GCE PHYSICAL EDUCATION

PE2 UNIT GUIDE

Content Title: Nutrition

Key points

- Nutrition for Health
- Nutrition to develop sporting performance
- Hydration before, during and after exercise

Nutrition for Health

A Balanced Diet

You must have carbohydrate, protein, fat, vitamins, minerals and fibre in the correct proportions within your diet (see tables below). If there is not enough protein, you will not be able to grow properly and you will not be able to repair yourself i.e. muscle repair after intense exercise. If you do not have enough energy containing foods (carbohydrate and fats) you will feel very tired and lethargic and there will be a severe drop in performance in any sport or exercise related activity. However, if you have too much energy containing foods you will become overweight, which can lead to **obesity**. Recommended daily allowances (RDAs) are:

- Carbohydrate 50-65%
- Fats 20-30%
- Proteins 10-20%

The main functions of these nutrients

Carefully planned nutrition must provide an energy balance and a nutrient balance.

The nutrients are:

- **Carbohydrates** - our main source of energy
- **Fats** - one source of energy and important in relation to fat soluble vitamins
- **Proteins** - essential to growth and repair of muscle and other body tissues
- **Vitamins** - water and fat soluble vitamins play important roles in many chemical processes in the body e.g. Vitamin A - maintenance of skin, mucous membranes, bones, teeth, hair and vision
- **Minerals** - those inorganic elements occurring in the body and which are critical to its normal functions e.g. calcium - Needed for bone and tooth formation; heart function and blood coagulation; muscle contraction.

- *For full details of specific vitamin and minerals and the foods that contain them see* www.liferesearchuniversal.com/minerals.html
- **Water** - essential to normal body function, 60% of the human body is water - as is used as a vehicle for carrying other nutrients e.g. glucose in the blood and is also used to control body temperature by carrying heat to the skin surface before being released as sweat.
- **Fibre** - the fibrous indigestible portion of our diet essential to health of the digestive system

Energy Balance

It is important that an individual has a neutral **energy balance**. This means that the amount of calories consumed, is equal to the amount burned throughout the day. If an individual consumes more calories than the burn then they will have a **positive energy balance** resulting in weight gain. Conversely if an individual burn more calories than they consume they will have a **negative energy balance** and will lose weight.

Carbohydrates

Carbohydrates are the most important **source of energy**. They contain the elements carbon, hydrogen and oxygen. The first part of the name "carbo-" means that they contain carbon. The second part of the name "-hydr-" means that they contain hydrogen. The third part of the name "-ate-" means that they contain oxygen.

We obtain most of our carbohydrate in the form of **complex carbohydrates** also known as **starch or polysaccharides**. This is found in fruit, vegetables, potato, rice, pasta, bread and cereals. Our digestive system turns all this carbohydrate into another carbohydrate called **glucose**. Glucose is carried around the body in the blood and is used by our tissues as a source of energy. Glucose is also stored in our muscles and liver in the form of glycogen. We also get some of our carbohydrate in the form of **simple carbohydrates** also known as **sugars or monosaccharides (single molecule structures);** e.g. glucose and fructose; there are also **disaccharides (double molecule structures)** such as sucrose (1 molecule of fructose and 1 molecule of glucose) and lactose. When we use glucose to produce energy we need oxygen. It takes approximately 15% less oxygen to break down a glucose molecule than it does a fat molecule. Hence this is the preferred food of sportsmen and women. Sugars are broken down at a faster rate than starches hence provide almost instant energy (see glycaemic index). This can be a problem because if the body does not use this immediate energy then it becomes stored as fat. Also diabetes is linked to high sugar consumption. Starches contain higher levels of energy and they often release this energy over a longer period of time. The **Glycaemic Index** of Foods shows the rate at which certain foods release energy into the bloodstream.

