Diet and Nutrition

Introduction

Throughout the discussions of the metabolism of organic foodstuffs, attention has been focussed particularly on the mechanisms and nature of their chemical transformations, various components of the body tissues that are undergoing degradation catabolism and resynthesis anabolism continually.

The chemical reactions that are involved in these metabolic processes are either:

Exergonic: they are accompanied by the liberation of energy.

Endergonic: they require the introduction of energy.

Energy expenditure by the body consists of two components:

A- Energy utilized for performing physical works and exercises.

B- Energy utilized for performing involuntary works.

A. The first category includes the expenditure of energy in the movement of the body, lifting off any object, doing day to day works and muscular exercises The extent of energy expenditure depends upon the extent of physical work done.

B. The second category includes the energy expenditure in doing osmotic work, absorption, transport of food materials, excretion, contraction of involuntary muscles, active transports, etc.

Energy is continuously expended in such involuntary work throughout the life period for which we are not conscious. This part of the expenditure is relatively constant and expenditure in such involuntary works occurs at a basal rate.

Globally, malnutrition is very common, leading to significant complications including impaired growth, defective immune system, and reduced work capacity. By contrast, in developed countries, and increasingly in developing countries, there is excessive food consumption, leading to obesity, and the development of diabetes, cardiovascular disease, and some cancers. Surprisingly, worldwide, overweight and obesity are much more common than malnutrition.

Caloric value of foods

Different foodstuffs on burning give different amounts of energy. How much heat will be obtained by burning a particular foodstuff is expressed by the term caloric value.

Definition: Caloric value is defined as the amount of heat energy obtained by burning 1.0 gm of the foodstuffs completely in the presence of O2. The caloric value of different foodstuffs is determined by a special apparatus called a bomb calorimeter.

Principle of measurement of caloric value:

-A weighed amount of sample is burnt in an atmosphere of O2 by an electrically heated platinum wire.

- The heat evolved is absorbed in a weighed amount of water that surrounds the burning chamber.

- The rise of temperature is recorded with the help of a sensitive thermometer.

Unit of energy

The unit of energy is a calorie (c) which defined as:

The amount of heat required to raise the temperature of 1.0 gm of water by 1°C (specifically from 15 to 16°C). This is the ordinary calorie and is found too small a unit for measuring the energy value of foods.

A unit thousand times of the ordinary calorie is called ”kilo-calorie” or simply Calorie (by capital ’C') is used for this purpose. Calorie in biological science always means a {’kilocalorie” (”C”)}.

-Food materials undergo combustion in the animal body and liberate energy in the same way as in bomb calorimeter, but in a graded and continuous stepwise manner instead of in an explosive way.

-There is relatively significant variations in caloric value of individual carbohydrate, fat, protein, their average energy value when metabolized may be represented as follows:

In C/ gm:

Carbohydrates = 4.1

Fats = 9.3

Proteins = 4.3

On accounts of losses in digestion and absorption and other unaccountable factors, the caloric values are usually rounded off and said to be 4.0 calories/gm of carbohydrates and proteins and 9.0 calories/ gm for fats.

Basal metabolism and BMR

The amount of energy required for any individual varies directly with the degree of activity and environmental conditions, but the rate of energy production in an individual by its over-all cellular metabolism is more or less constant under some standard conditions (basal conditions), and is known as "basal metabolism".

In other words, the basal metabolic rate (BMR), is defined as the energy required for performing vital body functions at rest, it is regarded as the largest contributor to energy expenditure.

Therefore estimating the total contribution of individual BMR to total daily energy expenditure is an important calculation for understanding, developing, and executing weight-related interventions.

Basal Metabolic Rate (BMR) represents the largest component of total energy expenditure and is a major contributor to energy balance.

The basal conditions during which BMR is calculated are as follows:

1- The person should be awake but at complete rest both physical and mental.

2- The person should be without food for at least 12 - 18 hrs, i.e. in the "postabsorptive state". Postabsorptive state is allowed to pass to avoid the effects of digestion and absorption.

3- The person should be in a recumbent position in bed.

4- The person should remain in a normal condition of the environment, i.e. at normal temperature, pressure and humidity (environmental temperature of between 20 C to 25°C).

Under these conditions energy output of the individual is to maintain respiration, circulation, muscle tone (skeletal and smooth muscles), functions of viscera like the kidney, liver and brain for the maintenance of the body temperature.

The rate of energy production under such basal conditions per unit time (one hour) and per square meter of body surface is known as the basal metabolic rate (BMR).

Definition of BMR:

BMR may be defined as the amount of heat given out by a subject who though awake is lying in a", state of maximum physical and mental rest under comfortable conditions of temperature, pressure and humidity, 12 to 18 hours (postabsorptive) after a meal.

A constant ratio of endogenous carbohydrates, lipids and proteins are metabolized under such basal conditions.

Factors influencing BMR

The rate of metabolism at basal conditions has been found to vary in different individuals and therefore BMR varies according to the following factors:

1- Age:

The BMR of children is much higher than the adults. Roughly speaking it is inversely proportional to the age.

In other words, with advancing age, BMR gradually falls. This is because children possess a greater surface area in proportion to their body weight.

2- Sex:

Women normally have a lower BMR than men. The BMR of female decline between the ages of 5 to 17 more rapidly than those of males.

3- Surface area:

Since much of the basal metabolism is for the maintenance of body temperature and since heat loss is proportional to the surface area of the body, the BMR is directly proportional to the body surface.

