skills can then be refined to take into account the environment of the adult body.

**Mobility**
During periods of rapid growth changes to the skeleton, muscles and tendons result in the redistribution in bodyweight towards the extremities and natural changes in range of motion around joints. This can lead to fluctuations in mobility, which can predispose athletes to injury. All of these changes together often result in a loss in mobility relative to pre-puberty.
Training Considerations

In this section we will describe some key considerations for training based on an understanding of the interaction between the developmental biological changes to an athlete’s physiology described in the previous section.
### UKA Athlete Development Model (V1.2)

**Figure 3: Training Considerations**

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<td>Bio-Mechanical Energy Return</td>
<td>Muscle CSA</td>
<td>PHV</td>
<td>PHV</td>
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<td>Strength</td>
<td>Neural Recruit.</td>
<td>Development of neural recruitment patterns</td>
<td>Refinement of neural recruitment</td>
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<td>Tendon</td>
<td>Ensure repeated and progressive tendon load</td>
<td>Specialised high load strategies</td>
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<td>Bone</td>
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<td>BMD post-puberty is a key predictor of adult osteoporosis risk</td>
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<td>General Co-ordination</td>
<td>Focus on developing key movement and training skills</td>
<td>Girls need extra time to relearn skills once their adult body shape has stabilised</td>
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<td>Develop event specific co-ordination</td>
<td>Refine event specific co-ordination through specialised training</td>
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<td>Mobility</td>
<td>Maintain mobility in fundamental movement patterns during periods of growth</td>
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Training Consideration Notes:

Biological Energy System Development

Alactic:
The relative energy contribution of the alactic system does not change substantially over the course of developmental growth. Therefore, athletes can perform high intensity short duration activity throughout their development.

In the past the fact that the anaerobic system (which comprises the alactic and lactic systems) of young athletes is not fully developed has frequently led to the conclusion that anaerobic training is neither beneficial nor necessary for young athletes. However, it should be noted that high intensity, high speed training carries multiple benefits for athletes (from both a structural and co-ordination standpoint) regardless of event group or developmental age, and both practical and scientific evidence suggests that high intensity activities are well-tolerated throughout childhood and adolescence.

Lactic:
Prior to puberty, the lactic energy system is not fully developed and as a result supplies a lower percentage of the overall energy required for movement, regardless of duration or intensity of activity.

The maturation of the lactic system occurs during puberty. This coincides with the increase in strength expression seen at that time and as a result there is a sharp rise in the absolute intensity of activity. The increased rate of energy production from the fully mature lactic system combined with increases in strength now permit athletes to undertake sustained high intensity activity at higher absolute intensities, which are all characteristics of elite level performance.

While the lactic system is always trainable to some degree, coaches should keep in mind that training aimed at stimulating the lactic system results in significant fatigue, which will compromise an athlete’s ability to perform co-ordinated movements. Since co-ordinated activities mastered pre-puberty need to be relearned after periods of rapid growth (especially in females where the changes that occur are often dramatic), until skills (including running, jumping and throwing) have been mastered by an athlete’s adult body shape the focus on dedicated training of the lactic energy systems should be a secondary consideration.

In summary, while the lactic energy system is always trainable, all be it to varying degrees, due to a variety of reasons specialised training programmes focused on the development of the lactic energy system should be postponed until skills are fully mastered in the athlete’s adult body shape. In practice, this will result in training programmes for youngsters with relatively little focus on development of the lactic system. As the athletes enter puberty the focus will increase gradually until the athletes are fully mature when dedicated specialised training of the lactic system can be implemented without compromising the development of other bodily systems.
Aerobic:
One of the key differences in energy production between children, young developing athletes, and mature adults, is that aerobic energy production is switched on much more quickly in young growing populations than in their mature counterparts.

While in pre-pubescent athletes the aerobic metabolic system predominates permitting them to sustain long periods of low (absolute) intensity activity this does NOT mean that they should be trained purely for aerobic endurance, as it is also at this stage of development that skills can be rapidly acquired. Furthermore, aerobic endurance training through activities involving impact (such as running) also places considerable demand on the skeletal system. While conservative and progressive amounts of impact are important to help stimulate increases in bone mineral density, too much, inappropriate progression or too little recovery between exposures can result in skeletal injuries such as stress fractures. Therefore, as with development of the lactic system the focus on dedicated training of the aerobic energy system should rise gradually throughout puberty until the athletes are fully mature. At this point dedicated and specialised training of the aerobic energy system, including high volume running strategies, can be implemented successfully because the structural changes in terms of bone, tendon, muscle and co-ordination that underpin them have already occurred.

