Unit 2: Sport and Exercise Physiology

Unit code: T/600/0039

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The unit provides learners with an understanding of how the body physiologically reacts to the onset and continuation of physical activity. It will also consider the mechanisms of fatigue and recovery.

Unit introduction

The human body is magnificent in being able to react and adapt to the changes it experiences. The body allows us to take part in a huge variety of differing sport and exercise activities. Every time we take part in sport or exercise, the body undergoes a series of changes providing us, the performer, with the ability and the energy to carry out these actions.

It is the interaction of the body's systems that makes this variety of sport and exercise activities possible. The responses of these systems will depend on the stage of the activity and the exercise history of the individual. Exercise cannot continue indefinitely; sooner or later we will have to cease exercising and take time to recover.

Understanding these systems is imperative in the sport and exercise industries. This is so that we can appreciate how the body copes with the stress of exercise, why we cannot continue to exercise indefinitely, and how we can train these systems to improve our fitness.

The unit starts by exploring the responses of the cardiovascular, respiratory and energy systems to the anticipation and initial stress of exercise. Learners will then explore the response of the body when a steady state has been achieved.

The mechanisms of fatigue are then examined, these include waste products, depletion of energy stores and neuromuscular fatigue. Recovery from sports and exercise is then investigated and finally, to complete the unit, learners will explore the ways in which the body adapts to repeated bouts of exercise; both the aerobic and anaerobic adaptations are covered.

Learning outcomes

On completion of this unit a learner should:

1 Be able to investigate the initial responses of the body to exercise

2 Be able to investigate how the body responds to steady-state exercise

3 Know fatigue and how the body recovers from exercise

4 Know how the body adapts to long-term exercise.

Unit content

1 Be able to investigate the initial responses of the body to exercise

Exercise: aerobic; anaerobic

Cardiovascular responses: heart rate (anticipatory increase and activity response); stroke volume; cardiac output; blood pressure (calculating – resistance to flow multiplied by heart rate; readings)

Respiratory responses: increase in breathing rate; intercostal muscles; increase in tidal volume; Valsalva manoeuvre; pulmonary ventilation

Neuromuscular responses: nervous control of muscular contraction, eg neuromuscular junction, motor unit; muscle spindles

Energy system responses: adenosine triphosphate production; creatine phosphate and lactic acid system; anaerobic glycolysis

2 Be able to investigate how the body responds to steady-state exercise

Steady-state exercise: eg 20 minutes of continuous same-speed jogging, 20 minutes of an aerobics class, 20 minutes of continuous same-speed swimming

Cardiovascular responses: heart rate; stroke volume; cardiac output; blood flow (vasodilatation and vasoconstriction); blood pressure; thermoregulation; increased venous return; Starling's law

Respiratory responses: tidal volume; breathing rate; effects of pH and temperature on the oxygen dissociation curve

Neuromuscular responses: increased pliability of muscles; increased transmission rate of nerve impulses

Energy system responses: adenosine triphosphate production; aerobic energy system; anaerobic glycolysis; mitochondria; Krebs cycle; electron transport chain

3 Know fatigue and how the body recovers from exercise

Fatigue: depletion of energy sources, eg creatine phosphate, muscle and liver glycogen; effects of waste products, eg blood lactate accumulation, carbon dioxide, increased acidity; neuromuscular fatigue, eg depletion of acetylcholine, reduced calcium-ion release

Recovery: excess post exercise oxygen consumption (EPOC); fast components, eg restoration of muscle phosphagen stores, removal of lactic acid; slow components, eg replenishment of myoglobin stores, replacement of glycogen

4 Know how the body adapts to long-term exercise

Long-term exercise: eg four 30-minute jogging sessions per week for eight weeks, a six-week resistance training programme

Cardiovascular adaptations: cardiac hypertrophy; increase in stroke volume; increase in cardiac output; decrease in resting heart rate; blood volume; capillarisation

Respiratory adaptations: increase in minute ventilation; efficiency of respiratory muscles; increase in resting lung volumes; increase in oxygen diffusion rate

Neuromuscular adaptations: hypertrophy; increase in tendon strength; increased myoglobin stores; increased numbers of mitochondria; increased storage of glycogen and triglycerides; neural pathways

Energy system adaptations: increased anaerobic and aerobic enzymes; increased use of fats as an energy source; higher tolerance to lactic acid

Skeletal adaptations: increased calcium stores; increased tendon strength; increased stretch of ligaments

