UNIT 3 PHYSICAL EDUCATION
SUMMARY NOTES FOR THE VCAA EXAMS

WRITTEN BY A STUDENT WHO OBTAINED A NEAR PERFECT STUDY SCORE

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UNIT 3: MOVEMENT SKILLS AND ENERGY FOR PHYSICAL ACTIVITY

AREA OF STUDY 1: HOW ARE MOVEMENT SKILLS IMPROVED?

KEY KNOWLEDGE

- Classification of movement skills including fundamental movement skills, sport specific skills, open and closed skills, gross and fine skills, and discrete, serial and continuous motor skills.

- Influences on movement including individual, task and environmental constraints on motor skill development.

- The link between motor skill development and participation and performance.

- Qualitative movement analysis principles (preparation, observation, evaluation and error correction).

- Biomechanical principles for analysis of human movement including:

  - Angular and linear kinetic concepts of human movement: Newton's three laws of motion, inertia, mass, force, momentum and impulse.

  - Angular and linear kinematic concepts of human movement: distance, displacement, speed, velocity, acceleration and projectile motion (height, angle and speed of release).

  - Equilibrium and human movement: levers (force, axis, resistance and the mechanical advantage of anatomical levers), stability and balance (centre of gravity, base of support and line of gravity).

- Direct and constraints based approaches to coaching and instruction.

- Sociocultural factors that have an affect on skill development, and the characteristics of the three stages of learning (cognitive, associative and autonomous).

- Practice strategies to improve movement skills including amount, distribution (massed and distributed) and variability (blocked and random).

- Feedback including type (intrinsic, augmented, knowledge of results and knowledge of performance) and frequency.

MOVEMENT SKILLS

Classification of movement skills including fundamental movement skills, sport specific skills, open and closed skills, gross and fine skills, and discrete, serial and continuous motor skills.

- **Skills** are the ability to do something well. They are activities or tasks requiring voluntary head, body, and/or limb movement to achieve a goal.
- We need to classify skills to understand the particular demands of a movement to best prepare for improving this movement.
- **Fundamental Movement Skills (FMS)** are foundation skills that provide the basis of all movements in sport. They are also formed for the development of more sport-specific skills, especially for children. FMS can be classified as either:
- **Stability skills** that involve balance and control of the body, such as static or dynamic balancing, rolling, stopping, landing, stretching, bending and climbing.
- **Locomotor skills** that enable us to move through space, such as running, swimming, walking and jumping.
- **Manipulative skills** that involve the control of an object, including catching, throwing, striking, dribbling and kicking.
- **Sport specific skills** often utilise a range of FMS in a sequence of movement. For example, rebounding a basketball combines multiple FMS (bending, jumping, reaching for the ball, grabbing the ball, landing) to be completed.

Three categories to classify skills, include:

Movement Precision

- **Fine motor skills** require precise movements, involving the use of small muscle groups and a balance of touch and control. Eg. darts throw, archery shot, golf put, table tennis serve.
- **Gross motor skills** involve the use of large muscle groups to result in a coordinated movement, where there is generally little precision involved. This usually produces a forceful or powerful movement. Eg. kicking a football, performing a somersault, swimming backstroke, triple jump.

Type of Movement

- **Discrete skills** are a single movement with a distinct start and finish. Eg. olympic shooting, a single basketball dribble, a chest pass, kicking a ball, hockey pass.
- **Serial skills** are a series of discrete skills put together. Eg. gymnastic routine, dodging an opponent in football, basketball layup.
- **Continuous skills** are ones that flow, and have no definite beginning or end. (length of the event is irrelevant) Eg. running, pedalling a bike, swimming.

- These skills are generally harder to identify, but endurance events such as marathons are usually formed by continuous skills

Predictability of the Environment

- **Closed motor skills** have a constant, predictable, self-paced environment. Eg. basketball free throw, darts throw, stationary softball on a T-stand, pool game.
- **Open motor skills** have a constantly changing, unpredictable, externally-paced environment. Eg. changing proximity of an opponent in a basketball game, changing height and speed of a wave you're surfing, changing speed of a hockey ball coming towards you.
- All movement skills can be placed on an open - closed **continuum** based on the predictability of the environment.

Influences on movement including individual, task and environmental constraints on motor skill development

- **Influences on Movement.** There are different influences that can explain the individual differences in movement patterns and skill development.
- Any factor that influences an individual's ability to learn and perform a skill is called a **constraint**.
- Constraints are not always negative things.

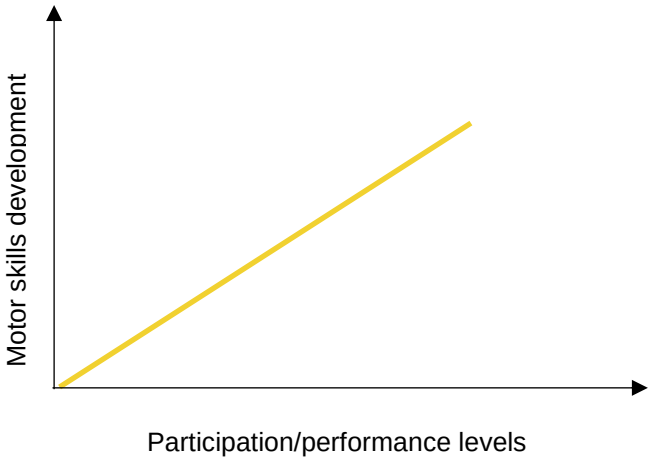
Three types of constraints:

- **Individual constraints** can be structural or functional.
- **Structural constraints** relate to the body structure of the individual. Eg. body size, body composition, flexibility, physiological capacity to perform tasks, endurance, motor skills.
- **Functional constraints** relate to behaviours or cognitive ability. Eg. skill learning, attention span, decision making skills, information processing skills, motivation, tactical knowledge.
- An adult with a slower reaction time is an example of a functional constraint.
- **Task constraints** are "what the coach puts on you". They are factors closely related to performance, such as rules of the sport, equipment available, team size and player numbers, instructions and field/pitch/court dimensions.

- A cricket coach who chooses to use a tennis ball rather than a cricket ball for primary school children is demonstrating awareness of task constraints on movement.
- **Environmental constraints** are either physical or sociocultural.
- **Physical constraints** include locality in which players were raise (parks, backyards etc), noise level, gravity, natural light, terrain, weather, wind.
- **Sociocultural constraints** include cultural norms, family support, peers, societal expectations (eg. Victoria plays AFL, NSW plays rugby league) and coaching.
- A psychologist who is working with an AFL player to improve his goal kicking in games in front of large crowds is attempting to overcome environmental constraints.
- Individual constraints can lead to modification of task related factors.
- A coach may have an athlete with an unorthodox technique, and they may realise that their body structure is the reason for this. Instead of forcing the athlete into a more traditional technique, they can work with the uniqueness of the athlete.
- A P.E teacher teaching softball to a group of inexperienced students may choose to use a tee instead of a pitcher and reduce the boundaries of the fields.

The link between motor skill development and participation and performance

- Motor skills, participation and performance are all directly interrelated.
- The more developed a person's motor skills are, the more likely they are to participate in more activities, thus improving their performance in those activities.
- As motor skills develop, so do performance levels
- Motor skills can be an enabler or barrier to movement. People are more likely to enjoy an activity and perform well if they have the skills required for it. A person lacking the skills may lack the confidence to participate.



Qualitative movement analysis principles (preparation, observation, evaluation and error correction)

- **Qualitative analysis** is the "systematic observation of the quality of human movement for the purpose of providing the most appropriate intervention to improve performance".
- Can also means **worded** feedback.
- Qualitative analysis provides fitness professionals with a structured approach to the analysis and improvement of movement.
- The main purpose of qualitative analysis is to improve skills.
- Qualitative analysis can:
- Identify strengths and weaknesses of players and teams
- Obtain a final result or rank in a competition
- Aid talent identification or team selection
- Predict future performance results

There are four stages to Qualitative Analysis:

- **Preparation** is where the analyst gathers information about:
- The critical features of the skill
- Information about the performer(s) physiologically and psychologically
- Details about the observation stage
- What constitutes effective instruction
- What the purpose of observation is
- How will the skill be observed
- Critical features of a high jump would be vertical angle at take-off, angle of approach and velocity at take off.
- The aim is to develop an observation strategy.
- Judges arrive earlier to the event, to view and consider conditions, if applicable (eg. surfing judges need to observe weather and waves)
- Preparation can give credibility to the results.
- **Observation** is when the skill is recorded/measured by watching the performer **digitally** or **live**, and observe the range of variables. The analyst collects any applicable data.

- The aim is to gather and organise the information provided in the preparation stage.
- The analyst organises the footage ready for evaluation.
- **Evaluation** is when the analyst judges the quality of the performance. They must decide what the problem is, what is causing it, and how to address it.
- Performance can be assessed either **objectively** (timing gates, timers) or **subjectively**. Subjectivity can be made more objective with the use of **checklists**, **criteria** and **rubrics**.
- Ideally, these methods should be both **valid** and **reliable**.
- Evaluation is based around the critical features of the skill, and each critical feature can be classified as inadequate, within the desirable range or excessive. Critical features within the desired range are strengths, and those outside are weaknesses.
- **Error correction** is when the analyst uses the strengths and weaknesses established to improve performance.
- Essentially, it is fixing the mistakes observed during earlier stages.
- Intervention can occur during the game or via training.

Error correction can include:

- **Feedback.** Can be given as corrective instruction and should be concise, specific, immediate and given regularly.
- **Modified practice**. Practice can be undertaken in a closed environment, or broken into parts, so there is more focus on the development of the technique.
- **Exaggeration or overcompensation**. Because small modifications can be difficult to improve, some coaches exaggerate the aspect of the skill they need to learn, so it is easier to learn.
- **Visual model**. The instructor could demonstrate or use video footage to show the correct technique.
- **Manual guidance**. The coach can physically move the body parts of the performer so they can actually experience the correct action.
- **Mechanical guidance**. A mechanical aid such as a brace is used to help them maintain correct position.

- Qualitative analysis is primarily used to provide feedback to a performer, however a **quantitative analysis** can provide data that supplements these assessments and answers questions.

- A sprinter receiving assessment feedback:

- **Qualitative:**

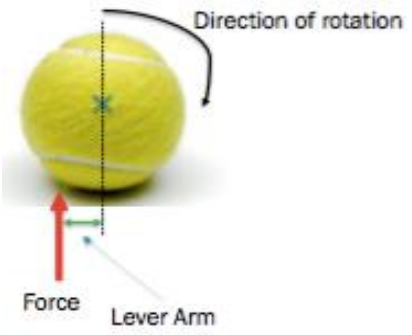
  "Slow out of the blocks as your weight was not far enough forward in the blocks."

- **Quantitative:**

  "Your 90 degree angle of your front leg allowed you to remain balanced and led you to your 2.2 second split time over the first 10m."

BIOMECHANICAL PRINCIPLES

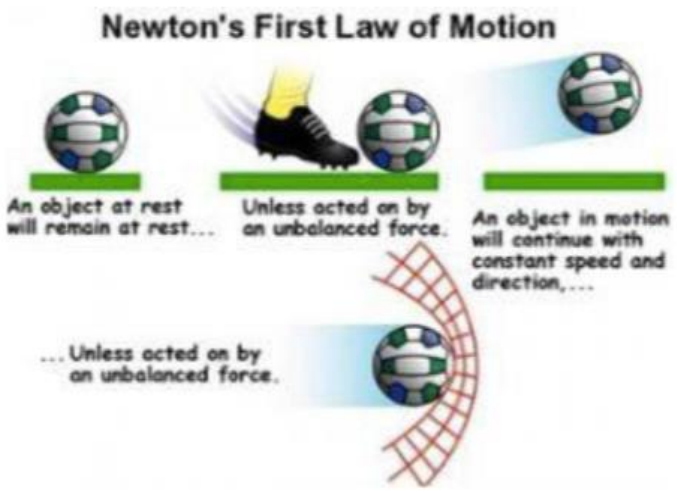
- **Biomechanics** is “the study of the mechanical principles that govern human movement”.
- Two branches of biomechanics are **kinetics** and **kinematics.**
- **Kinetics** are the study of forces that cause motion and the energies associated with causing the motion.
- **Kinematics** is the description of motion, without reference to the forces that caused the motion.
- Biomechanics is used to:
- Provide a description, explanation and prediction of movement
- Determine optimal techniques in sport
- Improve performance
- Develop and sustain healthy movement patterns
- **Motion** refers to “a body’s change in position in relation to time”.
- **Linear motion** is motion that occurs in a straight line (**rectilinear motion)**, or curved path (**curvilinear motion),** i.e from Point A to Point B.
- **Angular motion** occurs when a body moves along a circular path, around an axis.
- Angular motion is caused by an **eccentric force**, which is a force that does not act through an object’s centre of gravity. Eccentric forces cause objects to move and rotate, and will produce a torque.
- **Torque** is the tendency for an object to rotate.
- Torque is the force applied at a distance from the axis causing a turning effect. Greater torque = greater acceleration.
- **Torque = force x lever arm**
- **Lever arm** is the perpendicular distance between where the force was applied and the centre of the object (**axis of rotation**).



- ie. Greater lever arm = greater rotation of a ball.
- **General motion** is a combination of angular and linear motion, and is far more common than one type of motion alone.

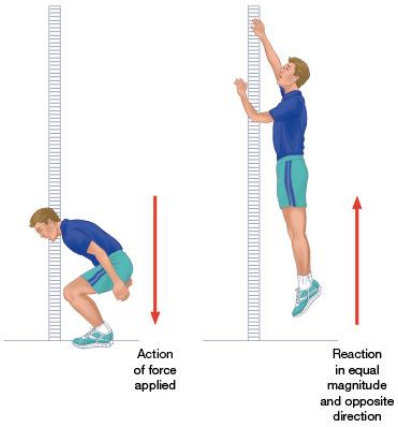
Angular and linear kinetic concepts of human movement: Newton's three laws of motion, inertia, mass, force, momentum and impulse

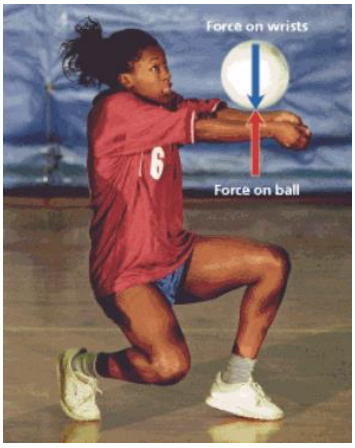
- **Law of inertia** states that "an object will stay at rest or continue to travel in the same direction at a constant velocity unless acted on by an unbalanced force."

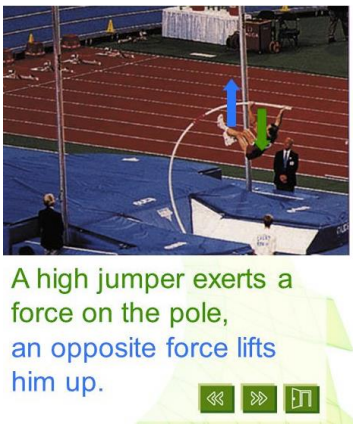


- Heavier object = greater inertia = greater force required to move it.
- **Law of acceleration** states that "the rate of acceleration of a body is proportional to the force applied to it and takes place in the direction in which the force is applied".
- **Force = mass x acceleration**
- ie. As mass is doubled, acceleration is halved, with the same amount of force generated, and vice versa.
- **Law of action & reaction** states that "for every action there is an equal and opposite reaction".
- Even though two forces are equal, they don't cancel each other out.
- This is sometimes harder to see. For example, when you hit a tennis ball with a tennis racquet, the racquet has an impact on the ball as the ball flies across to the other side of the court. The ball however will have an equal reaction on the racquet. However, because the racquet has a much greater mass than the ball, and f = ma, the acceleration of the racquet will be much smaller.

- In a 100m sprint, the athlete pushes into the block to obtain an equal and opposite reaction of pushing them forward down the track.







- **Laws of angular motion:**
- The angular momentum of a body remains constant unless acted upon by an external torque.
- A torque applied to an object will produce a change in angular motion in the direction of the applied torque that is directly proportional to the size of the torque, and inversely proportional to the moment of inertia that the object has.
- For every torque there is an equal and opposite torque.

- **Inertia** is the reluctance of a body to change in it's state of motion. Greater mass = greater inertia. Inertia can either be **static** (eg. barbell with weights on it) or **dynamic** (eg. rugby player running quickly)
- The greater the inertia, the greater the force required to change it's state of motion.
- Inertia is directly proportional to mass.
- **Mass** is the quantity of matter found within a particular body.
  Measured in **kilograms (kg)**.
- Mass is different than **weight**. **Weight = Mass x Gravity**

- **Force** is an effect on one body that results from the interaction of a second body. Measured in **Newton (N).**
- Can be created **internally** through muscle contractions or **externally** through gravity, friction, water and air.
- **Friction** occurs when two surfaces come in contact with one another. Friction resists movement when an object and the surface are in contact.

- It is the push or pull on an object to:
- Get it moving
- Speed it up
- Slow it down
- Stop it
- Change it's direction.
- Forces can either change the shape of an object or move the object.
- To get an object moving, you must apply a force that is greater than the maximum static friction value, or the net force of that object.
- **Maximal force production** is the aim for most events, like javelin or a penalty shot in soccer.
- **Sub-maximal force** is required in golf, or a basketball free throw.
- **Force summation** refers to the correct timing and sequencing of body segments and muscles through a range of motion.
- Force summation can be achieved **simultaneously** or **sequentially.**
- **Simultaneously** is when all body parts are moved at the same time (eg. sprinting).
- **Sequentially** is when body parts move in a sequence to produce force. (eg. cricket bowl).
- **Sequential force summation principles:**
- Activating stronger and larger muscles first
- Using as many body parts as possible
- Transferring momentum from one body part to another when at maximum velocity
- The presence of a stable base for maximal acceleration of body parts

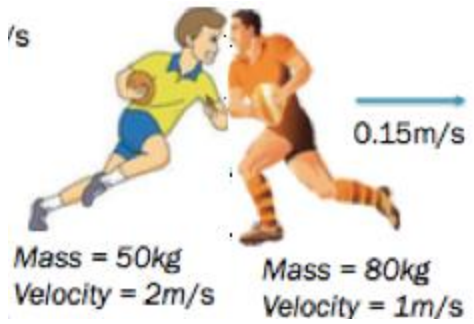
- Ensuring appropriate follow-through is used to prevent unnecessary deceleration

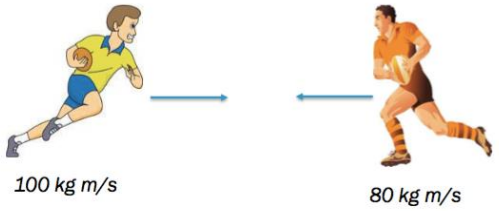
  In a throwing/bowling action:

  1. Run up
  2. Step forward with opposite foot to throwing arm
  3. Upper body turns in the direction of the throw
  4. Throwing arm extended behind body
  5. Body leans forward
  6. Elbow and wrist extend to release ball
  7. Arm follows through to target
  8. Falls forward once ball is released

- **Momentum** is the quantity of motion a particular body of mass has.
- Objects with greater momentum are harder to stop.
- Measured in kg m/s
- **Momentum (p) = mass x velocity**
- Momentum has a direction. (eg. 100 kg m/s to the right)
- **Conservation of momentum** states that whenever two bodies collide, the combined momentum of the two bodies is conserved.
- The total momentum before the collision = total momentum after the collision.
- Eg. In a game of lawn bowls, a ball with mass 1.5kg was rolled at 5m/s towards the stationary ball with a mass 1.2kg. When the balls collide, the moment is conserved. The moving balls momentum is 1.5 x 5 = 7.5 kg m/s. The stationary ball originally has a 0 momentum, but because of conversation of momentum, when the ball collides with the other ball, the combined momentum of the two balls must have a momentum of 7.5 kg m/s. Once the balls are both hit, they will both travel in the same direction. We can find the relevant velocities of the balls when they move at the same speed;

  $7.5 = (1.5 + 1.2)v$
  $7.5 = 2.7v$
  $v = 2.7$ m/s





Let's say the player on the left has a momentum of 100 kg m/s, and the player on the right has a momentum of 80 kg m/s. The net momentum = 100 - 80 = 20 kg m/s to the right.

This means the net momentum after the collision has to be 20 kg m/s to the right too. Once they collide. If we know the mass and velocity of the two players, we can calculate the momentum, and then the velocity after the collision. Momentum = mass x velocity. We know momentum = 20 kg m/s and mass = 130 kg. Therefore 20 = 130 x velocity. Velocity = 0.15 m/s to the right.

- **Angular momentum = moment of inertia x angular velocity.**
- **Moment of inertia** is a measure of an objects resistance to change in its rate of rotation.
- **Moment of inertia = mass x radius^2**
- To decrease moment of inertia, distribute mass closer the the axis (**radius**)
- The closer the mass is to the axis of rotation, the easier the object is to rotate. This is why gymnasts tuck into a ball while they flip, to increase velocity.
- As a gymnast goes into a tuck position, their moment of inertia is decreased, because their mass is closer to the centre. This means that their angular velocity must be increased, as angular momentum remains the same. This allows the gymnast to somersault more quickly.
- When rotating a baseball bat, angular momentum can be increased by increasing the mass of the bat, as well as the length of the bat. Modified equipment can reduce the moment of inertia, promoting the ability to move the equipment with more ease, but reduces the overall angular momentum.
- A bent arm when swimming in freestyle decreases moment of inertia and increases the velocity of the stroke with less force.
- Running when you bend your legs in the air decreases moment of inertia and increases velocity.

Sporting Example: An ice-skater spinning

High moment of Inertia

Opening arms
- Increase (high) moment of inertia
- Decrease in Angular Velocity

= decreases speed

Small moment of inertia

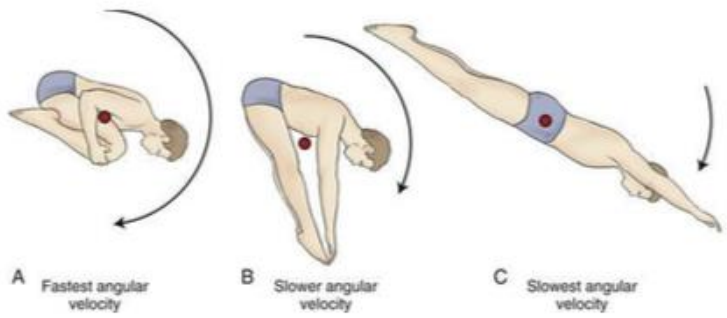
Pulling arms and legs together
- decreases (low) moment of inertia
- Increase in Angular Velocity

= increases speed

- Angular momentum is conserved while an object is in flight.
- Novice athletes often can't summate momentum and can't control a heavier bat.

