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Topic Guide: Exercise Physiology

AS and A Level Physical Education – version 2

Pearson Edexcel Level 3 Advanced GCE in Physical Education (9PE0)

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Physical Education (9PE0)

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GCE Physical Education 2016 Component guide 2: Exercise physiology

Contents

Introduction

The specification has been developed in consultation with the teaching community, higher education, learned societies and subject associations. Tutors from a range of schools and colleges – in focus groups, phone interviews and face-to-face conversations – have given feedback at each stage and have helped us to shape the specification. Physical Education academics in UK universities have helped us understand how to build on the strengths of the 2008 A level specification and advised on how progression to undergraduate study could be improved.

Component guide 2: Exercise physiology gives an overview of the new specification relating to this topic, to help you get to grips with the changes to content and assessment, and to help you understand what these mean for you and your learners.

Overview of changes

From September 2016, GCE Physical Education will be a linear qualification. This means that all examinations must be sat at the end of the two-year course. From September 2016, AS level Physical Education will be a stand-alone qualification. This means that it cannot be used to contribute towards an A level Physical Education grade. More information about the changes to subject content is given later on in the guide.

Each award will have two examinations: a scientific exam and a psychological and social exam. This is a change from 2008. The science examination comprises Topic 1: Applied anatomy and physiology and Topic 2: Exercise physiology and applied movement analysis. A new topic area is Biomechanical movement which is embedded within both the anatomy and the physiology. This is a topic area that was not included in the 2008 specification.

There is an increased focus on the theoretical content, now worth 70 per cent of the grade.

The subject content includes a more detailed need to develop quantitative skills – now worth up to 5 per cent of the qualification.

Learners will be expected to understand the importance of diet and nutrition pre-, during and post-physical activity. They will also study fatigue and recovery, which will build from their knowledge of energy systems in Topic 1: Applied anatomy and physiology. Learners will gain an understanding of how to apply knowledge of energy systems and how to train, maintain and improve their performance. This includes an understanding of fitness components, methods of training and physiological adaptations. Learners will also understand how to prevent and rehabilitate from injury.

Learners will be able to demonstrate an understanding of movement analysis through the use of examples to include linear motion, angular motion, projectile motion and fluid mechanics. **There is a separate guide for movement analysis: Component guide 3: Biomechanical movement.**

Where AS differs from A level

The AS and A level cover the same initial topics. However, at A level there are additional topics of **2.3 Injury prevention and the rehabilitation of injury**, as well as **movement analysis (Component guide 3)**. A level topics are shown in bold type throughout the booklet.

Key content

2.1 Diet and nutrition and their effect on physical activity and performance

Topic 2.1.1

Learners will develop knowledge and understanding of dietary manipulation for performance pre-, during and post-physical activity. This includes hydration, supplements, recovery drinks, protein and fuel consumption. It is important that learners think about which will be useful before, during and after to assist recovery in different activities.

Topic 2.1.2

Optimal weight for performance in different sports or roles within an activity (for example, a hooker or a fly half in rugby) to include energy balance, energy intake and expenditure. For example, learners should be able to analyse and evaluate why a hooker may be much heavier than a scrum half but the hooker may not be considered to have the optimal weight.

Topic 2.1.3

Learners must show knowledge and understanding of electrolytes, hypotonic, hypertonic and isotonic solutions, and their importance in maintaining hydration and performance in different activities.

- Isotonic is when the osmolality of the drink is the same as blood.
- Hypertonic is when the osmolality of the drink is greater than the blood.
- Hypotonic is when the osmolality of the drink is lower than the blood.

Question 10 in the Sample Assessment Materials A level Scientific Principles paper is a question on this topic with associated mark scheme which shows the level of application needed.

Useful resources include:

- https://www.youtube.com/watch?v=_slUL3kMZlU

Useful background information, although not applied to sports drinks – but some background that could then be applied.

Topic 2.1.4

It is important to understand supplements that affect performance and the effects they have on the body. For example, creatine will assist with energy stores. For example, whey protein would be used to assist recovery. Learners need to learn when different supplements would be used and why they are used: to enhance energy stores, hydration, recovery, metabolic process and delay fatigue.

- https://www.youtube.com/watch?v=ZgHPloKkqdk

A documentary that could generate good discussion. Centres need to be mindful that this resource this will date.

- https://www.youtube.com/watch?v=dlJ9DLnPVsk

Team Sky nutrition clip

Topic 2.1.5

The nature of this topic is that the supplements athletes are using will change throughout the life of the specification. Hence, there is a contemporary supplements section.