The Glycaemic Index

The glycaemic index is the rate at which carbohydrate releases energy (glucose) into the bloodstream. Carbohydrates vary greatly with regard to how quickly they increase blood sugar levels. Some types of carbohydrate release energy quickly and increase blood glucose levels very quickly (‘high GI’ foods) while others release glucose at a slower rate, (‘low GI’ foods). To make this easy to understand carbohydrates have been ranked on a scale of 1 to 100. Glucose has a ranking of 100 on this scale and is used as a reference against which the other foods are placed. Generally foods are categorised into low, medium and high GI foods e.g.

- High GI is between 70-100
- Medium GI is between 55-69
- Low GI is less than 55

It is important to understand that not all high GI foods are bad e.g. a baked potato is considered in the high category but is healthy, also milk chocolate is considered medium to low GI but because of the high fat content this is unhealthy. It is important to get a balance of the GI foods in your diet to provide both immediate and long term energy. Too much of any food will result in a positive energy balance and subsequent weight gain if sufficient exercise is not carried out.

The Glycaemic Index for health and weight loss

In general high GI carbohydrate should be avoided when attempting to lose weight because they release energy/glucose quickly into the bloodstream. If this energy is not used then it gets stored as fat in the adipose tissue. DIABETES can occur with continued consumption of High GI foods, when high GI foods are consumed it causes the pancreas to secrete INSULIN also known as an Insulin Spike, to control the blood sugar levels, the more high GI food consumed the greater the amount of insulin secreted. If such a diet continues over a period of time then the body can become more and more tolerant of the insulin. This tolerance to the insulin is Diabetes. Low GI foods are the opposite of high GI because they release energy at a far slower more gradual rate which makes it far easier for the body to use/burn the energy. Low GI carbohydrate also leaves the individual less hungry after a period of time thus reducing the likelihood of consuming more food. They also do not cause the same spike/secretion in insulin as high GI foods.

The Glycaemic Index of some Common Foods

High GI Food	GI	Medium GI Food	GI	Low GI Food	GI
White Bread	70	Boiled Potatoes	56	Apples	38
Swede	72	Honey	58	Pears	38
Cheerios	74	Raisins	64	Noodles	40
Jelly Beans	80	Couscous	65	Spaghetti	41
Corn Flakes	84	Pineapple	67	Carrots	47
Jacket Potato	85	Shredded Wheat	67	Baked Beans	48
Puffed Wheat	89	*Ryvita*	69	Kiwi Fruit	52
Parsnips	97	*Weetabix*	69	Banana	55
White rice	98	Wholemeal Bread	69	Sweet corn	55

Fats

Like carbohydrates, fats contain the elements carbon, hydrogen and oxygen. Fats are used as a source of energy and they are also stored beneath the skin as adipose tissue helping to insulate us against the cold. Fats are very energy rich and if consumed in high amounts will lead to a positive energy balance and weight gain. Likewise if you also eat too much carbohydrate and it is not burned then it will be converted and stored as fats resulting in further weight gain. You must balance the amount of energy rich foods with the amount of energy that you use when you carry out exercise. However it is important to have fat in your diet because it is not only an essential element of energy production for our daily lives but also you must have some fat in your diet because it transports essential **fat soluble vitamins A, D, E and K** around the body.

Fat facts

- Fat transports the fat-soluble vitamins A, D, E and K around the body
- It can often improve the flavour and perception of foods, increasing their palatability
- It supplies essential nutrients such as fat-soluble vitamins and **Essential Fatty Acids (EFAs)**
- EFAs must be supplied from the diet, and are thought to have a positive effect on heart health and the immune system.
- It has a key role in membrane structure.
- It cushions, and so protects, the internal organs.
- It's stored in adipose tissue (a thick layer of tissue under the skin). The greater the adipose tissue the higher an individual's % body fat resulting in eventual obesity.
- Excess fat may also accumulate around your organs, especially in the abdominal cavity.
- Many saturated fats and trans fats contain cholesterol which forms fibrous plaques in our capillaries, arterioles and arteries leading to an atheroma (see lifestyle choices – obesity and other associated diseases).

Fat is a concentrated source of energy. Just 1g provides nine calories - more than double the calories in 1g of protein or carbohydrate.