- **Impulse** is the change of momentum of an object. To change the momentum of a body, a force must be applied over a period of time.
- **Impulse = force x time = mass x change in velocity**
- The larger time the force is applied, the greater impulse and the greater the change in momentum. The length of time over which a force is applied can affect the acceleration of an object. This is why a **follow through** is important as it increases the time in which the force is applied, and the impulse is greater and so is the change in momentum.

$$Angular\ momentum = moment\ of\ inertia \times angular\ velocity$$



- Greater impulse = greater change in momentum

- By increasing the time over which the force is applied, less force is needed to stop an object. This is why we “give” with the ball, when catching a hard ball such as a cricket ball, to avoid hurting our hands. “Giving” with the ball increases the time it takes to stop the ball, which will reduce the force applied.

- The absorbent gymnastics mats allow an impulse to be applied over an extended period of time, reducing the force than if a harder surface was used.

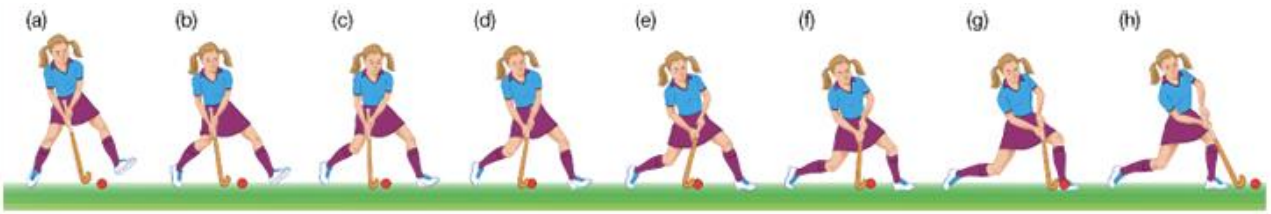


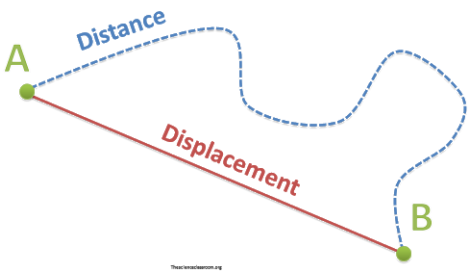
FIGURE 2.22 The hockey player applies greater momentum when making contact with the ball over a longer time frame (c to h).

- Increasing impulse can also be used to increase momentum.

- If the force is exerted in the opposite direction of the object’s original momentum, the object’s momentum will decrease.

Angular and linear kinematic concepts of human movement: distance, displacement, speed, velocity, acceleration and projectile motion (height, angle and speed of release)

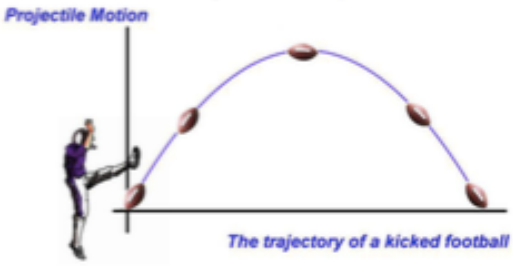
- **Distance** refers to how much ground an object an object travels throughout its motion.
- **Displacement** is the difference between the initial position and final position of an object. Eg. In a 400m race, displacement = 0m, as you finish in the same position you started.



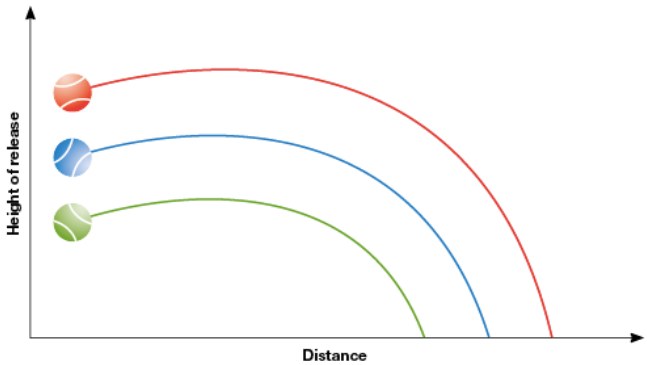
- **Speed** is the time taken to cover a certain distance.
- **Speed = distance/time (m/s)**
- **Velocity** is the time taken to change position.
- **Velocity = displacement/time (m/s)**
- Velocity also has a direction (eg. 10m/s north)
- **Acceleration** refers to the rate of velocity change experienced by an object over time.
- **Acceleration = change in velocity / change in time**
- **= (final velocity - initial velocity) / time (m/s^2)**
- Can be positive, negative or zero, indicating whether an object is speeding up, slowing down or at a constant velocity.

- **Angular distance** is the total of all angular changes of a rotating body.
- **Angular displacement** is the difference between the initial and final angular position of a rotating body.
- **Angular speed** is the angular distance covered by the time taken to complete the motion.
- **Angular speed = distance/time (degrees per second)**
- **Angular velocity** is the rate of change of the angular displacement of a body overtime.

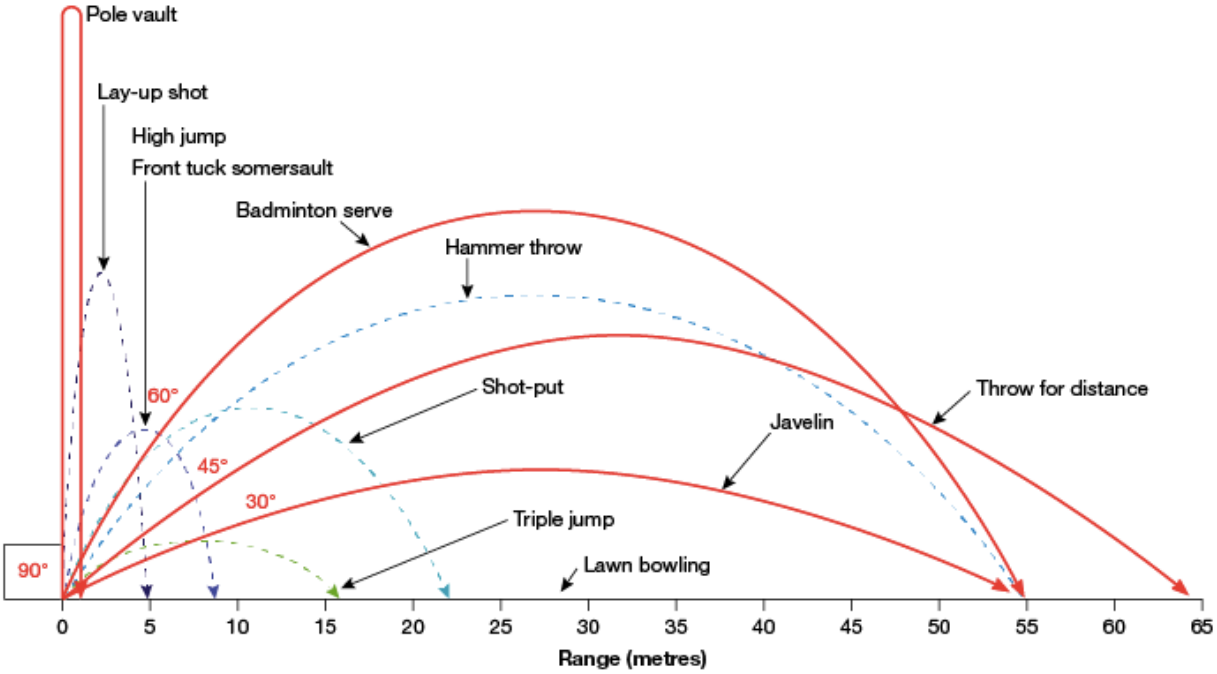
- **Angular velocity = displacement/time (degrees per second)**
- **Angular acceleration** is the rate of change of angular velocity **(degrees / second^2)**



- A **Projectile** is an object or body released into the air and is under the influence of external forces of gravity and air resistance.
- A projectile has a **vertical** and **horizontal** component.
- The flight path of a projectile is referred to as **trajectory**.
- **Air resistance** is a force working against motion, acting horizontally.
- **Drag forces** cause the projectile to slow down and reduce its flight time.
- <u>The following factors influence a projectiles air resistance</u>:
- **Velocity** (higher velocity = greater air resistance)
- **Mass** (lower mass = less drag as air can flow over the object)
- **Surface area** (greater surface area = greater air resistance eg. badminton shuttlecock)
- **Nature of surface area** (smooth surfaces decrease drag and are less likely to be affected by air resistance)
- **Gravity** acts against motion vertically by pulling an object back to the ground. Therefore, any projectile in the air has an acceleration of **9.8 m/s** towards ground.
- Other factors also can determine the trajectory of a projectile
- **Height of release** is the height from which the projectile is launched, in comparison to when it lands. An object released from a higher point will travel further than one released lower.
- **Speed of release** is the speed at which the projectile is laughed into the air. The greater the force applied to the projectile, the greater the speed of the projectile and the further it will travel.



- **Angle of release** is the angle that the projectile makes to the ground when it is released. The optimal angle of release is generally 45 degrees, for maximal horizontal distance.

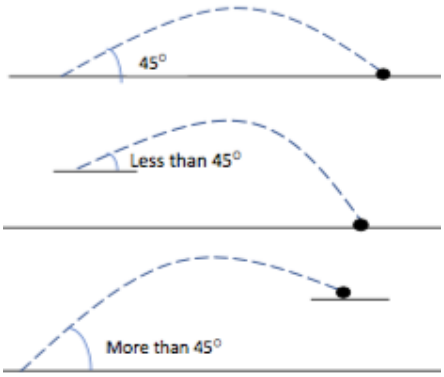


If the height of release is zero, then the optimal angle of release is 45°.

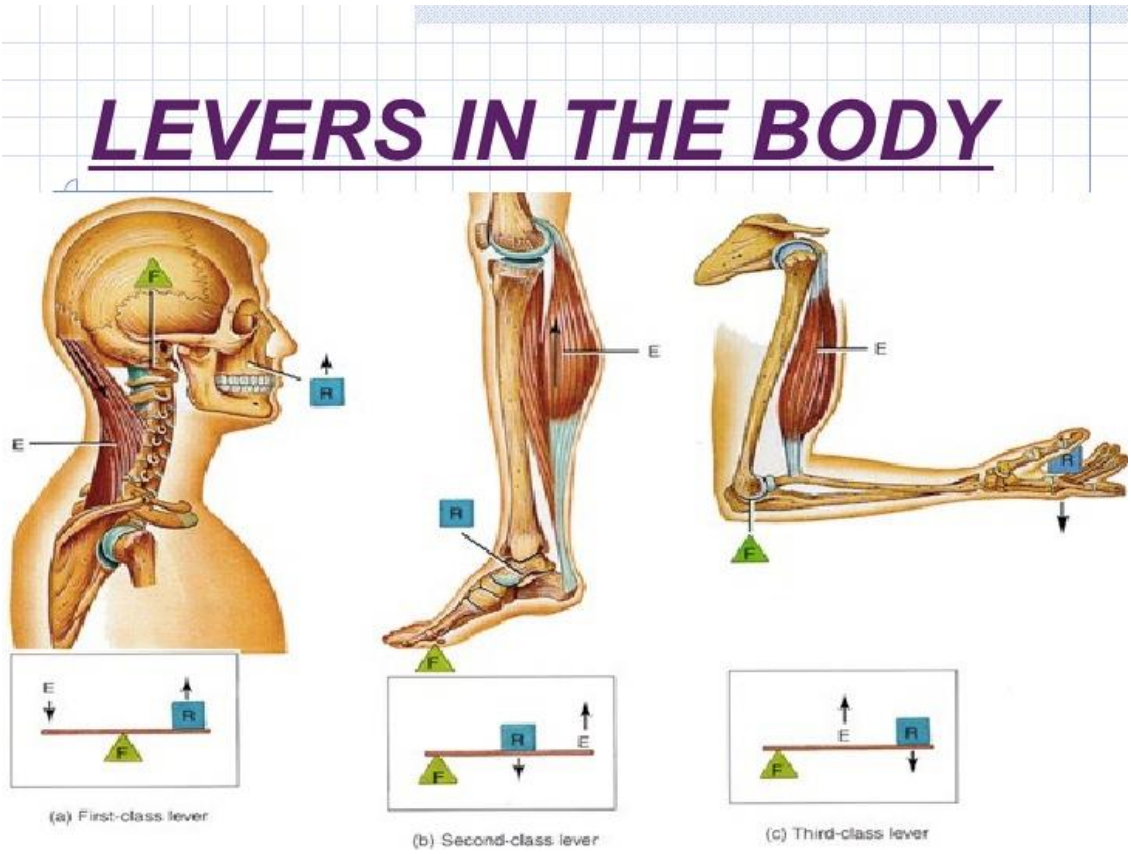
If you are launching the projectile from above where it will land, then the optimal angle of release is less than 45°.

If you are launching the projectile from below where it will land, then the optimal angle of release is more than 45°.

One way to think about it – if you have to throw high, you throw 'up'.



Equilibrium and human movement: levers (force, axis, resistance and the mechanical advantage of anatomical levers), stability and balance (centre of gravity, base of support and line of gravity)



- A **lever** is a rigid structure that rotates around an axis to exert force on another object. Levers are used to improve performance, and anatomical levers can provide an advantage where a small amount of force can be used to move a larger force.
- Levers are used to magnify force.
- **Leverage** describes the action or advantage of using a lever.
- **Axis** is the turning point of the lever.
- **Force** is the point where force is applied.
- **Resistance** is the weight of whatever a person is trying to move.
- **First class levers** have the axis in the centre between the force and the resistance (eg. see saw, your head and neck).
- **Second class levers** have the resistance in the centre between the axis and force (eg. performing a calf rise, wheelbarrow).
- **Third class levers** have the force in the centre between the axis and resistance.
- These levers are most commonly seen in the human body.

- To move a body part, a force needs to be applied by the muscles to change the angle of the joint (axis).

- **Force arm** refers to the distance between the force and the axis.
- **Resistance arm** refers to the distance between the axis and resistance.
- **Mechanical advantage = force arm/resistance arm**
- **If mechanical advantage > 1**
- The force required to move the load is less than the force of the resistance.
- Less effort is required to move the resistance.
- Found in second class levers.
- **If mechanical advantage < 1**
- A greater force is required to overcome the resistance.
- However, the range of motion of the lever is increased and this increases the angular speed of the lever.
- Found in third class levers.
- An increase in **lever length** increases the distance from the axis to the resistance, so the resistance arm is longer than the force arm.
- This makes the mechanical advantage < 1
- A greater force is required to swing the lever (usually a club or bat), but the increase in range of motion results in an increase of velocity.
- This is why soccer players fully extend their leg when kicking a ball, and tennis players fully extend their arm up with their racquet when hitting a serve
- If you can't increase the length of your lever (ie. in a game of lacrosse, everyone's equipment is the same), increase the extension of your arms, or lower your grip on the lever.
- Using a 3 iron (longer lever) as opposed to a 9 iron (smaller lever) will increase the range of motion of the golf club resulting to it travelling at a faster velocity and therefore being able to hit the ball at greater speeds.

- **Equilibrium** refers to a state in which there is a balance of forces or influences in opposition to each other.
- **Static equilibrium** is the state in which a body has zero velocity and zero acceleration (eg. a ball stationary on the ground, a gymnast holding a handstand).
- **Dynamic equilibrium** is the state in which a body is in motion with a constant velocity (eg. a gymnast moving throughout a floor routine with stability and strength).
- **Stability** refers to the degree to which a body resists changing its equilibrium (eg. gymnast holding a handstand).
- **Balance** is the ability to control the state of an equilibrium (eg. netballer moving with speed and control through the court).
- When stability is increased, the more difficult it is to unbalance an object.
- Factors affecting stability:
- **Base of support:** The larger the base of support, the greater the stability
- Base of support is the area within all body parts that are in contact with the ground.
- As the base of support increases the degree of muscular effort required to maintain stability tends to decrease.
- **Centre of gravity:** The higher the centre of gravity, the less stable a body will be.
- Centre of gravity is the point around which its weight is balanced regardless of position.
- **Line of gravity:** The closer the line of gravity is to the centre of the base of support, the more stable the body will be.
- Line of gravity is the imaginary line which passes through the centre of gravity.
- **Body mass:** The greater the mass of an object or body, the greater the force required to move it and therefore disrupt its equilibrium.
- **Friction between the body and the surface or surfaces contacted:** Increasing friction between the body and the surface it is in contact with increases the persons stability.
- Studs in a football boot aim to increase the friction between the grass and the boot to allow the player to stay balanced
- Chalk on a gym bar helps to increase the friction between the bar and the hands to allow the player to remain a strong grip and exert force to the bar
- The grooves on tyres on a motor race car apply friction to the road surface and allow the car to grip to the road so the car can take the bend at the fastest speed possible

To decrease friction:

- The smooth clay surface on the French Open tennis has decreased friction allowing the tennis player to slow momentum gradually when sliding into shots, reducing the risk of knee injuries
- In ice hockey, the ice has no friction, allowing the puck to slide quickly along the surface
- Reducing stability promotes **agility**.
- A sprinter would lean forward when beginning their sprint, to put them off balance so they don't require as much force to move.
- Swimmers start on the blocks with one foot slightly in front of the other when waiting for the starter's gun, to increase base of support and increase stability, so maximum power can be generated off the block.

COACHING AND LEARNING

Direct and constraints based approaches to coaching and instruction

- **Direct style coaching** is an explicit, autocratic, coach orientated style coaching.
- **Coach orientated** means learners are given explicit instructions about skill execution and tactical awareness.
- **Explicit learning** is when the learner is told what to do and when do to it
- A coach tells the players in a basketball drill to dribble from the base line to the free throw line, and then shoot and rebound.
- A tennis coach might feed 50 forehands to a player in exactly the same spot, getting them to hit the same shot continuously
- It is "skill and drill", and involves breaking sports down into technical skills.
- Learners are passive receivers of information.
- There is emphasis on the textbook technique.
- The coach makes all the decisions in relation to:
    - task selection
    - task sequencing
    - structure and timing of how tasks are performed
    - duration of time spent on task
    - how tasks will be modified
    - how technique will be refined
    - how feedback will be provided

<u>Advantages:</u>

- Learners are kept on task
- Facilitates the early-stage learning level
- Improvements in performance are rapid
- Emphasis on mastering technique
- Use of a predictable/closed environment

<u>Disadvantages:</u>

- Boring, repetitive drills
- Unable to apply skills in a game situation
- Dependence on coach instructions, don't develop decision making skills
- Learners at risk of choking under pressure

- **Constraints style coaching,** or indirect coaching, is implicit, learner orientated style coaching.

- **Implicit learning** occurs as a result of being involved in a game and discovery rather than being directed.

- It involves short-sided, modified games, and the coach becomes the facilitator and guides learning. Learners are often able to perform different tasks in different ways suited to their strengths and weaknesses.

- Errors are critical for learning as the learner learns how to problem solve.

- Involves manipulation of the **individual, task** and **environmental** constraint factors, typically task constraints.

- **Constraints** are boundaries that shape a learner's self-organising movement patterns, cognitions and decision making processes.

- Eg. changing the rules of a basketball game to make it half-court (task)

- Involves the idea of **perception-action coupling.**

- This describes the reciprocal relationship between what the performer sees, and the actions they have. (ie. perception and actions influence each other)

- A batsman in cricket learns to interpret (perception) a bowler's action and the bowler's grip on the cricket ball to predict the type of delivery before playing the appropriate shot (action). This may not happen if a batsman is only exposed to "throw downs" — a coach throwing the ball to a predetermined length to replicate and perfect a prescribed technique.

- Constraints style learning utilises the **game sense approach**, which is a means of coaching that uses small-sided, modified games to develop tactical and strategic thinking, as well as movement skill performance. Games sense approach has five key elements:

1. Designing **short-sided, modified games** to simulate decision making and movement skill demands.

2. Coaches use **questioning** to guide the learning process. Questions should be open-ended and encourage the learners to think for themselves. Questions should cover:

- **Time** : when should you….?

- **Space**: where should you….?

- **Risk** : which option…?

- **Execution** : how should you….?

- Questioning increases athlete's problem solving ability, improves the athletes ability to self-correct, and decreases the athlete's reliance on the coach.

3. Establishing an **environment where learning occurs through problem solving**. Learners take more ownership in discovery-based instruction.

4. **Constraints are manipulated** to emphasise a particular learning goal regarding tactical/technical awareness and skill application.

5. Sports are classified into four game categories:

- **Invasion games** (ie. soccer, netball)
- **Striking field games** (ie. cricket, basketball)
- **Net/court games** (ie. tennis, badminton)
- **Target games** (ie. archery, shooting)

- Constraints can give more success, eg. a decreased playing field (task) can give more of a chance of being involved
- A larger playing field (task) can improve 1v1 and reduce congestion, improve speed and endurance and teach players to use space

TABLE 3.1 A brief overview of the fundamental concepts for each game category

Category	Team in possession	Team without possession
Invasion	▪ Use a safe pass ▪ Move to create or receive a pass ▪ Advance to score	▪ Pressure the ball/receiver ▪ Track a player and the ball ▪ Use a zone or one-on-one defence to cause a turnover of possession
Striking/fielding	▪ Maximise time batting ▪ Maximise runs scored	▪ Minimise time in the field ▪ Build pressure ▪ Minimise unnecessary score (e.g. leg byes, no balls, four-ball walks)
Net/court	▪ Place object within boundaries where it cannot be returned	▪ Return object within boundaries
Target	▪ Place object as close as possible to intended target	▪ Prevent or protect object from being placed nearest to the target

- However being outside in a large playing field (task) can be a distraction, especially for cognitive learners with low retention and concentration

<u>Advantages:</u>

- Learner improves decision making skills
- Learners improves skill execution
- Practice replicates game situations
- More variety ensuring versatile development of skills
- Implicit learners are better problem solvers
- Learners develop technical and tactical awareness
- Learners less likely to choke at times of stress
- Learners can be more motivated

Disadvantages:

- Cognitive learners become overwhelmed with rules, tactics and skills
- Technical skills may lack refinement
- Coaches are often unfamiliar with a game sense approach
- May not suit large groups or younger athletes
- May take longer to achieve results

Sociocultural factors that have an affect on skill development, and the characteristics of the three stages of learning (cognitive, associative and autonomous)

- **Cognitive stage** is also known as the "**beginner stage**".
- Novice performer.
- The learner must dedicate a lot of attention to understand the skill.
- Many skill errors, and they generally ask a lot of questions.
- Learning occurs through "trial and error".
- Performance is inconsistent; they are simply trying to work out what skills they actually need to perform.
- Jerky, non fluent movement.
- Cautious and weary.
- Usually the shortest of the three stages.
- Improvements in skill performance tend to be rapid.

Appropriate instruction should include:

- Simple feedback
- Watching repeated demonstrations
- Clear and concise verbal feedback
- Strategies to correct faults
- Provide feedback on the relative success
- Complex skills broken into smaller parts

- **Associative stage** is also known as the "**practice stage**", or **intermediate.**
- Consistent performance of the basic and refining and replicating movement.
- Learner begins to understand why they make errors and adapt strategies to correct errors.
- Fluency increases.
- They are able to pay more attention to the game environment.
- Performance improvement is more gradual.
- Not all individuals move past this stage.