BioMECHANICAL Energy Return

Strength
Throughout development the key factors that contribute to strength expression can all be improved through appropriate training. However, the mechanism behind strength increases change as the athlete develops.

CSA
During puberty the increase in hormones including testosterone permit an increase in the CSA of muscle fibres through appropriate strength training. Since females and males undergo puberty at different times the windows for development of CSA in boys and girls differ and as a general rule of thumb females can begin training to increase CSA earlier than males. However, since mature males tend to have circulating testosterone levels 10K20 times that of females, after puberty males are likely to respond to general strength training with larger changes in muscle cross-sectional area than either pre-pubertal males, or pre or post-pubertal females.

Neural Recruitment
Neural changes that occur as a result of training include; the generation and transmission of a clearer more precise activation signal from the brain to the musculature, and increases in co-ordination both within muscles and between groups of muscles.

Since neural factors are responsible for the vast majority of strength increases in children prior to puberty, training that promotes improvements in neural recruitment that are developmentally appropriate and take into consideration the status of other systems such as tendons and bone can be employed.
Once an athlete’s adult body shape has stabilised and structural changes to the bones and connective tissues are complete, specialised training aimed at refining strength expression in specific movement patterns can then be implemented.

**Tendon**
Tendon adapts to regular training through increases in both thickness and density - enabling safer handling of either high and/or repetitive loads.

**Ensure repeated and progressive tendon loads:** For growing athletes it is important to ensure they are exposed to repeated and progressive tendon loading by way of a wide selection of running and jumping activities as well as appropriate strength training modalities. Without a progressive base of this kind of work the tendons will not be adequately prepared for the high forces athletes will need to withstand as adults.

**Specialised high load strategies:** Research shows that high force eccentric activities can stimulate positive tendon adaptation even in mature athletes. However, such specialised activity places exceptional physical and psychological strain upon the athlete and therefore should be reserved for fully mature athletes.

**Bone**
Healthy bone is responsive to gradually progressive loading through either impact activities such as running or jumping, as well as appropriate strength training modalities. Research shows that the bone mineral density achieved post puberty is indicative of a greater risk of osteoporosis (loss of bone mineral density to below a critical level) in later life. The higher the bone mineral density the less likely the athlete is to develop osteoporosis.

Consequently measures should be taken to ensure all athletes, and especially developing female athletes, are exposed to appropriate loading during adolescence and early adulthood so as to provide the stimulus necessary to promote healthy bone growth.

**General Co-ordination**
**Focus on developing key movement and training skills:** Building general coordination in developing athletes is a key factor in optimising the nervous systems ability to accurately control movement, promoting future movement efficiency and thus performance, and reducing the likelihood of future injury. Prior to puberty, while the body and mind are optimised for rapid skill development young athletes should be exposed to activities that develop key movement patterns across a range of sports. From an Athletics perspective this will include running, jumping and throwing as well as those patterns often used in conditioning programmes such as multilateral lunges, single and double leg squats etc.

**Girls need time to relearn skills once their adult body shape has stabilised:** As athletes undergo periods of rapid growth their body proportions and the distribution of body weight, both in terms of fat and muscle, changes considerably. Therefore, time is needed for them to modify the movement patterns they learned pre puberty to their new body. This is especially important for female athletes who undergo the most dramatic changes during this time.
Specific Co-ordination

**Develop event specific co-ordination:** Prior to puberty athletes should begin to develop the movement patterns necessary for participating in the events of Athletics. Within the throws group, for example, this will include the differences between throwing a javelin and a tennis ball, or a discus and the rotational shot.

**Refine event specific co-ordination:** Post puberty, once athletes have finished growing and their adult body shape has stabilised they can begin refining event specific technique. This will include refining technique using senior weighted implements or hurdle heights.

