Anatomy and physiology for exercise and fitness instructors

For this unit you will be assessed via an externally set multiple choice theory paper relating to the below unit content. Please note, the course learning materials (elearning, manual, powerpoints) at times go over and above this content to give you a greater depth of knowledge, however you will only be assessed on the below content in the exam.

Unit content:

Know the structure and function of the circulatory system

Identify the location and function of the heart, to include:

- it is the size of an adult's clenched fist
- the position of the heart – behind the sternum, just to the left of centre
- the heart is a muscular pump that circulates blood around the body
- the function of circulating oxygen and nutrients within the blood to the body
- the function of circulating carbon dioxide and waste products within the blood to be expelled from the body

Describe the structure of the heart, to include:

- the heart walls are formed from cardiac muscle (myocardium)
- the four chambers in the heart (two atria, two ventricles)
- the size and description of the atria and ventricles:
    - atria are smaller than the ventricles and have less muscular walls
    - the left ventricle has thicker, more muscular walls than the right ventricle to enable it to pump blood to the body via the aorta
- the heart valves:
    - atrioventricular valves (tricuspid valve and bicuspid or mitral valve)
    - semilunar valves (pulmonary valve on right and aortic valve on left)
    - sinoatrial valve – the pacemaker of the heart which initiates the heartbeat

Describe how blood moves through the 4 chambers of the heart, to include:

- how blood is collected and pumped (cardiac cycle)
- how the atria receive blood from veins. The left atrium receives oxygenated blood from the pulmonary veins. The right atrium receives blood from the vena cava
- how the ventricles pump the blood into the arteries under force
- how the right ventricle pumps blood to the lungs via the pulmonary arteries
- the terminology and meanings associated with cardiac cycle, to include:
    - heart rate
    - stroke volume
    - cardiac output

Describe systemic and pulmonary circulation, to include:

- a brief overview of systemic and pulmonary circulation
- direction of blood flow
- associated blood vessels

Describe the structure and functions of blood vessels, to include:

- the vascular network and how it connects to the heart, lungs and muscles
- arteries, veins and capillaries, in terms of:
    - thickness of vessel wall
    - internal diameter
    - blood pressure
    - direction of blood flow
    - function of non-return valves in veins
- arteries carry blood away from the heart at high pressure (oxygenated blood in all arteries except the pulmonary arteries). They are pressurised and have thick, smooth, muscular walls. The aorta is the major artery that carries blood from the left ventricle to the body. The pulmonary arteries carry blood from the right ventricle to the lungs
- veins carry blood towards the heart at low pressure (deoxygenated blood in all except the pulmonary veins) and have thinner, less muscular walls. They have a series of one-way (non-return) valves to prevent backflow of blood and require the assistance of skeletal muscle to help venous return. The vena cava has two branches (inferior and superior) and returns blood from the body back to the right atrium. The pulmonary veins return blood back to the left atrium
- arterioles and venules are smaller versions of arteries and veins respectively
- capillaries are the smallest of the blood vessels with very thin walls to allow gaseous exchange to take place

Define blood pressure, to include:

- blood pressure as a measure of force in the artery walls
- the body's need for blood pressure
- systolic blood pressure as the pressure in the arteries during ventricular contraction
- diastolic blood pressure as the pressure in the arteries during ventricular relaxation
- the effects of exercise on blood pressure

Identify blood pressure classifications, to include:

- optimal, normal blood pressure classifications
- definitions of hypotension and hypertension
- pre-hypertension, stage 1, 2 and 3 hypertension definitions
- the implications for exercise of hypertension
- current and up-to-date guidelines detailed from the following bodies:
    - World Health Organization (WHO)
    - National Institute for Health and Care Excellence (NICE)
    - American College of Sports Medicine (ACSM)

Understand the structure and function of the respiratory system

Identify the location and function of the lungs, to include:

- the position of the lungs within the thoracic cavity
- the process of gaseous exchange
- the process of respiration:
    - take in air from the atmosphere
    - pass oxygen into the circulatory system
    - remove carbon dioxide from the circulatory system

Describe the structure of the lungs, to include:

- the function and location of each structure:
    - trachea (windpipe)
    - bronchus (bronchi)
    - bronchioles
    - alveolus (alveoli)

- capillaries
- how the alveoli and capillaries link the respiratory and cardiovascular systems

Identify the main muscles involved in breathing, to include:

- the function and location of each muscle
  - intercostals (internal and external)
  - diaphragm

Describe the passage of air through the respiratory tract, to include:

- the passage of air during inhalation (inspiration) and exhalation (expiration)
- nose and mouth
- pharynx
- larynx
- trachea
- bronchi
- bronchioles
- alveoli

Describe the process of gaseous exchange of oxygen and carbon dioxide in the lungs, to include:

- the composition of gases in both inhaled and exhaled air
- the role of the alveoli and capillaries in gaseous exchange
- the process of the diffusion of gases from areas of high concentration to areas of low concentration

Understand anatomical terminology

Identify movements/exercises that occur in each anatomical plane

- Frontal (coronal) plane of the body, which passes from side to side at right angles to the sagittal plane; also called the coronal plane, divides the body front and back. Movements/exercises include abduction and adduction eg, side leg lifts (abduction), lateral raises, jumping jacks
- Sagittal vertical plane of the body, which passes from front to rear dividing the body into two symmetrical halves, left and right. Movements/exercises include flexion and extension eg, walking, running, bench press, forward lunge, biceps curl

- Transverse, any horizontal plane of the body that is parallel to the diaphragm; also called the horizontal plane, divides the body upper and lower. Movements/exercises include rotation, pronation and supination eg, oblique curls/crunches, twisting movement such as boxing jabs

Identify anatomical terms of location, to include:

- superior and inferior
- anterior and posterior
- medial and lateral
- proximal and distal
- superficial and deep

Understand the structure and function of the skeleton

Describe the basic functions of the skeleton, to include:

- movement (levers, attachment sites for ligaments, tendons, muscles)
- storage (calcium is stored in bone)
- production red and white blood cells, platelets
- shape/structure/framework
- protection of vital organs
- skeleton

Identify the structures of the axial skeleton, to include:

- cranium
- cervical vertebrae
- thoracic vertebrae
- lumbar vertebrae
- sacral vertebrae
- coccyx
- sternum
- ribs

Identify the structures of the appendicular skeleton, to include:

- scapula
- clavicle

- humerus
- ulna
- radius
- carpals
- metacarpals
- phalanges
- ilium
- ischium
- pubis
- femur
- patella
- tibia
- fibula
- tarsals
- metatarsals

Explain the classification of bones, to include:

- bones classified by their shape
- examples of major bones that fit into each classification:
  - long bones
  - short bones
  - flat bones
  - irregular bones
  - sesamoid bones

Explain the structure of a long bone, to include:

- epiphysis
- diaphysis
- periosteum
- epiphyseal plates (growth plates)
- medullary cavity
- hyaline cartilage
- compact bone
- cancellous bone

- yellow and red bone marrow

Explain the stages of bone growth, to include:

- the development of bone from cartilage
- ossification and basic references to osteoclasts and osteoblasts
- the importance of calcium for bone growth

Describe posture in terms of curves of the spine, to include:

- neutral spine alignment
- movement potential of the spine
- postural deviations of the spine (to include kyphosis, lordosis and scoliosis):
  - the effect of pregnancy
  - hyper lordosis
  - hyper kyphosis

Understand joints in the skeleton

Describe the classification of joints, to include:

- common examples of each type of joint:
  - immovable (fused/fibrous)
  - slightly moveable (cartilaginous)
  - freely moveable (synovial)

Describe the structure of synovial joints, to include:

- the structure, characteristics and functions of:
  - articular cartilage
  - joint capsule
  - synovial membrane
  - synovial fluid
  - ligaments
  - tendons
  - hyaline (articular cartilage)

Describe the types of synovial joints and their range of motion, to include:

- common examples of each type of joint:
    - gliding
    - hinge
    - pivot
    - ball and socket
    - saddle
    - condyloid

Describe joint movement potential and joint actions, to include:

- flexion and extension
- adduction and abduction
- rotation (internal and external)
- circumduction
- horizontal flexion and horizontal extension
- lateral flexion
- elevation and depression
- protraction and retraction
- pronation and supination
- dorsiflexion and plantarflexion
- inversion and eversion

Understand the muscular system

Identify the 3 types of muscle tissue, to include:

- examples and location of each different muscle type:
    - voluntary/skeletal
    - involuntary/smooth
    - cardiac

Define the characteristics and functions of the 3 types of muscle tissue, to include:

- voluntary – striated, under conscious control, controlled by somatic nervous system, found in consciously controlled skeletal muscles

- involuntary – visceral or smooth, under unconscious control, controlled by autonomic nervous system, found in structures not under conscious control
- cardiac – striated and involuntary, under unconscious control, initiated by the sinoatrial node (SA node), found in the heart

Describe the basic structure and function of skeletal muscle, to include:

- structure:
  - muscle contents of water (70%), protein (23%), minerals and substrates (7%)
  - muscles cross joints, attach to bones via tendons
  - origins and insertions
  - fascia
  - connective tissue
  - muscle fibres
  - fasciculi
  - epimysium
  - endomysium
  - perimysium
  - myofibrils
  - myofilaments
  - sarcomeres
  - actin and myosin
  - mitochondria
- function:
  - contract to create movement
  - generate heat (shivering)
  - keep the body upright by resisting the force of gravity
  - protect the skeletal system by preventing excessive or unwanted movement
  - stabilising joints along with the ligaments
  - they have contractility, extensibility, elasticity and excitability
  - can be agonists (prime movers), antagonists, synergists, fixators

Name and locate major superficial and deep skeletal muscles, to include:

- anterior skeletal muscles:
  - biceps
  - deltoids

- pectoralis major
- transverse abdominis
- rectus abdominis
- obliques
- hip flexors (Iliopsoas)
- quadriceps
- adductors
- tibialis anterior

· posterior skeletal muscles:

- triceps
- trapezius
- latissimus dorsi
- erector spinae
- rhomboids
- gluteals
- hamstrings
- gastrocnemius
- soleus
- abductors

Describe the structure and function of the pelvic floor muscles, to include:

· structure:

- deep and superficial layers
- fast- and slow-twitch muscle fibres
- muscle attachments

· function:

- stability for the pelvic girdle
- support for organs and growing foetus, during pregnancy
- controlling continence

Describe the different types of muscle action, to include:

· types of muscle contractions:

- isometric
- isotonic (concentric and eccentric)

- advantages and disadvantages of isotonic/isometric movement in relation to everyday activity, activity for health and within an exercise and fitness session, to include:
    - delayed onset muscle soreness (DOMS)
    - Valsalva effect functionality
- the principles of muscle contraction, to include:
    - basic sliding filament theory – the role of actin and myosin, the formation of a cross-bridge during contraction, the role of ATP, the 'all or none' law, motor neuron impulses, motor unit recruitment
    - muscles – cross over a joint, only pull, they cannot push, contract along the line of fibre, work in pairs
- types of muscle attachment, to include:
    - via tendon
    - aponeurosis
    - directly onto the bone
- definition of:
    - agonist (prime mover)
    - antagonist
    - synergist
    - fixators

Identify the joint actions brought about by specific muscle actions, to include:

- identification of the primary concentric and eccentric actions of each muscle detailed below to include:
    - name of the muscle
    - joint(s) crossed
    - prime action when contracting concentrically
- identification of the major muscle, from those below, that brings about the following joint actions:
    - flexion and extension
    - adduction and abduction
    - rotation (internal and external)
    - circumduction
    - horizontal flexion and horizontal extension
    - lateral flexion
    - elevation and depression

- protraction and retraction
- pronation and supination
- dorsiflexion and plantarflexion
- inversion and eversion

- gastrocnemius
- soleus
- tibialis anterior
- hamstring
- quadriceps
- gluteus maximus
- hip flexors (Iliopsoas)
- abductors
- adductors
- rectus abdominis
- erector spinae
- obliques
- transverse abdominis
- pectoralis major
- trapezius
- latissimus dorsi
- deltoids
- biceps
- triceps
- rhomboids

