CHEMICAL COORDINATION IN HUMANS

By the end of this topic, you should be able to:

a) differentiate between hormones and enzymes (u)

b) know and understand the effects of various hormones in the human body (k, u)

c)know and describe the causes and symptoms of common hormonal disorders/diseases (diabetes, goitre and osteoporosis) in humans (k, u)

d) appreciate the role of diet in managing hormonal disorders/diseases in humans (u)

Key words

- Coordination
- Hormone
- Enzyme
- Endocrine gland
- Exocrine gland
- Target organ
- Stimulate
- Inhibit

INTRODUCTION

This chapter aims at enabling learners to differentiate between hormones and enzymes. Allow them to know and understand the effects of various hormones in the human body. Guide learners to understand and describe the causes and symptoms of common hormonal disorders (diseases).

INTRODUCTION:

Coordination is the way all the organs and systems of the body are made to work efficiently together. Human bodies contain two communication pathways: **the nervous** and **hormonal** systems. In the nervous system, messages travel as electrical signals while in the hormonal system, messages travel in form of chemical signals. There are two forms of chemical systems in our bodies, that is the **endocrine** and **exocrine** systems**.** The endocrine glands secrete chemical signals directly into blood while exocrine glands secrete chemical signals through ducts or tubes.

This chapter will focus on the chemical system, specifically the endocrine system.

ENDOCRINE AND EXOCRINE GLANDS

A gland is a group of cells that make substances needed elsewhere in the animal's body. Our body has many glands which produce different secretions, such as sweat, saliva, milk, tears, enzymes and hormones. Whereas both enzymes and hormones regulate activities of organs and cells, they differ in so many ways.

Exocrine glands are glands that produce and release their secretions into tubes or ducts. They can also be called duct glands. Their secretions move outside the animal's body or into a space inside one of the organs in the body. Examples of exocrine glands include: pancreas, salivary gland, gastric gland, sweat glands, tear glands and mammary glands.

Endocrine glands are glands that produce and release their secretions directly into blood. They lack ducts and hence called ductless glands. Their secretions are called hormones. Hormones are chemicals produced by animals to regulate the organism's activities.

Examples of exocrine glands include: pituitary gland, pancreas, adrenal gland, thyroid gland, ovary, testis and thymus gland.

THE ENDOCRINE SYSTEM

This is made up of glands that secrete chemicals called hormones directly into the blood stream. A hormone is a chemical substance produced from a special group of cells (glands), travels through blood to its target organ where it produces an effect. The target organs have receptors on the cell membranes that pick up the hormone molecules, triggering a response in the cell.

Many processes in your body are coordinated by these hormones. Some hormones can act very rapidly but compared to the nervous system, many hormonal effects are slower but long lasting. Hormones that give rapid responses include insulin which controls your blood glucose and adrenaline which prepares your body for fight or flight. Slow-acting hormones with long term effects include growth hormones and sex hormones.

Activity (a): DISTINGUISHING BETWEEN HORMONES AND ENZYMES.

Key Question: What are the differences between hormones and enzymes?

1. Use textbooks to research the differences between endocrine and exocrine glands with differences between hormones and enzymes.
2. Prepare a chart showing the location of endocrine glands in males and females plus the hormones they secrete.
3. Share your findings with the rest of the class.