Hence it is customary to express BMR as C/ sq. m/hr. When expressed in terms of surface area, the BMR of different individuals are remarkably constant.

4- Climate:

In colder climates, the BMR is high and in tropical climates the BMR is proportionally low.

5- Racial variations:

When the BMR of different racial groups is compared, certain variations are noted.

6- State of nutrition:

BMR is lowered in conditions of malnutrition, starvation, and wasting diseases.

7- Body temperature:

BMR increases by about 12% with each 1C rise in temperature.

8- Habits:

Trained athletes and manual workers have a slightly higher BMR than persons with a sedentary lifestyle.

9- Hormones:

Thyroxine and epinephrine increase BMR. In thyrotoxicosis, BMR increases by 50-100% above normal while in severe hypothyroidism BMR is diminished to 30-45% below normal.

10- Pregnancy

BMR of a pregnant woman is significantly increased after the 6th month of gestation.

Clinical aspect

Pathological variations in BMR

Fever

Infections and febrile diseases elevate the BMR, usually in proportion to the increase in temperature.

Diseases

Certain diseases are characterized by increased activity of cells and increase heat production due to increased cellular activity. Thus, BMR may increase in such diseases as:

Leukaemias (21 to 80%)

Polycythemia (10 to 40%)

Cardiac failure (25-80%)

All of which are associated with increased cellular activity.

Endocrine diseases

The most important hormones which alters BMR are:

1- thyroid hormones 2- cortisol

3- growth hormone 4- epinephrine.

Importance of BMR measurement

Measurement of BMR can be useful in the following conditions:

1- as a diagnostic aid:

To diagnose various pathological conditions especially in the assessment of thyroid function.

2- for calculation of caloric requirement:

This is useful in prescribing proper diet in the treatment of nutritional disorders.

3- to study the effect of different types of foods and drugs on BMR.

Protein-energy malnutrition (PEM)

The World Health Organization (WHO) defines malnutrition as *"the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions."*

Malnutrition is a state arising from an insufficient calorie intake causing undernutrition and/ or insufficient intake of one or more of the essential nutrients, especially proteins that lead to deficiency.

The above two situations represent the primary causes and responsible for Marasmus and Kwashiorkor respectively.

Other causes leading to secondary' malnutrition, include:

1- inadequate absorption or utilization of essential nutrients (malabsorption syndrome).
2- increases in the requirement.
3- destruction or excretion of nutrients generally secondary to diseases.

Malnutrition may occur acutely or chronically, and the metabolic response is somewhat different in each type.

Three conditions are usually considered when discussing malnutrition:

The first condition is observed in young children with protein-energy malnutrition commonly seen in the developing countries which represent a major cause of death in children worldwide. This form of PEM occurs acutely and presents as marasmus, kwashiorkor or marasmic-kwashiorkor.

The second condition occurs in older children and adults who live in persistent inadequate dietary intake leading to chronic deficiency of energy. In children, this condition presents with stunted growth, mental apathy, developmental delay, and poor weight gain.

The third condition is more commonly related to people with severe illnesses that lead to anorexia and wasting. This malnutrition has a synergistic effect with the primary disease leading to further morbidity and mortality.

The metabolic response to starvation

Starvation is defined as a severe form of deficiency dietary intake below the required limit to maintain the basic functions of the body. It is associated with a metabolic response that has a specific major goal which is maintaining the blood glucose level within the reference range. This response occurs in the following sequence:

1. Initially, there is an increase in BMR with increased glycogenolysis.
2. Once glycogen stores are consumed, gluconeogenesis represents the entire source of glucose. This process occurs mainly in the liver but the kidneys may play a role with prolonged starvation. The main substances enrolled in gluconeogenesis are:
   A- Amino acids: specifically alanine and glutamine.
   B- Glycerol from breaking down of TG.
   C- Lactate produced by glycolysis.
3. With persistent starvation, ketone bodies are produced by the liver to be used by brain cells.
4. Gluconeogenesis persists but with more dependence on TG and sparing amino acids to preserve proteins. This explains the decrease in urinary excretion of nitrogen in prolonged fasting. Brain cells depend more on ketone as a source of energy with less dependence on glucose to less than 50% of the original consumption of glucose.

The basal metabolic rate actually increases during the first few days of starvation, under the influence of catecholamines that are secreted in response to decreasing blood glucose concentrations.This probably reflects the high rate of gluconeogenesis that occurs at this time. As fasting progresses, however, metabolic rate decreases as free T3 and catecholamine levels decrease and the rate of gluconeogenesis decreases.

There are 3 main types of protein-energy malnutrition (PEM):
1- Marasmus
2- Kwashiorkor
3- Marasmic-Kwashiorkor
These 3 conditions are quite common in developing countries and regarded as major causes of morbidity and mortality in children in these countries.

Differentiation of marasmus from kwashiorkor

Feature	**Marasmus**	**Kwashiorkor**
Age	Infant	2-3 years
Deficiency	Calorie	Protein
Growth retardation	Characteristic	May be present
Edema	Not present	Characteristic
Face and skin	Emaciated	Swollen
Appetite	Hungry	Anorexia

In general, kwashiorkor is characterized by adequate carbohydrate consumption and decreased protein intake that leads to decreased synthesis of visceral proteins. The resulting hypoalbuminemia contributes to extravascular fluid accumulation, while marasmus is characterized by an insufficient energy intake to match the body's requirements. As a result, the body draws on its stores, resulting in emaciation. In both conditions, there is an associated deficiency of other essential nutrients such as vitamins and minerals which might contribute with many clinical features commonly seen in PEM.

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