Appropriate instruction should include:

- Regular feedback and practice opportunities
- Exposure to a more 'open' competitive environment, with variety
- Coaches should continue to assist the learners in recognising why they have made an error and how to self-correct error

- **Autonomous stage** is also known as the "**expert stage**" or **advanced**
- Learner can perform a skill almost automatically.
- Skills is 'ingrained' and 'second-nature' to performer, requiring minimal attention.
- Can multi-task.
- For example, an elite cricket bowler doesn't have to focus on their run up, so they can instead focus on where they want to deliver the ball.
- Performers become more aware of the competitive environment.
- Development of tactical and strategic awareness and decision making capabilities.
- Able to provide and respond to self-feedback.
- Fluency and smooth action is visible.

Appropriate instruction should include:

- Precise feedback, as small improvements can make a significant difference at elite level
- Performers should stay motivated
- Practice with high levels of variability

Stages of learning	Cognitive	Associative	Autonomous
Characteristics of learner	• Complete beginner • Many errors in performance • Learner's attention is given to understanding the skill • Trial and error learning style • Unable to detect and correct performance errors	• Consistent performance of the basic mechanics of the skill • The learner concentrates on • skill refinement • Improved ability to detect and correct errors • Some perception of important cues/information in a game environment	• Performance almost automatic • Highly skilled • Very few errors • Multitasking evident • Able to adjust skills to games environment • Greater tactical and strategic awareness • Highly developed ability to detect and correct errors
Considerations for coaches	• 'Keep it Simple' • Don't overload learner with information • Verbal instructions should be clear and concise • Learner benefits from skill demonstrations • Teach learner how to detect and correct errors • Skills may be simplified or broken into smaller skill components.	• Provide opportunity to practise • Learners continue to work on error detection and correction • Assist learner to recognise important cues/information in a game environment	• Precise feedback • Match practice • Ensure learner motivation is high through varied and engaging practice • Continue to challenge the learner

- Use match simulation to enhance tactical knowledge and decision making

- **Skill development** is generally a result of a combination of the learner's genetic traits (biological physiological and psychological characteristics), the amount of practice taken and the availability of expert coaching, and sociocultural factors that encourage and facilitate learning opportunities.

- Sociocultural factors have a significant influence on determining sporting success in the future.

- **Family:** parents facilitate their children's involvement in sport by driving them to practice and buying their uniforms, registration fees and equipment.

- Parents encourages their children to get involved and apply to practice.

- Family backyard can give children an opportunity to practice movement skills.

- **Deliberate play** is used, as opposed to deliberate practice. It describes an unsupervised learning environment where children devise their own interpretation of competition rules.

- Backyard cricket is an excellent example of deliberate play.

- **Cultural norms, traditions and beliefs:** Different nationalities identify with different sports.

- Prevalence of sport in a community can have a significant impact on skill development.

- Swimming is a high profile sport in Australia, as well as the country having a warm climate and an abundance of beaches and pools. This makes the standard of swimming skills in Australia relatively high.

- There may be language barriers in accessing important information regarding organised sport.

- There may be lack of culturally appropriate venues and facilities.
- There may be a lack of appropriate role models.
- **Peers** play an important role in influencing the type of sport people participate in.
- Younger athletes are generally motivated to play with friends and choose sports based on the popular ones in their social group.
- If a peer group has a tendency toward sedentary behaviour, this can present a barrier to physical activity and movement skill development.
- **Gender stereotypes** means girls and boys will be socialised into different sports.
- Women are more likely to develop coordination, flexibility and balance and other skills associated with sports such as gymnastics and dance.
- Some sports such as netball and softball are seen as 'girls' sports, whereas AFL and rugby are seen as 'boys' sports.
- Historically, women have experienced significantly more barriers to participation in sport and physical activity. Factors include:
- Lack of appropriate, accessible, affordable and acceptable facilities, such as sport gymnasiums not having adequate female change rooms.
- Lack of media coverage to promote prominent role models.
- Lack of role models.
- Social stereotyping. In society, there are perceptions that sport is unfeminine
- Sporting organisations have fewer women sitting on managerial boards, and hence there is a lack of advocacy for women's sporting issues.
- **Socioeconomic status.** People of low socioeconomic status typically have a disadvantage in participating in physical activity.
- Remote communities may lack adequate facilities required for some organised sport
- Socioeconomic status can influence the type of sport in which an individual chooses to participate. For example, rugby league has a working class background whereas those of a more privileged background are more likely to sail or row.
- **Local community.** There is overrepresentation of elite sportspeople who grew up and developed their sporting process in small country towns.
- A high proportion of young people in rural settings are involved in their local netball or football club.
- Urban sporting facilities have to cater for larger populations, which potentially limits the time available for a team or an individual to use the facilities.
- Country towns can struggle to find sufficient participants to fill their teams.

- A young sportsperson in a rural community may find themselves playing in a number of different sports, and this experience can create a highly stimulating learning environment, allowing them to develop fundament movement skills and game sense

Other sociocultural factors include:

- **Time**
- **Self-belief**
- **Housing**
- **Values and attitudes**

Factor	Cognitive stage	Associative stage	Autonomous stage
Role models	Visual demonstrations are essential, so coaches should demonstrate the skill. Elite athletes can also serve as a role model and encourage participation and enthusiasm	Visual demonstrations are still important to refine skills and techniques	Visual demonstrations are no longer important, instead the athlete should analyse the opponent to develop game plans
Family dynamics	Having parents and siblings that participate in the same sport can encourage motivation and interest in developing skills	Family members are often required to provide transportation to and from training and games, as well as someone to practice with	Family dynamics are unlikely to be an important influencer in this stage of learning
Resources	Individuals may need access to basic equipment and a playing space	Individuals may need to regularly access playing grounds, and have reasonable equipment	Athletes may need high-level training facilities, as well as sponsorship
Time	Having some free time is important to begin with. Family members should take you to play too	Hundreds of hours of practice are often needed to be put in in this stage	A huge amount of time is required to progress. Once in this stage, athletes should continue to spend a lot of time practicing
Politics	Development of supportive policies such has having compulsory PE in schools has the potential to influence skill development	Assessable government funded/supported resources and facilities allow people to access sporting clubs	Athletes in this stage require to have access to world-class training facilities, and quality coaches

PRACTICE AND FEEDBACK

Practice strategies to improve movement skills including amount, distribution (massed and distributed) and variability (blocked and random)

- Generally, coaches should consider the following:
- The more you practice, the more you learn, and thus increase the **amount of practice.**
- **Gladwell's theory** states the 10 000 hours rules, that the key to mastering any elite spot, is to accumulate 10 000 hours of practice. However coaches don't have the luxury of limitless time at their disposal.
- **Maximise meaningful skill practice** within the time available. This also ensures greater learner engagement and motivation.
- In the interest of learner engagement, develop a sense of when it's best to stop working on one skill and move on to a new activity. Be weary of the **amount of time spent on task**; coaches can't afford a perfectionist approach.
- Be aware the **principle of diminishing returns** when deciding how to make the most of training time.
- Diminishing returns dictates that performers in the early stage of learning will improve rapidly in response to practice.
- However as the performer progresses through the learning stages, their rate of improvement in response to practice decreases.
- When discussing how to practice, we consider the two variables:
- How much rest should there be between practice trials?
- Do we practice one at a time or different tasks in random order?

- **Practice distribution** refers to the ratio of the time spent practicing compared to time spent resting, and the schedule of training

- **Massed practice,** or **continuous practice**, involves little to no rest between performances of a skill
- This can be useful when developing discrete skills that are non-fatiguing.
- Practicing these discrete skills in one continuous training block can help assist the learner to replicate efficient movement patterns.
- Experienced athletes, or autonomous stage learners, are suited to this practice distribution when they want to focus their time and attention to work on complex skills.

- However more novice performers might use this method to work around the barriers of time.
- The attention span of the cognitive learner may be low, and therefore they could get bored during the massed practice.
- Because massed practice requires learners to concentrate for an extended period of time, they can develop mental and physical resilience.

Advantages:

- Maximises practice time
- May suit a non-fatiguing discrete skill
- May suit an elite, highly motivated performer

Disadvantages:

- Physical and mentally fatiguing
- Repetitious and boring

- **Distributed practice** is when sessions are broken into smaller practice intervals, with rest periods in between.
- Rest periods are generally greater than the work periods.

Advantages:

- Greater learner engagement
- Assists a beginner (cognitive) or less motivated learner
- Reduction of fatigue
- May help to learn a new or complex skill
- Recovery period allows for memory consolidation and allows the learner to digest the coaches instruction and reflect upon what they have learnt

Disadvantages:

- More time-consuming
- May be less suited to discrete skill rehearsal

- **Practice variability** refers to the degree to which a coach varies the conditions in which skills are rehearsed, as well as the number or variety of skills that are practiced
- Practice variability is largely dependent on the **type of skill** and the **performer's stage of learning.**
- Generally, there should be more variability in the later stages of learning.
- There should be a higher degree of variability for open sports rather than closed sports.
- Lower variability in practice will lead to better performance in practice, however greater variability in practice will result in greater learning and greater preparedness for the game environment.

- **Blocked practice** involves practising the same skill repetitively in the same practice conditions for a set period of time.
- Eg. a tennis player spending 15 minutes working on forehand, 15 minutes on backhand, 15 minutes on serve etc.
- These sessions have low levels of variability.
- The learners attention is predominantly on executing and replicating ideal skill technique.
- Useful for cognitive learners.

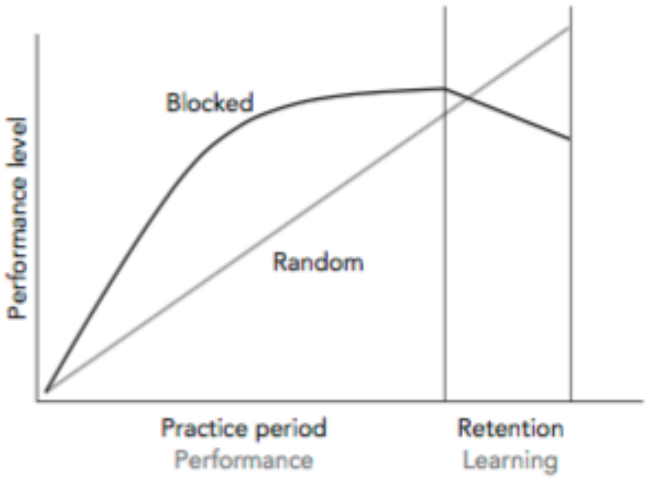
<u>Advantages:</u>

- The novice learner is able to concentrate on one skill at a time, free of distractions
- The learner can become familiar with the basic mechanics of the skill
- Helps the learner develop confidence in their skill performance
- Facilities significant improvement in skill execution during practice sessions

- **Random practice** is when a variety of skills are rehearsed within the same session.
- Eg. a tennis player may serve, hit a forehand and then a volley
- Skills are practiced in random order
- Usually specific to the game environment
- The learners attention is predominantly to decision making
- A large number of errors will occur
- This is useful for learners in the associate and autonomous stages

Advantages:

- Effective at preparing learners for a game environment, as a game is random
- More closely represents the physical and cognitive demands of a game
- Enables the learner to develop more applicable skills
- Enables the learner to improve decision making skills
- Substantial improvements in competition performance



Feedback including type (intrinsic, augmented, knowledge of results and knowledge of performance) and frequency.

- **Feedback** is any form of information a learner receives about their skill performance
- We give feedback to:
- **Motivate** the learner by providing information on the progress of skill learning
- **Highlight skill errors** and enable the learner to make appropriate corrections
- **Provide positive reinforcement**, confirming when the learner is performing correctly

- **Intrinsic feedback** is information the performer receives directly from their sensory systems as well as their skin, to judge their performance.
- It is self-correction, and allows the athlete to correct or improve their skill execution during the performance.
- This is useful if the performer understands the task.
- Eg. a basketball player shooting a free throw is aware of their balance and coordination at the time, and they feel the spin on the ball as they release it and see the flight of the ball in the air.
- Coaches may use questioning as a strategy to enhance the performers use of intrinsic feedback. Eg. 'do you feel unbalanced as you bowl the ball?'
- **Proprioception** is sensory information received from within the muscle. Eg. if you are blindfolded, you know through proprioception if your arm is above your head or on the side of you body.
- Sensory feedback can also be **visual, auditory**, or **touch**
- **Augmented feedback** is information that comes from sources external to the player (coach).
- Includes the use of video analysis.
- Endurance sports use augmented feedback in the form of monitors that record heart rate and speed.
- This type of feedback can more motivate performers and provide positive reinforcement for good feedback.
- Augmented feedback can be divided into two categories:
- **Knowledge of performance** is feedback that provides information about the progress of performing a skill.
- Eg. a golfer is able to recognise they have a problem with their weight transferral after watching a video of their swing.
- It is feedback on how the skill is performed and its characteristics, rather than the outcome or result.

- Comes from either the coach or video analysis.
- Coaches should mostly focus on providing knowledge of performance feedback as that is the most effective means of correcting faults and facilitating learning.
- **Knowledge of results** is information about the outcome of skill performance.
- Eg. the golfer sees the resulting ball flight when they hit the ball and they see where it lands.
- Eg. tennis serve speed.
- The learner can often see where their shot lands, so the coach doesn't need to provide knowledge of results feedback's often.
- This type of feedback is particularly important in the early stages of learning, as successful outcomes can be a strong motivating factor for cognitive learners.
- Players can align this feedback with their own intrinsic feedback, to improve consistency.
- Statistics can be either knowledge of performance or knowledge of results. Eg. missed tackles are knowledge of results, but can indicate for a team to increase their intensity, indicating knowledge of performance.

- **Timing of feedback** refers to when feedback is provided in relation to the performance
- For feedback to be effective, it should be accuracy, relevant and immediate.
- **Concurrent feedback** is feedback that occurs during the activity.
- Eg. a netball coach yelling out to their team on the sidelines.
- Advantages are that it can have an immediate impact on skill performance, and is time-efficient, and allows for no interruption of training intervals.
- Concurrent feedback should not be used if it distracts the learner, which is more likely to be the case in the early stages of learning.
- **Terminal feedback** is feedback that occurs after the performance.
- Eg. a football coach talking to their team post-match.
- The advantage is that the player can give full attention to the coach as feedback is being given out, which is important for a cognitive learner.
- It is recommended the coach momentarily delays the delivery of feedback post skill performance, as this allows the learner to first evaluate their own intrinsic feedback.

- **Frequency of feedback:** feedback should be provided regularly to facilitate skill acquisition.
- However, too much feedback can lead to information overload.
- Too much feedback in the early stages of learning can lead to the learner becoming overly dependent on the coach's guidance
- Generally, more feedback should be provided in the early stages of learning, and less in the later stages, so they can detect their own error.

Type of learner	Cognitive	Associative	Autonomous
Type of feedback	Knowledge of results	Knowledge of performance	Knowledge of performance
Frequency of feedback	High frequency	Medium frequency	Low frequency
Coaching type	Direct	Direct / Constraints	Constraints
Practice distribution	Distributed	Distributed (Task dependent)	Massed / distributed (task dependent)
Practice variability	Blocked	Blocked / Random	Random
Timing of feedback	Terminal	Terminal / Concurrent	Terminal / Concurrent

KEY SKILLS

- analyse and classify movement skills
- analyse individual, task and environmental factors influencing movement skill development
- analyse the link between motor skill development and participation and performance
- perform a qualitative analysis of a movement skill using video and systematic observation to analyse and improve a variety of movement skills
- analyse, interpret and apply graphical, visual and physical representations of biomechanical principles to improve movement skills in a coaching context
- explain and apply theories of learning to practical coaching situations
- explain sociocultural factors that influence movement skill development at different stages of learning
- discuss how skill classification affects the selection of appropriate practice strategies
- participate in, observe and record the characteristics of different types of practice strategies
- perform, observe, analyse, and report on the role of feedback in improving performance through practical- based activities.

ANALYSE AND CLASSIFY MOVEMENT SKILLS

When answering these kind of questions, make sure you indicate the nature of the skill (eg. movement type, predictability of the environment, precision of movement)

Outline the difference between open and closed skills, using shooting in basketball as an example of each *(3 Marks)*

An open skill is a skill where the environment is unpredictable, such as a layup with an opponent in front of you, as there are more factors you have to consider when performing the skill (height of the opponent, proximity from the ring, etc). Whereas a closed skill has a predictable, consistent environment, such as a free throw, as there are less factors to consider

1 mark for outlining what a closed skill is
1 mark for outlining what an open skill is
1 mark for relating it back and using basketball as an example

When we are first learning a skill, what environment should we be learning in and justify why (*2 marks*)

You should first learn in a closed environment, as there aren't as many factors to consider when performing the skill; it is predictable, and this allows you to fully focus on the correct technique of the skill. It would be too hard to learn in an open environment when you are first learning as there are too many distractions and is externally paced and unpredictable.

1 mark for correct identification of the closed environment
1 mark for the justification

Use the photo above to describe the movement skills occurring within this photo *(6 Marks)*

- On the predictability of the environment continuum, surfing sits towards the open end, largely due to the unpredictable nature of the surf, where the surfer's timing is dependent upon external factors that often change.
- The surfers movements are forceful, utilising large muscle groups such as the gluteals, quadriceps and hamstrings, making it a gross motor skill.

- The surfer links together a series of discrete skills, including turns, aerial manoeuvres and tube rides in a routine, making it a serial performance.

  1 mark for identification of an open skill
  1 mark for justification of an open skill
  1 mark for identification of a gross skill
  1 mark for justification of a gross skill
  1 mark for identification of a serial skill
  1 mark for justification of a serial skill

ANALYSE INDIVIDUAL, TASK AND ENVIRONMENTAL FACTORS INFLUENCING MOVEMENT SKILL DEVELOPMENT

The Kellysville Kolts Baseball Club has programs for people of various ages. Their Modball competition is for under-10 boys and girls. The game is played on a diamond with 60-foot base paths, with minor, age-appropriate variations to rules to provide a deeper learning opportunity. The game introduces the player to a pitched ball, developing their understanding of the strike zone, as well as introducing the position of catcher with proper protective equipment. A parent of the batting team pitches the ball to the batter, thus encouraging the player to hit, rather than a pitcher trying to strike the batter out.

a. Choose three of the modifications that have been made and identify whether they are related to task, individual or environmental constraints on movement. (*3 marks*)

- Individual: Introduction of the strike zone, so the children can decide whether or not to bat the ball and develop their decision making skills

- Task: Using parents to pitch the ball, to keep the pitching consistent rather than children pitching the ball, is an alteration of the rules.

- Environmental: Playing the diamond on 60 foot base paths is a modification of the field size

  3 marks for identifying each modification correctly

b. Individual constraints can be assigned to two categories. Identify and explain these categories. (*2 marks*)

Structural constraints relate to body structure of the individual, such as how the under-10s will have a smaller physique. Whereas functional constraints relate to behaviours. The under-10s will have less developed perpetual skills and need more time to learn the rules of the sport

2 marks for identifying both functional and structural constraints

c. **The Modball program has been designed to assist the under-10s to progress towards regular baseball. Explain two ways in which the introductions that have been made to the Modball program can help the players to overcome movement constraints in the game of baseball. (*4 Marks*)**

- Using a strike zone to help the players learn the skills required in baseball and deciding whether or not to swing the bat can improve their decision making skills and improve their game awareness.
- Using a parent to pitch the ball to them rather than using a tee, can develop the timing and batting technique skills of the children and improve their judgement.

2 marks for explaining two introductions that have been made
2 marks for linking to overcoming movement constraints

Describe how you could manipulate the size of playing equipment to focus on a particular concept when implementing constraints-based coaching (*2 marks*)

A softball coach could get batters to swing with a lighter bat to encourage batters to get their hands through quicker, to generate enhanced bat speed.

1 mark for explaining how to manipulate the size of the playing equipment
1 mark for explaining how it focuses on a particular concept, or improves performance

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ANALYSE THE LINK BETWEEN MOTOR SKILL DEVELOPMENT AND PARTICIPATION AND PERFORMANCE

The key concept is the greater an individual's motor skills have been developed, the more likely the are to participate in sports and have a stronger performance

Why is it important that children have well developed fundamental motor skills? (*1 mark*)

To make the transition into more sport specific skills, such as rebounding or performing a gymnastics routine, easier, and to make them more likely to participate in sport later in life.

Explain the relationship between movement skills, participation and performance (*2 marks*)

People who have have strong movement skills such as running or kicking are more likely to participate in sports that require these skills more often, which then improves performance, through practice. Whereas people with weak movement skills are less likely to participate, which decreases the success in their performance.

1 mark for explaining the effect of people with strong movement skills
1 mark for explaining the effect of people with weak movement skills

How can a lack of skill development impact on students' experiences with physical education programs? (*1 mark*)

Children not proficient in basic motor skills will have little success performing more complex sport specific skills that feature heavily in secondary school physical education and sport program.

PERFORM A QUALITATIVE ANALYSIS OF A MOVEMENT SKILL USING VIDEO AND SYSTEMATIC OBSERVATION TO ANALYSE AND IMPROVE A VARIETY OF MOVEMENT SKILLS

Qualitative analysis should be undertaken by applying the four stages. This should be undertaken with the aim to improve performance.

Henry has qualified for the Olympics and is currently working with his coach to improve his long jump. Henry's coach will make some changes to the training program and knows that these changes need to be based on a systematic observation of Henry's technique.

a. Identify a type of analysis that Henry's coach could perform and outline the tasks that he would undertake during this analysis. (*9 marks*)

- Henry's coach would perform a qualitative analysis. Qualitative analysis involves four tasks: preparation, observation, evaluation and error correction.
- Preparation — during this phase, the coach will research the critical features, such as take off, run up and landing of the movement and have an understanding of times or other measures that Henry needs to achieve for each of these aspects of the skill.
- Observation — this phase involves the actual recording of Henry's technique in accordance with what was outlined in the preparation stage. It would most likely involve using high speed video of him performing his jump.
- Evaluation — once the footage has been recorded, it will be evaluated. The data collected during the evaluation will be compared to the performance expectations outlined in the preparation phase. Each critical feature will be analysed. This will provide information about aspects of the performance that are adequate or those that could be improved.
- Error correction — once the critical features that could be improved have been identified, the coach will provide Henry with feedback, including verbal feedback or modified practice, and make changes to his training regime to best improve his jump.

1 mark for a identifying qualitative analysis
4 marks for identifying the key components
4 marks for explaining each

b. **Identify two critical features of a long jump. (*2 marks*)**

Take-off speed and height of jump

2 marks for each component correctly identified

c. **Select one critical feature identified in part b and outline a possible error correction method that could be used to improve Henry's performance. (*2 marks*)**

Physical conditioning — Henry could train to increase his running speed, which would help him to increase his velocity at take-off.