This means it's much easier to consume too many calories when eating high-fat foods. People trying to manage their weight should reduce fatty foods to help cut calories. We all need some fat in our diets, but only small quantities of EFAs are the key to good health.

THE TWO TYPES OF FAT OF NATURALLY OCCURRING FATS

Fat can be divided into two main groups - saturated and unsaturated.

Saturated fat

This is generally solid at room temperature and is usually from animal sources. It's found in lard, butter, hard margarine, cheese, whole milk and anything that contains these ingredients, such as

cakes, chocolate, biscuits, pies and pastries. It's also the white fat you can see on red meat and underneath poultry skin.

How much saturated fat you eat is associated with **increased blood cholesterol (Low Density Lipoprotein - LDLs)** concentrations and an increased risk of heart disease. Eating less saturated fat helps to minimise the risks it poses to heart health.

Unsaturated fat is usually liquid at room temperature and generally comes from vegetable sources. Monounsaturated and polyunsaturated fats are both included in this group.

Unsaturated Fats

These are found in vegetable oils and are a healthier alternative to saturated fat and can be found in sunflower, soya and olive oil, soft margarine (*Flora*) and in foods such as oily fish, including mackerel, sardines, pilchards and salmon. Where possible, you should ensure the fat you eat is unsaturated.

Commercially produced fats - Trans Fats

These are unsaturated fats that have hydrogen atoms added to them making the bonds between the fat molecules more difficult to breakdown. The process is an artificial process carried out by food companies to preserve the shelf life of the product therefore increasing the 'sell by' date. They are often found in many everyday products such as margarine, pastries, donuts, muffins, biscuits, cakes, pies, crackers, chips and the majority of fast food. No trans fats are **essential fatty acids** and therefore possess no nutritional value; indeed, the consumption of trans fats increases the risk of coronary heart disease by raising levels of "bad" LDL cholesterol and lowering levels of "good" HDL cholesterol. Health authorities worldwide recommend that consumption of trans fat be reduced to trace amounts. Trans fats from are more harmful than naturally occurring saturated fats.

Proteins

Proteins are required for **growth and repair**. Proteins contain carbon, hydrogen, oxygen, nitrogen and sometimes sulphur. Proteins are very large molecules, so they cannot get directly into our blood; they must be turned into **amino acids** by the digestive system. These amino acids are used by the muscle to repair any damaged tissue after intense exercise e.g. muscle fibres have micro damage/tears after intense exercise and the amino-acids help rebuild the fibres into often bigger stronger structures – **muscular hypertrophy**. Proteins can also be used as a source of energy in very extreme conditions when all carbohydrate stored have been depleted. If there is an over consumption of protein, then some is stored as fats but when amino acids are removed from the body through our urine.

Quick revision

- A balanced diet consists of carbohydrate 60%, fat 25%, protein 15%.
- Carbohydrates and fats predominantly provide us with energy, while proteins are responsible for growth and repair.
- The glycaemic index is the rate at which carbohydrates release energy.
- High glycaemic carbohydrates release energy at the fastest rate which can result in them being stored as fat if they are used by the body for energy.
- High GI foods cause a rapid rise in blood sugar levels which results in increased levels of insulin secretion. Over time the body can become tolerant of the insulin thus increasing the risk of diabetes.
- Low GI foods release energy at slower rate leaving the individual not feeling so hungry for longer periods. They also do not cause high levels of insulin secretion.
- Overconsumption of both carbohydrate and fats will lead to weight gain.
- Saturated fats and trans fats are high in calories and high in LDL cholesterol.
- Nevertheless, fats are an essential nutrient for the body, providing energy and transportation of vitamins A, D, E, and K.

Top tips:

Most exam questions on nutrition and health have been asked as part of the lifestyle choices section of the paper and often as part of an extended writing, 10 mark question. It is vital that there is an understanding of the constituents of a balanced diet and the roles of carbohydrate, fats, proteins, vitamins and minerals in maintaining normal bodily function. Likewise it is important that there is knowledge and understanding of the negative effects of over consumption of carbohydrates and proteins and the health problems associated with saturated fats.