Discussion

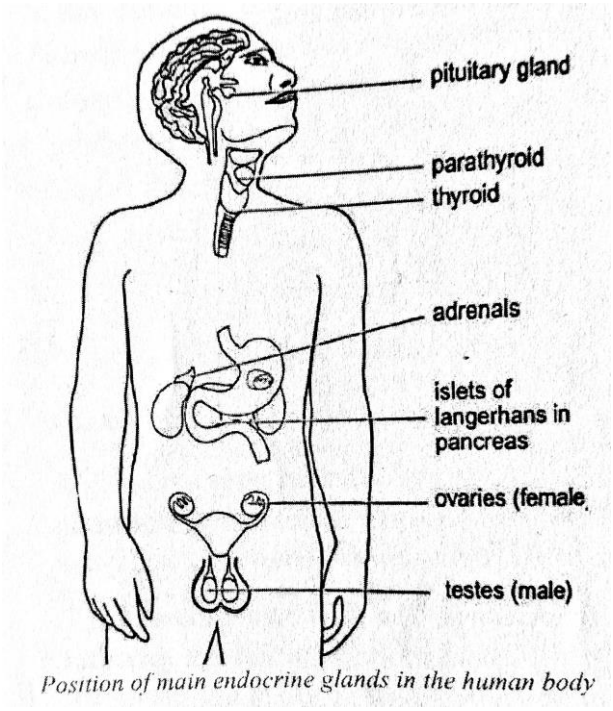
Difference between endocrine and exocrine glands.

Exocrine glands are glands that produce and release their secretions into tubes or ducts onto your body's surface whereas **Endocrine glands** are glands that produce and release their secretions directly into your blood stream.

Differences between hormones and enzymes.

Hormones	**Enzymes**
Are biological messengers that trigger functions or responses.	Are biological catalysts that speed up the rate of chemical reactions.
Hormones may be composed of proteins, amino acids, steroids etc.	All enzymes are generally made up of proteins.
Chemical composition changes after use hence may or may not be re-used.	Retain chemical make-up after use hence can be reused again.
They may either increase or decrease the rate of biochemical reactions.	They increase the rate of metabolic or physiological process.
Most hormones usually act slowly.	Act very quickly.
Are diffusible through the cell membrane.	Are non-diffusible through the cell membrane.
Transported by blood to the site of action.	Act at the site of production or nearby organ.
Secreted by endocrine glands.	Secreted by exocrine glands.

A chart drawing the location of endocrine glands in the male and female human being.



Position of main endocrine glands in the human body

Hormones produced by the endocrine glands

Endocrine gland	Hormones secreted
Pituitary gland	▪ Anti-diuretic hormone (ADH) or vasopressin. ▪ Follicle stimulating hormone (FSH) ▪ Thyroid stimulating hormone (TSH) ▪ Growth hormone ▪ Adrenal cortical stimulating hormone (ACSH). ▪ Interstitial cell stimulating hormone (ICSH). ▪ Luteinizing hormone (LH). ▪ Prolactin ▪ Oxytocin
Parathyroid gland	▪ Parathyroid hormone or parathormone
Thyroid gland	▪ Thyroxin
Thymus gland	▪ Thymosin
Pancreas	▪ Insulin hormone ▪ Glucagon hormone
Adrenal gland	▪ Cortisone hormone ▪ Adrenaline hormone
Ovary	▪ Oestrogen hormone ▪ Progesterone hormone
Testis	▪ Testosterone

Note: The endocrine system regulates the amount of each hormone is released. This can depend on levels of hormones already in the blood or on levels of other substances in the blood, like calcium, hypertonic blood. Many things affect hormone levels such as stress, infection and changes in the balance of fluid and minerals in blood.

FUNCTIONS OF ENDOCRINE GLANDS

Whenever secreted hormones travel in blood to cause a specific response in other cells of the body which are usually located far away, a little quantity of hormones cause a huge effect in the body.

Activity (b): DEMONSTRATING KNOWLEDGE OF ENDOCRINE GLANDS.

Key question: *Which body activities and processes are coordinated by hormones. What are the effects of hormones in the human body?*

Task: In groups

1. Using textbooks, research about hormones in the human body and identify the effects of each hormone in the human body.
2. Describe what would happen in case of low or excess secretion of each hormone.
3. Record your findings and share with the rest of the class.

Discussion

The effects of each hormone in the human body.