1 mark for identifying a correct method
1 mark for explaining how it could improve performance

Apply the four qualitative principles if you were critiquing a baseballer (*4 marks*)

I would prepare by gathering information about the pitcher, and determine what constitutes an effective pitch. I would then observe the athlete and set up video recordings, to watch them and observe the range of critical features they perform. I would then evaluate the skill and assess the pitch by watching over the video, and then class the critical features as strengths and weakness, using checklists as an aid to make evaluation more objective. Once strengths and weaknesses have been established, I would use error correction to provide visual feedback through the video of the athlete, and then over-exaggerate their weakness and give them modified practice, so they can practice and further improve their pitch.

4 marks for correctly explaining each of the four principles

Observations can be performed live or recorded digitally. Describe an advantage of a coach recording a performance before completing their observational analyses. (*2 marks*)

The coach can look over and analyse the performance multiple times, to make sure they study all the critical features of the skill and how the player performs it. The coach can also provide visual feedback by showing the athlete various examples of what they did.

1 mark for identifying the review and re-review of video
1 mark for identifying the visual feedback

During the evaluation phase the athlete needs to be judged on the quality of the performance or skill. Performance can be assessed either objectively, subjectively or both. Compare objective and subjective measures of performance. (*3 marks*)

Objective measures are based on the collection of data, eg. a score or time, or development of a checklist/rubric. Objective measures are not subject to personal opinion, whereas subjective measures are. Subjective measures are based on a person's perception, or interpretation of an event, such as how they think a game should look.

1 mark for explaining what objective measures are
1 mark for explaining the difference between objective and subjective measures
1 mark for explaining what subjective measures are.

ANALYSE, INTERPRET AND APPLY GRAPHICAL, VISUAL AND PHYSICAL REPRESENTATIONS OF BIOMECHANICAL PRINCIPLES TO IMPROVE MOVEMENT SKILLS IN A COACHING CONTEXT

No calculations are needed in the exam, however you must know the relationship between the terms in the formulas.

A rugby player receives a pass from a team mate while stationary. Immediately after receiving the ball, he is tackled by an opposition player. Explain, using the principle of transfer of momentum, what would happen next (*2 marks*)

Since the opposition player has a certain momentum by running at a high velocity, the principle of transfer of momentum states that momentum in a collision is conserved. This means that the stationary rugby player will begin moving in the direction he was tackled, absorbing the impact of the collision and keeping the net momentum the same, until they fall and hit the ground.

1 mark for using the principle of transfer of momentum
1 mark for explaining what would happen

There are two wrestlers, one with a larger mass than the other. Explain, using Newton's first law of motion, why the wrestler with the larger mass would be harder to move than the wrestler with smaller mass, all other factors being equal (*2 marks*)

Newton's first law states that in order for a body to move a force must be applied them that is great enough to overcome their inertia. The larger a wrestler's mass, the greater their inertia and the more force required to overcome their state of motion, hence why it would be harder to move the heavier wrestler.

1 mark for explaining what Newton's first law does
1 mark for explaining why the heavier wrestler will be harder to move

Brooke Stratton set a new Australian women's long jump record in Perth during 2016 with a jump of 7.05 metres. Describing this achievement, a sports scientist said Brooke's jump was outstanding as she first had to overcome inertia and develop enough force during the run up to propel herself into the air for this performance.

a. **Describe what the term *inertia* means. (*1 mark*)**

The reluctance of a body to change in it's state of motion

b. **Prior to Brooke moving, she has to overcome her static inertia. What is this static inertia directly proportional to? (*2 marks*)**

Her mass. A greater mass = greater inertia, and the more force needed to change her state of motion.

1 mark for identifying mass
1 mark for explaining the relationship

c. **After Brooke propelled herself into the air, she was confronted by two external forces that prevented her from jumping even further. Name these two forces. For each of these forces explain how they acted on Brooke. (*4 marks*)**

Gravity acted on Brooke and pulled Brooke down to Earth from the air vertically. Air resistance also acted on Brooke, and affected her by resisting her forward horizontally.

1 mark for identifying gravity
1 mark for identifying air resistance
2 marks for explaining the vertical/horizontal impact of the two

d. **Describe what Newton's third law of motion states. (*1 mark*)**

For every action there is an equal and opposite reaction.

e. **Use Newton's third law to describe how Brooke was able to run down the long jump track prior to her jump, explaining what the terms *equal* and *opposite* mean in this context. (*2 marks*)**

The third law state that for every action there is an equal and opposite reaction. When Brooke pushes downwards and backwards on the track to run, the ground exerts an equal and opposite force back, causing Brooke to run forwards and upwards.

1 mark for explaining how Brooke could run down the track
1 mark for linking to Newton's third law

Two 13-year-old students competed in a 100-metre race during an athletics competition.

Runner 1
Rachael, who weighs 40 kg

Runner 2
Kylie, who weighs 60 kg

a. **If Rachael and Kylie produce the same amount of force at the beginning of the race, explain, using Newton's second law of motion, who would be leading in the 100-metre race. (*3 marks*)**

If Rachael and Kylie take off with the same force, the lighter one (Rachael) will go faster. Force = mass x acceleration. For the same force, as mass decreases acceleration increase and vice versa. Therefore Rachael will have greater acceleration.

1 mark for identifying who will lead
1 mark for explaining Newton's second law
1 mark for relating it back to the example

b. **Use Newton's first law of motion to explain why Kylie would find it harder to slow down after the conclusion of the race. Use the key words *mass* and *inertia* in your response. (*2 marks*)**

Kylie will have to be acted upon by an unbalanced force to change her state of motion to stop. Because Kylie has a heavier mass, she has a greater inertia and requires more force for her to stop.

1 mark for using the first law of motion
1 mark for explaining with reference to mass and inertia

c. **At the start of the race, both girls push back and down against the starting blocks with great force. Using Newton's third law, explain what occurs next and why. Why do the girls use great force? (*2 marks*)**

The girls use great force in their action, because for each action there is an equal and opposite reaction. So the force that is applied against the starting blocks will push back against and towards the girls, which can cause them to accelerate.

1 mark for using Newton's third law
1 mark for explaining what happens and why

What is the common variable in Newton's first, second and third laws of motion? Explain your answer (*4 marks*)

Force is the common variable. A force is required to change the motion of an object (first law). A force is required to increase the acceleration of the object (second law). The force applied to an object is equal in magnetite and opposite in direction to the force the object applies back (third law).

1 mark for identifying the common variable as force
3 marks for explaining why and relating back to each of the three laws of motion

Explain how a sumo wrestler can increase his stability and balance (*3 marks*)

A wrestler should lower his centre of gravity to a lower height, by squatting down, increase his area of his base of support by widening his legs and shift his line of gravity over the centre of his base of support by remaining upright. This will give him more support to resist changing his state of motion and any attacks from opponents, increasing his stability and his ability to control his balance of forces.

2 marks for explaining and given examples of at least two factors that affect stability
1 mark for explaining how this increases balance and stability

In baseball, what is the advantage of being able to run through first base? (*2 marks*)

You already have momentum going as you sprinted already to first base, meaning you don't have to worry about decelerating as you approach the base. You can get to your fastest velocity get to the base faster.

1 mark for identifying the correct biomechanics principles
1 mark for explaining why it is an advantage

Explain how modifying a push up from your toes to your knees changes the mechanical advantage of the lever system and the impact it has on performance (*3 marks*)

Performing a pushup on your knees decreases the size of the resistance arm, which increases the mechanical advantage (force arm/resistance arm) of the lever. When mechanical advantage > 1, the force required move the body is less than the force of the resistance, which means that there is not as much force required to lower the body to the ground, making the push-up easier to perform.

1 mark for explaining how modifying the pushup affects the lever
1 mark for explaining what mechanical advantage is
1 mark for explaining why the pushup will be easier to perform

Netball players often need to change direction suddenly. Is it better for the netball player to assume a position in which their stability is decreased? Explain (*3 marks*)

Netballers would need to assume a position in which their stability is decreased, so it is easier for them to move and change position. They do this by increasing the height of their centre of gravity by going on their toes, so they can be more nimble and less force is required to unbalance them and change direction faster

1 mark for identifying if they should increase or decrease stability
1 mark for explaining how they decrease their stability
1 mark for explaining the effect on performance

Clearly discuss how you can use the principle of "summation of momentum" to improve your performance / skill development in throwing. (*3 marks*)

Summate maximum momentum by activating stronger and larger muscles, like the legs, first, using as many body parts as possible, transferring momentum at maximum velocity from one body part to the other and ensuring an appropriate follow through is used to prevent deceleration. When these principles are applied, momentum will be achieved in the throw, allowing the ball to travel with greater velocity through the air, causing it to travel a further distance, improving performance.

3 marks for referencing 3 summation of momentum principles

Impulse occurs when there is a change of momentum applied on an object and it occurs in many ways during sporting performances. Provide two examples where the change in momentum of an object has occurred to (i) speed up and (ii) slow down an object (*4 marks*)

(i) A hockey player would apply an impulse by making sure the stick comes into contact with the puc for a longer period of time, to create a greater impulse and greater change of momentum, and thus increase the velocity of the puc when hit.

(ii) A baseball player when fielding and catching a ball would 'give' with the ball, the increase the amount of time the ball comes into contact with the glove, increasing the impulse and creating a greater change of momentum, and thus decreasing the velocity of the ball. This means less force is required to stop the ball.

4 marks for explaining two examples in impulse in sport

By using biomechanics principles, namely those associated with moment of inertia, discuss why it is preferable to give beginners equipment that is shorter and lighter when playing baseball/softball/cricket and as they improve their skill level that these become heavier and strong (*3 marks*)

Equipment that is lighter has a smaller mass, and shorter has a smaller radius, which decreases the moment of inertia. When moment of inertia is decreased, the equipment can be swung at a greater angular velocity as angular momentum remains the same. This is beneficial for beginners as they have more control of the equipment and can make it swing faster, when then increases momentum and velocity of the ball they're hitting, as momentum is conserved. As they improve their skill level, they can increase the mass and length of the equipment, to give it a higher moment of inertia, and allow for greater momentum and velocity to be transferred to the ball.

1 mark for referencing what decreased moment of inertia can do
1 mark for justifying why this is useful for beginners
1 mark for referring to the sport and the shorter and lighter equipment

Netball and basketball both involve shooting the ball through a hoop/basket that is 3.05cm high.

a. **Discuss any differences in the height of release for the tallest student in your class contrasted to the shortest student in your class, when shooting a basket (*2 marks*)**

Tall students will release at an optimal angle, while a shorter athlete will need to increase this angle of release and use more force in an effort to reach the ring and score a goal.

1 mark for outlining that tall students have a more preferred angle
1 mark for outlining what the shorter student would need to do

b. **If you had to teach a group of Year 4 students how to effectively shoot in basketball or netball, discuss the biomechanics reasons why you would lower the hoop/basket height (*2 marks*)**

Lowering the ring height means younger students don't need to exert as much force, and they are able to throw at an optimal angle more easily.

2 marks for referencing two biomechanics principles

c. **Discuss two other modifications you might consider making when coaching juniors in basektball/netball to enable them to experience more success during training sessions, ensure you refer to relevant biomechanics principles to support your discussion (*4 marks*)**

- Decrease the mass of the ball, so less force is required to accelerate the ball when juniors are throwing it.

- Use a smaller ball, so smaller hands can get a 'grip' on the ball and increase the friction between their hands and the ball, increasing stability they have over the ball.

4 marks for discussing two modifications and identifying biomechanics principles

In biomechanics terms, explain why some shorter elite tennis players use a longer racquet to improve their serve (*2 marks*)

Increasing the length of the racquet increases the length of the lever and increases the resistance arm. This makes the mechanical advantage < 1, so that more range of motion is covered by the lever and allows it to be swung at an increased velocity, and the tennis ball can have a greater acceleration and travel further.

1 mark for referring to the mechanical advantage
1 mark for explaining that a mechanical advantage <1 can create increased velocity

Explain how Newton's second and third laws apply to a volleyball game. *(4 marks)*

The greater the force with which the spiker hits the ball the greater the acceleration of the ball and the more likely it is that the blockers will not be able to successfully block the ball. (2nd law). The volleyball hitting the blockers hands/arms at an angle bounces off on an angle with similar force to that with which it was spiked. (3rd law)

2 marks for giving examples of newton's 2 laws in action
2 marks for explaining how the laws work in the game of volleyball

Inertia can be advantageous or disadvantageous in a sport such as rugby union. Describe why. *(6 marks)*

- A player having a greater inertia means more force is required to overcome that player's state of motion. If you are in a rugby scrum and have a high inertia, the opposing players will need to apply a larger face to knock you over and get the ball.
- Inertia and mass are directly proportional, meaning if you have a high inertia, you have a high mass. Having a high mass means more force is required to accelerate faster. This means it'll be more difficult to change the player's state of motion and run faster, or change direction, which is a disadvantage when trying to out run other players.

2 marks for describing an advantage and disadvantage
2 marks for using rugby as the example
2 marks for referring to inertia in both the advantage and disadvantage

Explain the advantage a taller athlete may have over their shorter competitors in throwing events such as javelin. Explain what the shorter athlete can do to make up for their height difference. *(4 marks)*

A taller athlete will naturally have a higher height of release, which will mean the javelin will travel further in the horizontal direction, which is an advantage in throwing events. For a shorter athlete to make up for their height difference, they should increase their angle of release and release velocity, to try and make the javelin travel further.

1 mark for identifying the taller athlete has a higher height of release
1 mark for explaining the effect height of release has on a projectiles motion
1 mark for identifying the increase in angle of release for a shorter athlete
1 mark for identifying the increase in speed of release for a shorter athlete.

Explain how longer tennis racquets produce greater serve velocities. *(2 marks)*

Longer levers allow for tennis players to generate greater speeds during serving because of the increased linear velocity of the racquet head, which imparts greater velocity on the ball.

1 mark for identifying the increased lever length
1 mark for identifying the increased velocity of the lever

Sporting equipment is often modified for children to be shorter and lighter. Explain why this is suitable for younger children learning to play tennis. *(3 marks)*

The shorter and lighter racquets are easier to manipulate due to the smaller moment of inertia, allowing children to have greater control and greater success in hitting the ball. The increased opportunities to execute the stroke, combined with the increased success experienced by the children, enhances skill development and enjoyment for the children

1 mark for referencing moment of inertia
1 mark for explaining that children can have more control and success
1 mark for explaining that success enhances skill development

Two students perform a biceps curl with a 10kg dumbbell. Student A is taller and has much longer forearms than student B. Which student is required to generate more muscular force to perform the bicep curl? Explain your answer. *(4 marks)*

Student A will be required to generate more force than Student B, because they have a longer forearm and longer resistance arm, decreasing the mechanical advantage. Having a longer lever arm increases the torque (t = f x lever arm) generated by the dumbbell. When mechanical advantage is decreased, there is a greater force required to move the lever.

1 mark for correct identification of who would need to generate more force
1 mark for explaining that Student A has a decreased mechanical advantage
1 mark for referring to torque
1 mark for explaining decreased mechanical advantage increases force required

During an olympic routine, what must a gymnast do in order to generate angular motion? (*2 marks*)

The gymnast must apply an eccentric force, which is a force that acts outside the centre of gravity. This force is achieved by the gymnast pushing off the beam with her hands or feet and ensuring that the rest of her body is outside the centre of gravity, which then starts angular motion.

1 mark for identifying the eccentric force
1 mark for explaining what this is

Why can shot-putters get better results when using the rotational/spin technique? (*2 marks*)

They are applying the force over a longer period of time, which generates impulse and allows for a greater increase in angular momentum, which then gets transferred to the shot and the shot will have an increased velocity and travel a further distance.

1 mark for explaining the increased impulse
1 mark for referring to increased momentum and conservation of momentum

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EXPLAIN AND APPLY THEORIES OF LEARNING TO PRACTICAL COACHING SITUATIONS

Practice using scenarios and identify the type of coaching and practice/feedback that is happening

Be aware of the advantages and disadvantages of the different types of coaching and practice methods. The constraints-based approach and the direct approach both have their relative strengths and weaknesses. The coach should choose an instructional approach based on the participant's stage of learning (individual) and the nature of the movement skill (task).

Ben is an under-12 AFL footballer who demonstrates effective technique when executing a drop-punt kick during uncontested line drills. His kicks generally hit their intended targets but lack consistency and and skill execution. However, when Ben is involved in match practice, his kicking skills deteriorate significantly.

a. **Name the stage of learning most applicable to Ben's kicking skills and provide two instructional strategies applicable to this stage of learning. *(3 marks)***

Ben's kicking is in the associative stage of learning. Firstly, Ben needs regular supervised kicking practice and secondly, the coach should assist Ben to understand why he has made a kicking error, as well as develop strategies to correct skill errors.

1 mark naming the associative stage of learning
2 marks for naming two instructional strategies

b. **Name the instructional approach that would most likely enhance Ben's kicking skills in a match. Explain how this instructional approach facilitates the execution of effective skills under match conditions. Provide an example to support your answer. *(4 marks)***

A constraints-based approach to instruction. The constraints-based approach places the learner in a small-sided game modified to simulate match conditions and hence develop applicable movement skills; for example, a game of 'keepings off', in which Ben and three other teammates try to maintain possession by kicking the ball to each other within a designated space and avoid being intercepted by two designated defenders. The game implicitly teaches important and applicable kicking skills that are generally not developed in line drills, such as kicking the ball out 'in front' of the leading teammate and practising externally paced skills.

1 mark for naming the constraints-based approach
2 marks for explaining how the constraints-based approach simulates match conditions to produce applicable movement skills
1 mark for an example of the approach

Outline two coaching tips for autonomous learners (*2 marks*)

Autonomous learners would require precise, detailed feedback from the coach to allow for improvements in skill execution. They also need to be exposed to a game sense, and match simulation to enhance tactical knowledge and decision-making skills.

2 marks for two coaching tips

You have to design training sessions for a newly formed tennis club that consists of many members with a wide range of skills and experiences. Discuss typical skills/drills you would design for players at the cognitive and associative stages of development. (*2 marks*)

For the cognitive stage, I would give them simple drills in a blocked style of practice, with a closed environment, focusing on discrete skills such as forehand, backhand, and serving, and give repeated demonstrations.

For the associative stage, I would spend some time allowing them to focus on refining their serving, forehand and backhand skills, before sending them into a game situation, where the game is more open and practice is more random. Instructions can be detailed.

1 mark for skills/drills at the cognitive stage
1 mark for skills/drills at the associative stage

EXPLAIN SOCIOCULTURAL FACTORS THAT INFLUENCE MOVEMENT SKILL DEVELOPMENT AT DIFFERENT STAGES OF LEARNING

It is sometimes difficult to tell exactly where an individual falls on the spectrum of stages of learning, as there is no clear start or end point between each of the stages. The same individual can also fall into different stages for different skills.

Be able to identify how different factors affect different stages of learning

Explain how having an active and skilled role model could positively influence a young person's opportunity to develop their motor skills. (*2 marks)*

A coach can demonstrate correct technique of a particular skill, which a young person can then model. The coach's role modelling may provide motivation to the young person to try harder.

Joel lives in Mans eld in the alpine region of Victoria. His cousin Tom lives in Anglesea on the west coast of Victoria. Explain the influence geographic location may have on the boys' skill acquisition opportunities in the cognitive stage (*2 marks)*

Geographic location can influence people's access to various physical activities and the variety of sports they can try. Joel is more likely to have access to programs, facilities and resources related to alpine sports, whereas Tom is more likely to have access to aquatic activities.

DISCUSS HOW SKILL CLASSIFICATION AFFECTS THE SELECTION OF APPROPRIATE PRACTICE STRATEGIES

Skill classification describes the type of skill in terms of precision of movement (fine or gross), the predictability of the performance environment (open or closed), whether it is complex (multiple sub-routines) or whether it is continuous or discrete

A. **What is the type of feedback a hockey player would rely on while playing in a game? Provide an example of this type of feedback in your discussion. (*2 marks)***

A hockey player would rely on intrinsic feedback, feedback that comes from within such as feeling the control they have over the puc, as it is difficult for them to obtain external feedback during a game.

1 mark for explaining intrinsic feedback
1 mark for the example

B. **Suggest how and when a coach could use the following types of practice in hockey for maximal benefit:**

Random practice
Massed practice *(2 marks)*

A coach could use random practice when players aim to practice their decision making skills and improve their awareness of the game, most likely to be used in the associate and autonomous stages of learning, whereas they could use massed practice when they aim to emphasis skill execution on a certain skill in the cognitive stages of learning.

1 mark for explaining when and how random practice works
1 mark for explaining when and how massed practice works

Identify and justify whether an open or closed environment is most preferable for an associative learner (*2 marks*)

The environment should be more open and random, as there are more factors to consider and this more closely replicates a game environment. This will help associative learners build tactical and strategic thinking, and allow for a greater transfer of learning.

1 mark for open environment
1 mark for the justification

OBSERVE AND RECORD THE CHARACTERISTICS OF DIFFERENT TYPES OF PRACTICE STRATEGIES

This is about learning about practice strategies and their characteristics and how they can lead to certain outcomes in learning

Why would a coach provide beginners with a lot of blocked practice in a very structured predictable environment? (*2 marks*)

Blocked practice has low levels of variability and involves performing the same skill repeatedly, and the closed environment gives little distractions to the beginner learner so they can focus on developing and improving their skill and technique.

1 mark for explaining what blocked practice is
1 mark for explaining why a closed environment helps beginners

Describe the relationship between the stage of learning and the amount of variability of practice (*2 marks*)

Early stages of learning will generally have more blocked practice with low levels of variability so the learners can concentrate. As they progress through the stages. the amount of variability they experience will be greater, and they'll be involved in more random practice, to enhance their decision making skills and ensure they develop applicable skills.

Why is massed practice better suited to performers at the associative and autonomous stages of learning? (*2 marks*)

The massed practice allows for continuous practice of the skill, and generally requires high levels of motivation and self-monitoring. This maximises practice time and allows associative and autonomous learners to precisely replicate and refine their skill further, and allow for better movement skills performance which they can apply in the game.

1 mark for explaining what massed practice is
1 mark for explaining why this type of practice is better suited

Why is distributed practice better suited to performers when they are learning a skill for the first time? (*2 marks*)

The rest periods allow for memory consolidation and the player can give themselves feedback intrinsically or externally from a coach. This helps a cognitive learner as the rest periods give them time to think through a skill and avoid fatigue, and to keep them motivated.

1 mark for explaining what distributed practice does
1 mark for explaining how this helps a cognitive learner

Why does random practice result in greater retention of skill when compared to blocked practice? (*2 marks*)

Random practice more closely replicates a game situation, as games are random, and the learner is more actively involved in the learning as opposed to the simple, repetitious activity performed in blocked practice. This makes random practice more likely to result in retention of skill in a game environment for players

2 marks for justifying why random practice results in greater skill retention

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PERFORM, OBSERVE, ANALYSE, AND REPORT ON THE ROLE OF FEEDBACK IN IMPROVING PERFORMANCE THROUGH PRACTICAL- BASED ACTIVITIES

This is about knowing the types of feedback and how they can be used in various scenarios to improve performance

Describe the type of feedback elite Hockeyroo Anna Flanagan would use while playing a match and explain how she would utilise this feedback to enhance her skill performance. (*5 marks*)

Anna would be reliant on concurrent augmented feedback from her coach on the sideline, as well as her own intrinsic feedback; for example, Anna can feel when she has struck the ball with the appropriate speed and accuracy. As an experienced hockey player, Anna can process her coach's instructions while playing and further enhance her skill performance and her contribution to the team's success.