Identify skeletal muscle fibre types and their characteristics, to include:

- slow-twitch muscle fibres (type I), good blood supply, red in colour, many mitochondria, slower to fatigue than type II
- fast-twitch (type II – including types IIa and IIb), white in colour

Understand the life-course of the musculoskeletal system and its implications for special populations exercise

Describe the life-course of the musculoskeletal system, and its implications for special populations exercise, to include:

Young people in the 13–18 age range, to include:

- skeletal development (endomorphs, ectomorphs, mesomorphs)
- growth and development of the spine
- maturation of the skeletal system (13–18 years)
- ossification (primary and secondary sites)
- implications for the incomplete fusing of the epiphyseal plate
- growth plate damage
- fractures
- growth spurts
- considerations for exercise – suitable exercise

Older people (50 plus), to include:

- ageing and the skeletal system
- hormone changes
- loss of bone mass
- changes in osteoblast/osteoclast activity
- implications of reduction in bone-mineral density and connective tissue
- osteopenia/osteoporosis
- osteoarthritis
- hyaline cartilage wear and tear
- increase risk of falls and fractures
- joint degeneration
- reduced range of motion
- considerations for exercise – suitable exercise

Ante- and post-natal, to include:

- skeletal system changes including potential postural changes
- hormone changes – effect of relaxin and other hormones
- changes affecting balance
- considerations for exercise including warning signs – suitable exercise pre 16 weeks and post 16 weeks together with considerations for post-natal

Understand the structure and function of the digestive system

Identify the function of the following in the digestive process:

Mouth (tongue, teeth, salivary glands)

Pharynx

Oesophagus

Stomach

Pancreas

Gallbladder and bile ducts

Liver

Small intestine

Large intestine (colon)

- functions of each of the above, including:
  - mastication
  - peristalsis
  - absorption (villi and microvilli – the inner surface folds and finger-like projections that provide a large surface area in the small intestine to allow for effective absorption)
  - diffusion
  - emulsification
- digestive substances and enzymes, to include:
  - salivary amylase (enzyme in saliva)
  - hydrochloric acid (gastric juice released in the stomach)
  - pepsin (enzyme released in the stomach for breaking down protein)
  - lipase (enzyme released by the pancreas to break down fats)
  - amylase (enzyme released by the pancreas to break down carbohydrates into glucose)
  - trypsin (enzyme released by the pancreas to break down protein into amino acids)
  - bile acids (produced by the liver and stored in the gallbladder, until released into the small intestine)

Describe how the main nutrient groups are broken down and absorbed in the digestive system, to include:

- the transport, storage and metabolised forms of each macronutrient
- the inability of the body to absorb or use large particles of food, therefore using a process of digestion to break these down into smaller components which can be more easily absorbed and transported
- how carbohydrates are digested and absorbed as sugars
- how fats are digested and absorbed as fatty acids
- how proteins are digested and absorbed as amino acids
- macronutrient digestive end products:
  - carbohydrate – glucose
  - protein – amino acids
  - fat – fatty acids
- digestive enzymes – location of release and affected nutrients:
  - carbohydrate – mouth – salivary amylase
  - protein – stomach – pepsin
  - fat – released from the pancreas into the small intestine – lipase

- protein – released from the pancreas into the small intestine – trypsin

Identify the role of fibre in the digestive process, to include:

- Soluble fibre which dissolves in the water of the digestive system may help to reduce the amount of cholesterol in the blood, and increasing the amount of soluble fibre (fruit, vegetables, oats, golden linseeds) in the diet can reduce constipation.
- Insoluble fibre or non-starch polysaccharide (NSP) does not dissolve in water: it passes through the gut without being broken down and helps other foods move through the digestive system more easily. Insoluble fibre prevents digestive problems and keeps the bowels healthy. Sources include root vegetables, nuts and seeds, oats, fruit, cereals and wholemeal bread.