Secreting gland	Hormone	Function or effect of hormone
Adrenal gland	Adrenaline	▪ It increases the rate of heart beat. ▪ It increases the breathing rate. ▪ It causes dilation (widening) of the pupils of the eyes. ▪ It increases the rate of respiration in order to ensure adequate supply of energy to body muscles. ▪ It increases blood supply to the muscles particularly to the limbs. ▪ It brings about conversion of glycogen to glucose in the liver. ▪ It brings about the growth of goose pimples on the body.
	Aldosterone	▪ Stimulates the nephrons to reabsorb salts from glomerular filtrate and maintaining osmotic pressure of blood.
Thyroid gland	Thyroxine	▪ It influences the body's rate of metabolism i.e rate of cell respiration and other chemical reactions. ▪ It controls our rate of activity, promotes skeletal growth and is essential for normal development of the brain.
Parathyroid gland	Parathormone	▪ They control/ influence the calcium levels in the bones and blood.
Pancreas	Insulin	▪ It is secreted by the beta cells in the pancreas and it regulates the blood glucose levels in the body from getting too high. ▪ It stimulates the liver to convert excess glucose to glycogen and fats, decreasing the amount of glucose in blood.

	Glucagon	▪ It is secreted by the alpha cells of the pancreas and it helps the body to prevent the glucose levels from dropping too low. ▪ It stimulates the liver to convert glycogen to glucose, increasing blood sugar level back to normal, decreases metabolic rate.
Ovaries	Oestrogen	▪ Development of female reproductive organs, secondary sexual characteristics, healing and repair of uterus wall after menstruation.
	Progesterone	▪ Causes thickening of uterine wall and maintains pregnancy and inhibits production of luteinizing hormone.
Testis	Testosterone	▪ Promotes development of male sex secondary characteristics.
Pituitary gland		▪ Stimulates the adrenal glands to secrete cortisol, a steroid hormone controls a range of activities from controlling the body's metabolism to stimulating blood pressure.
	Prolactin	▪ Stimulates the production of milk by the mammary glands. ▪ It also participates in the control of reproduction.
	Follicle Stimulating Hormone	▪ Stimulates growth of ovarian follicles in females and seminiferous tubules of the testes of a male.
	Luteinizing hormone	▪ Induces ovulation and the development of the corpus luteum. ▪ Also stimulates secretion of sex hormones by ovaries and testes.
	Growth hormone	▪ Stimulates the adrenal cortex to produce and release several hormones including sex hormones. ▪ It enhances protein synthesis and growth especially of bones of limbs.
	Thyrotropic hormone	▪ Stimulates the thyroid gland to produce and release thyroxin which helps in regulating growth and development.
	Antidiuretic hormone (ADH)	▪ Increases the reabsorption of water from the distal convoluted tubules of the kidney nephrons and so concentrates the urine.
	Oxytocin	▪ Stimulates lactation and it also causes the muscles of the uterus to contract during childbirth.

The **pituitary gland** is located at the base of the brain and it has the anterior and posterior lobes. It is the most important endocrine gland in the body and it is known as the master gland because it controls the activities of the other endocrine organs.

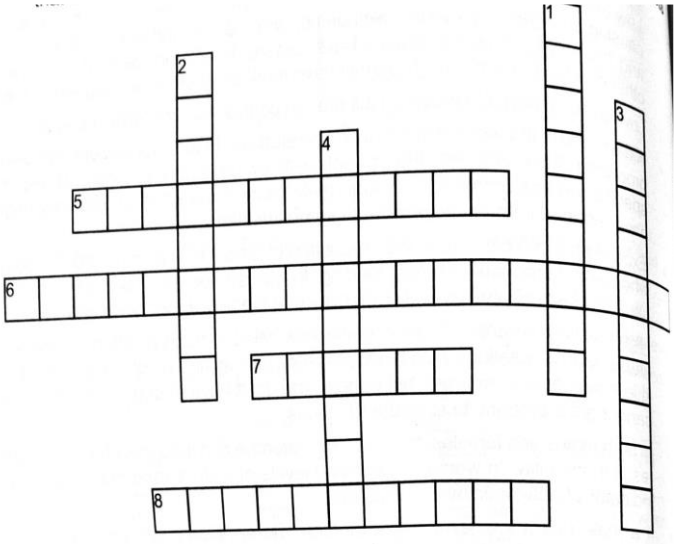
What would happen in case of low or excess secretion of each hormone.