New supplements are frequently developed and the specification does not name specific ones, but questions would be worded to allow learners to show their understanding of the topic area. For example, consider the possible use of supplements to aid an athlete in recovery.

Topic 2.1.6

Learners should be aware of the strategies for ensuring optimal food, fuel and fluid intake for pre-, during and post-physical activity: carbohydrate (CHO) loading, two-hour window of opportunity, protein intake, pre-, during and post-event hydration.

- www.runnersworld.co.uk/nutrition/60-second-guide-carb-loading/3961.html is a useful quick guide to carb-loading.

2.2 Preparation and training methods in relation to maintaining and improving physical activity and performance

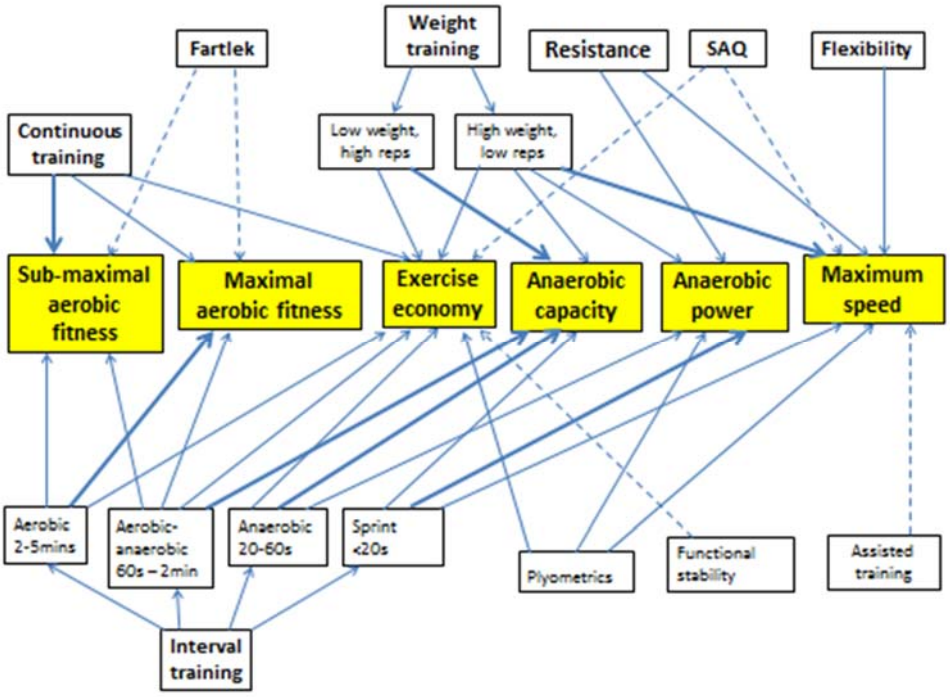
Topic 2.2.1

Learners should understand all the listed training methods in 2.2.11, in particular how they maintain and improve physical activity and performance.

Learners should understand the physiological factors that determine performance in different sports.

Topic 2.2.2

Learners are expected to know a range of fitness tests and select an appropriate test to assess the different physiological determinants of performance. The diagram below shows the main determinants of performance (yellow boxes) and the most appropriate methods of training to improve them,



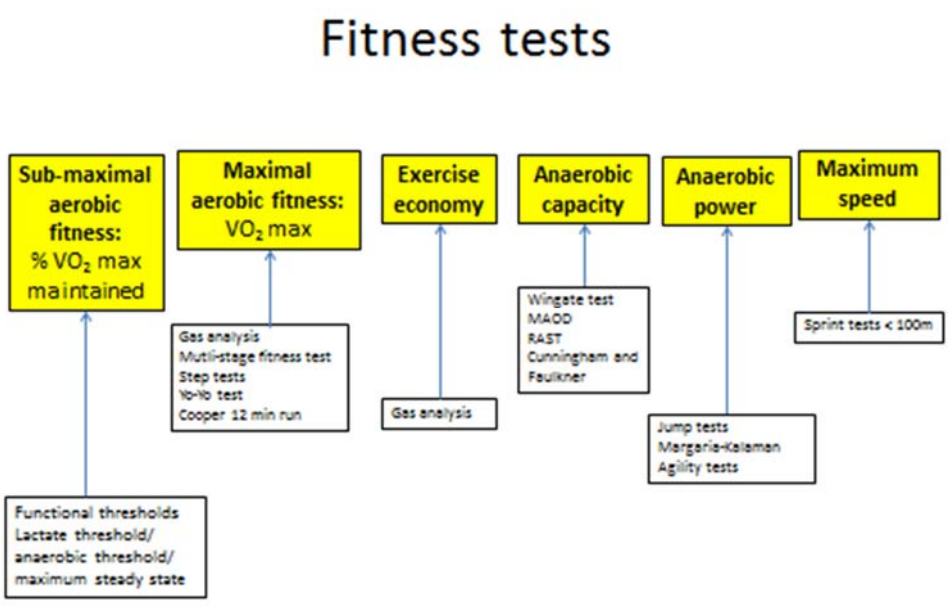
- A solid line = major effect
- A thin line = has an effect
- Dotted line = thought to have an effect but lacks scientific evidence