1 mark for acknowledging Anna is experienced
2 marks for two types of feedback
2 marks for providing examples of each type of feedback

Describe the best type of feedback for a cognitive learner (*2 marks*)

Augmented, knowledge of results would be the best for the cognitive learner, as they don't get overwhelmed with information, as well as keeping them motivated through successful outcomes.

1 mark for identifying augmented, knowledge of results
1 mark for describing why it helps the cognitive learner

Provide an example of how both terminal and concurrent feedback could be used in the sport of basketball (*2 marks*)

Concurrent feedback could be used when a coach tells out instructions to the team from the sidelines while they're playing a match, and terminal feedback could be used after a match when a coach sits down and discusses the game with the team.

1 mark for how terminal feedback could be used
1 mark for how concurrent feedback could be used

Feedback is vital for improving learning and skill development. Why is it important that feedback is provided as soon as practical after a skill is performed? (*2 marks*)

Feedback highlights skill errors and allows learners to refine their technique and make appropriate corrections efficiently. Feedback also provides positive reinforcement, so learners can recognise what they are doing correctly.

2 marks for two points about the importance of the timing of feedback.

AREA OF STUDY 2: HOW DOES THE BODY PRODUCE ENERGY?

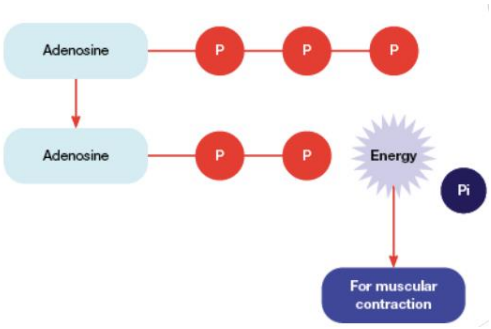
KEY KNOWLEDGE

- fuels (both chemical and food) required for resynthesis of ATP at rest and during physical activity, including the relative contribution of fuels at varying exercise intensities
- characteristics of the three energy systems (ATP–CP, anaerobic glycolysis, aerobic system) for physical activity, including rate of ATP production, the yield of each energy system, fatigue/limiting factors and recovery rates associated with active and passive recoveries
- interplay of energy systems in relation to the intensity, duration and type of activity
- oxygen uptake at rest, and during exercise and recovery, including oxygen deficit, steady state, and excess post-exercise oxygen consumption
- acute physiological responses to exercise in the cardiovascular, respiratory and muscular systems.

FUELS

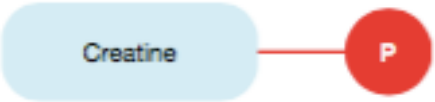
Fuels (both chemical and food) required for resynthesis of ATP at rest and during physical activity, including the relative contribution of fuels at varying exercise intensities

- **Adenosine triphosphate (ATP)** is the chemical energy of all body cells. It powers all of the cell's metabolic activities, including the muscle's ability to contract.
- ATP is the only source of energy for muscular contractions. Other fuels simply allow ADP to be rebuilt into ATP.
- The energy that powers the mechanisms involved in muscular contraction is obtained from **catabolism** (breaking down) of **ATP.**
- **ATP,** or **Adenosine Triphosphate** is one **adenosine** and **three phosphate molecules.**

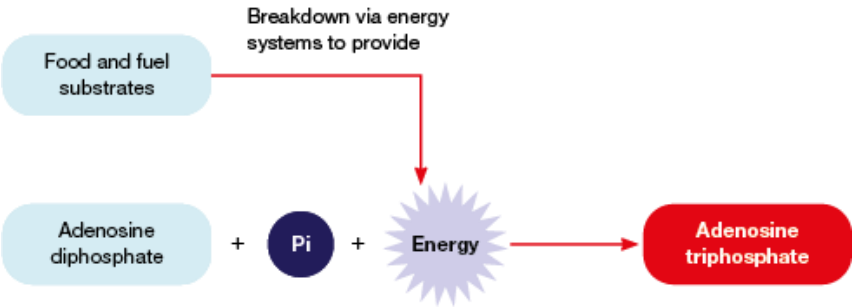


- **ATP —> ADP + Pi + Energy**
- However, the body only stores a very small quantity of ATP within the cells, enough to only power 1-2 seconds of maximal exercise.
- As most sporting activities last longer than this, the body must **resynthesise** ATP on an ongoing basis.
- To do this, chemical reactions using the body's available fuels add a phosphate back to **ADP** to make more ATP.
- During energy production, a phosphate molecule splits off. ATP is split into **ADP** and **Pi**.
- Energy is required to rejoin ADP and Pi back into ATP so more energy for muscular contractions can be released.

- **Phosphocreatine**, or **PC**, is stored in limited quantities within the muscles, however as supplies are limited PC is quickly depleted during maximal exercise.
- PC only requires simple chemical reactions, so it can be broken down at a fast rate.

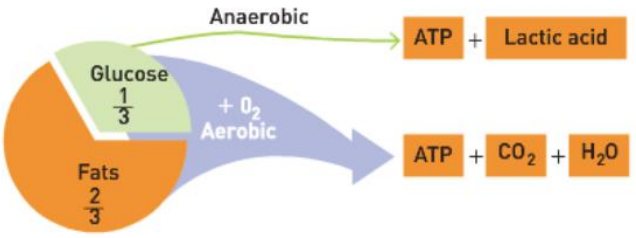


- PC splits into **creatine** and **inorganic phosphate** when broken down. This produces energy that is used to rebuild ATP.



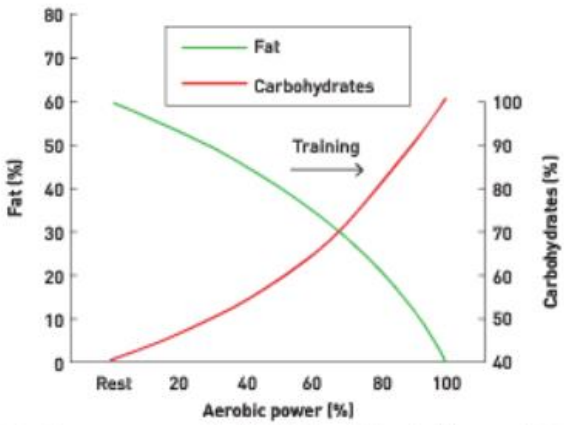
- Only approximately 10 seconds worth of PC can be stored at the muscles.

- **Carbohydrates**, or **CHO**, are the preferred source of food fuels during exercise.
- They are stored as **glycogen** within the **liver** and **muscles.**
- Glycogen is broken down into **glucose**, where glucose travels in the blood and enters muscle cells.
- Excess CHO is stored as fats.
- **High Glycemic Index (High GI)** foods are absorbed fast compared to low GI food
- Carbohydrates require less oxygen to be oxidised than fats and are broken down at a much faster rate, and therefore are the preferred fuel for when exercising at moderate-high intensities.
- When CHO is broken down without oxygen, they are **incompletely broken**, as opposed to being **completely broken** with oxygen.
- Examples of foods containing carbohydrates are potatoes, rice, bread, flour, popcorn etc.



Food fuel sources at rest

- **Fats**, or **lipids**, are the preferred source of food fuels during rest and low intensities.
- They are stored as **adipose tissue** around the body or within the muscle as **triglycerides.**
- Fats contain the most energy and a great yield of ATP but need a lot of oxygen to breakdown.
- Fats require complex chemical reactions to breakdown, and therefore produce energy at a much slower rate.
- After digestion, lipids get broken down to **free fatty acids (FFA)** and are transported through the blood.
- During exercise, the percentage of fats being used as an energy source decreases as the exercise intensity increases.
- However, as exercise duration increases, the percentage of fats being used in the production of ATP increases.
- Fats become increasingly important when stores of CHO deplete during endurance exercise (around 90-120 minutes).



During aerobic training the crossover point shifts to the right and delays carbohydrates becoming the predominant fuel source during endurance events.

- Examples of foods containing fats are butter, margarine, cheese, oils.

- **Protein** is only used in extreme circumstances, such as an ultra marathon.
- They are stored as **muscle tissue.**
- Proteins are built from basic units called **amino acids**, which travel through the blood.
- Protein requires a lot of oxygen to break down for energy release.
- Used for **growth** and **repair.**
- They are only used when all other sources have been depleted.
- Examples of foods containing protein are meat, fish, eggs, cheese.

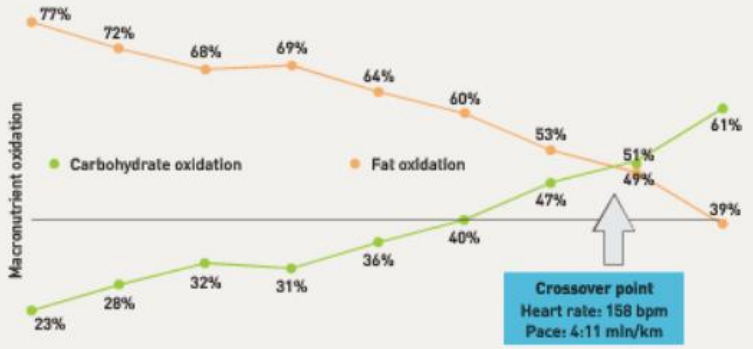
- At **rest and low-intensity activity**, the body uses two-thirds lipids and one-third CHO. Fats can liberate more energy than CHO as there is an abundance of oxygen at rest.
- During **moderate-intensity exercise**, there is a mixture of lipids and CHO being used for fuel. Extended duration efforts will see glycogen deplete and lipids become the dominant provider, at this point intensity is decreased as more oxygen is needed for lipid breakdown compared to CHO.
- But if you can metabolise triglycerides at higher intensities **(glycogen sparing)** this is an advantage.
- This allows the athlete to metabolise triglycerides at higher intensities allow you to conserve glycogen.
- Using a greater percentage of fats (not necessarily the dominant fuel source) allows you to maximise carbohydrates for longer.
- It is important to recognise that glycogen sparing is not a strategy to improve performance, it is an adaptation!
- During **high-intensity exercise**, phosphate creatine and CHO are predominantly used.
- **Carbohydrate loading** is a process that allows for performance enhancement by increasing your glycogen stores and carbohydrate intake 3-5 days prior to a major competition.
- This should be also done alongside a **taper** period, where training frequency decreases but intensity maintains the same. This is to ensure the extra carbohydrates consumed aren't burned off.
- This allows for a prolonged performance, however could increase a person’s bodyweight and increase their water storage.

REAL WORLD APPLICATION

Fuel for marathons

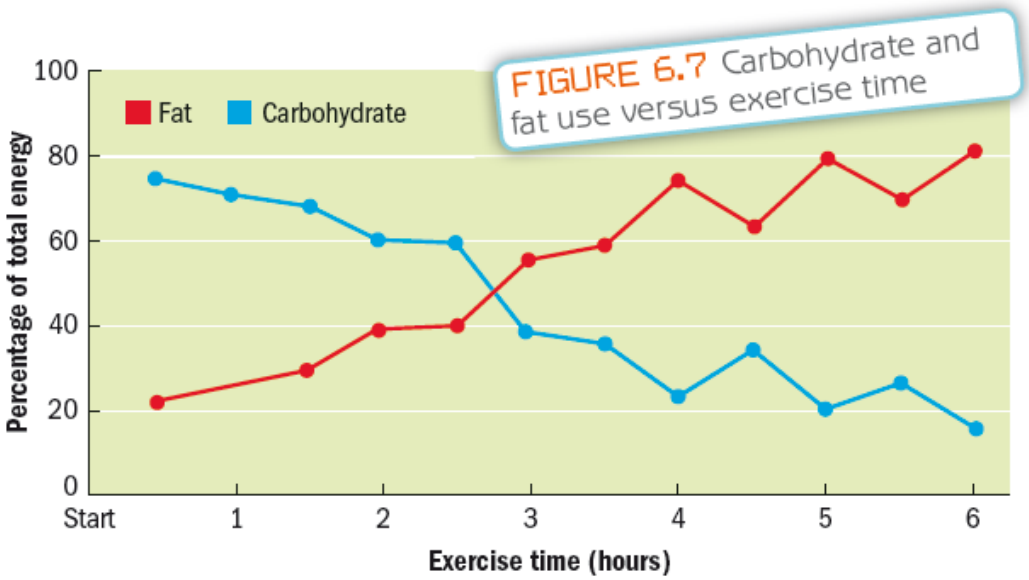
The following graph shows the carbohydrate and fat usage for a runner completing an 80-kilometre ultra-marathon. At slower paces, he relied predominantly on fat to recharge ATP. At a pace of 4:11 minutes per kilometre and a heart rate of 158 bpm, he reached his crossover point, where he began relying more on carbohydrates than fat to recharge ATP.

The runner's goal would be to shift the crossover point to the right to preserve carbohydrates until later in the event. How could this be achieved?



Carbohydrate and fat usage for a runner competing in an 80 km ultra-marathon

- Carbohydrate loading cannot be mentioned without talking about tapering!



Adapted from: McArdle, Katch & Katch 2006

ENERGY SYSTEMS

Characteristics of the three energy systems (ATP–CP, anaerobic glycolysis, aerobic system) for physical activity, including rate of ATP production, the yield of each energy system, fatigue/limiting factors and recovery rates associated with active and passive recoveries

- The energy for muscular contractions is produced either **anaerobically** or **aerobically** via three every systems.

Anaerobic systems:

- ATP-PC system
- Anaerobic glycolysis system

Aerobic systems:

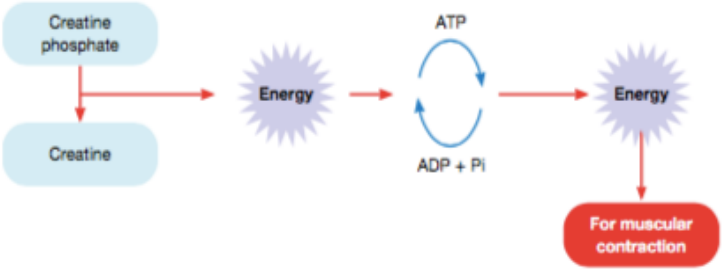
- Aerobic glycolysis system
- Aerobic lipolysis system

- At rest the body has lots of oxygen available, however during activity, increased oxygen supply is needed to go to the working muscles.
- Exercises of **short duration and high intensity** means the anaerobic systems supply most of the energy.
- Exercises of **longer duration and low intensity** means the aerobic system supplies most of the energy.

	ATP-PC	Anaerobic glycolysis	Aerobic
AKA	Phosphate system, phospagen system	Lactacid system	Oxygen system
Fuel source	PC (Phosphate creatine)	Glycogen	Glycogen and triglycerides
Intensity	Maximal, explosive, 95% HR max	High intensity, 85%+ HR Max	Sub-maximal < 85% HR Max
Rate of ATP production	Most rapid / explosive	Fast	CHO : Moderate Fats : Slowest
Yield of ATP produced	Limited, low, 0.7 ATP per molecule of PC	Small amount, 2-3 ATP per glucose molecule	36-38 ATP per glucose 147 ATP per glyceride (450 per triglyceride)
Dominance	0-10 seconds / 0-25 for elite	10-60 seconds	60 seconds + 2 hours + aerobic lipolysis
Peak power	2-4 seconds	5-15 seconds	1-2 minutes
By-products	Inorganic phosphate, ADP	Lactate, hydrogen ions, ADP	Carbon dioxide, heat, water
Fatigue mechanism	Depletion of PC, leading to increased reliance on anaerobic glycolysis system	Accumulation of metabolic by-products	Elevated body temperature
Recovery method	Passive recovery	Active recovery	High GI foods, active recovery
Sporting eg.	100m sprint, shot put, jumping	200m sprint, 100m swim, defensive play	Marathon, midfield football, beep test
Work : rest ratio	1:5	1:3	2:1 +

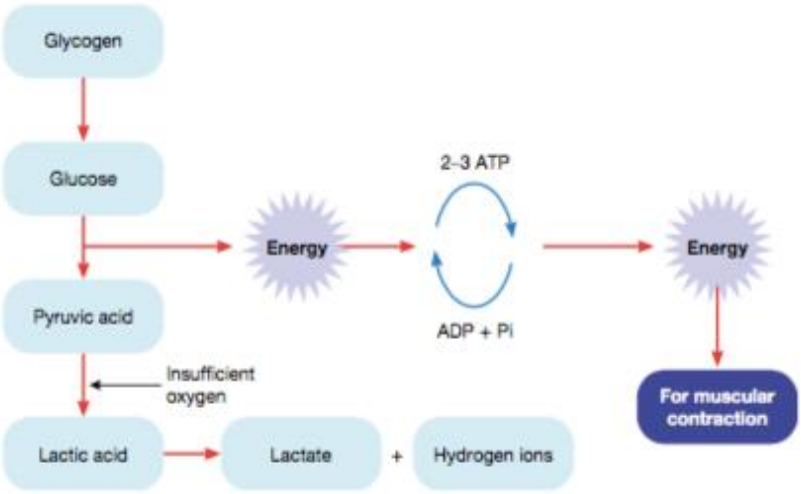
- ATP is resynthesised using ADP and a free phosphate molecule (Pi).
- This process requires energy.
- Phosphocreatine is the chemical compound that provides this energy.
- So PC is broken down to phosphate and creatine to produce energy, and this allows
- ADP to be rebuilt to ATP, which can then produce the energy needed for muscular contractions,

- The **ATP-PC system** provides the most readily available source of ATP for energy, because it depends on short and simple chemical reactions.



- ATP and PC are both stored in the muscle and available for immediate energy release
- Processes occur anaerobically, so there is no reliance on oxygen.
- Once **PC is depleted**, ATP must be resynthesised in other ways, usually via glycogen through the anaerobic glycolysis system.
- Anaerobic glycolysis system supplies ATP at a slower rate, therefore there is a decrease in the amount of force in muscular contractions and rate.
- There is also an accumulation of **metabolic by-products**, **inorganic phosphate and ADP.**
- **Pi accumulation** decreases the rate and force at which the muscles contract, causing fatigue in very high intensity activities where Pi accumulates at a fast rate.
- **ADP accumulation** results in decreased contraction velocity, causing fatigue in very high intensities where ADP accumulates quickly.
- Once PC is depleted, it gets replenished via a **passive recovery**.
- 70% of PC gets replenished in 30 seconds.
- 98% after 3 minutes.
- 100% replenished in 10 minutes.

- The **anaerobic glycolysis system** produces energy from the breakdown of glycogen to glucose, the process is known as **glycolysis.**
- This provides the energy necessary to rebuild ADP to ATP.
- Because oxygen is not present, the glycogen is not fully broken down.
- **Pyruvic acid** is created and because there is no oxygen, it is converted to **lactic acid** and then **lactate.**
- **Hydrogen ions** are also released.
- As these **by-products** increase in the muscles it decreases the rate of ATP rebuilding and leads to fatigue.

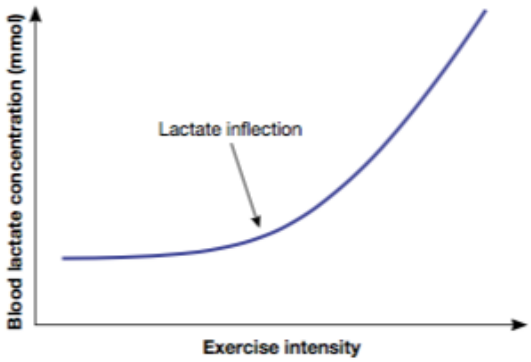


- The anaerobic glycolysis system requires more complex reactions than the ATP-PC system to release energy.
- An **accumulation of H+ ions** leads to a decrease in pH in the muscle and increased muscle acidity, which contributes to decreased muscle function. The acidic environment slows down enzyme activity and ultimately the breakdown of glucose slows down. This causes the muscle to become fatigued.
- Lactate doesn't cause fatigue, accumulation of H+ ions do.

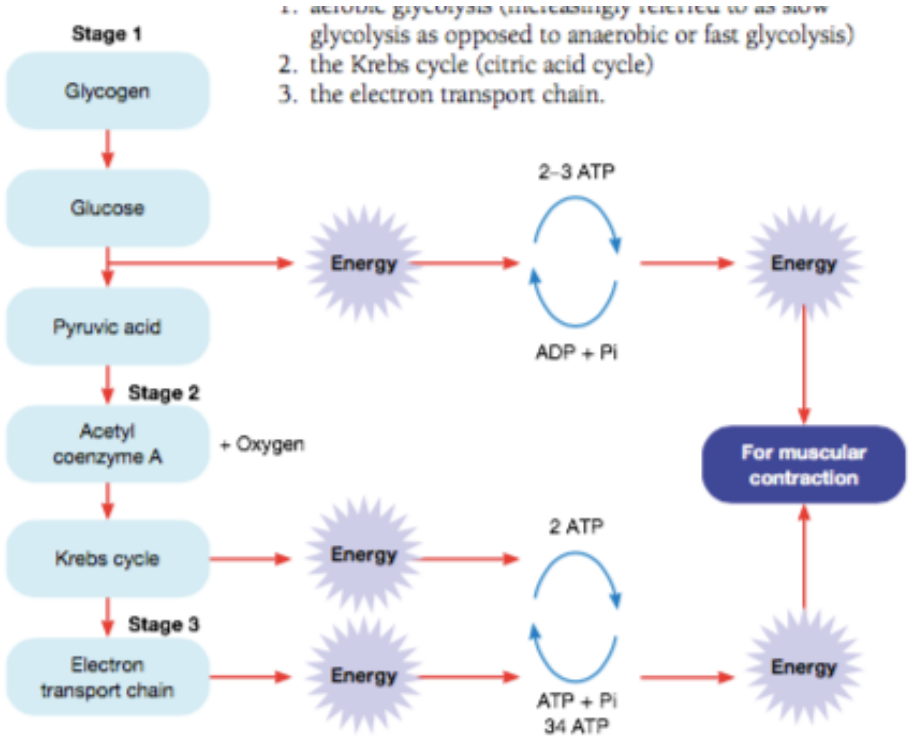
<u>Recovery methods include</u>:

- **Active recovery**, which is where you continue the activity but at a reduced intensity. Here oxygen can be delivered to the working muscles and remove metabolic by-products and prevent **venous pooling**, and assist **venous return.**
- By performing an active recovery over a passive recovery, you can half your recovery time.
- **Massage**, which increases blood flow to muscles and aids in removal of by-products.
- **Hold/cold therapy**, involving **vasodilation** and **vasoconstriction**, which increases blood flow to remove by-products.