**Mobility**

Due to the drastic changes in bone that occur during puberty it is unrealistic to expect athletes to retain the same levels of mobility they had prior to pre-puberty after they have finished growing. However, it is important that athletes maintain appropriate levels of mobility in fundamental movement patterns during the periods of rapid growth that occur during puberty.

**Further Detail on Training**

This document outlines the general strategies for training athletes of different ages. More detail on how to specifically achieve these adaptations will be presented on uCoach.
Training and Competition Requirements

*In this section we will describe some recommendations for how the training and competition requirements of athletes change as they develop.*
UKA Athlete Development Model (V1.2)

**Developmental Age +/-**

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**Figure 4: Training and Competition Requirements**

- **Sports Focus**
  - Multi-Activity
  - Multi-Event
  - Event Group
  - Event Specialisation (inc. Hpt/Decathlon)

- **Training Freq**
  - Frequency stabilises
  - 12+ hours week (including training)
  - *European Youth Heart Study published in July 2006
  - Generally Training Only
  - All Year

- **Total Physical Activity**
  - Local
  - Regional
  - National
  - Entry International
  - Olympics WCs

- **Athletics Specific Weeks/Year**
  - Grass / Sports Hall
  - Track / Grass / Sports Hall
  - Track / Grass / Sports Hall / Gym
  - Good Outdoor / Indoor Facility / Gym / Pool
  - Altitude / Hypoxic Environment / Alter G etc...

- **Competition Priority**
  - Local
  - Regional
  - National
  - Entry International
  - Olympics WCs

- **Performance**
  - Fun
  - Club Competition
  - International Representation
  - Top 8 Finish
  - Podium OG/WC

*These diagrams are for illustration purposes only. They can only be fully interpreted after reading the accompanying notes and audio presentations.*
**Training and Competition Requirement Notes:**

The training and competition requirements of developing athletes are dictated by their developmental needs.

**Education**

Education within the UK is generally structured in three phases. The first phase is compulsory for all children and is generally split into Primary and Secondary education. Children begin primary education at the age of 5 and the program lasts six years. Between the ages of 11 to 16 children enter secondary education culminating in the award of General Certificates of Secondary Education (CGSE) or Vocational Certificate of Secondary Education (VCSE). At sixteen individuals can begin to work but most go onto a further education College or 6th Form and study for a range of qualifications for a further two years. At 18 individuals are then likely to transition to some form of Higher Education/University or directly into Employment.

**Sports Focus**

**Multi-Activity:** Up until the age of around 12 all children should ideally be engaged in multiple sports with little specific focus on one over the others. This period coincides with the periods of rapid skill acquisition for both girls and boys, where the broadest range of sports possible will allow the young athletes to rapidly pick up all the fundamental movement patterns required for training in the future.

**Multi-event:** From the age of around 12 to 16 young athletes should be exposed to a range of Athletics events across as many event groups (running, jumping and throwing) as possible. At this stage in their development it is very difficult to predict what event or even event group the athletes may be best suited to when they are fully mature. Furthermore, as a fully mature athlete, regardless of event, their training will to some degree involve a variety of running, jumping and throwing activities and so a background in a range of events will provide a solid foundation for the future.

**Event-group:** around the ages of 15 to 16 athletes will probably begin to focus on a specific event group (sprints, endurance, jumps, throws or multi events) as they begin to realise where their potential and interests lie. At this point the athlete should focus on a range of events within the event group so as to develop a good all round event group specific conditioning and co-ordination base.

**Event-Specialisation:** once the athlete is reaching full maturity they will probably begin specialising in a single or perhaps two closely related events (shot and discus, long jump and triple jump, short sprints and sprint hurdles, 1500m and steeplechase, multi-events etc). If they have gone through a suitable progression from multi-sport to multi-event to event group they will have acquired a strong foundation in terms of conditioning and run, jump, throw specific skills from which they can now draw upon to improve performance in their favoured events.

Note: those entering the sport late at 18/20 may have to revisit some of the skills required to train. However, they will probably have being doing other sports where they may have
developed many of these abilities (for example cricket for throwing, basketball for throwing and jumping, team sports for running, cycling or swimming for endurance etc).