Circuit training has not been included because its effect depends on the exercises, the number of stations, the duration at each station and the recovery. Cross training has not been included because it could be interval or continuous.

The fitness tests learners must know include:

- functional thresholds
- lactate threshold/anaerobic threshold/maximum steady state
- gas analysis
- multi-stage fitness test
- step tests
- yo-yo test
- Cooper 12 minute run
- Wingate test
- maximum accumulated oxygen deficit (MAOD)
- RAST (repeat anaerobic sprint test)
- Cunningham and Faulkner
- jump tests
- Margaria-Kalaman
- strength tests
- agility tests
- sprint tests < 100m.

The diagram below highlights which fitness tests to select for each determinant of performance:



www.topendsports.com/testing/tests/index.htm has protocols of the tests. Learners are expected to be able to analyse and evaluate the different fitness tests to decide

which are most useful for different types of athletes and different activities, and why.

These websites are useful for MAOD:

- www.elitetrack.com/article_files/oxygendeficit.pdf
- http://www.amazon.co.uk/Practical-Fitness-Testing-Analysis-Professionals-ebook/dp/B0143JM1WI/ref=sr_1_1?s=books&ie=UTF8&qid=1441555655&sr=1-1&keywords=coulson+and+archer+practical

Useful resources include:

- https://www.youtube.com/watch?v=nkOk_P5VnOA
  An example of people doing the yo-yo test
- https://www.youtube.com/watch?v=Weum-PY2uRQ
  An example of Margaria Kalaman Step Test
- https://www.youtube.com/watch?v=tss7Z5DwGtE&t=86s
  An example of the Wingate test

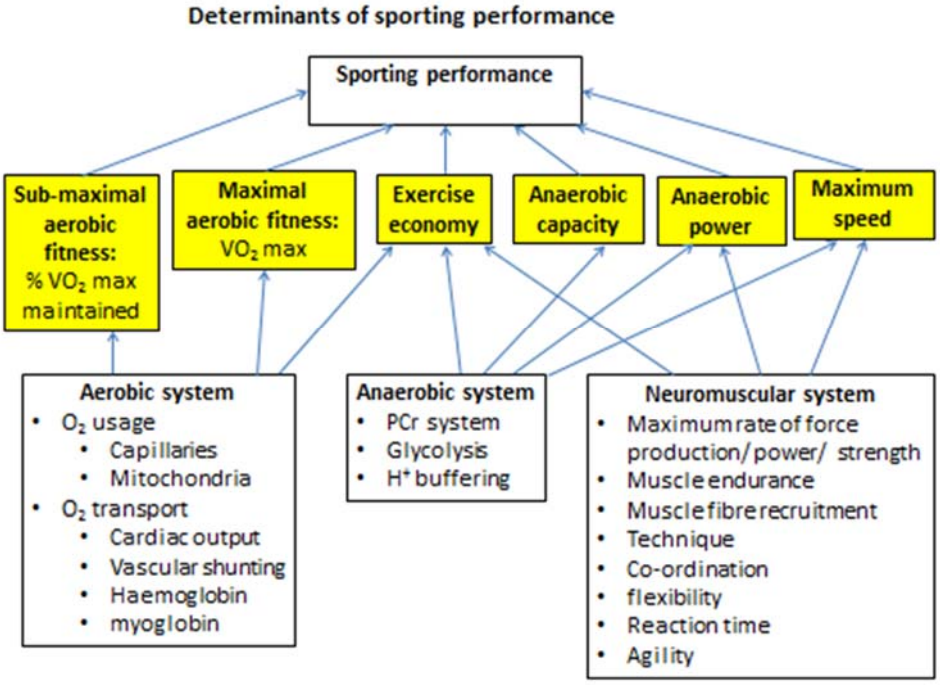
Topic 2.2.3

Learners must be able to interpret, calculate and present data (tables and graphs) based on fitness test results.

This could be, for example, a table of someone's results and then a learner plotting the results, or suggesting which training should be a priority for a particular athlete given their sport and their fitness test results.