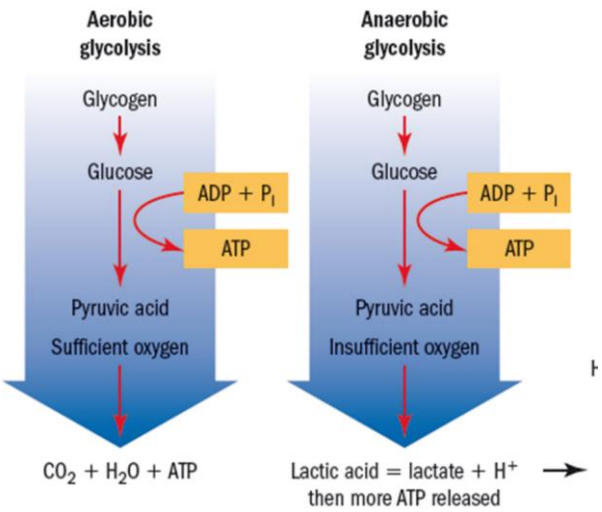
- The **lactate inflection point (LIP)** refers to the last exercise intensity where blood lactate production equals blood lactate removal within the body (is balanced) (generally aerobic work).
- This typically occurs around 85-90% MHR, but can be up to 95% for elite athletes.
- Lactate is always present in the blood, but at lower intensities it is able to be oxidised and removed at a similar rate to what it is produced.
- LIP is an aerobic concept; a higher LIP indicates that an athlete can work at a higher intensity for a longer period of time predominantly aerobically. That means less reliance on anaerobic glycolysis contribution at higher intensities an they can effectively transport oxygen to working muscles and oxidise lactate at the rate it is being produced. Therefore not allowing LIP to be reached and no accumulation of lactate.
- **Lactate tolerance** is an anaerobic concept. An athlete with a greater lactate tolerance will be able to maintain performance despite the accumulation of lactate and continue to derive significant contribution from their anaerobic glycolysis system.
- Any work above LIP requires an increased contribution from the anaerobic systems to supply energy.
- Lactate accumulation is associated with an accumulation of H+ ions.
- After LIP, H+ ions will begin to accumulate in the muscles and cause fatigue.
- At exercise intensities beyond LIP, blood lactate concentration increases. exponentially; this is believed to result from the accumulation of H+ ions, not lactate itself.



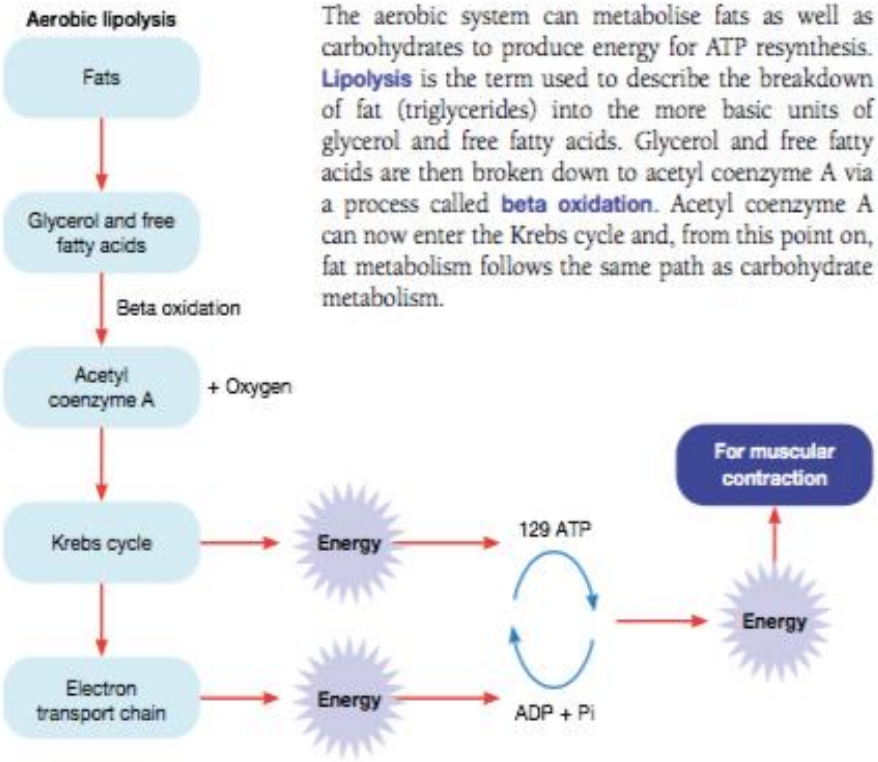
- To recover from LIP, an active recovery is best. This keeps blood flow high to help break down lactate into pyruvic acid and ATP again. When oxygen is available it can help to produce ATP and give lactate a positive effect on performance.
- In order to delay the accumulation of metabolic by-products, an athlete would most likely train at or slightly below their LIP.
- Eg. its ideal for a marathon runner to run at or just above their LIP.



- The **aerobic system** breaks down glycogen into glucose and pyruvic acid using oxygen (**aerobic glycolysis**).
- This occurs in the **mitochondria.**
- Because oxygen is present a more complete breakdown of glycogen occurs, resulting in no lactate.
- Pyruvic acid gets channeled into the **Krebs Cycle** and **Electron Transport System**, where more ATP is produced, and instead of lactate forming, pyruvic acid is eventually broken down into **heat, carbon dioxide (CO2)** and **water (H2O).**



- None of these cause fatigue, and the aerobic system can be used indefinitely



The aerobic system can metabolise fats as well as carbohydrates to produce energy for ATP resynthesis. **Lipolysis** is the term used to describe the breakdown of fat (triglycerides) into the more basic units of glycerol and free fatty acids. Glycerol and free fatty acids are then broken down to acetyl coenzyme A via a process called **beta oxidation**. Acetyl coenzyme A can now enter the Krebs cycle and, from this point on, fat metabolism follows the same path as carbohydrate metabolism.

- The aerobic system prefers to break down CHO rather than fats.
- Although fats can produce more ATP, they require more oxygen to be broken down.
- Stores of glycogen in the muscle and liver can fuel continuous exercise for over 90 minutes. When glycogen stores are depleted there is an increased reliance on triglycerides to produce ATP.
- Fats require more oxygen, therefore an athlete must decrease intensity as ATP is resynthesised at a slower rate.
- To prevent glycogen **fuel depletion**, athletes should **carbohydrate load** before exercise, as well as **exercise taper.**
- During exercise, they should drink **hypertonic sports drinks** or consume **sports gels.**
- After exercise, high GI foods should be consumed as soon as possible.

- In **aerobic lipolysis**, the aerobic system metabolises fats for ATP resynthesis.
- **Lipolysis** is the breakdown of triglycerides into **glycerol** and **free fatty acids**. These are then broken down to **acetyl coenzyme A**, which can enter the Krebs cycle and be broken down in the same way as carbohydrate metabolism.

- During aerobic exercise, heat is generated during energy production causing an **increase in core body temperature.**
- The body must monitor its balance between cooling and muscle blood supply, which occurs through **thermoregulation.**
- When **body temperature increases**, more blood is **redirected to the surface of the skin** (**vasodilation at the skin**) as a **cooling mechanism**, therefore less blood is supplied to the working muscles.
- This has a cooling effect as heat radiates with the environment.
- However less oxygen is going to the working muscles to remove waste products.
- Therefore a greater contribution from the anaerobic glycolysis system is required and potential accumulation of H+ ions.
- **Sweat production** also increases due to **dehydration.** Dehydration won't occur without elevated body temperature.
- This assists with cooling the body.
- However, this reduces blood plasma levels and decreases electrolytes in the body, which can lead to dehydration.
- Decreased blood volume results in decreased cardiac output, reducing oxygen delivery to the muscles, and decreases the ability to remove by-products.
- Both increased blood flow to the skin and increased sweat production leads to decreased oxygen delivery to the working muscles and can cause fatigue.

To prevent / recover from this:

- **Hydrate** before, during and after events.
- Consume **sports drinks containing sodium** to encourage **fluid retention.**
- **Ice baths or cold showers.**
- **Wear light weight, light coloured clothing.**
- **Use shade.**
- Take **regular breaks.**
- **Acclimatise to conditions.**

Interplay of energy systems in relation to the intensity, duration and type of activity

- **Interplay** refers to the energy systems working together, but at different rates, to supply the ATP required for an activity.
- All three energy systems contribute to the resynthesis of ATP during physical activity.
- How each system works alongside the other energy systems is referred to as the **interplay** of energy systems.
- Two factors determine the ATP demand of an activity:
- **Duration**: determines the yield of ATP expended that is required to be resynthesised over the course of the activity.
- **Intensity**: determines the rate of ATP use, and consequently, resynthesis during the activity.
- **Availability of oxygen** and **availability and resynthesis of chemical/food fuels** can also determine the contribution of each energy system.
- The three systems do not function independently, all three energy systems are activated at the start of exercise.
- The intensity and duration of the physical activity determine which of the energy systems is the dominant contributor to ATP production.
- The figures below assume that continuous exercise is being performed.
- After 60-90 seconds, the aerobic system becomes dominant generally.

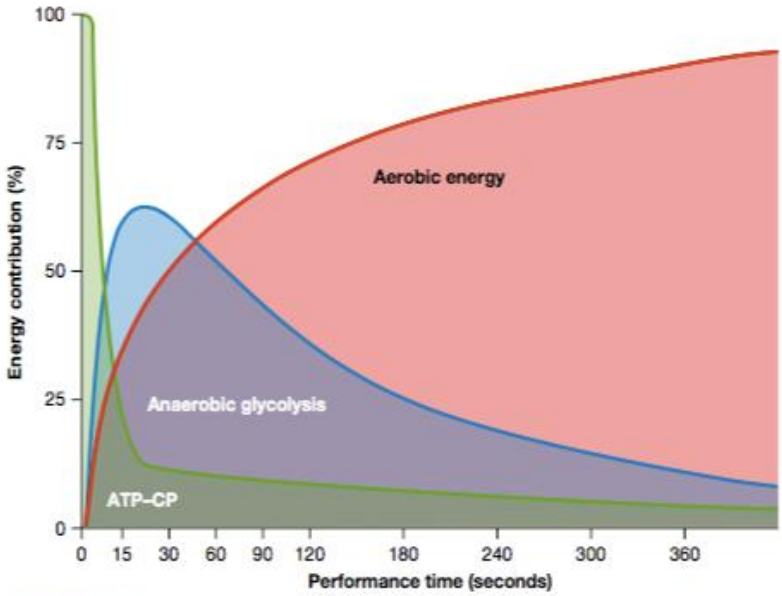


FIGURE 5.35 Relative percentage contribution of the three energy systems to maximal exercise of various durations

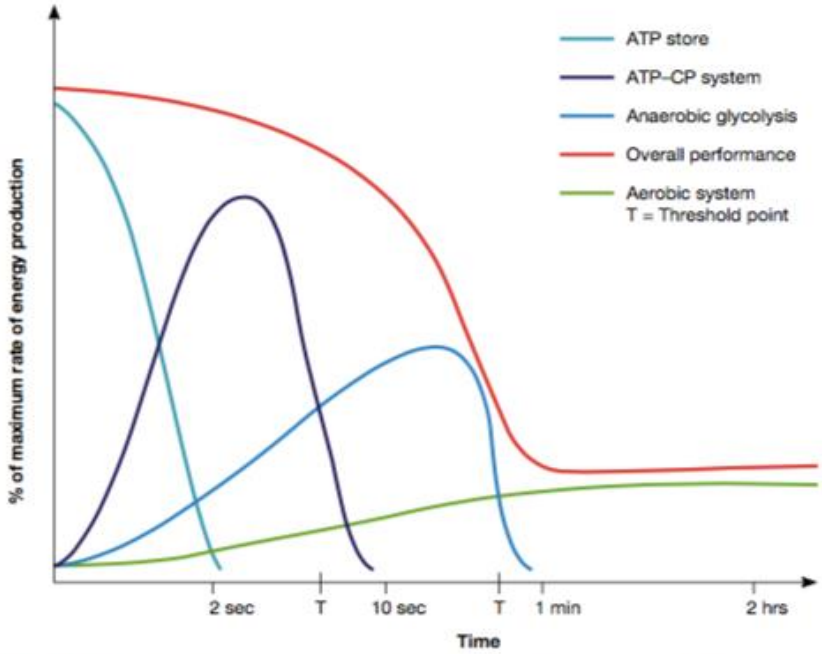


FIGURE 5.34 Approximate relative contributions of the three energy systems to energy production at maximum sustainable exercise intensity for varying durations

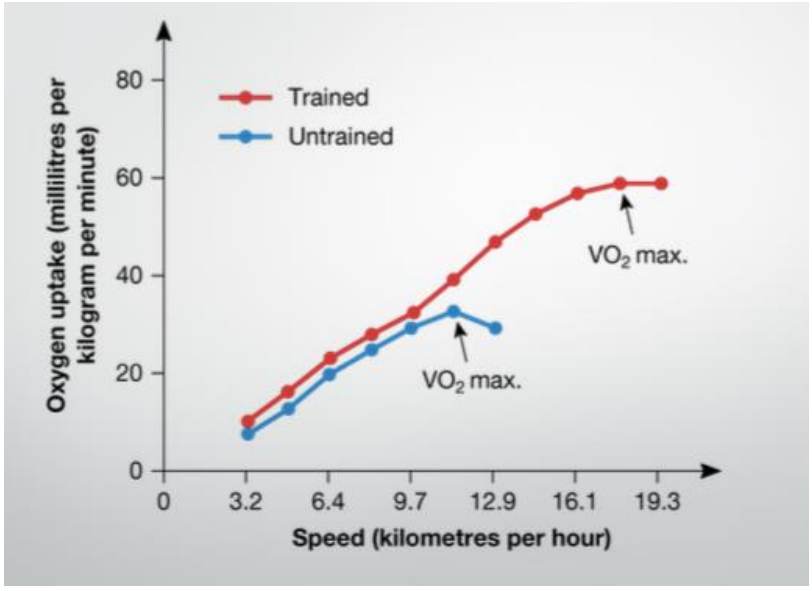
- The ATP-PC system is the only system with the capacity to meet the high power output demand of very high intensity exercise (eg. shot put) for 0-6 seconds.
- Other energy systems will produce ATP at slower rates, but their contribution to the energy supply will be minimal in proportion compared to the ATP-PC.
- When exercise of high intensity lasts for more than 10 seconds, the the intensity has to be reduced for activity to continue. As PC stores deplete, the anaerobic glycolysis increases its contribution to energy production.
- If activity is to continue beyond 60 seconds, the intensity would have to be decreased and the aerobic system becomes the dominant supplier to energy production.

- Transitioning from rest to exercise always results in an increased energy demand and requires an increased oxygen supply to the working muscles.
- However the respiratory and circulatory systems are unable to meet this increased demand immediately, so the body must use the anaerobic energy pathways to meet the ATP demands until the body has time to increase its oxygen delivery to meet the oxygen demand of the activity.
- This “lag” period, where oxygen supply does not meet oxygen demand is referred to as **oxygen deficit.**
- In intermittent exercise, athletes may be required to perform movements at maximal intensity for a short duration, but also maintain speed and endurance throughout the entire exercise.
- There may be rest periods within the exercise where athletes can replenish PC in their body or flush out lactate and hydrogen levels.

ACUTE RESPONSES

Oxygen uptake at rest, and during exercise and recovery, including oxygen deficit, steady state, and excess post-exercise oxygen consumption

- **Oxygen uptake (VO2)** refers to the amount of oxygen transported to, taken up by, and used by the body for energy production.
- At rest, the body consumes oxygen at a rate of approximately 0.25 litres per minute. The need for ATP is relatively small, requiring minimal oxygen consumption.
- When exercise begins, oxygen uptake increases as the working muscles use more of the oxygen made available by the cardiovascular and respiratory systems.
- There is a linear relationship between oxygen uptake and oxygen intensity. This continues until the **maximum oxygen uptake (VO2 max)** occurs.

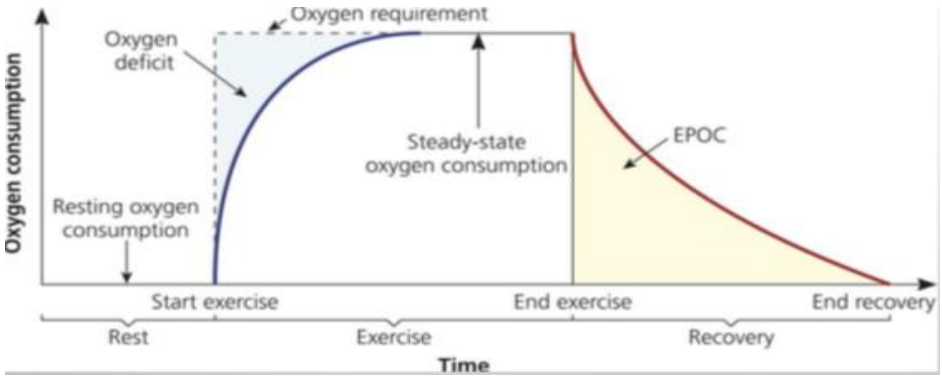


- **VO2 max** is the maximum amount of oxygen that can be taken up, transported, and utilised per minute.
- VO2 max can either be measured as **relative** or **absolute.**
- **Relative** takes into account body weight (**mL/kg/min**) whereas **absolute** doesn't (**L/min**).
- Relative allows for an easier comparison between individuals.
- Factors affecting maximum oxygen uptake include:
- **Body size.** A heavier, larger person requires more oxygen than a smaller person.
- **Gender.** Males generally have a higher VO2 max due to greater muscle mass, blood volume and larger lung and heart sizes.

- **Genetics.** Aerobic capacity may have a 25-50% variation between individuals due to genetics.
- **Age.** VO2 max peaks during late adolescence and early adulthood, and then declines.
- **Training status / fitness level.** Aerobic, endurance athletes can have significantly higher VO2 max.
- It is possible for an athlete to work above 100% VO2 max, by calling upon the anaerobic energy systems.
- VO2 max = a-VO2 diff (mL of O2 per 100mL blood) x cardiac output (L/min) at maximal exercise levels.
- An elite athletes VO2 max might be:
- **65mL/kg/min** for males.
- **56mL/kg/min** for females.
- Cross-country skiers are generally athletes with the highest VO2 max — highly aerobically trained

- **Oxygen deficit** refers to the point where oxygen demand exceeds oxygen supply.
- Whilst this is occurring, ATP is gained anaerobically.
- During any exercise, there will be a time of oxygen deficit.
- Oxygen deficit can be reduced by decreasing intensity, completing a warm-up, and training aerobically.
- Oxygen deficit occurs because the respiratory and circulatory systems take time to adjust to the new oxygen demand.
- When the oxygen supply does equal oxygen demand, the athlete is working aerobically and has reached a **steady state.**
- This steady state also coincides with a plateau in heart rate and ventilation.
- There can be multiple oxygen deficits and multiple steady states in an exercise session.
- A plateau doesn't always mean sub-maximal intensity has been reached. A plateau could mean you cannot obtain any more oxygen, which is the case for maximal intensity exercises, or it could mean you don’t need any more oxygen.

- At the completion of exercise, the demand for ATP decreases. But the amount of oxygen we require still remains above the amount required at resting levels.
- This is known as **oxygen debt (EPOC - excess post-exercise oxygen consumption).**
- This is vital for recovery. The excess oxygen is used to decrease body temperature, prevent venous pooling and remove by-products.
- The greater the accumulation of lactate, the larger EPOC.



- In this graph, the white area underneath the blue line and the steady state line can represent either the **oxygen consumption** or the **aerobic energy contribution**
- It is important to understand that oxygen consumption, VO2 and heart rate graphs never start from 0!

Acute physiological responses to exercise in the cardiovascular, respiratory and muscular systems.

- When exercise begins, the body needs to make a number of **physiological changes** to accomodate the energy requirements of the activity. There is an increased demand for **oxygen** and **energy substrates**, and the **cardiovascular, respiratory** and **muscular systems** respond to meet these needs.
- The level of response is dependent on the intensity and type of exercise being undertaken
- **Acute responses** are the body's immediate, short-term responses that last only for the duration of the training or exercise session and for a short time period afterwards.

- **Acute respiratory responses**

- The primary purpose of the respiratory system is to deliver oxygen to, and removal carbon dioxide, from the cells of the body.

- **Increased ventilation (V).** At the start of exercise we increase our breathing rate. We breathe more often and more deeply. Therefore our ventilation (amount of air breathed in and out in one minute) increases. Increased ventilation means there is more oxygen in the lungs that can be delivered to the working muscles.

- Ventilation increases because **respiratory rate (RR)** (number of breaths taken in one minute) and **tidal volume (TV)** (amount of air inspired and expired in one breath - litre per breath) both increase.

- **V = RR x TV**

- Tidal volume at rest is typically **0.5L/breath**, and during exercise can increase to **2L/breath.**

- Respiratory rate at rest is typically **12 breaths/min**, and **50 breaths/min** during exercise.

- During sub maximal exercise, ventilation increases rapidly at the start of exercise and then plateaus after 4-5 minutes. This means a steady state is reached.

- A typical ventilation at rest might be **6 litres**, and one during exercise might be **100 litres.**

- During maximal exercise, ventilation increases rapidly at the start of exercise and continues to increase until exercise stops. (No plateau period or steady state).

- Tidal volume plateaus at high (but not maximal) intensities.

- **Increased pulmonary diffusion.** Diffusion of molecules is movement of molecules from an area of higher concentration to lower concentration. Pulmonary diffusion occurs when oxygen is taken in via the lungs to the blood, and carbon dioxide is diffused from the blood to the lungs.

- When oxygen levels are high in the alveoli, they diffuse into the bloodstream, and then into the working muscles. Alternatively, when carbon dioxide levels are high in the working muscles, they diffuse into the bloodstream and then into the alveoli, for removal from the body via the lungs.

- Diffusion capacity increases so greater amounts of oxygen and carbon dioxide can be exchanged.

- **Increased oxygen uptake.** When exercise begins, oxygen uptake increases as the working muscles use more of the oxygen made available by the circulatory and respiratory systems.

- As exercise intensity increases, oxygen uptake increases linearly, until a maximum level of oxygen uptake is attained.

- **<u>Acute cardiovascular responses to exercise</u>**

- The primary purpose of the cardiovascular system is to transport more blood to the working muscles.

- **Increased cardiac output (Q)**. Cardiac output (amount of blood pumped out of the heart in one minute) increases, because **stroke volume (SV)** (amount of blood ejected from the left ventricle per beat) and **heart rate (HR)** (number of times heart b eats per minute) both increase.

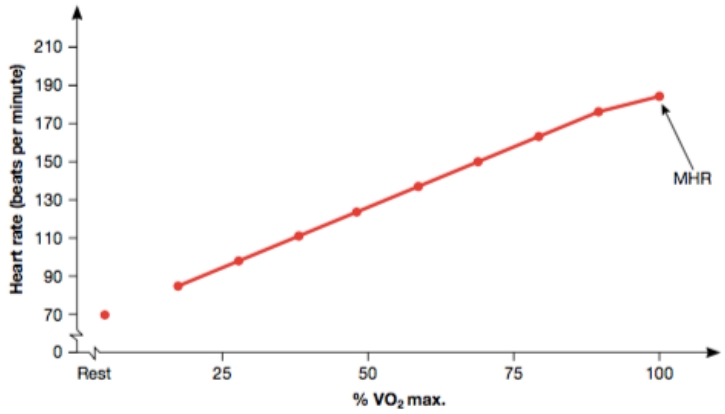
- Cardiac output at rest might be **4-5 L/min** and **20-30 L/min** during maximal exercise.