Training Frequency

Training frequency is closely linked to sports focus. The number of times per week the athlete is training for Athletics will be closely linked to the level of specialisation in their training. As a general rule of thumb the frequency of training will increase as the athlete develops, however, an increase in the frequency of Athletics specific training should only occur if performance is stagnating and there is good reason for thinking more training sessions will yield better results.

It is also important to remember that while an athlete is engaged in other activities, those activities have a conditioning component to them. For example, if an athlete is doing the sport of Weightlifting a couple of times a week in addition to Athletics, this will take care of a lot of their physical conditioning requirements and so a lower frequency of athletics specific sessions may be most appropriate for this individual. Similarly, if an athlete is playing football several times a week this may take care of their aerobic training requirements.

Frequency Stabilises: It should also be noted that there will come a point where the frequency of training cannot increase further as the athlete is unable to recover from and adapt if more training is added.

Total Physical Activity

Until the event specialisation stage athletes should be actively encouraged to participate in other sports and general activities. Therefore, although they may only be training for Athletics twice a week, developing athletes should also undertake other physical activity of which Athletics training counts towards their weekly total.

The current UK government guidelines recommend an hour of exercise per day for all children. However, the Physical activity and clustered cardiovascular risk in children: a cross sectional study, published in The Lancet (volume 368) recommends at least 90 minutes of moderate intensity exercise for young people.

This finding is also backed up by the results of the European Youth Heart Study published in July 2006. The authors of the European Youth Heart Study looked at over 1,730 children, aged nine or 15 years, from schools in Denmark, Estonia, and Portugal. For each child they measured a combination of risk factors for cardiovascular disease, including blood pressure, weight and cholesterol, to calculate a combined risk factor score. Over one weekend and two week days the children were asked to wear a monitor that measured how physically active they were. The researchers found that their risk score for cardiovascular disease decreased with increasing physical activity.

Professor Lars Bo Anderson, from the Norwegian School of Sports Sciences in Oslo, and his team stress that the 90 minutes of daily exercise they are recommending for children does not have to be done in one chunk; it would be spaced over the day. For example, a child
could walk or cycle to and from school, run around at lunchtime and play sports in the evenings and at weekends.

The Department of Health has said it will consider whether its guidelines needed to be reviewed following the study.

**12+ hours week (including training):** In light of this information, it is appropriate for children to be engaged in around twelve or more hours of physical activity per week. This includes the time they spend training for athletics but as previously stated the frequency of athletics training should be appropriate for their developmental needs and should not be so great as to detract from the development of physical literacy brought about by participation in other sports.

Generally Training Only: Having begun to specialise in a single event at a high level of performance the training and recovery requirements will leave little time for structured training in other sports. Therefore, apart from periods of active recovery (where participation in other sports may be encouraged) generally it is only appropriate for athletes to engage in training for Athletics.

**Athletics Specific Weeks / Year**
For young athletes Athletics training should initially be seasonal with a variety of sports being played throughout the year.

**All year:** As development continues and commitment to Athletics increases the number of week per year will rise until at the event specialisation stage athletes are training for Athletics all year around.

**Ratio of General vs Specialised activity**
With young athletes, a significant amount of time will be spent on activities aimed at improving generic athleticism with only a small amount of time dedicated to event specific preparation, most of which will take the form of technical practice of the events of Athletics. As the athlete develops the ratio of general training to specialised work will shift in favour of specific forms of work that support the physical and technical requirements around a specific event(s). This coincides with the shift towards event specialisation and having undertaken many years of training high performing athletes will require less and less general preparatory work as they have already achieved a high level of generic athleticism, physical literacy and are highly conditioned for the events they compete in.
The Difference Between Specificity and Specialisation

The relationship between specificity and specialisation are often confused. Yes, it is true that the younger an athlete is the less specific training they should be performing. But this does not mean that they should not be doing any specific training. Obviously, the various events they train and compete in are specific in nature (e.g. Long Jump, Javelin, Cross Country, Wheelchair Racing etc). For instance, when a young athlete performs technical training that is specific work. As well, medicine ball throws are a form of special strength work, and are completely appropriate for young athletes.

Where the problem lies is when an athlete moves into more formal and specialised forms of training before they are physically, mentally and emotionally prepared to undertake them. ‘Specialised’ can mean a number of things.