Topic 2.2.4

Determinants of movement/running performance and their application to sprint, endurance and intermittent activities. Sporting performance is determined by a range of physiological factors (plus skill and psychological factors). The figure below highlights the six principle determinants of physiological capability: sub-maximal aerobic fitness, maximal aerobic fitness, exercise economy, anaerobic capacity, anaerobic power and maximum speed.



- Submaximal aerobic fitness: the ability to maintain a high percentage of VO2 max for a prolonged period of time. This is essential for long duration aerobic activity, for example long distance running.

- Maximal aerobic fitness: the maximum volume of oxygen that can be utilized in one minute. This is the upper limit of the aerobic system (the person's VO2 max).
- Exercise economy: energy required to maintain a constant velocity of movement. This is the ability to transfer energy into movement. For example, if two people running at the same speed, one of them could be using less energy than the other because they are more economic.
- Anaerobic capacity: the amount of energy obtained from anaerobic sources (creatine phosphate breakdown and anaerobic glycolysis) in a single bout of exercise. This is the greatest amount of energy that can be released from the anaerobic system. There is only a limited amount of energy that can be produced anaerobically, when it is used up the athlete must slow down however it can be (partially) replenished during rest intervals or low-intensity periods of a match.
- Anaerobic power: the rate at which energy is produced. This is the fastest rate at which energy (ATP) can be produced anaerobically during an activity. If two athletes are equal in terms of movement economy, then the athlete with greatest anaerobic power will be the fastest. It is an important factor in sprint speed but not the only factor.
- Maximum speed: time taken to move a body (part or whole) through a movement over a pre-determined distance OR speed (distance divided by time). This is the fastest sprint speed attainable. It is determined not only by the rate of ATP production but also by fast twitch fibre recruitment and force production. The diagram above shows the main physiological factors that influence these determinants of performance.

Topic 2.2.5

Learners will need to learn definitions of each of the components of fitness and be able to apply which are most relevant for different athletes. They will also need to be able to explain which training methods athletes should employ to improve them. These components are:

- local muscular endurance: the ability of a muscle or specific group of muscles to sustain repeated contractions against a resistance for an extended period of time.
- VO2 max: maximum volume of oxygen that can be utilized in one minute.
- anaerobic capacity: the amount of energy obtained from anaerobic sources (creatine phosphate breakdown and anaerobic glycolysis) in a single bout of exercise.
- maximal strength: the maximum force that can be developed in a muscle or group of muscles during a single maximal contraction.
- strength: the force that can be developed in a muscle or group of muscles during a contraction.
- power: the rate at which force is produced.
- speed: time taken to move a body (part or whole) through a movement over a pre-determined distance OR speed (distance divided by time).
- agility: changing position quickly and with control without losing balance in response to a stimulus.
- coordination: the ability of the body to link movements together, either with other movements or in relation to an external object
- reaction time: the time taken for a performer to respond to a stimulus and the initiation of their response.
- balance: the ability to maintain your centre of mass over a base of support. There are two types: static and dynamic.

- flexibility: the range of movement available at a joint.
- exercise economy: energy required to maintain a constant velocity of movement.
- submaximal aerobic fitness: the ability to maintain a high percentage of VO2 max for a prolonged period of time.

Topic 2.2.6

Learners need to be able to utilise this information to be able to interpret fitness test results and inform planning of training. Definitions of each must be learned.

The principles are:

- Individual needs: a successful training programme will meet individual needs which are personal fitness needs based on age, gender, fitness level and the sport for which we are training.
- Specificity: the principle of training that states that sports training should be relevant and appropriate to the sport for which the individual is training in order to produce a training effect.
- Progressive overload: the need to increase training demands on the body in order to encourage it to adapt further.
- Frequency Intensity Time and Type (FITT): this describes how often you train, how hard you train, how long you train for and which method of training you select.
- Overtraining: where a person trains too much, too often or with too little time for recovery between training sessions, risking injury or illness or an imbalance between training and recovery.
- Reversibility: the reversibility principle dictates that athletes lose the beneficial effects of training when they stop working out. Conversely, it also means that detraining effects can be reversed when athletes resume training.

Topic 2.2.7

There are also different ways of measuring and calculating intensity: percentage of functional intensity, percentage of one repetition maximum (RM), Rate of Perceived Exertion (RPE), percentage of functional threshold, target HR, work to rest ratios.