- When you have too much growth hormone, your bones increase in size. In childhood, this leads to increased heigh and is called gigantism. But in adulthood, a change in height doesn't occur and instead the increase in bone size is limited to the bones of your hands, feet and face and is called acromegaly.
- People with low growth hormone levels may feel tired and lack stamina. They may experience sensitivity to hot or cold temperatures.
- High levels of Oestrogen may put you at higher risk of blood clots and stroke. Oestrogen dominance may also increase your chances of thyroid dysfunction. This can cause symptoms such as fatigue and weight changes. While low Oestrogen levels can interfere with sexual development and sexual functions. They can also increase your risk of obesity, osteoporosis and cardiovascular disease.
- Low levels of Oestrogen can affect many parts of the body including the brain, causing changes in emotional wellbeing and the skin, influencing its elasticity and thickness. Once the ovaries have caused their production Oestrogen other changes take place which may have more of an effect on long term health.
- Low levels of oxytocin would inhibit uterine contraction and milk secretion.
- A decrease in the amount of prolactin secreted can lead to insufficient milk being produced after giving birth. Most people with low prolactin levels do not have any specific medical problems, although preliminary evidence suggest they might have reduced immune responses to some infections.
- Excess prolactin can cause the production of breast milk in men and in women who are not pregnant or breast feeding. In women, too much prolactin can also cause menstrual problems and infertility (the inability to get pregnant).
- High levels of adrenaline can increase your risk of a heart attack or stroke and cause heart palpitations, high blood pressure, anxiety and weight loss. Having too little adrenaline is very rare, but people who don't have enough of the hormone cannot react properly to stressful situations.
- In both males and females, too much testosterone can lead to early puberty and result in infertility. In women, high blood levels of testosterone may also be an indicator of polycystic ovary syndrome.
- If a male has a low level of testosterone, the symptoms can include erectile dysfunction and reduced bone mass and sex drive. The hormone has many important functions including: the development of the bones and musclkes, the deepening of the voice, hair growth and other factors related to appearance.
- Low levels of luteinizing hormone can also cause infertility, because insufficient levels will limit the production of sperm or the ovulation process. Too little luteinizing hormone stops ovulation in women or creates a deficiency in gonadotrophin-releasing hormone (GnRH) secretion in men.
- High progesterone levels are believed to be partly responsible for symptoms of premenstrual syndrome (PMS), such as breast tendemess, feeling bloated and mood swings.
- Women who have low progesterone levels are at higher risk for miscarriage or pre-term delivery, because the hormone helps maintain the pregnancy. Signs of low progesterone include: Abnormal uterine bleeding, irregular or missed periods.

In the above activity; You have been able to identify the different effects of hormones. Use internet to research about other hormones which are not included in the table and their functions.

Exercise

Complete the puzzle below by identifying the hormone that causes the effects that are mentioned in "across" and "down".



Down

1. Stimulates the mammary glands to release breast milk.
2. Stimulates birth/uterine contraction
3. Flight, fight and fright hormone
4. Stimulates the development of female secondary sexual characteristics.

Across

5. Stimulates the development of male secondary sexual characteristics.
6. Stimulates the development of the graafian follicles.
7. Stimulates growth
8. Stimulates ovulation

ROLE OF TEENAGE HORMONES IN REPRODUCTION AND PUBERTY

As early as 8 years old, the body begins to produce hormones that cause physical growth and development of sexual organs in preparation for adult life. The changes experienced from puberty through adolescence into adulthood happen to everyone.

Thought

Did you know that hormones play a great role in the development of the secondary sexual characteristics?

Not only do hormones play a role in puberty but also, they are involved in reproduction.

Activity (c): EXPLORING THE PHYSICAL, SEXUAL AND EMOTIONAL CHANGES AT PUBERTY.