- **Q = HR x SV**

- A trained, fit, aerobic athlete would generally have a lower heart rate, and an increased stroke volume. This means the athletes heart does not have to beat as often to eject the same amount of blood.

- An untrained athlete might have **60-80 bpm** heart rate at rest, whereas a trained athlete might have **30-50 bpm** heart rate at rest.

- During sub-maximal exercise where the body reaches a steady state, heart rate will level off.

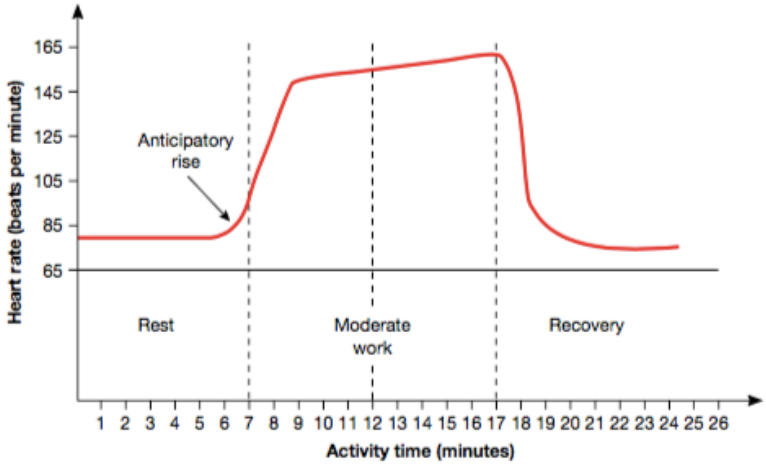


- Heart rate increases linearly with exercise intensity, and if a steady state is reached, heart rate plateaus.

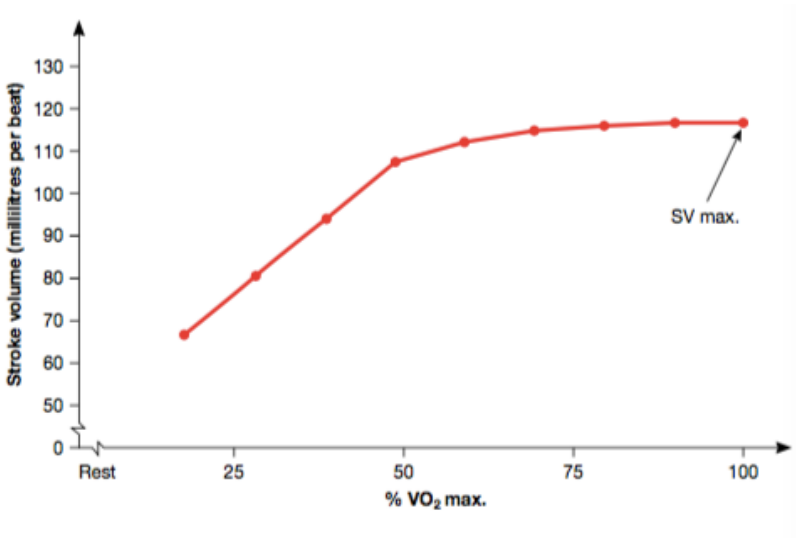
- A prolonged steady state in exercise can cause **cardiac drift**, where heart rate increases as body temperature increases.

- An estimation of maximum heart rate can be calculated by subtracting your age from 220.

- Heart rate actually does rise above resting levels just before the start of exercise. This is called the **anticipatory response**, and helps to prepare the body for exercise, also contributed to by an increase in adrenaline.



- Stoke Volume does level off however after sub-maximal exercise, as it has a finite capacity. Therefore, any increase in cardiac output after this point will be due to the increase in heart rate.



- An untrained athlete might have a **50-70 mL/beat** stroke volume at rest, and **110-130 mL/beat** during exercise.

- A trained athlete might have a **80-100 mL/beat** stroke volume at rest, and **160-200 mL/beat** during exercise

- **Increased blood pressure.** Increase in cardiac output results in an increased blood pressure, as blood is pumped more forcefully out of the heart.

- **Blood pressure** is the pressure exerted by the blood against the artery walls.

- **Systolic blood pressure** is the only blood pressure that increases with exercise. **Diastolic blood pressure** increases only during resistance training.

- A typical blood pressure reading at rest is 120/80 mm/Hg.

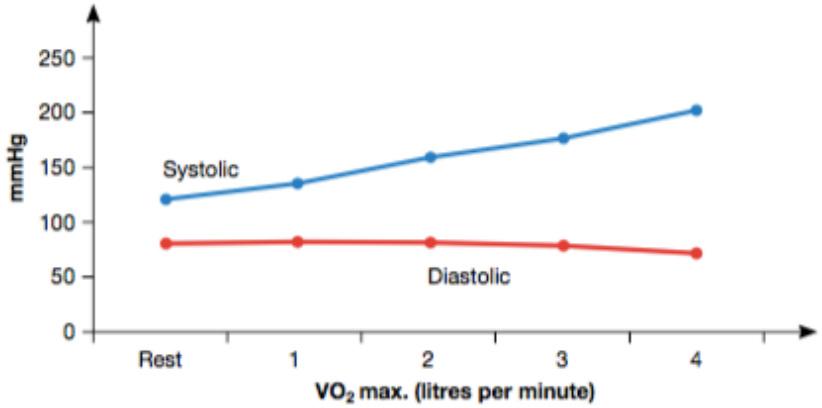
- **Blood pressure = systolic/diastolic mmHg.**

- **mmHg = millimetres of mercury**

- Systolic blood pressure is the pressure in the arteries as blood is ejected during the contraction phase of the heart cycle.

- Diastolic blood pressure is the pressure in the arteries during the relaxation phase of the heart cycle.

- Holding your breath during exercise (**valsalva manoeuvre)** can increase blood pressure significantly.



- **Increased venous return.** During exercise the heart is ejecting large amounts of blood, which means blood needs to be returned quickly to the heart. Increased venous return allows blood to keep moving around the body so it can be refuelled with oxygen and delivered to the working muscles repetitively.

- Venous return is increased through: **muscle pump, respiratory pump,** and **vasoconstriction**.

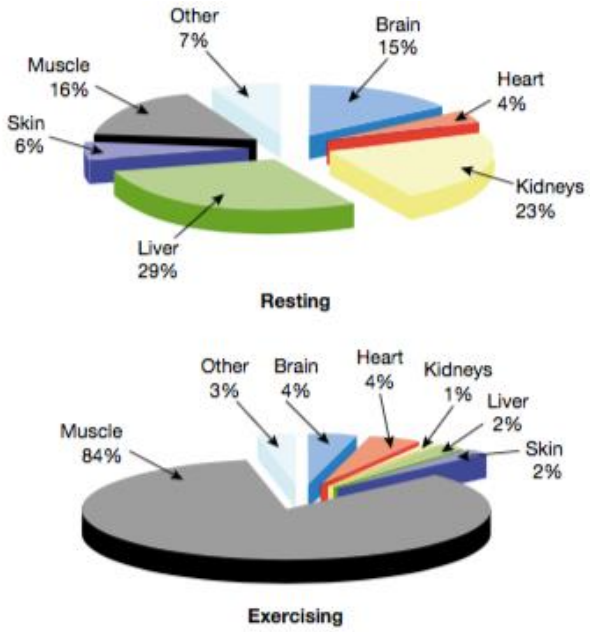
- During vasoconstriction, the veins constrict, forcing more blood back to the heart.

- In muscle pump, and when the muscles contract, the veins are squished together.

- In respiratory pump, when an individual breathes in, their diaphragm increases pressure in the abdominal area, forcing veins there to be emptied towards the heart. When they breathe out, the pressure is released and the veins fill with blood again.

- **Decreased blood volume.** This occurs due to lost plasma levels while sweating.

- **Increased redistribution of blood flow.** Extra blood is redistributed away from some of the vital organs to the working muscles, to give them extra oxygen.



- **Vasodilation** at the working muscles and **vasoconstriction** at the non-essential organs help with this process. This allows the muscles to work harder for longer.

- **Vasodilation** is when blood vessels increase in size, allowing for an increase in blood flow.

- **Vasoconstriction** is when blood vessels decrease in size, decreasing blood flow.

- **Increased arteriovenous oxygen difference (a-VO2 diff).** a-VO2 diff is the difference in oxygen concentration in the arteries compared with the veins. It is measured in millilitres per 100mL of blood.

- The working muscles extract greater amounts of oxygen from the blood. This means that less oxygen is remaining in the veins as the blood travels back to the heart. This means the difference between the oxygen concentration in the arteries compared to the veins becomes larger.

- This has a linear relationship with intensity.

- **Acute muscular responses to exercise**

- During exercise, there must be an increase in muscular contractions.

- **Increased blood flow to the muscles.** There is a redistribution of blood flow to the working muscles. This allows a greater delivery of oxygen to meet the metabolic demands of the exercise.

- **Increased motor unit and muscle fibre recruitment.** During exercise, the force required by the muscles increases. This increase is met by recruiting greater number of motor units, or increasing the frequency of motor unit recruitment. This allows for a greater muscular contraction to occur.

- A **motor unit** is the means by which the central nervous system controls the muscles.

- The number of motor units recruited depends on the **speed** and **force** of the contraction required.

- Smaller motor units will be recruited first, followed by larger motor units.

- A motor unit will contract maximally or not at all. This is the **all-or-nothing principle**.

- **Decreased energy substrates.** Energy stores (**ATP, PC, glycogen, triglycerides**) decrease as they are used to fuel the body.

- **Increased lactate.** Regardless of the type of exercise, there is always some lactate produced. If anaerobic exercise increases the body produces more lactate.

- If steady state has been reached during exercise, there is enough oxygen available to break down lactate, and the athlete will be working at or below their LIP.

- **Increased body/muscle temperature.** When we exercise our body heats up. Heat is a by-product from exercise.

- Our body tries to cool itself by **sweating** and **vasodilating capillaries at the skin.** This has a cooling effect as heat is exchanged with the environment.

- Increased muscle temperature also allows for increased enzyme activity.

- **Increased muscle enzyme activity.** Enzyme activity increases to produce the increased amounts of ATP required by the muscles.

- **Increased oxygen supply and use.** The muscle cells extract and use more oxygen from the blood during exercise because of the increased demand for ATP.

- **Increased arteriovenous oxygen difference (a-VO2 diff)**. The muscles extract more of the available oxygen from the blood during exercise.

KEY SKILLS

- Participate in a variety of physical activities and describe, using appropriate terminology, the interplay and relative contribution of the energy systems
- Perform, observe, analyse and report on laboratory exercises designed to explore the relationship between the energy systems during physical activity and recovery
- Explain the changes in oxygen demand and supply at rest, and during sub-maximal and maximal activity
- Participate in physical activities to collect and analyse data on the range of acute effects that physical activity has on the cardiovascular, respiratory and muscular systems of the body
- Explain the fatiguing factors associated with the use of the three energy systems under varying conditions.

OBSERVE, ANALYSE AND REPORT ON LABORATORY EXERCISES DESIGNED TO EXPLORE THE RELATIONSHIP BETWEEN THE ENERGY SYSTEMS DURING PHYSICAL ACTIVITY AND RECOVERY

This relates to explaining the fuels of energy systems, the characteristics of energy systems and how they are used in physical activity and recovery.

You must know the three systems very well. When are they used? Under what conditions? What fuels are used? What are the by-products? What is the limiting factor of each energy system?

You should be able to determine which energy system predominates in a given situation, and provide examples of sports or activities where each system is predominant. What are the approximate contributions to some activities?

You should also be able to read graphs to determine energy system contributions.

Common mistakes:

- No use of data
- Calling the ATP-PC system "ATP"
- ATP lasts for 10 seconds… PC does
- Calling the anaerobic glycolysis system "anaerobic"
- Not putting "accumulation" in front of metabolic by products when discussing fatigue

Describe what happens to the use of fats in the production of ATP as exercise intensity increases, and give a reason for this change in fuel (*2 Marks*)

As exercise intensity increases, the percentage of fats being used for ATP production decreases. High intensity exercises require ATP to be provided quickly, and fats cannot be broken down fast enough to provide this energy as they require a significant amount of oxygen.

1 mark for identifying that as intensity increases the use use of fats decreases
1 mark for explaining that fats take longer to break down and high intensity exercises need energy immediately

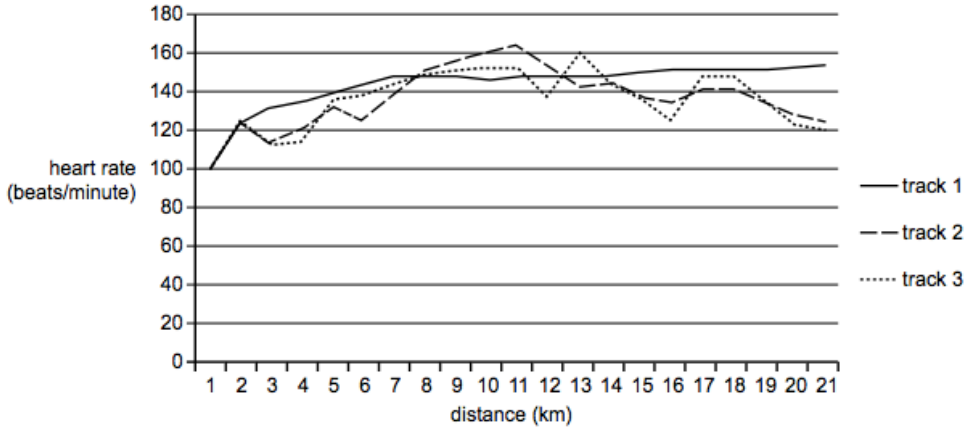
Glycogen is the preferred fuel for endurance activity, even though fats provide more ATP. Why? (*2 Marks*)

Glycogen has a lower oxygen cost and are broken down much faster than triglycerides, as there are less complex chemical reactions involved. Therefore glycogen produces energy at a faster rate, and allows the athlete to work at a higher intensity as they have more ATP being delivered to them readily.

1 mark for describing the oxygen cost and rate of ATP production for glycogen verses fats
1 mark for linking back to why we use glycogen over fats

VCAA Exam 2013

Alice is a 40-year-old female who enjoys recreational mountain biking. To adjust her training, she varies her choice of riding terrain. The graph below shows her heart rate responses for three different rides that she completed



a. **<u>Which food fuel would be used predominantly throughout each ride? (*1 mark*)</u>**

Carbohydrates

b. **<u>Support your answer to part a. using the data provided in the graph (*2 marks*)</u>**

All tracks go for 21km, and lasts for several minutes, indicating the aerobic glycolysis system will be the dominant contributor to energy production throughout the rides. Due to the intensity of the ride being sub-maximal (between 100-160bpm), carbohydrates would be the preferred fuel source due to producing a higher yield of ATP for less oxygen.

1 mark for justifying why carbohydrates would be predominant
1 mark for using data

c. **<u>How would the fuel usage of an elite mountain bike rider be different from that of Alice? (*2 marks*)</u>**

The elite cyclist could be able to glycogen spare, which means they use more fats at higher intensities, compared to Alice who would predominantly use her glycogen stores earlier.

2 marks for two points about glycogen sparing

Compare and contrast the use of the anaerobic glycolysis and the aerobic energy systems (*4 Marks*)

The anaerobic glycolysis system and aerobic energy system both work to produce ATP for energy in the body. They both involve the breakdown of glucose, but because the anaerobic glycolysis system doesn't have oxygen present in the glycolysis, pyruvic acid gets converted to lactic acid, which gets broken down into lactate and hydrogen ions, which causes fatigue. The anaerobic glycolysis system has a finite capacity, although ATP is produced at a fast rate. Whereas the aerobic energy system has sufficient oxygen present, so pyruvic acid can be broken down into CO2 and H2O, and can be used indefinitely and produce more ATP yields without any fatiguing by-products, although at a moderate rate.

1 mark for recognising they both produce ATP through glycolysis
1 mark for recognising the use of oxygen vs no oxygen
1 mark for comparing the by-products formed
1 mark for comparing the rate and yield of the systems

Why does the lactate inflection point occur? (*1 Mark*)

At or before LIP, lactate production and removal are balanced. After LIP, there is an increased contribution for the anaerobic glycolysis system, and lactate production exceeds lactate removal.

1 mark for outlining that the increased contribution from the anaerobic glycolysis system results in an imbalance in lactate production and removal

VCAA Exam 2012

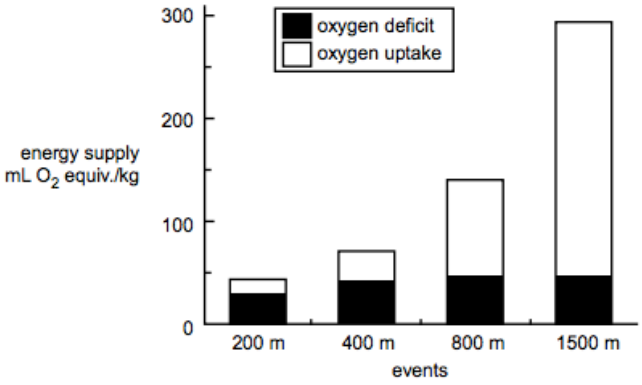
Training their anaerobic capacity would be beneficial to both a 3000m pursuit cyclist and 500m time trialist. Explain why this is the case (*3 Marks*)

The 500m race is predominantly anaerobic, which requires a high tolerance to lactate to sustain speed gained from the anaerobic glycolysis system working, and the 3000m cyclist would benefit by being able to run at a faster pace, especially at the beginning and end of the race when they aren't in steady state. By training their anaerobic capacities, they are able to work at higher intensities above VO2 max where there is a great reliance on the anaerobic systems to produce energy. This can allow both cyclists to have a faster speed, as the anaerobic systems have a faster rate of ATP production.

1 mark for outlining how they can work above VO2 max
1 mark for explaining how these provides faster speed
1 mark for linking to the two events

VCAA Exam 2015

The graph below shows the energy system contribution in track athletes during simulated running



Source: P Gastin and P Le Rossignol, 'Energy systems: Re-evaluating high intensity energy contributions', in 'Update of content: Energy systems', VCE Physical Education, February 2001, Board of Studies (Vic), p. 5

a. **Explain why the contribution from the aerobic energy system increases as the race distance changes from 400 m to 1500 m (*2 Marks*)**

The anaerobic energy systems have a finite capacity and can only fuel short-duration energy. So the additional energy required to complete the 1500m compared to the 400m must come from the aerobic system

1 mark for explaining the anaerobic systems have finite capacity
1 mark for linking to the two events

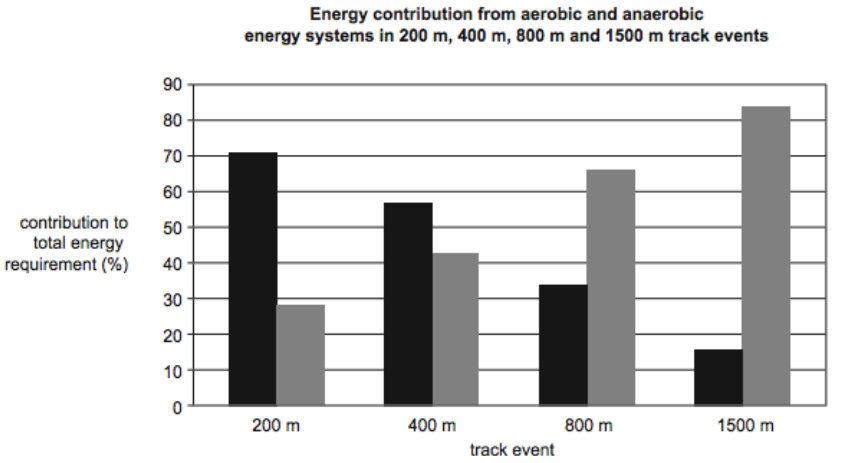
b. **The rate of ATP production is greater in the anaerobic energy systems. Explain how the rate of ATP production influences the average speed for both the 400 m and 1500 m events. (*2 marks*)**

The anaerobic energy systems are the dominant supplier of ATP for energy for the 400m events, whereas the 1500m event has the aerobic system the dominant supplier. Because the anaerobic energy system produces ATP at a faster rate than the aerobic system, the average speed of the 400m events is faster than the 1500m events.

1 mark for explaining why the anaerobic systems generate greater speed
1 mark for linking to the two events

VCAA Exam 2014

The graph below shows the contribution of the anaerobic and aerobic energy systems to the total energy requirements for four different track events: 200 m, 400 m, 800 m and 1500 m.



Source of data: MR Spencer and PB Gastin, 'Energy system contribution during 200- to 1500-m running in highly trained athletes', in *Medicine & Science in Sports & Exercise*, 33(1), 2001, pp. 157–162

a. **Which column – black or grey – represents the contribution from the anaerobic systems? (*1 mark*)**

Black

b. **With reference to the data, justify your answer above (*3 marks*)**

The anaerobic systems are the dominant supplier of energy for high-intensity, short-duration events such as the 200m and 400m events. ATP demand is high, and the anaerobic systems provide energy at a fast rate. The 200m sprint and 400m sprint predominantly have energy coming from the black columns (70% and 55% respectively). As duration increases the contribution from the anaerobic systems decrease, as they have a finite capacity and create fatigue causing by-products, meaning events of longer duration cannot sustain these systems being dominant. This can be seen as for the 800m and 1500m events, anaerobic work does not exceed 35% of total energy contribution.

1 mark for using data
2 marks for explaining what relates to the anaerobic systems to make them the black column

c. **<u>What is the role of the anaerobic systems in the 1500m event? In your response, refers to the data provided (*4 marks*)</u>**

The anaerobic systems contribute a small percentage of the total energy requirements of the 1500m event (only 15%). Since the aerobic system takes a while to respond to the increased demand for ATP and oxygen, the anaerobic system is the dominant provider of ATP during this period of oxygen deficit, until the energy demands of the race can be met aerobically. The anaerobic systems also increase their contribution during any surges in the race, such as the final sprint to the finish line, where the runner must increase their intensity.

1 mark for using data
2 marks for explaining the role of the anaerobic system
1 mark for linking to the 1500m event

VCAA Exam 2014

The men's track cycling team pursuit event is competed over a distance of 4 km by a team of four riders. Riders in a team follow each other closely and, periodically, the lead rider (who works the hardest) moves up the bank of the track and rejoins the team at the rear.
Since the winning team is decided by the third rider across the line, it is common for one rider to take a 'death pull', where he rides so hard that he cannot maintain the group pace afterwards. This allows his teammates to briefly recover behind him before they make a final three-man acceleration towards the finish line. The world record for this event is 3:53.31 minutes.

<u>Explain why a rider would be working above their LIP when riding at the front of the team (*2 marks*)</u>

In order for a rider to ride out at the front, they would have to be working at higher intensities, which results in an increased contribution from the anaerobic glycolysis system. This is associated with a greater accumulation of lactate, and consequently working above LIP.