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 investigate the initial responses of the cardiovascular and respiratory systems to exercise [IE3, IE4]	**M1** explain the initial responses of the cardiovascular, respiratory, neuromuscular and energy systems to exercise	**D1** analyse the initial responses of the cardiovascular, respiratory, neuromuscular and energy systems to exercise
P2 describe the initial responses of the neuromuscular and energy systems to exercise		
P3 investigate how the cardiovascular and respiratory systems respond to steady-state exercise [IE3, IE4]	**M2** explain how the cardiovascular, respiratory, neuromuscular and energy systems respond to steady-state exercise	**D2** analyse the responses of the cardiovascular, respiratory, neuromuscular and energy systems to steady-state exercise
P4 describe how the neuromuscular and energy systems respond to steady-state exercise		
P5 describe fatigue, and how the body recovers from exercise	**M3** explain fatigue, and how the body recovers from exercise	
P6 describe how the cardiovascular and respiratory systems adapt to long-term exercise	**M4** explain how the cardiovascular, respiratory, neuromuscular, energy and skeletal systems adapt to long-term exercise.	**D3** analyse how the cardiovascular, respiratory, neuromuscular, energy and skeletal systems adapt to long-term exercise.
P7 describe how the neuromuscular, energy and skeletal systems adapt to long-term exercise.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit lends itself to a variety of delivery methods. Whilst theory must be taught, there should be as much practical activity as possible.

The initial responses of the body to exercise could be taught through learners recording resting measurements of heart rate, breathing rate and blood pressure. They could then take part in some form of exercise which lasts for only a few minutes. Once the exercise is complete, learners should measure heart rate, breathing rate and blood pressure and compare these values to resting measurements. It may be a good idea for learners to work in groups of four so that one person exercises, one person measures heart rate, one person measures breathing rate and the other measures blood pressure. This practice is invaluable as it will allow learners to get used to working with others and aid their preparation for working in the sports industry.

In order to take physiological measurements whilst exercising, access to ergometers would be very useful. This enables measurements to be taken from a person who is exercising at a set intensity and in a suitable position. Similar practical activities can be carried out to understand how the body responds to steady-state exercise; however, learners will have to carry out continuous exercise for at least 20 minutes before physiological measurements can be recorded. Fatigue and recovery can be examined through learners taking part in a range of exercises, each of which use different energy systems, for example, vertical jump predominantly uses the phosphocreatine system, ski squat predominantly uses the lactic acid system and long distance running predominantly uses the aerobic system. Learners would then describe how they felt at the end of each exercise and why they could no longer continue the exercise.

The adaptation of the body to long-term exercise can be explored by using diagrams and pictures of muscle tissue, hearts and bones of aerobically and anaerobically trained athletes. This can then be coupled with theoretical teaching of energy system adaptation and respiratory adaptation. Depending on the group it may be possible to compare data to determine which learners have evidence of some adaptation to strength training, for example via a one Repetition Maximum (1-RM) test, and those that have evidence of adaptation to aerobic training, for example via a multi-stage fitness test. Relevant health and safety considerations should be taken before practical activities, such as obtaining informed consent.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction and overview of the unit.
Assignment 1: How Does the Body Respond to Initial and Steady-State Exercise? (P1, P2, M1, D1, P3, P4, M2, D2). Tutor introduces the assignment brief.
Identification of cardiovascular, respiratory, neuromuscular and energy systems: recap of structure and function of the systems – question and answer sessions, group discussion, formal input to summarise.
The initial responses to exercise and to steady state exercise for each of the systems: practical activities to show responses, record data using fitness testing equipment, eg spirometer, HR monitor, manual taking of pulse etc, in order to provide discussion, feedback to the group and assignment evidence.
Assignment 2: Fatigue and Recovery From Exercise (P5, M3). Tutor introduces the assignment brief.
Fatigue: reasons behind and result of fatigue process – learner research tasks and practical activities.
Recovery: how the body recovers – interactive lecture and case studies.
Fatigue and recovery: learner practical activities to demonstrate safely under supervised conditions – no maximal testing. Possible use of other fitness tests eg multistage fitness test – presentation of findings using variety of methods such as poster or presentation.
Assignment 3: How Does the Body Adapt to Long-term Exercise? (P6, P7, M4, D3). Tutor introduces the assignment brief.
Adaptations made by each of the identified systems – learner research activities.
Use of case studies to look at adaptations made by the body in relation to differing sporting activities.
Review of unit and assessment.

Assessment

For P1, learners need to practically investigate what happens to the heart rate before exercise has started (anticipatory response) and what happens to the heart rate, stroke volume, blood pressure, cardiac output and breathing rate during the first few minutes of exercise. Evidence could be in the form of a group presentation, supported by a tutor witness statement. Alternatively, learners could produce a report describing their physiological data results and what they mean.

For P2, learners should describe the process of nervous control of the muscles in order to allow the muscles to contract and also the energy systems employed to produce the energy required for the first few minutes of exercise.