Key question: *What hormones bring about secondary sexual changes and what are roles of hormones in adolescent boys and girls?*

In groups

1. Brainstorm all the physical and emotional changes at puberty and adolescence that boys and girls experience during growth.

(a) Record your findings in the table

In boys only	**In girls only**	**In both boys and girls**

(b) How would these changes from puberty:

i) Affect the behavior of young people and

ii) Affect moods, sense of identity and relationship with peers?

2. Use reference sources suggested to

(a) Find out the right information to identify the hormones that cause secondary sexual characteristics in boys and girls.

(b) Distinguish between primary and secondary sexual characteristics.

3. Share your findings with the rest of the class.

Discussion

The physical and emotional changes at puberty and adolescence that boys and girls experience during growth.

Boys only	**Boys and girls**	**Girls only**
Voice breaks.	Pubic hair grows	Softening of voice
Hair grows on face and body.	Under arm hair grows	Hips get wider
Body becomes more muscular.	Sexual organs grow and develop	Breasts develop
+Testes start to produce sperm cells.		Ovaries start to release egg-cells and menstruation starts.

(a) The hormones that cause secondary sexual characteristics in boys and girls

Sex	Gland	Hormone	Secondary sexual development changes
Boys	Testes	Testosterone	▪ Deepening of the voice. ▪ Growth of beards. ▪ Body becomes muscular. ▪ Widening of the chest. ▪ Enlargement and elongation of the penis. ▪ Enlargement of testes. ▪ Growth of pubic hair. ▪ Sperm production. ▪ Ejaculation through wet dreams.
Girls	Ovary	Oestrogen	▪ development of breasts. ▪ Growth of pubic hair. ▪ Widening of hips. ▪ Enlargement and thickening of the vagina. ▪ Smoothening of skin. ▪ Softening of the voice. ▪ Also causes repair of the uterine lining after menstruation.

(b) Difference between primary and secondary sexual characteristics.

- ❖ The primary sexual organs present at birth to distinguish a girl from a boy while secondary sexual characteristics are changes experienced at the onset of puberty preparing the body for adult sexual life.

EDOCRINE (HORMONAL) DISORDERS

The endocrine system continuously monitors the quantity of hormones secreted into blood. However, there are cases when endocrine glands secrete abnormal amounts of hormones hence causing disorders or diseases. Many pregnant mothers today experience miscarriages, rise in number of patients who are diagnosed with abnormal blood sugar levels in hospitals.

Activity (d): Understanding the causes and symptoms of diabetes, goitre and osteoporosis.

Key question: *What are the causes and symptoms of diabetes, goitre, osteoporosis, dwarfism, acromegaly and gigantism.*

What you need: Pictures showing different hormonal disorders/ diseases.

In groups

1. Use the reference sources suggested to you or visit a health centre to contact a health professional with the help of your teacher.
2. Find information about the causes and symptoms, as well as ways of prevention of diabetes, goitre, osteoporosis, dwarfism, acromegaly and gigantism.
3. Summarise your discussion and produce a chart or table to share in class.