Identify the role of the liver and pancreas in assisting digestion, to include:

- the function of the liver to process the nutrients absorbed from the small intestine. Bile acids produced from the liver are secreted into the small intestine plays an important role in digesting fat
- the function of the pancreas as an exocrine gland which secretes an enzyme-rich fluid needed to aid digestion in the small intestine. Trypsin released by the pancreas breaks down protein into amino acids

Identify the timescales for the digestive process to take place, to include:

- generally, it takes about 6 to 8 hours for food to pass through the stomach and small intestine. Food then enters the large intestine (colon) for further digestion, absorption of water and, finally, elimination of undigested food
- food can take 24 to 72 hours to move through the digestive tract
- the exact time of digestive processes will depend on the amounts and types of foods eaten. The rate is also based on factors such as gender, metabolism and any digestive issues that could slow down or speed up the process
- initially, food will travel relatively quickly through the digestive system. Within 6 to 8 hours, the food has moved its way through the stomach, small intestine and large intestine. Once in the large intestine, the partially digested food can sit for more than a day while it's broken down even more.
- digestion rate depends on what is eaten. Meat and fish can take as long as 2 days to fully digest due to the complex protein and fat molecules. Fruit and vegetables which contain fibre move through the digestive system in less than a day. Processed foods can be digested in a matter of hours

Describe the importance of fluid intake in the digestive process, to include:

- chemical reactions in all cells take place in water
- assisting the removal of waste from the body

- enabling the transport and absorption of nutrients around the body
- preventing constipation

Understand energy systems and their relation to exercise

Describe how carbohydrates, fats and proteins are used in the production of energy, to include:

- the function of the food groups (fuels) in the production of aerobic/anaerobic energy
- the ATP cycle
- the main factors affecting choice/use of fuel, to include:
    - intensity
    - duration of activity
    - fitness level

Explain the use of the 3 energy systems during exercise, to include:

- how each of the following energy systems relates to exercise duration and intensity, including:
    - creatine
    - phosphate
    - lactic acid
    - aerobic
- the characteristics for each of the following energy systems:
    - creatine phosphate – high intensity, very short duration, no harmful waste products
    - lactic acid – moderate to high intensity, short duration, lactic acid waste product
    - aerobic – low to moderate intensity, long-term duration, CO_2 and water waste products
- the effects of exercise on energy systems, to include:
    - how each energy system works in conjunction with the others to produce energy in a range of activities
    - how exercise variables result in the adaptation of the relative contribution of each energy system
    - the effects of intensity (increased intensity would increase the contribution of the anaerobic systems)

- the effects of duration (longer-duration activities would require increased input from the aerobic energy system because the anaerobic systems cannot function effectively for long periods)
- the effect of type of exercise (unfamiliar exercise would result in a higher anaerobic system contribution in line with the specificity principle)

Understand the nervous system and its relation to exercise

Describe the role and functions of the nervous system, to include:

- structure and function of central and peripheral systems, in relation to:
  - sensory input
  - interpretation
  - motor output
  - maintaining homeostasis
- central nervous system (CNS) including the brain and spinal cord
- peripheral nervous system (PNS) – nerves that branch out from the spinal cord
- PNS consists of the somatic nervous system (voluntary) and the autonomic nervous system (involuntary)
- the autonomic system consists of the sympathetic (fight or flight, war) and parasympathetic (rest and digest) nervous systems
- structure of a motor neuron, to include axons, dendrites, cell body, nucleus, myelin sheath

Describe the principles of muscle contraction, to include:

- how nerve impulses are conducted
- basic sliding filament theory – the role of actin and myosin, the formation of a cross-bridge during contraction, the role of ATP, the 'all or none' law, motor neuron impulses, motor unit recruitment

Describe the 'all or none law'/motor unit recruitment, to include:

- in relation to strength of muscle contraction
- how a stimulus must be strong enough to trigger an action potential to pass down the motor neuron
- all muscle fibres within a single motor unit will be maximally innervated by the action potential or none will
- the size principle of motor unit recruitment. Motor units are recruited in order of size, from small to large

Describe how exercise can enhance neuromuscular connections and improve motor skills, to include:

- short-term and long-term effects of exercise on the nervous system
- speeding up the frequency of nerve impulses to motor units
- improved synchronous recruitment of motor units