One repetition maximum is 'the maximum amount of weight an individual can lift in a single repetition for a given exercise'. (www.bodybuilding.wikia.com/wiki/One-repetition_maximum)

BORGs 20 point scale is the recognised method of rate of perceived exertion, see image: www.max-form.com/a-simple-workout-intensity-scale-rpe/

Another useful resource is:

- https://www.youtube.com/watch?v=HhRDUYmIALU

This provides an explanation

Topic 2.2.8

Target heart rate: understanding and use of Karvonen's theory.

Karvonen's theory will need to be taught so that heart rate reserve is understood. There is also detail about this topic in the anatomy and physiology booklet.

www.britishcycling.org.uk/knowledge/article/izn20140808-Understanding-Intensity-2--Heart-Rate-0 has some good information about percentage of functional intensity and threshold.

There is a worked example in the Sample Assessment Materials of the calculation of target heart rate using Karvonen's theory. It is question 9b in the Scientific

Principles A level paper (section B, Exercise physiology). It uses heart rate reserve as a means of calculating your training zone.

Calculating target heart rate with the Karvonen Formula:

- 220 – age = maximum heart rate
- Maximum heart rate – resting heart rate = heart rate reserve
- (Heart rate reserve x training percentage) + resting heart rate

A worked example can also be found on this website: www.sport-fitness-advisor.com/heart-rate-reserve.html

Another useful resource is:

- https://www.youtube.com/watch?v=Nab53QeovXo
  The second half of the video explains Karvonen's theory

Topic 2.2.9

This section also includes a section on contemporary technologies used by the performer and coach to monitor fitness and performance because this area may change over the life of the specification as new technologies are used by athletes. For example, current technology includes heart rate monitors and apps to track routes taken for runs. A learner should be able to analyse the benefits of using technology to monitor work rate, fitness and performance, and use examples to support their answers.

Topic 2.2.10

Learners should understand periodisation. Wesson and Wiggins textbook has useful detail on this.

This includes the macro, meso and micro cycles and being able to explain each of these terms. Learners should also have an understanding of the preparation phase (includes the off-season and pre-season – general conditioning, aerobic endurance training, mobility training, training to maintain strength and to give a base upon which to build), competition phase and transition phase (which is post competition and bridges) the gap between the season passed and the next training year, a period of active rest with some low intensity aerobic work).

Being able to interpret diagrams such as this one below and make comments about how training has been planned will be important.

See image from: http://gregniclewiscasestudy.blogspot.co.uk/p/annual-periodised-training-programme.html

Other useful resources are:

- https://www.youtube.com/watch?v=ZnELRTIlVWQ&index=3&list=PLPhHSZWjt-K7r501f-9mk-pVSMoLmYoVB
  Covers periodisation: Macrocycle, Mesocycle, Microcycle
- https://www.youtube.com/watch?v=W5VJafi1cx0
  Covers parts of the season with England Rugby and can be linked to discussion around training method

Topic 2.2.11

Methods of training and their appropriateness for different activities are also on the specification. This should link to fitness testing and selecting the most appropriate methods for the individual needs. Definitions of each of these will need to be learnt

as well as the advantages and disadvantages of each method. Learners will need to be able to justify why different types of training may be used by particular athletes.

These methods are:

- Interval training: training with a work-to-rest ratio (W:R) that is repeated.
- Circuits: performing different exercises in a sequence at different exercise stations.
- Cross: training in two or more sports in order to improve fitness and performance in a main sport.
- Continuous: long duration where intensity remains constant throughout.
- Fartlek: a long duration activity where the intensity varies.
- Flexibility:
- Static stretching: a stretch that is held in a challenging but comfortable position for a period of time, usually somewhere between 10 to 30 seconds.
- Ballistic: the use of momentum of a body or limb to force it beyond its normal range of motion.
- Proprioceptive neuromuscular facilitation (PNF): a muscle group is passively stretched, then contracts isometrically against a resistance while in a stretched position and is then passively stretched again. Often uses a partner to give resistance. www.stretching-exercises-guide.com/pnf-stretching.html is useful if you want to read more about PNF.
- Weights (free weights and machines): training with weights against a (variable) resistance either on machines or with free weights. Learners will need to know the difference between the use of machines and free weights.
- Resistance training (including pulleys and parachutes): exercising your muscles using an opposing force.
- Assisted training (including bungees and downhill):Bungee running uses the recoil action of the bungee cord to pull you at a faster rate than you could achieve on the flat or in a voluntary sprint.. This technique forces your muscles to work at a higher intensity than they normally would, which trains the nerve cells that control movements and coordinate leg-muscle activity during very quick contractions to function at accelerated firing rates.

  http://www.hardcorehockey.co.uk/article/fitness-factor/assisted-speed-training-bungees
- Plyometrics: a movement involving an eccentric contraction immediately before a concentric contraction.
- Speed agility quickness (SAQ): targeting neuromuscular adaptations to aid speed of muscle firing.
- Functional stability training: ensure there is a stable base for the limbs to function from otherwise there's a loss of force and possible injury risk. A stable core requires a well-conditioned deeper lying trunk muscles and a balance between opposing muscle groups.