Discussion

Endocrine gland	Hormonal disorder	Causes of hormonal disorder	Signs and symptoms	Prevention
Thyroid gland	Goitre	▪ Iodine deficiency ▪ Pregnancy ▪ Hyperthyroidism ▪ Hypothyroidism or under secretion of thyroxine.	▪ Coughing. ▪ A feeling of tightness in your throat. ▪ Hoarseness (scratchy) of voice. ▪ Difficulty in swallowing ▪ Difficulty in breathing. ▪ A swelling in the front of the neck.	▪ Use of radioactive iodine treatment. ▪ Thyroid surgery. ▪ Providing iodine in the diet in the form of iodized salts such as potassium iodate and potassium iodide.
Pancreas	Diabetes	▪ Under secretion of insulin. ▪ Insufficient sleep. ▪ Damaged pancreas ▪ Pregnancy	▪ Excessive thirst or hunger. ▪ Fatigue ▪ Frequent urination. ▪ Weight loss ▪ Blurred vision ▪ Getting a lot of infections such as gum, skin and vaginal infections.	▪ Regular physical exercises. ▪ Insulin therapy ▪ Use of oral medication ▪ Pancreas transplant. ▪ Eat a variety of healthy, fiber-rich foods, which include fruits such as tomatoes, peppers and fruits from trees.
Parathyroid Gland	Osteoporosis	▪ Menopause ▪ Low calcium intake. ▪ Over secretion of parathyroid hormone (hyperparathyroidism) ▪ Hyperthyroidism ▪ Hypogonadism ▪ Some medications such as steroids, anti-	▪ Curvature of the spine ▪ Fracturing of back bone, wrists and hips. ▪ A loss of height ▪ Back or neck pain ▪ Brittle fingernails may be early warning signs.	▪ Regular exercises ▪ Maintain a healthy lifestyle and diet. ▪ Use of dietary supplements. ▪ Treat with bisphosphonates. ▪ Absorb enough vitamin D. ▪ Avoid smoking and limit alcohol consumption. ▪ Limit caffeine.

		epileptic drugs among others.		
Pituitary gland	Dwarfism	▪ Under secretion of growth hormone	▪ A very short trunk ▪ A short neck ▪ Shortened arms and legs. ▪ Average size hands and feet. ▪ Broad, rounded chest. ▪ Slightly flattened cheekbones.	▪ For individuals with dwarfism due to growth hormone deficiency, treatment with injections of a synthetic version of the hormone may increase final height. ▪ In most cases, children receive daily injections for several years until they reach a maximum adult height often within the average adult range for their family.
Pituitary gland	Gigantism	▪ Over secretion of growth hormone	▪ Abnormally large lips, nose or tongue. ▪ Abnormally large or swollen hands or feet. ▪ Altered facial bone structure. ▪ Body and joint aches.	▪ Surgery to remove or reduce the pituitary tumor. ▪ Radiotherapy to reduce tumor growth and growth hormone levels. ▪ Drug therapy to control growth hormone levels and symptoms and shrink the tumor.
Pituitary gland	Acromegaly	▪ Over secretion of growth hormone	▪ Abnormally large lips, nose or tongue. ▪ Abnormally large or swollen hands or feet. ▪ Altered facial bone structure. ▪ Body and joint aches.	▪ The goal of treatment is to restore the pituitary gland to normal function, producing normal levels of growth hormone. ▪ Treatment may include removal of tumor,

				radiation therapy and injection of growth hormone blocking drugs. ▪ Left untreated acromegaly can lead to worsening diabetes mellitus and hypertension.

Factors that lead to endocrine disorders include;

- ❖ Acromegaly, an overproduction of growth hormone and prolactinoma, an overproduction of prolactin hormone resulting from damage to the pituitary gland.
- ❖ Diabetes mellitus, which arises when the pancreas does not produce sufficient insulin when or when the body cannot respond to the insulin that is present.
- ❖ Environmental or nutritional factors, such as lack of iodine in hypothyroidism, which can affect hormone production.
- ❖ Genetic factors, which may play a role in endocrine disorders especially with diabetes and other disorders such as autoimmune thyroiditis.
- ❖ Tumors, since the underlying cause of the endocrine disorder can be linked to a growth or tumor of the gland.

What causes diabetes mellitus?

If your pancreas does not make enough (or any) insulin, your blood glucose concentration is not controlled. You have **type 1 diabetes (insulin dependent diabetes)**. Without insulin, your blood glucose levels get very high after you eat. Eventually, kidneys excrete glucose in your urine ***(sweet urine).*** You produce lots of urine frequently **(diabetes insipidus)** and feel thirsty all the time. Without insulin, glucose cannot get into the cells of your body, so you lack energy and feel tired most times. You break down fat and protein to use as fuel instead, so you lose weight. Type 1 diabetes usually starts in young children and teenagers and there seems to be a **genetic** element to the development of the disease.