For P3, learners should practically investigate what happens to the heart rate, stroke volume, blood pressure, cardiac output, re-direction of blood flow, breathing rate, change of tidal volume, changes to the oxygen dissociation curve and methods of thermoregulation after 20 minutes of continuous exercise. Learners should undertake practical activities/experiments to collect physiological data and use this as a basis for their description.

For P4, learners should describe how nervous control changes after a period of steady-state exercise. They must also describe the energy systems employed to produce the energy required during 20 minutes of continuous exercise.

For P5, learners must describe the mechanisms of fatigue; this includes the effect of waste products, neuromuscular fatigue and depletion of energy sources.

For P6, learners should describe how the cardiovascular system and respiratory systems adapt to long-term (chronic) exercise; the exercise period explored should be no less than eight weeks. Both aerobic and anaerobic exercise should be examined and the effects described.

For P7, learners should describe how the neuromuscular system, skeletal system and energy systems adapt to long-term (chronic) exercise, the exercise period should be no less than eight weeks. Both aerobic and anaerobic exercise should be examined and the effects described.

For M1, learners should explain what happens to the cardiovascular, respiratory, neuromuscular and energy systems during the first few minutes of exercise and why it happens.

For M2, learners should explain what happens to the cardiovascular, respiratory, neuromuscular and energy systems after 20 minutes of continuous exercise and why these changes occur.

For M3, learners must explain the causes of fatigue and how the body recovers.

For M4, learners should explain how the cardiovascular, respiratory, neuromuscular, energy and skeletal systems respond and adapt to long-term (chronic) exercise; the exercise period should be no less than eight weeks. Both aerobic and anaerobic exercise should be examined and the effects explained.

For D1, the cardiovascular, respiratory, neuromuscular and energy systems' initial response to exercise should be analysed, including why each process takes place.

For D2, learners should analyse what happens to the cardiovascular, respiratory, neuromuscular and energy systems after 20 minutes of continuous exercise and give explanations as to why these changes occur.

For D3, learners should analyse the adaptations to long-term (chronic) exercise of the skeletal, cardiovascular, respiratory, neuromuscular and energy systems.

Criteria P1, P2, M1 and D1 could be assessed by asking learners to monitor their resting blood pressure, heart rate and breathing rate. They would then be asked to think about exercise and monitor heart rate again. They could then take part in a practical activity such as jogging on a treadmill for up to one minute. Heart rate, breathing rate and blood pressure could be taken during the activity and recorded. Learners would then be asked to compare the readings and discuss the energy systems that were supplying the body with energy during this period.

Criteria P3, P4, P5, M2, M3 and D2 could be assessed in a similar manner. However, readings should be taken after 20 minutes of constant exercise participation, for example treadmill running at a constant speed, cycle ergometer.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, M1, M2, D1, D2,	How Does the Body Respond to Initial and Steady-State Exercise?	Practical exploration to identify the body's reaction between initial and steady-state exercise.	Group presentation/poster. Witness statement. Written report.
P5, M3	Fatigue and Recovery from Exercise	Practical exploration/research task to identify the body's reaction to fatigue and how it recovers from exercise.	Written report.
P6, P7, M4, D3	How Does the Body Adapt to Long-term Exercise?	Learners to research adaptations for each of the identified systems.	Case study report.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Sport and Exercise Sciences sector suite. This unit has particular links with the following unit titles in the BTEC Sport suite and the BTEC Sport and Exercise Sciences suite:

Level 2 Sport	Level 3 Sport	Level 3 Sport and Exercise Sciences
Anatomy and Physiology for Sport	Principles of Anatomy and Physiology in Sport	Anatomy for Sport and Exercise
Effects of Exercise on the Body Systems	The Physiology of Fitness	Exercise, Health and Lifestyle
Fitness Testing and Training	Fitness Training and Programming	Fitness Testing for Sport and Exercise
Planning and Leading Sports Activities	Sports Coaching	Fitness Training and Programming
Practical Sport	Fitness Testing for Sport and Exercise	Sport and Exercise Massage
Nutrition for Sports Performance	Sports Nutrition	Analysis of Sports Performance
Development of Personal Fitness	Exercise, Health and Lifestyle	Sports Nutrition
Exercise and Fitness Instruction	Instructing Physical Activity and Exercise	Instructing Physical Activity and Exercise
	Exercise for Specific Groups	Sports Injuries
	Sports Injuries	Sports Coaching
	Analysis of Sports Performance	Applied Sport and Exercise Physiology
	Talent Identification and Development in Sport	Exercise for Specific Groups
	Sport and Exercise Massage	

This unit links with the National Occupational Standards (NOS) for:

- Coaching, Teaching and Instructing at Level 3
- Instructing Physical Activity and Exercise at Level 3.