Whilst it is not necessary to know all the G.I. values of the various carbohydrates being able to provide examples of low, medium and high G.I. carbohydrate is important. Also it is vital to have knowledge and understanding of the impact of low, medium and high G.I. carbohydrates on health and weight control.

Questions

1. Explain how high levels of harmful LDL cholesterol can lead to associated diseases. **(4)**

2. Outline the role played by fats within a balanced diet. **(3)**

3. Explain the possible short-term and long-term health risks associated with a diet high in fats and proteins. **(4)**

4. Explain how a prolonged positive energy balance could lead to heart attack or stroke. **(4)**

Nutrition and Sporting Performance

As with nutrition and health it is vital for a sportsperson to have a sufficient balance diet to meet the needs of their sport, event or activity e.g. a marathon runner would have a different diet to that of a sprinter because of the differing energy demands. Nevertheless the primary source of energy for their training and competing regimes would come from carbohydrate. As previously stated, it takes approximately 15% less oxygen to break down carbohydrate (glucose) than it does a fat molecule. Hence, as well as proteins being an essential element of recovery after exercise, knowledge of the type of carbohydrate to consume and when to consume it is essential for any sportsperson.

Food as the Fuel for Exercise

Nutrition for sport is built upon an understanding of how nutrients such as carbohydrate, fat and protein contribute to the fuel supply needed by the body to perform exercise. These nutrients get converted to energy in the form of adenosine triphosphate (ATP). It is from the energy released by the breakdown of ATP that allows muscle to contract.

Fuelling the Energy Systems

Carbohydrates and fats get converted to ATP based upon the **intensity** and **duration** of activity, or the **aerobic/anaerobic fitness level** of the performer. Carbohydrate are generally the main source of energy fuelling exercise of a moderate to high intensity, with fat providing energy during exercise that occurs at a lower intensity. Fat is a good fuel for high endurance activities such as hiking, but it is not adequate for high intensity exercise such as sprinting or exercising close to the Anaerobic Threshold because it requires approximately 15% more oxygen than carbohydrate to be metabolised. If exercising at a low intensity (or below 50 percent of max heart rate), you have enough stored fat to fuel activity for hours or even days as long as there is sufficient oxygen to allow fat metabolism to occur.

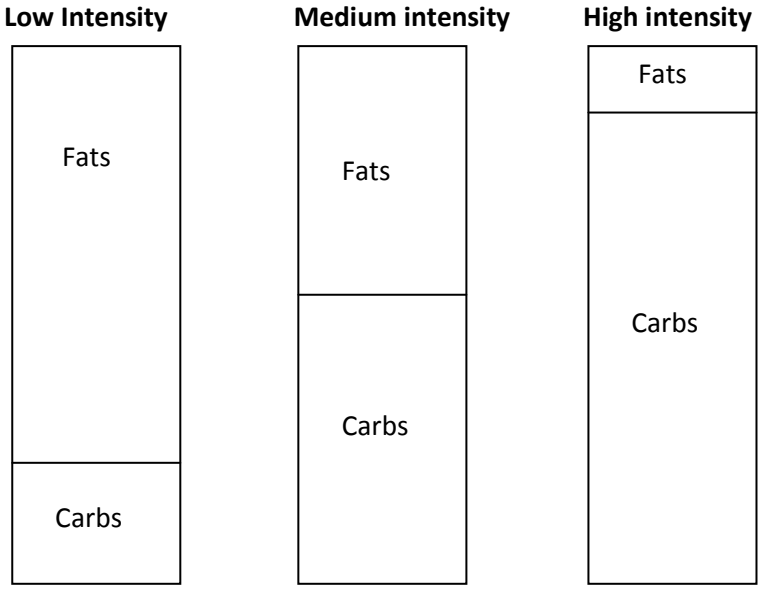
As exercise intensity increases, carbohydrate metabolism takes over. It is more efficient than fat metabolism, but has limited energy stores. This stored carbohydrate (glycogen) can fuel about 2

hours of moderate to high level exercise depending on an individual's level of fitness. After that, glycogen depletion occurs (stored carbohydrates are used up) and if that fuel isn't replaced athletes may hit the wall. An athlete can continue moderate to high intensity exercise for longer by simply replenishing carbohydrate stores during exercise (High GI foods, isotonic drinks/gels etc). This is why it is critical to eat easily digestible carbohydrates during moderate exercise that lasts more than a few hours. If insufficient carbohydrates are consumed during this period, then the performer will be forced to reduce exercise intensity and return to fat metabolism to fuel activity.