- First, it means a shift or focus in training upon a single sport, event group or event. This can be a problem for athletes in the long term if initiated too early because it robs the athlete of the wide range of movement experiences that coordination and athleticism are built upon.
- Second, it means exacting a commitment to training that is, in an emotional sense, difficult even for the most seasoned athlete. Immature athletes are simply not prepared psychologically for this kind of work. They may tolerate it for a while, but sooner or later they will collapse under the load.
- And third, within the context of training for a specific sport, it also means a reallocation of energies to very precise forms of training designed to elicit very exact responses from the athlete. For instance, maximal strength training generates a highly specific response from an athlete and is generally not appropriate or necessary for young athletes. This is because the high intensities inherent in such work stress both the musculoskeletal and physiological systems beyond what they are capable of, leading to either injury or fatigue. But not just any fatigue... fatigue at the expense of the development of other more important systems... otherwise known as burnout.

In summary, you can be relatively specific without specialising, but you cannot specialise without being specific.

Competition Priority

The priority given to different levels of competition will vary with the development of the athlete and should follow a progression from Local to Olympic/Paralympics /World Championships across the athlete’s career. While there is a great deal of variance between individuals and events, in terms of the age at which athletes achieve their best performances, British athletes are generally not successful at the highest levels until they are into their mid to late twenties.

The overriding philosophy behind developmental coaching is to organise training to maximise an athlete’s chances of senior success. Therefore, while it may be possible for an athlete to achieve a qualification standard for the Olympic/Paralympic Games aged 15, the priority should be placed at National Level competition at that age. Attempting to try and train an athlete for success in Athletics at an Olympics/Paralympics at 15 years old will
necessitate training that is far more specialised than is appropriate for someone of that age and is likely to compromise the health and future potential of that athlete. Athletics is a late specialisation sport and even if an athlete is capable of qualifying for an Olympics/Paralympics at 15, given appropriate training and progression, with the natural increase in strength, power and endurance that comes with full maturation such an athlete should be more than capable of qualifying, if not medalling as a senior. Therefore, with the long term future of the athlete in mind it is appropriate to place a National level competition ahead of a major international senior championships at that age because ultimately it will facilitate senior success. The only time this rule of thumb may be ignored is if an athlete had a performance level that suggested they could potentially medal, which is highly unlikely at an Olympics although potentially possible at the Paralympics.

**Facilities**
Facilities should be appropriate to support the training demands for the athlete’s stage of development. As an athlete gets older and reaches ever higher performance standards they will increasingly require specialised facilities.

**Grass/sports hall:** Initially all that may be required is access to grass and a sports hall.

**Track/grass/sports hall:** With increased specialisation access to track facilities and a sports hall for indoor work during the winter will probably be required.

**Track/grass/sports hall/gym:** As athletes finish puberty and become increasingly interested in strength training they may also require access to a gym.

**Good outdoor, good indoor, gym, pool:** As the athlete begins to engage in more specialised training, perhaps multiple times per day, they will probably require access to indoor facilities and possibly a pool for recovery work.

**Altitude/hypoxic environment, Alter-G etc:** As athletes begin to target podium success they may also require access to very specialised facilities such as altitude and hypoxic environments or access to an Alter-G running machine for endurance athletes.

**Performance**
Assuming an athlete has the potential to achieve a podium finish at the Olympic/Paralympic Games or World Championships they should move through a performance spectrum that begins with Club Competition pre-puberty and progresses to International Representation during their mid to late teens. As the athlete becomes fully mature they will begin to achieve a Top 8 Finish at Commonwealth Games, European Championships and finally World Championships and Olympic/Paralympic Games. Statistics show that most athletes who achieve a Podium position at the Olympic/Paralympic Games and World Championships will be over the age of 22 years old. The age at which athletes achieve podium performances varies across events with younger athletes achieving success in the sprints, while throwers and endurance athletes are usually in their mid to late twenties. It should also be noted that statistics suggest that female athletes may also mature later than male athletes in the sprint events.
Conditioning

In this section we will describe some recommendations for how conditioning programmes for athletes should vary to meet their developmental needs.
### UKA Athlete Development Model (V1.2)