Essential resources

Learners will need access to practical sports facilities, such as a sports hall, as well as sports science equipment and resources, including heart rate monitors, blood pressure monitors and spirometers. Access to ergometers and/or treadmills would be beneficial.

Employer engagement and vocational contexts

This unit focuses on the practical aspects of sport and exercise physiology. It gives learners opportunities to investigate the body's response to exercise and how it adapts over time.

Centres are encouraged to develop links with local education professionals and fitness instructors so that the vocational value is made explicitly aware to learners. This could be via talks, visits to fitness centres or practical involvement under instruction. This information will help inform learners of training processes, the body's responses and how to appropriately supervise and guide individuals undertaking a training regime.

Indicative reading for learners

Textbooks

Adams G M – *Exercise Physiology Laboratory Manual: Health and Human Performance* (McGraw Hill Higher Education, 2001) ISBN 97800724891 25

American College of Sports Medicine – *ACSM's Health-Related Physical Fitness Assessment Manual* (Lippincott Williams & Wilkins, 2007) ISBN 9780781775496

Coulson M – *The Fitness Instructor's Handbook: A Complete Guide to Health and Fitness – Fitness Professionals* (A&C Black, 2007) ISBN 9780713682250

Hazeldine R – *Fitness for Sport* (The Crowood Press, 2000) ISBN 9781861263360

Heyward V H – *Advanced Fitness Assessment and Exercise Prescription* (Human Kinetics, 2006) ISBN 9780736057325

Howley E T and Franks B D – *Health Fitness Instructor's Handbook* (Human Kinetics Europe, 2003) ISBN 9780736042109

National Coaching Foundation – *Physiology and Performance – NCF Coaching Handbook No. 3* (Coachwise Ltd, 1987) ISBN 9780947850241

Powers S K and Howley E T – *Exercise Physiology: Theory and Application to Fitness and Performance* (McGraw Hill Higher Education, 2006) ISBN 9780071107266

Sharkey B J and Gaskill S E – *Fitness and Health* (Human Kinetics, 2006) ISBN 9780736056144

Watson A W S – *Physical Fitness and Athletic Performance: A Guide for Students, Athletes and Coaches* (Longman, 1996) ISBN 9780582091108

Wilmore J and Costill D – *Physiology of Sport and Exercise* (Human Kinetics, 2008) ISBN 9780736055833

Journals

American College of Sport Medicine's Health and Fitness Journal

British Journal of Sports Medicine

Exercise and Sport Sciences Reviews

International Journal of Sports Science and Coaching

Medicine and Science in Sports and Exercise

Research Quarterly for Exercise and Sport

Websites

American College of Sports Medicine	www.acsm.org
British Association of Sport and Exercise Sciences	www.bases.org.uk
Coachwise	www. l st4sport.com
Human Kinetics	www.humankinetics.com
Peak Performance	www.pponline.co.uk
Sports Coach	www.brianmac.co.uk
Sports Coach UK	www.sportscoachuk.org
Top End Sports	www.topendsports.com

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	investigating the initial responses of the cardiovascular and respiratory systems to exercise investigating how the cardiovascular and respiratory systems respond to steady-state exercise.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	describing the body's response to varying levels of exercise, ie initial, steady-state and long term via group discussion
Creative thinkers	producing posters, leaflets, or other visual presentation evidence to illustrate findings
Team workers	working in groups to produce presentation of findings working in groups to record data from practical physical assessment
Effective participators	undertaking practical assessment – performing exercise.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	researching the body's response to initial, steady-state and long-term exercise
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	recording response to exercise assessment data preparing visual evidence of research findings
Manage information storage to enable efficient retrieval	recording response to exercise assessment data
Follow and understand the need for safety and security practices	recording and interpreting response to exercise assessment data
ICT – Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	preparing response to exercise assessment data
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	recording response to exercise assessment data preparing visual evidence of research findings
Bring together information to suit content and purpose	interpreting response to exercise assessment data for initial, steady-state and long-term exercise
Present information in ways that are fit for purpose and audience	recording and interpreting data results for initial, steady-state and long-term exercise
Evaluate the selection and use of ICT tools and facilities used to present information	interpreting response to exercise assessment data
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	accurately recording data results
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	interpreting exercise assessment data results
Select and apply a range of skills to find solutions	interpreting exercise assessment data
Draw conclusions and provide mathematical justifications	interpreting data results

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing how to assess the body's response to initial, steady state and long-term exercise
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the effects of long-term exercise interpreting assessment results
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	accurately recording data and producing reports based on findings.