As exercise intensity increases, the aerobic system using carbohydrate cannot provide sufficient energy (ATP) and anaerobic metabolism takes over, the body will then use the **Anaerobic Glycolysis** and **Creatine Phosphate** energy systems to produce ATP. This is because your body can not take in and distribute oxygen quickly enough to use either fat or carbohydrate metabolism. Even though carbohydrates can produce nearly 20 times more energy (ATP) per gram when metabolised in the presence of oxygen than when generated anaerobically, such energy cannot be produced quickly enough to cope with the excessive energy demands of high intensity exercise.

With appropriate training, these energy systems adapt and become more efficient and allow greater exercise duration at higher intensity. For example, as an individual becomes more **aerobically** fit, thus increasing their VO_2 max and subsequently increasing their uptake of oxygen and are able to metabolise fats for a longer period than that of someone who is less aerobically fit. This will allow glycogen levels to be maintained which is beneficial when exercise intensity is increased and carbohydrate/glycogen will be the main fuel used. Similarly if an individual is **anaerobically** fit then they will have an increased glycogen and creatine phosphate stores thus allowing longer periods of high intensity exercise.

Approximate food fuel usage for varying exercise intensities



Quick revision

- Carbohydrates are the main source of fuel during moderate to high intensity exercise.

- During rest and low intensity exercise predominantly fats are the main source of energy.
- As exercise intensity increases then more carbohydrates are used as fat usage decreases.
- During anaerobic exercise CP and glycogen (carbohydrate) are the main source of energy.
- The higher the individual's aerobic fitness (VO2 max) then the longer the fats will be metabolised, sparing important carbohydrate stores.
- The higher degree of anaerobic fitness means greater CP and glycogen stores which allows an individual to exercise at a high intensity for a longer period of time.

The Glycaemic Index and Exercise

Low GI Carbohydrate

Pre Exercise

The best strategy for athletes is to consume low GI carbohydrates in a pre-exercise meal to allow for sustained energy (3-4 hours before to allow full digestion).

Post Exercise

Consume both low and high GI foods within 30 minutes post-exercise to enhance recovery with fast glucose/glycogen uptake in the muscles from the high GI foods and sustained release of energy from the low GI foods. However consuming low GI foods should be avoided immediately prior to and during exercise because of the slow digestion of the foods not releasing energy quickly enough during exercise and it will leave the athlete with undigested food in the stomach which can lead to sickness.

High GI Carbohydrate

During Exercise

High GI foods are important during an event to maintain blood glucose and muscle glycogen levels. They release energy immediately which is vital to a performer for sustained performance. High GI foods are often consumed through isotonic drinks during exercise. However many physiologists suggest that high GI foods should be avoided immediately prior to exercise because of the inevitable insulin spike that is caused, this spike can reduce the availability of energy for exercise.

Post Exercise

After intense exercise when the bodies' glycogen stores are depleted, it is vital that they are replenished as quickly as possible, ideally within 30 minutes. Consumption of high GI foods after exercise is a good way of initially beginning to restore glycogen.

How the Glycaemic Index is used in sport

An athlete participating in an endurance event should consume a low GI meal between 3-4 hours prior to exercise consisting of foods such as brown bread, fruit, vegetables, porridge (see other items on the index below). During the event high GI foods such as isotonic drinks and gels, jelly babies, jaffa cakes are often consumed. Post exercise a mixture of both high and low GI foods should be consumed with 30 minutes of ceasing exercise; this is the optimum time for glycogen uptake for the muscles. Specific recovery drinks/shakes that include a mix of low/medium and high GI carbohydrate and protein are often consumed immediately after exercise. After the athlete has showered and changed, glycogen and protein stores are further restored with a balanced meal containing a high proportion of low GI carbohydrate and protein. This helps to continue to restore glycogen stores as metabolic rate remain elevated up to 4 to 5 hours after exercise has ceased. Protein helps repair the muscle tissue. Replacement of fluids is also essential to re-hydrate the body.