**Developmental Age +/-**

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### Figure 5: Conditioning

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<th>Conditioning Strategy</th>
<th>Conditioning goals mainly achieved via technical work</th>
<th>Progression Focus</th>
<th>Performance Focus</th>
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<td>Multi-lateral incorporating Bilateral power movement patterns</td>
<td>Performance Enhancement Focus</td>
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<td>Fundamental Movement Skills</td>
<td>General strength</td>
<td>General and ancillary strength</td>
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*These diagrams are for illustration purposes only. They can only be fully interpreted after reading the accompanying notes and audio presentations.*
Conditioning

Conditioning Strategy
This category provides direction as to the overall focus of the conditioning programme. Conditioning goals mainly achieved via technical work: Through the age ranges of 9E15 years old the conditioning requirements of most athletes can be met through technical work for the various athletics events they are training for. However, it is also worthwhile to include some non-specific jumping, general strength and/or medicine ball circuits at the end of the technical sessions if they were not included in the warm-up. This is especially important for athletes who do not cover the full spectrum of running, jumping and throwing events in their technical work. For example an athlete who mainly sprints and jumps should do a variety of general medicine ball and tennis/baseball throwing activities. Supervised strength training can also be exploited to assist in the development of healthy tendons and bones.

Progression Focus: From 15E20 the completion of puberty and its associated hormonal and structural changes permits the conditioning focus to shift towards a progressive build up in supplementary conditioning work.

Performance Focus: By the time the athlete is around 20 year of age and has completed all but the final stages of maturation they should be prepared to undertake conditioning activities that aim to fully exploit all aspects of conditioning appropriate to their chosen event(s). The focus now shifts towards achieving conditioning levels suitable for high-level performance.

Conditioning Orientation
This category describes the focus of supplementary conditioning activity, which is used alongside event specific technical training.

Multi-lateral with emphasis on Unilateral and Contralateral movement patterns: Uni-lateral patterns are exercises primarily on a single support (i.e. one leg) such as a step up or single leg squat. Contralateral patterns are those that transfer weight from one leg to the other such as a lunge step, exercises in a split leg position such as a lunge, split clean or split snatch. Upper body movements can be performed in a similar fashion using dumbbells.

The purpose of focusing on uni-lateral and contralateral movements for athletes at this stage are:
1. The fact that the exercises are on a rather unstable support meant that loads on the spine are kept to a safe minimum relative to what could be used with double support loads
2. Using single leg patterns helps to develop coordination by cultivating stabilising musculature around the various weight bearing joints.
Multi-lateral incorporating Bilateral power movement patterns: Once an athlete has developed good competency in uni-lateral and bilateral movement patterns and have matured to such an extent where they can begin to tolerate increased loading a greater proportion of their conditioning can be focused around bilateral patterns (exercises with an even weight distribution across a double support such as a squat or power clean).

Technical Focus: Until post puberty conditioning work should be focused on technical execution of movement patterns (including strength training exercises) with loading as a secondary objective. However, appropriate loading is necessary for optimal development of the skeleton and connective tissue.

Performance Enhancement Focus: Once bone growth has slowed and an athlete has developed excellent technical proficiency the stage is set to progress towards using performance loading strategies to achieve specialised physiological adaptations.

Loading Focus

Conservative loading: Until the onset of puberty a focus on managing one’s own bodyweight is an appropriate level of loading for athletes under most conditions. It is also appropriate to introduce athletes to formal strength training if the coach has the appropriate technical skills, ensures perfect execution and is conservative with their loading selection.

The incidence of weight training injuries (across all ages) is likely to be significantly reduced by implementing training programmes that utilise exercise modes and loads appropriate to the athlete’s levels of:

- Prior training experience
- Instruction
- Supervision
- Technical proficiency

Comfort Loads: In term of intensity a ‘comfort-load’ is a subjective assessment by the athlete for the determination of a working load. While the loading is chosen by the athlete this almost certainly excludes loads that would typically be used for maximal strength work in the 80-100% 1RM range. While there is little scientific or empirical evidence to suggest working at 80E100% 1RM cannot be tolerated by athletes at this age, it should be remembered that a significant amount of mental focus is required to lift maximal loads in a safe manner. Therefore, comfort loads are recommended to help to protect a developing athlete from attempting to use intensities that could potentially compromise the development of their skeletal system.