Type 2 diabetes (insulin independent diabetes) is another, very common type of diabetes. It gets more common as people get older and is often linked to obesity, lack of exercise or both. There is also a strong **genetic tendency** to develop type 2 diabetes.

In type 2 diabetes, the pancreas still makes insulin, although it may make less than your body needs. Most importantly, your body cells stop responding properly to the insulin released. In Uganda, cases of diabetes type 2 are rising as the number of obese people rise due to passive lifestyles and poor nutrition.

DIABETES MELLITUS

Diabetes mellitus is one of the commonest hormonal disorders in our community. It is a condition that results from high blood sugar levels. Untreated high blood sugar from diabetes can damage your nerves, eyes, kidneys and other organs. Some of this glucose is expelled from the body through urine.

Individuals with diabetes mellitus have the following symptoms;

- Extreme hunger due to excessive loss of glucose.
- Increased thirst due to excessive loss of water due to excessive urination.
- Frequent urination due to the presence of glucose in the glomerular filtrate that inhibits water selective re-absorption leading to large volumes of urine produced.
- Blurred vision due to destruction of nerves in the eyes.
- Tiredness due to frequent loss of glucose in the urine and the one present in the blood failing to enter body cells to be respired to produce energy.

HORMONAL DIET PLAN

A diet plan is a long term or permanent lifestyle change in feeding to maintain good health. **A hormonal diet plan** guides when, what and how much to eat so as to keep hormones under control. A good meal plan for a diabetic person is one that provides all the healthy nutrition needed while helping keep the blood sugar level in target range. A good diet plan also caters for personal goals, tastes, lifestyle as well as medication someone may be enrolled in.

Activity (e): APPRECIATING DIABETES DIET MANAGEMENT

Key question: *What kind of diet is recommended for diabetic people?*

In groups

1. Brainstorm the kinds of food people with diabetes should feed on and how they can get such food wherever they are including while in school.
2. Develop a one-day meal plan for a person suffering from diabetes.
3. Share your findings with the rest of the class.

Discussion

According to the American Diabetes Association 2019 nutrition guidelines, there are many different ways to create a healthy diabetes meal plan, but there is growing evidence to show that low-carbohydrate eating patterns can benefit people with diabetes and prediabetes. This plan is what many will consider moderately low carbohydrates which means;

- Less than 25 grams of carbohydrates in each meal or snack.
- Protein and healthy fats in every meal.
- Plenty of fiber to aid digestion and help manage blood sugar levels (by slowing down the absorption of carbohydrates).
- No processed carbohydrates or added sugars.
- Limited natural sugars (from fruit, etc) that can cause blood sugar spikes.
- Moderate in sodium.

The kinds of food people with diabetes should feed on

- Healthy fats from nuts, olive oil, fish oils, flax seeds or avocados.
- Vegetables like broccoli, carrots, green peppers and tomatoes.
- Fruits and vegetables- ideally fresh, the more colorful the better; whole fruit rather than juices.
- Higher fiber cereals and breads made from whole grains.
- Fish and shellfish, organic chicken or turkey.

A one-day meal plan for a person suffering from diabetes.

- ✓ A hormonal diet plan emphasizes eating a minimum amount of food daily.
- ✓ A person must consume at least the minimum of each food group i.e vitamins, carbohydrates, proteins and vegetables.

Sample item

(UTEC-MOCK, UCE 553/1 2024)

George was often sick and initially failed to seek medical attention, he later realized his life was deteriorating. When he was eventually taken to hospital, he reported symptoms of frequent urination, thirst, fatigue, weakness, poor vision weight loss, irritability and moody changes after meals. His diet mainly consisted of posho and sweet potatoes. The examination revealed difficulty in standing steadily and alcohol on his breath.

(a) Mention which organs are affected by the patients' symptoms explaining the roles these organs play in the body.

(b) Identify the possible causes of his conditions.

(c) Explain the strategies for managing the condition.

To God be the Glory