Quick Revision

- The glycaemic index is the rate at which carbohydrate releases energy (glucose) into the bloodstream.
- High GI carbohydrates such as sugars release energy the fastest which is beneficial during exercise and just after exercise.
- Low GI carbohydrates release their energy slowly which is beneficial 3 hours prior to exercise and within 30 minutes after intense exercise.
- A mixture of low, medium and high GI foods, are consumed after intense exercise to refuel the bodies depleted glycogen stores.
- Protein and fluids are also essential for growth and repair and rehydration during recovery.

Carbohydrate loading

Theory of carbohydrate loading

At the end of day three, the body will think that there is a problem with its glycogen stores and that it should store more glycogen than normal. In the last three days, when the athlete consumes carbohydrate, the body will replenish the glycogen stores and top them up with extra glycogen. This process is called super compensation.

Carbohydrate loading is a method used to maximise an athlete's GLYCOGEN stores prior to an endurance event. There are numerous ways to 'carbo load' but all follow a similar principle. The two main methods are the Astrand and Shearman techniques but it is the Sherman method that's most widely used. The Shearman technique follows the following stages:

- Depletion stage (reducing the muscle glycogen stores)
- Tapering stage (reducing the amount of training)
- Loading stage (increasing the consumption of carbohydrate

A typical carbohydrate loading week with the competition on the Saturday would be as follows:

Day/s	Diet	Training	Stage
Sunday	Balanced diet	Light	Recovery
Monday/Tuesday	Balanced diet	High intensity	**Depletion**
Wednesday	Balanced diet	Medium intensity	**Tapering**
Thursday	Medium/High Carbohydrate (Low/medium GI foods)	Light	**Tapering/Loading**
Friday	High Carbohydrate 80% of diet. (Low/medium GI foods)	Light	**Loading**
Saturday	Low-Medium GI meal 3-4hrs prior to competition	Competition	**Loading**

Quick carbohydrate loading

A quicker method of carbohydrate loading is to deplete glycogen stores one day prior to competition with a short burst of high intensity activity, no more than 15 minutes in duration. The loading phase would begin immediately after exercise consuming 80% carbohydrate.

Quick revision

- Carbohydrate loading increases stored glycogen stores in the body.
- The three phases are Depletion, Tapering, and Loading.
- In the loading phase up to 80% of the athlete's diet is made up of carbohydrate.
- Pre-competition meal is predominantly Low GI in order to release energy gradually over the competition.

Top tips:

It is important to have knowledge and understanding of:

Hydration

Hydration is maintaining the correct levels of water in the body thus allowing normal bodily functioning. If water levels drop then the body is said to be dehydrated which, can have a dramatic, negative effect on sporting performance.

Physiological responses to dehydration

We can become dehydrated when water used for normal bodily functions such as producing energy is not replaced. For every molecule of ATP that is produced a chemical reaction must take place which releases heat. The more we exercise the greater the heat produced. This heat is controlled by the water in the blood plasma as it's taken to the surface of the skin. The heat is then released through the skin which condenses forming sweat. If this water in the blood plasma is not replaced through drinking water or any other fluids then **the blood plasma** becomes more viscous (thicker). This means the blood cannot be transported around the body as quickly. This results in:

- Increase in heart rate and breathing rate.
- Oxygen being transported at a slower rate through the blood vessels.
- Less glucose/glycogen and fatty acids being transported to the muscles for energy.
- Increased levels of lactic acid production.

All of these factors result in a reduction in the production of ATP, resulting in a reduction in the intensity of exercise.