Topic 2.2.12

Learners should have a knowledge and understanding about how an athlete will prepare for performance at altitude, in heat and in humidity. This should include both training and nutrition. It may also include any contemporary technologies.

- www.sport-fitness-advisor.com/acclimatization-to-altitude.html may be useful to read about acclimatisation to altitude.
- www.acsm.org/public-information/articles/2012/01/13/preparing-for-and-playing-in-the-heat may be useful to read about heat.

Another useful resource is:

- https://www.youtube.com/watch?v=ZwzeUT82ZxQ

Altitude – what happens? Useful background as to the impact of altitude. Opens up option of a discussion as how to best prepare for this.

Topic 2.2.13

Learners will also need knowledge and understanding of strategies for speeding up recovery following physical activity: cooling down, massage, ice baths and compression clothing. Question 7B in the A level Sample Assessment Materials looks at compression clothing. The mark scheme gives additional detail on this section. Learners will need to be able to explain each method and how it works to speed up recovery by giving physiological detail.

2.3 Injury prevention and the rehabilitation of injury

Topic 2.3.1

Learners will require knowledge and understanding of the two different classifications of common sporting injuries: acute and overuse. Acute can be viewed from two perspectives. Injuries can occur from two sources from contact and non-contact scenarios.

Topic 2.3.2

Acute injuries include cruciate ligament injury, soft tissue damage, sprain, Achilles tendon injury, fracture and dislocation. Learners will need to show an understanding of each injury and how they may occur.

- **www.sportsmedicine.about.com is a useful website for an explanation of each injury.**

Topic 2.3.3

Overuse injuries include strain, shin splints (periostitis), tendonitis (including tennis elbow and golfer's elbow) and stress fractures. Learners will need to show an understanding of each injury and how they may occur.

- **www.sportsmedicine.about.com is a useful website for an explanation of each injury.**

Topic 2.3.4

Learners should have a knowledge and understanding about the ways of preventing injuries. This should include conditioning, muscle balance, technique, protective equipment and managing risks. Learners should show knowledge of how these work together and which are most effective.

Topic 2.3.5

Learners need to have an understanding of rehabilitation from injuries. Recovery methods will change over time hence the inclusion of contemporary recovery methods in the specification.

In researching each of the injuries listed above learners will need to consider how an athlete would recover from this injury and how long it might take to return to match fitness after this injury. Learners will be expected to research different injuries and a possible way of doing this is that they could follow an athlete with a long-term injury, so they can gain a greater understanding of the topic area. The questions in the exam will

be worded so that learners will be able to answer it from their own research whether theoretical or of a specific case study.

Examples of rehabilitation methods include ultrasounds, physiotherapy, hyperbaric chambers, oxygen tents, compression garments, ice baths, nutrition, climate chambers and cryotherapy.

- **www.cryoclinics.co.uk/benefits-of-cryotherapy-in-sports-recovery/ is a useful article about cryotherapy. Learners will need to be able to explain and discuss each of these methods.**

POLICE (Protection, Optimal Loading, Ice, Compression and Elevation) and RICE (Rest, Ice, Compression and Elevation) are two strategies well documented for recovery. Learners should be able to discuss the advantages and disadvantages of these rehabilitation strategies.

- **www.bjsm.bmj.com/content/46/4/220 - BIBL is a useful article about POLICE as a rehabilitation strategy.**

Topic 2.4–2.7

All of the Biomechanical movement elements are in Component guide 3.

Detailed content changes

The major differences between 2008 and 2016 come in the level of detail required in the topic. Theory is now worth 70 per cent so there is an increased content detail.

Section 2.1 was included in 2008 specification but there are significant new things to notice such as cardiovascular endurance not being a component of fitness. However, VO2 max, anaerobic capacity and exercise economy are all added components from 2008. There are several fitness tests that should be taught to include:

- functional thresholds
- lactate threshold
- anaerobic threshold/maximum steady state
- gas analysis
- yo-yo test
- Wingate test
- maximum accumulated oxygen deficit (MAOD)
- RAST (repeat anaerobic sprint test)
- Cunningham and Faulkner
- jump tests
- Margaria-Kalaman.