Progressive Loading: Once an athlete has completed the majority of the structural changes associated with puberty weight training intensities can be progressively increased up to high performance specific loads. During this timeframe the progressions should be conservative and postural integrity should be maintained at all times.
**Performance Loading:** Once the athlete’s body is fully matured and they have undertaken a progressive program using comfort loads and progressive loading they should be prepared, physically and mentally, to utilise high performance specific loads. This will include all forms of maximal, special and specific strength work.

*Note on strength progressions:* All athletes should undergo some form of progressive long term conditioning plan. Ideally this would include a structured conditioning approach spread across several years as indicated in the UKA Athlete Development Model. However, Athletics is a late specialisation sport and therefore talented athletes may begin formal training at relatively advanced ages (18+). For these athletes it would not be appropriate to force them to undertake several years of progression. However, an assessment of their skill set would need to be made and a plan created to meet their needs and deficiencies. This conditioning plan should consist of a condensed progression period to get them up to speed. In the case of an 18 year old with some basic lifting experience, this may include 6E12 months at each stage of progression before beginning to engage in bilateral power exercises using performance loading schemes.

### Exercise Classification Hierarchy

**Competitive Exercises (CE)**

*With modified equipment / distances:* For developing athletes it is necessary to use modified equipment to introduce the techniques of Athletics (e.g. foam javelins). Running distances will also need to be substantially reduced. Due to the predominance of the aerobic metabolic pathway in prepubescent’s thought must be given to the distances used for high intensity sprint work. While a degree of aerobic running is appropriate for more endurance based athletes, high densities of specialised training for the lactic energy system should be postponed until the system is fully mature.

*With modified equipment where appropriate:* Athletes who have gone through puberty but have not yet accumulated enough strength to successfully utilise standard equipment without significant modifications in technique may benefit from using modified equipment. This is perhaps most prevalent in the throws for late developers. Once fully mature, athletes can use standard equipment and distances because they will not impact upon their physical or technical development.

**Specific Developmental and Specific Preparatory Exercises (SDE, SPE)**

*Be cautious of activities that compress the spine and avoid repetitive stress:* The nature of SDE often refers to overload (e.g. throwing heavy implements or doing jumps with a weighted vest). Therefore, coaches should be cautious of using training modifications to the competitive event that specifically target the under developed lactic system and/or compress the spine. For example, caution should be exercised when using intensive repetition work for speed athletes or jump training with a weighted vest. However, there are many other forms of SDE such as hurdling with reduce or extend spacing to overload speed or rhythm qualities which are completely appropriate.
SPE encompasses exercises that overload systems used in the competitive event (energy systems, musculoskeletal etc) and so once again exercises at this hierarchical level that aim to elicit very specialised adaptations to the lactic system or incorporate a lot of spinal loading should be used with extreme caution. An example of an exercises where care should be taken may be jump squats using a barbell held across the shoulders and so high compressive forces are placed on the spine.

Both SDE and SPE by definition work on developing factors utilised in the Competitive Exercise. Since the majority of injuries to young athletes occur due to overuse, coaches should be cautious about prescribing exercises that stress regions of the body already targeted under other classification groups or trained excessively within other sports their athletes also engage in on a regular basis.

**Be cautious of activity that significantly compresses the spine:** Until the musculoskeletal system is fully mature caution should be exercised when loading the spine using SDE and SPE. This can often be resolved by using appropriate loading as discussed under ‘Loading Focus’.

**Full range of means:** Once the body is fully mature all means of training at the SDE and SPE hierarchical levels can be utilised.

**General Preparatory Exercises (GPE)**

**Fundamental Movement Skills:** GPE are ‘athlete specific’ and used to improve general athleticism rather than be directed at a specific event. For children up to the age of 12, GPE will be composed of fundamental movement skills.

**General strength:** At the onset of puberty it becomes appropriate to engage in general strength activities while observing the guidelines presented in ‘Loading Focus’.

**General strength and ancillary strength:** After PHV when athletes begin to enter the training windows for cross sectional area (CSA) it becomes developmentally appropriate to include ancillary strength exercises while continuing to observe the guidelines presented in ‘Loading Focus’.

**Full range of means:** Once the rate of bone growth has slowed all means of training at the GPE hierarchical level can be utilised