Signs of dehydration

Thirst is the most common sign of dehydration, along with a dry mouth and lips. This is a bad sign for athletes particularly in endurance events; because once this state has been reached it is very difficult to rehydrate unless you stop exercising. A far more accurate test of levels of hydration is monitoring the colour of the athlete's urine. Generally the ideal colour for full hydration is a clear or straw colour. The more yellow in colour the urine then the greater the levels of dehydration.

How to maintain levels of hydration

It is vital to hydrate before during and after exercise. An individual should remain hydrated at all times and not just before competition. The bigger the individual and the greater the amount of training, means the greater amount of water should be consumed.

Prior to exercise

Generally between 4-7 litres of water should be consumed over a 24 hour period. Just prior to exercise, particularly in events or sports taking place over an extended period of time it is important to be fully hydrated prior to competition. Depending on weather conditions, an individual should consume up to 2 litres of water. This amount of water should be consumed over 2 to 3 hours and not all at once to prevent bloating and possible sickness.

During exercise

Again the amount of water consumed during exercise depends on climate conditions and the size of the individual. It is important to consume small amounts of fluids but drink them at regular intervals. A guide to hydration during exercise is to consume between 150-250 ml every 10-15 minutes or between ½ - 1 litre per hour of exercise. If exercising for longer than 90 minutes then the consumption of energy drinks can also be beneficial to replace lost carbohydrate/glycogen stores and electrolytes, which are all essential for energy (ATP) production.

After exercise

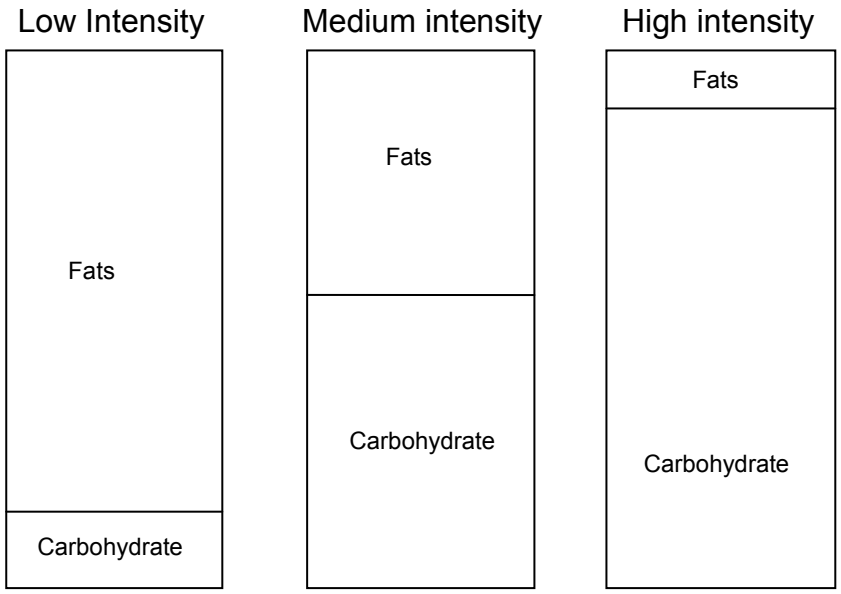
It is essential to rehydrate after exercise in order to aid the recovery process. A method used to control levels of hydration often used by professional athletes is to weigh the athlete before and after prolonged exercise or competition. Then for every 1 KG of body weight that is lost approximately 1 litre of water should be consumed over a period of hours rather than all at once.

Quick revision

- Depending on body size 4-7L of fluids should be consumed per 24 hours.
- 2-4 hours prior to exercise and competition approx 2 litres of water should be consumed.
- During prolonged exercise 150-250 ml of fluids every 10-15 minutes should be consumed. Isotonic drinks are also useful in activities over 90 minutes.
- After exercise for every 1 KG of lost body weight 1 litre of water should be consumed.

Exam Style Questions

1. Exercise intensity is a major factor in food fuel usage during exercise



(a) Using information from the diagram and your own knowledge, explain the variation in food fuel usage. [4]

(b) Nutrition is a key element in any **endurance** activity. Explain how nutrition can be manipulated **before**, **during** and **after** exercise to enhance performance. [6]

Answers