2 marks for explaining how increasing speed makes the rider work above LIP

EXPLAIN THE FATIGUING FACTORS ASSOCIATED WITH THE USE OF THE THREE ENERGY SYSTEMS UNDER VARYING CONDITIONS

Explain how physiologically an accumulation of metabolic by-products contributes to fatigue (*3 Marks*)

Once LIP occurs, lactate accumulates and this is associated with hydrogen ions accumulating. H+ ions increase muscle acidity and slow down enzyme activity in the muscles, which decreases muscle function and the breakdown of glycogen. This would decrease the rate of ATP production, which will cause the athlete to perform exercise at a slower intensity.

1 mark for identifying the accumulation of hydrogen ions
1 mark for explaining how hydrogen ions affect muscle function
1 mark for explaining how this affects the athletes intensity

Explain the consequences of glycogen depletion to ATP production (*3 Marks*)

When glycogen is depleted after about 2 hours, there is an increased reliance on triglycerides to produce ATP for energy. Because there are more complex chemical reactions and fats require more oxygen to be broken down, they produce ATP at a slower rate, there is a decrease in the intensity of the athlete, which causes fatigue.

1 mark for outlining there's an increased reliance on fats
1 mark for explaining how ATP is produced at a slower rate
1 mark for explaining the consequences is that the athlete must decrease intensity

a. **Explain a major cause of fatigue for: (*6 marks)***

I. ATP-PC system:

Depletion of PC stores after around 10 seconds of explosive movements require an increased contribution from the anaerobic glycolysis system to supply energy, which produces ATP at a slower rate than the ATP-PC system and causes an athlete to decrease their intensity.

II. Anaerobic glycolysis system

An accumulation of metabolic by-products of H+ ions and Pi increase muscle acidity, which slows down enzyme activity in the muscles. This slows down muscle function and the breakdown of glucose, which means ATP gets produced at a slower rate and the athlete fatigues.

III. Aerobic system

Thermoregulation and elevated body temperature causes vasodilation at the skin and vasoconstriction at the working muscles, and a redistribution of blood flow from the working muscles to the skin, which means less oxygen gets transported to the working muscles and the muscles fatigue

b. **<u>Explain an appropriate recovery method for each of the fatigue mechanisms recognised in part a. (*6 marks*)</u>**

IV. A passive recovery where you sit or lie down allows PC to be replenished. 70% of PC gets replenished in 30 seconds of passive recovery and 98% in 3 minutes

V. An active recovery, where you continue to perform the activity, but at a reduced intensity, promotes blood flow and allows oxygen to break down fatiguing by-products.

VI. Elevated body temperature can cause dehydration from sweating. To recover, an athlete should hydrate and increase their fluid consumption, to restore blood plasma levels that have been lost. Cold showers and ice baths can also have a cooling effect on the body

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DESCRIBE, USING APPROPRIATE TERMINOLOGY, THE INTERPLAY AND RELATIVE CONTRIBUTION OF THE ENERGY SYSTEMS

The aerobic system will be dominant during EPOC, recovery and steady state.

If a system isn't dominant during a passage of play, still mention it by saying it contributes to energy, it just wasn't dominant.

Examiners generally are not looking for specific pieces of information, but instead the answer as a whole. (Eg. high quality answers = full marks)

- Avoid using numbers such as "the anaerobic system will be dominant for the next 30 seconds"
- However, it is important to make specific reference to the stimulus material if given (there usually is a stimulus)

When you are asked to explain why one event takes less time to complete or why it is performed at faster speeds compared to another event you must:

- Refer to interplay if it's an interplay question
- Identify the event's predominant energy system
- Discuss how the predominant energy systems are different to each event and therefore the athlete's speed/performance will be slower/faster
- Refer to the rate of ATP production
- Use data

For a continuous activity:

- 1 mark for "**all there energy systems work together….**"
- 1 mark for explaining how at the beginning of the event, there will be a period of **oxygen deficit**, and the **anaerobic systems will be predominantly providing ATP** where there is insufficient time for the cardio-respiratory systems to respond and meet the oxygen demands from the working muscles
- 1 mark for providing specific examples of when the **PC system will be dominant** by making reference to the **intensity and duration** of those examples. Explain why this energy system will be no longer dominant after maximal exercise
- 1 mark for providing specific examples of when the **anaerobic glycolysis system** will be dominant (eg. during o2 deficit), or when there will be increased contributions from this system, by making reference to the **intensity and duration** for those examples. Explain why this system cannot be sustained for long periods
- 1 mark for providing examples of when the **aerobic system** will be dominant by making reference to s**teady state, intensity and duration** of those examples. Explain how this system helps to r**emove metabolic by-products and replenish PC stores** (check for rest periods)
- 1 mark for concluding by identifying the **overall predominant energy system** for the sport or activity

Step 1

- Introduction- "**All three energy systems work together to produce ATP during the entire sport/event, however one energy system will be more dominant.**"

Step 2

- Provide specific examples of when the **PC system** will be dominant by making reference to the **intensity, duration, demand** and **rate** for ATP of those examples. Explain why this energy system will no longer be dominant after 5 seconds of maximal exercise. **(1mark)**

Step 3

- Start by saying that the **Anaerobic Glycolysis** system will be dominant when PC stores are depleted. **(1/2 mark)**
- Provide specific examples of when the **Anaerobic Glycolysis** system will be dominant by making reference to **intensity, duration** and the **demand** for ATP of those examples. **(1mark)**

Step 4

- Provide examples of when the **Aerobic system** will be dominant by making reference to **intensity** and the **demand** for ATP of those examples. **(1mark)**
- Explain how this energy system helps to remove metabolic by products and replenish PC stores (**Check for rest periods**). **(1mark)**

Step 5

- Conclude by identifying the overall predominant energy system for the sport or phase of play mentioned. **(1mark)**

Discuss energy system interplay (*1 Mark*)

All three energy systems contribute to ATP production at any given time, but their relevant contribution is determined by the intensity and duration of the activity

Discuss the energy system interplay in a basketball game (*6 Marks*)

All three energy systems contribute to energy production in a game of basketball. Their relevant contribution is determined by the duration and intensity of the activity. In basketball, explosive, maximal intensity movements such as shooting and jumping or blocking and rebounding will require the ATP-PC system to be the dominant contributor to energy production, as it produces ATP at the fastest rate to quickly meet the energy demands of the movements. However PC depletes after around 10 seconds, and high intensity movements will then require an increased contribution from the anaerobic glycolysis system. The anaerobic glycolysis system will become dominant when a basketball needs to work at a high intensity for any movement between 10-60 seconds, such as running up and back a court to defend. However metabolic by-products oh H+ ions and Pi will accumulate and cause fatigue. The aerobic system will be the dominant contributor to ATP when a play lasts for several minutes in any steady state. Because a basketball game lasts for four 12-minute quarters, the aerobic system will overall be the dominant energy system.

VCAA Exam 2015

The following is an account of 2 minutes 30 seconds of play in an Australian Football League (AFL) game.

'From his position as full forward, Zach sprinted 20 m from the top of the goal square, leading out to receive the ball. Zach leapt powerfully into the air to mark the ball successfully before landing on his feet. He walked back from the player on the mark. He placed the ball on the ground, pulled up his socks and checked the direction of the breeze before picking up the ball, beginning his run up and kicking the ball towards goal. Having only scored a point, Zach jogged back to pick up his opponent and waited for the ball to be kicked back into play.'

Using specific examples from this account, explain how the energy systems interplay to provide the energy required for Zach to complete this passage of play. (*6 Marks*)

All three energy systems work together to produce ATP during this period of the AFL game, however at any given time one system will be more dominant. When Zach first sprinted 20m from the top of the goal square and leapt powerfully into the air, his ATP-PC system would be dominant, as it provides the fastest rate of ATP to meet the high energy demands for these short-duration, explosive, maximal intensity movements. However the ATP-PC system has a finite capacity, and once PC depletes, the anaerobic glycolysis system would increase it's contribution, although in this passage of play, there are no repeated efforts where the anaerobic glycolysis system is dominant. Zach's aerobic system becomes the predominant pathway for ATP production during rest, steady state or low-intensity periods, such as when he walks back from the player on the mark. Here the aerobic system allow Zach's PC stores to be replenished and ready to be used again in another explosive movement, such as kicking towards the goal. Overall in this passage of play, Zach's aerobic system was dominant, as majority of the time he was involved in sub-maximal intensity movements, and the duration of this play is 2 minutes and 30 seconds.

VCAA Exam 2011

The world record for the 100-metre swim is 46.91seconds compared to the 400-metre record of 3:40.07 minutes. It takes the 400-metre swimmer approximately 51 seconds to complete each 100-metre split.

Explain why this occurs by discussing energy system interplay and by making reference to the data provided. (*4 Marks*)

All three energy systems work together to produce ATP during both swimming events, however one system would be more dominant. Although the ATP-CP and aerobic systems contribute, the predominant energy system for the 100-metre swim is anaerobic glycolysis as it takes 46.91 seconds compared to the 400-metre swim, which takes 3.40 minutes, meaning that the predominant energy system for this event is the aerobic system. The aerobic system produces ATP at a slower rate than anaerobic glycolysis and therefore the times for each 100-metre split will be slower.

The world record times for running the 100-m and 400-m sprints are shown below.

100 m – 09.58 seconds
400 m – 43.18 seconds

Explain why a 400-m race cannot be run at the same pace as a 100-m race. In your answer, make reference to energy system interplay (*3 Marks*)

All three energy systems work together to produce ATP in both track events, however the 100m sprint will predominantly be anaerobic work, with the ATP-PC system being dominant. The 400m is longer than the 100m and therefore has a greater contribution from the anaerobic glycolysis system and aerobic system to provide energy. These systems cannot provide ATP at as fats as rate as the ATP-PC system, so the pace for the 400m must decrease.

1 mark for referencing interplay
1 mark for contrasting the anaerobic system's rate of ATP
1 mark for linking to the 100m and 400m races

Explain how the energy systems interplay to provide energy required to complete a 20 minute swimming session (*6 Marks*)

All three energy systems work together to produce energy during the swimming session, however at any given time, one system will be more dominant. During the initial period of oxygen deficit and at the start of the swim the anaerobic systems will be predominantly be providing ATP, where there is insufficient time for the cardio-respiratory systems to meet the oxygen demands of the working muscles. When the swimmer first dives in the water, the ATP-PC system will be the dominant provider of ATP, as it provides ATP at the fastest rate to meet the immediate high energy demands of the swimmer. However, the ATP-PC system has a finite capacity, and once PC is depleted, the anaerobic glycolysis system will increase its contribution and become dominant. The anaerobic glycolysis system will remain dominant as it supplies a fast rate of energy, until the swimmer reaches a steady state and there is enough oxygen present for the aerobic system to be the predominant provider of energy. The aerobic system would remain dominant for the majority of the duration of the swim, as it produces the largest yield of ATP that can be used to sustain the duration of the 20 minute swim. Dominance of the aerobic system can break down fatigue causing metabolic by-products H+ and Pi, that are accumulated during periods where the anaerobic glycolysis system is dominant. This allows for the anaerobic glycolysis system to be ready to be used again when ATP needs to be provided at a faster rate, during periods where intensity needs to be increased, such as when the swimmer tumble turns at the end of the lap. As the swim lasts for 20 minutes, the aerobic system will overall be the dominant contributor to energy production.

EXPLAIN THE CHANGES IN OXYGEN DEMAND AND SUPPLY AT REST, AND DURING SUB-MAXIMAL AND MAXIMAL ACTIVITY

- At rest, oxygen uptake is low as the body's need for ATP is relatively small
- During exercise, the demand for ATP increases, however the cardiorespiratory systems cannot meet the oxygen demand of the task immediately. This causes an oxygen deficit, and ATP will be resynthesised using the anaerobic pathways
- The relationship between exercise intensity and oxygen uptake is linear
- After the cessation of exercise, oxygen remains temporarily elevated (EPOC)
- EPOC replenishes PC

- Are you able to draw and label an oxygen uptake graph?
- Do you know the definitions of oxygen deficit, steady state, and EPOC?
- Do you know what energy system is dominant during each period of oxygen uptake?

Provide an explanation for how oxygen deficit during the onset of exercise causes an increase in heart rate (*2 Marks*)

When exercise commences, there is an increased demand for oxygen by the working muscles. It takes time for the heart and lungs to adjust to the increased demand for oxygen, and energy is provided by the anaerobic systems during this time of oxygen deficit, where oxygen supply doesn't meet oxygen demand. As a result heart rate rapidly increases and the cardiorespiratory mechanisms adjust until a steady state is reached, and oxygen supply equals oxygen demand, then heart rate plateaus.

1 mark for how oxygen deficit works
1 mark for how this can increase heart rate

VCAA Exam 2012

How will the EPOC of a runner be affected by him running at maximal intensity for the last 500m of his run instead of maintaining a steady state until the end of his run (*2 Marks*)

EPOC will increase and it will take longer to return to resting levels if the athlete sprints the final 500m, due to the increased contribution from the anaerobic systems. EPOC is directly influenced by periods of work where the athlete is in oxygen deficit. If the athlete maintains a steady state for the last 500m, EPOC will be reduced.

VCAA Exam 2015

Explain the changes in oxygen uptake from rest, during sub-maximal exercise in recovery, and how this has an impact on ATP production (*4 Marks*)

At rest the body can easily take in oxygen, as demands for ATP are low. Oxygen uptake increases from rest to sub-maximal exercise, as there is an increased demand for oxygen as demands for ATP increase. However it takes time for the cardiorespiratory mechanisms to kick in and meet the oxygen demand, and as a result the athlete will experience oxygen deficit. Here ATP will be produced predominantly anaerobically. Oxygen uptake will continue to increase until the body reaches a steady state. This allows ATP to be produced aerobically, and oxygen uptake will plateau. During recovery, the demand for ATP decreases, and oxygen uptake will decrease from that of sub-maximal exercise, but will still remain higher than oxygen uptake during resting conditions, as the athlete experiences oxygen debt. This allows the body to return to a pre-exercise state.

1 mark for explaining resting conditions
1 mark for explaining what happens when exercise commences and outlining oxygen deficit
1 mark for outlining steady state
1 mark for explaining what happens during recovery

Provide an explanation for a 1km swimmer to have periods of oxygen deficit, steady state and oxygen debt (*3 Marks*)

During periods of oxygen deficit, oxygen supply doesn't equal oxygen demand. It takes several minutes for the cardiorespiratory mechanisms to work to increase oxygen supply, until then the athlete is working anaerobically. Once oxygen supply equals oxygen demand, ventilation plateaus and the swimmer reaches a steady state, where they are working aerobically. The swimmer will remain in a steady state for the duration of the swim, until they begin recovery and reduce their intensity. During this time period, they will experience oxygen debt, where the demand for ATP is reduced, however the amount of oxygen required is still greater than that required at rest, as the swimmer must return to a pre-exercise state.

3 marks for correctly explaining each period, including energy system dominance

Describe what is occurring in the body in relation to ventilation and oxygen that allows for a steady state to occur (*2 Marks*)

During exercise, we breathe more often and more deeply to result in an increase in ventilation, resulting in an increase in oxygen in the lungs, which allows more oxygen to be supplied to the working muscles. During sub-maximal exercise, the increased oxygen supply is enough to meet he oxygen demands, allowing the athlete to work aerobically and a steady state occurs, resulting in a plateau in ventilation.

1 mark for explaining oxygen supply equals oxygen demand
1 mark for identifying aerobic system dominance

Analyse data on the range of acute effects that physical activity has on the cardiovascular, respiratory and muscular systems of the body

- Be familiar with, and able to explain the graph and tables of the cardiorespiratory acute responses to exercise
- Understand the key equations, including the relationship between stroke volume, heart rate and cardiac output, respiratory rate, tidal volume and ventilation, and cardiac output and oxygen uptake
- Be able to explain what the benefit of these acute responses are to the athlete
- Recognise that there is a difference in ventilation and energy substrate levels between maximal and sub-maximal exercise
- Compare a trained and untrained athletes heart; a trained athlete has a greater cardiac output at maximal intensities

Explain the relationship between ventilation and maximal exercise and sub-maximal exercise. (*2 marks*)

During the onset of exercise, ventilation increases rapidly to account for the increased oxygen demands in the body. During sub-maximal exercise, ventilation will increase until it plateaus at around 3-4 minutes, where the athlete has reached a steady state. During maximal exercise, ventilation will continue to increase until exercise stops.

1 mark for explaining ventilation at maximal exercise
1 mark for explaining ventilation at sub maximal exercise

Briefly outline what happens to blood pressure when we start to exercise. (*2 marks*)
Blood pressure increases, as an increase in cardiac output increases the force of the blood against the artery walls as it is pumped out of the heart. Systolic blood pressure is the only blood pressure that increases during aerobic exercise though.

What energy substrates are stored in muscles? What happens to the amount of these when we start to exercise? What is the end result of this? (*3 marks*)

ATP and PC are stored in limited quantities in the muscle, as well as glycogen and triglycerides. When we begin to exercise, there is an increased demand for fuels and energy, and as a result ATP, PC, glycogen and triglycerides decrease. This allows for more energy to be used by the working muscles.

1 mark for stating what energy substrates are in the muscles
1 mark for explaining what happens to them during exercise
1 mark for explaining the result

Redistribution of blood flow is an acute response to exercise. This is an important mechanism in the thermoregulation of the body. Explain how blood flow to the skin assists in regulating the body's temperature during sub-maximal exercise (*3 Marks*)

Since body temperature increases during sub-maximal exercise, as heat is produced as a by-product of aerobic energy production, the body must thermoregulate and cool down. Increased redistribution of blood flow to the skin, including vasodilation of capillaries at the skin, and vasoconstriction of capillaries at the inactive muscles and non-essential organs (kidneys, spleen), has a cooling effect where waste products and heat can be exchanged with the environment, and the body can cool down.

1 mark for explaining heat is produced during exercise
1 mark for explaining vasodilation of vessels at the skin allows for increased blood flow to the skin
1 mark for explaining how this can help cool the body

Outline two reasons for an increase in heart rate from resting levels prior to exercising commencing (*2 Marks*)

- Anticipatory response to prepare the body for exercise
- Warm-up to prepare the body for exercise

Describe the relationship between cardiac output and oxygen uptake, and the role of the stroke volume and heart rate when moving from a resting state to exercise (*3 Marks*)

There is a linear relationship between cardiac output and oxygen uptake; as cardiac output increases so does oxygen uptake, and vice versa. Stroke volume and heart rate both increase when moving from rest to exercise, as there is an increased demand for oxygen by the working muscles. As a result, cardiac output increases, and so does oxygen uptake, when moving from a state of rest to exercise.

1 mark for explaining the relationship between cardiac output and oxygen uptake
1 mark for explaining how stroke volume and heart rate impact cardiac output
1 mark for explaining what happens when moving from a resting state to exercise

Contrast the energy substrate levels of a 100m sprinter and a 10k runner at the end of their respective event (*4 Marks*)

As the ATP-PC system is the dominant energy system for the 100m sprint, the sprinter is going to have a decrease in their ATP and PC stores by the end of the event. Whereas since the 10k run is predominantly aerobic, the runner is more likely to have a decrease in their glycogen and triglyceride stores.

2 marks for identifying substrate levels decrease for both athletes
1 mark for identifying the ATP and PC stores of the sprinter will decrease
1 mark for identifying the glycogen and fats stores of the runner will decrease

How do the changes in a-VO2 diff from rest to exercise enhance an athlete's ability to exercise? (*3 Marks*)

a-VO2 diff increases during exercise, as there is an increased demand for oxygen by the working muscles. When a-VO2 diff increases, more oxygen is being extracted from the capillaries by the working muscles, resulting in an increased difference between oxygen concentration in the arteries compared to the veins. This allows the working muscles to have more oxygen available to work aerobically, enhancing performance.

1 mark for identifying a-VO2 diff increases from rest to exercise
1 mark for explaining more oxygen can be extracted
1 mark for explaining how the athlete can work aerobically

How does the process of diffusion enhance the ability of the body to exercise? (*2 Marks*)

Increased pulmonary diffusion means more oxygen is being inhaled in to the lungs, which diffuses into the bloodstream and then working muscles, allowing them to have more oxygen available to work aerobically harder for longer. Diffusion also means carbon dioxide can be exchanged with oxygen and transported from the working muscles into the bloodstream and then lungs, and exhaled into the environment.

1 mark to explain what increased diffusion means, in relation to carbon dioxide and oxygen
1 mark to explain the effects this will have on the body, and how more oxygen can go to the working muscles

Briefly explain the effect of a trained individual having a larger left ventricle and a higher stroke volume at rest than an untrained individual and how it effects resting heart rates, when considering similar cardiac output (*2 Marks*)

Because the trained athlete has a higher stroke volume at rest, their heart does not have to beat as often to eject the same amount of blood in a minute and have the same cardiac output as an untrained individual. As a result, the trained athlete would have a lower resting heart rate than the untrained athlete.

1 mark for explaining the effect of a higher stroke volume
1 mark for linking this back to resting heart rate

Outline the advantage of having a higher stroke volume for the trained athlete (*2 Marks*)

The trained athlete's has a more efficient heart, which does not have to work as hard and beat as often compared to the untrained athlete. This means at maximal intensity exercise where the athlete reaches maximum heart rate, the trained athlete can produce a greater cardiac output and the muscles can receive more oxygen than the untrained athlete.

1 mark for explaining the heart of the trained is more efficient
1 mark for explaining at MHR, the trained athlete will have higher cardiac output and more oxygen being supplied to the working muscles

Outline the interplay between the body systems that allow an increase in oxygen uptake to occur (*4 Marks*)

There is an increased demand for oxygen during exercise, so oxygen uptake must increase. The respiratory system works to increase the amount of oxygen being taken in through the body via lungs, by increasing respiratory rate, tidal volume, and ventilation, as well as increasing diffusion so more oxygen can be exchanged into the blood. The cardiovascular system works to increase the amount of oxygen being supplied to the working muscles, by increasing heart rate, stroke volume, and cardiac output, as well as a redistribution of blood flow to the working muscles. The muscular system works to increase the use of oxygen at the working muscles to create energy, by increasing a-VO2 diff and oxygen supply and use, so more oxygen is extracted from the blood by the working muscles. Since oxygen uptake is the amount of oxygen being taken in, transported to and used by the working muscles, the three systems work to increase oxygen uptake during exercise.

3 marks for explaining each systems contribution
1 mark for explaining what oxygen uptake is

Outline how two acute muscular response to exercises would assist a 100m sprinter (*4 Marks*)

- During exercise, there is an increase in motor unit recruitment at the working muscles. This allows for more muscle fibres to contract maximally, and the 100m sprinter can produce a greater force and have a stronger take off from the starting blocks.

- During exercise, there is an increase in muscle enzyme activity. This allows for a faster rate of ATP breakdown for energy, which can allow the sprinter to sprint faster.

4 marks for describing two acute responses and linking it to a 100m sprint