No specific fitness tests were named in the 2008 specification but there are several named in this specification. Many can be conducted by learners but some will require a theoretical knowledge if centres do not have access to the equipment. It would be worth trying to see them in action in a university lab as part of the course if this is possible.

Another new concept is the 'determinants of movement/running performance' and their application to sprint, endurance and intermittent activities. There is a useful diagram explaining the determinants in the section above (Topic 2.2.4).

Principles of training now include individual needs and progressive overload (rather than progression and overload as distinct concepts as in the 2008 specification).

Another new concept is the inclusion of different ways of measuring and calculating intensity: percentage of functional intensity, percentage of one repetition maximum (RM), Rate of Perceived Exertion (RPE), percentage of functional threshold, target heart rate and work-to-rest ratios. This is best taught via a practical approach so that learners understand it in more detail.

The inclusion of target heart rate: understanding and use of Karvonen's theory lends itself to calculation style questions.

Under periodisation the competition phase and transition phase are new elements.

The 2008 specification had training methods but this now includes a few extras such as flexibility (static, ballistic and proprioceptive neuromuscular facilitation (PNF)), weights (free weights and machines), resistance (including pulleys, parachutes), assisted (including bungees, downhill), and functional stability. Advantages and disadvantages of each method of training are the key areas in Exercise physiology.

Adaptations to body systems remain in the specification but are in the anatomy and physiology section. They are not specifically linked to the training methods in the specification, although they will only occur through training. Learners could be asked to link this knowledge in a synoptic question.

2.3 Injury prevention and the rehabilitation of injury at A level this is a completely new topic area.

Delivery approaches including ideas for practical delivery

This unit lends itself to a practical approach as much as possible.

Topic	Ideas for delivery
Optimal weight	• Food diaries, calculation of energy balance intake and expenditure for learner and then an athlete and compare with case study.
Electrolytes, hypotonic, hypertonic, isotonic solutions	• Investigate properties of different sports drinks. Create a commercial for each type.
Supplementation	• Individual learners research each supplement and its uses and then present to the class.
Components of fitness	• Clips of elite athletes and which fitness components are most useful – e.g. diamond 9 where you rank them in order of how useful they are to an athlete. • Learners do a practical lesson on each component teaching the group with examples of activities.
Measuring intensity	• Practical lessons where learners have to gauge intensity via the different methods and compare the results. Make tables of results and then graph them.
Methods of training	• Learner-led mini session on each method of training. Create a handout with advantages and disadvantages, and an explanation of which sports the method is most useful for.
Fitness tests	• If you can visit a university to try out any tests in lab conditions this would be great. Do the tests as accurately as you can, gather results and analyse them. Create athlete profiles and then assess which sports the athlete is most suited to and why.
Strategies for speeding up recovery	• Practical investigation into which method recovers faster by comparison of results. Graphs and tables of results to compare. Using a set intensity (link to measuring intensity lesson) you could use a set training method (link) and then recover in each way each time. Plot recovery heart rate on a graph. Might make a good homework investigation task.
Classifications of injury	• **Case studies of different athletes who have had different injuries. If you can get hold of any x-rays then you may want to ask learners to diagnose symptoms, or alternatively someone describes an injury and they work in pairs to try to diagnose it.**

Rehabilitation strategies	• **Research POLICE and RICE and compare the differences.** • **Individuals research each of the methods listed.**

Quantitative skills guidance

There are several topics in this section that lend themselves to quantitative skill: most notably interpreting and presenting data on fitness test results, target heart rates and calculation of heart rates using Karvonen's theory, and interpreting and calculating different ways of measuring intensity. The more graphs and tables presented in different ways that learners can become familiar with the better so that they are ready to interpret or do their own calculations. Calculating their energy balance, intake and expenditure is another example of a practical investigation that can yield tables and values to interpret. Calculating energy usage of different sports is another area that could be useful to interpret.

Sample questions

Regular testing of learners on the key terms in the glossary that are part of the specification is important (see Appendix 7, page 88).

When practising questions ensure that tutors and learners are using the command words in the specification and that learners understand the requirements of each command word.

For examples of questions and mark scheme please refer to the Sample Assessment Materials on the Edexcel website.

Section B on the Scientific Principles A level paper contains example questions.

These are questions 7, 8, 9b, 10, 11 and 12. In the AS Sample Assessment Materials it is questions 9–16 (section B, Exercise physiology).

Learners can also write their own questions using the following examples of sentence starters:

- The components of fitness can be used by an athlete…
- The fitness test… is…
- An athlete would prepare for performance by…
- Principles of training are…
- Methods of training are used by…

Resources and references

Useful textbooks

- Bean, A. (2008) The Complete Guide to Strength Training (Complete Guides) London: A&C Black Publishers.
- Bean, A. (2013) *The Complete Guide to Sports Nutrition (Complete Guides)*, London: Bloomsbury Sport
- Bean, A. (2014) *Food for Fitness: How to Eat for Maximum Performance* London: Bloomsbury Sport
- Bean, A. (2015) *Sports Supplements: Which Nutritional Supplements Really Work*, London: Bloomsbury Sport
- Beashel, P. and Taylor, J. (1999) *Advanced Studies in Physical Education and Sport*, Cheltenham: Nelson Thornes
- Benardot, D. (2012) *Advanced Sports Nutrition (Second Edition)*, Champaign, IL: Human Kinetics Publishers
- Coulson, M. (2013) *The Complete Guide to Personal Training (Complete Guides)*, London: Bloomsbury Sport.
- Davis, R., et al. (2000) *Physical Education and the Study of Sport*, St. Louis, MO: Mosby
- Honeybourne, J., Hill, M. and Moors, H. (2004) *Advanced Physical Education and Sport for A level (Third Edition)*, Cheltenham: Nelson Thornes
- Kenney, W., Wilmore, J. and Costill, D (2015) *Physiology of Sport and Exercise*, Champaign, IL: Human Kinetics
- Kent, M. (2007) *Oxford Dictionary of Sports Science and Medicine*, Oxford: OUP
- McArdle, W. and Katch, F. (2010) *Essentials of Exercise Physiology (Fourth Edition)*, Philadelphia, PA: Lippincott Williams & Wilkins
- Nash, C. (2014) *Practical Sports Coaching*, London: Routledge
- Peterson, L. and Renstrom, P. (2016) *Sports Injuries (Fourth Edition)*, Boca Raton, FL: CRC Press
- Wesson, K., et al. (2005) *Sport and PE: A complete guide to advanced level study (Third Edition)*, London: Hodder Education

(There are also Complete Guides to other training methods in this series such as circuits, core stability, training with free weights and so on.)

Useful websites

Carb-loading:

- www.runnersworld.co.uk/nutrition/60-second-guide-carb-loading/3961.html

POLICE:

- www.bjsm.bmj.com/content/46/4/220 - BIBL

Protocols of fitness tests:

- www.topendsports.com/testing/tests/index.htm

Injuries:

- www.physiosinsport.org/media/wysiwyg/ACPSM_Physio_Price_A4.pdf

Cryotherapy:

- **www.cryoclinics.co.uk/benefits-of-cryotherapy-in-sports-recovery/**

Training and contemporary information:

- www.rio2016.com
- www.marathontraining.com
- www.sportengland.org
- www.teamgb.com
- http://exercise.about.com/library/blexerciseglossary.htm
- www.openhere.com/sports/professional
- www.teamsky.com
- www.britishathletics.org.uk

Supplements:

- www.lucozadesport.com
- www.gssiweb.org

MAOD:

- www.elitetrack.com/article_files/oxygendeficit.pdf
- http://www.amazon.co.uk/Practical-Fitness-Testing-Analysis-Professionals-ebook/dp/B0143JM1WI/ref=sr_1_1?s=books&ie=UTF8&qid=1441555655&sr=1-1&keywords=coulson+and+archer+practical

Functional intensity and threshold:

- www.britishcycling.org.uk/knowledge/article/izn20140808-Understanding-Intensity-2--Heart-Rate-0

Rating of perceived exertion:

- www.max-form.com/a-simple-workout-intensity-scale-rpe/

Heart rate reserve:

- www.sport-fitness-advisor.com/heart-rate-reserve.html

Periodisation:

- http://www.google.co.uk/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0CAUQjhxqFQoTCMmogKfr0cgCFYE2GgoduiELng&url=http%3A%2F%2Fgregniclewiscasestudy.blogspot.com%2Fp%2Fannual-periodised-training-programme.html&psig=AFQjCNGph6LIu2ZDWI1wNc75P9P8Rpnjzg&ust=1445457593932818

PNF stretching:

- www.stretching-exercises-guide.com/pnf-stretching.html

Functional stability training:

- www.functionalstability.com

Assisted Training:

- http://www.hardcorehockey.co.uk/article/fitness-factor/assisted-speed-training-bungees

Altitude and heat preparation:

- www.sport-fitness-advisor.com/acclimatization-to-altitude.html
- www.ausport.gov.au/sportscoachmag/sports_sciences/climate_control_acclimatising_to_the_heat
- www.acsm.org/public-information/articles/2012/01/13/preparing-for-and-playing-in-the-heat

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