

# **Energy requirements and their estimations**

# Introduction

- Food is the fuel of the body and the utilization of food stuffs yields energy for the living organisms.
- Energy is required for growth and muscular activity and for maintenance of the warmth and various vital functions of the body.
- Even under resting conditions energy is required for the pumping of the heart and for the movements of respiration, for the secretory activity of various glands and for kidney action for nervous function and involuntary muscular movements.

# Calorimetry

- The measurement of energy requirements of the body under various physiological conditions and the determination of energy requirements of the body under various physiological conditions and the determination of energy values of foods is called calorimetry.

# Calories

- Energy requirements of the body and energy content of food are measured in terms of calories.
- **Definition**
- In nutrition the term kilocalorie is used
- It is defined as the amount of heat required to raise the temp of 1 Kg of water through one degree centigrade (from 15° to 16°C) and 1000 times of calories.

# Factors that determine the total energy requirements

1. Basal metabolic rate,
2. Physical activities
3. Specific Dynamic Action

# 1. Basal Metabolic Rate- BMR

It is the amount of energy needed when the body is at complete rest.

It is referred to as the energy needed for Basal Metabolism occurring when the subject is comfortably relaxed in bed at physical and mental rest in the post absorptive state about fourteen hours after food.

Under these conditions the heat generated by the body is utilized only to permit vital activities and maintain body heat at 37°C.

# Measurement of BMR

- The measurement of BMR is done either
- Directly from the oxygen consumption for 2-6 min from the graph obtained with Benedict-Roth apparatus or the Du Bois apparatus or
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- By an indirect method by analyzing the expired air and estimating the oxygen consumption and CO<sub>2</sub> output.
- The total heat production is then determined.
- Since greater part of heat is radiated away it has been assumed that the production of heat from the body is largely dependent on the surface area of the body.

- **Units of BMR**

- It is expressed as the no. of K.cal. liberated per square meter of body per hr. K.cal/sq.m/hr.
- The the average value for an adult man is about 40 K.cal/sq.m/hr while that of an adult women is 37 K.cal/sq.m/hr.
- It increases from 5 to 52-55 K.cal/sq.m/hr. in the 1 year.
- Then decrease slowly as age advances.



- By measuring the O<sub>2</sub> consumption for a certain period the energy needed for BMR can be calculated.
- The consumption of every 1 lt. of O<sub>2</sub> produces a heat equivalent of 4.82 K.cal.

## Factors that affect BMR

The rate of O<sub>2</sub> consumed depends on

- The degree of muscular activity
- The quality and amount of food eaten
- The difference between environmental and body temperature
- Emotional excitement
- The effect of drugs
- Age and sex
- 7. Internal secretions

e.g. 1. The secretion and thyroid gland, thyroxine.

If the secretion increases the BMR increases (up to 75%) and if it is decreased the BMR is decreased (30%).

- 2. Adrenaline secreted by adrenal cortex also affects BMR.
- 3. Over activity of pituitary gland also affects BMR.
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- It is accelerated by fever during different diseases.
- BMR also increases during pregnancy and growth.

## 2. Physical activities

- Energy is used for the maintenance of mechanical, electrical, synthetic and osmotic work done by the cells.
- By metabolic reactions, chemical energy is liberated and part of the energy liberated is converted to energy rich compounds and the remaining part is liberated as heat and used for the maintenance of body temperature.
- The energy output is so well balanced that the body weight in adults generally remains constant.
- Energy is needed to carry out physical work. The energy requirement depends upon the type of activities involved.

## . Energy Needs for Various Activities

<b>Functions</b>	<b>Activity</b>	<b>Men Kcal/kg/h</b>	<b>Women Kcal/kg/h</b>
Very Light	Seated and standing activities, painting, auto and truck driving, Laboratory work, Typing	1.5	1.5
Light	Walking (2.5-3, mile/h), Carpentry, shopping, restaurant trades, washing clothes, gif	2.9	2.6
Moderate	Walking fast (3.5-4, mile/h) jogging, weeding, hoeing, cycling, tennis, dancing, volleyball	4.3	4.1
Heavy	Walking fast (3.5-4, mile/h) jogging weeding, hoeing, cycling, tennis, dancing, volleyball	4.3	4.1

### 3. Specific Dynamic Action (SDA)

The increased heat production brought about by the ingestion of food itself is called the specific dynamic effect or calorogenic effect.

It represents the additional calories necessary for ATP production when nutrients are oxidized.

SDA for metabolism of the following:

- i. Protein metabolism -30%
- , ii. Fats -6%
- iii. Carbohydrates- 4%

# Measurement of energy requirement

The energy requirement can be measured

- i. Directly by calorimetry or
- ii. Indirectly by measuring the heat output from the amount of O<sub>2</sub> consumed and the CO<sub>2</sub> evolved.

# Direct calorimetry

- The energy released by combustion of food stuffs can be measured directly in the bomb calorimeter designed by Berthelot
- It is a robust metal case sealed with O<sub>2</sub> under pressure and surrounded by water inside an insulated container.
- The food stuff is ignited by an electron spark
- The change in the temperature of the surrounding water caused by the combustion of the food stuff gives a measure of the heat produced which is expressed in Kilocalories.

- The average amount of heat produced on combustion of the three important basis varieties of food stuffs in the bomb calorimeter
- Carbohydrate - 4.1 Kilo cal./g,
- Fat - 9.3 Kilo cal./g
- Protein -5.3 Kilo cal./g
- When the food is oxidized in the body, the oxidation is almost complete for carbohydrates and lipids.



- **Factors affecting energy production in the Body**

- The proteins are not completely oxidized in the body
- Yield nitrogenous excretory products, like urea, creatinine, uric acid and ammonium salts after their overall metabolism and contain oxidisable carbon and hydrogen.
- Incomplete digestion: When foodstuffs are ingested the carbohydrates, fats and proteins are not digested and absorbed totally.
- Hence their calorific value in the body is only 4, 9 and 4 Kilo cal/g of carbohydrate, fat and protein respectively.

# Indirect calorimetry

- In indirect calorimetry, heat output is calculated from the amount of O<sub>2</sub> consumed and the CO<sub>2</sub> evolved.
- The amount of O<sub>2</sub> utilized per unit of time is proportional to the energy liberated but the quantity of O<sub>2</sub> required for oxidation varies slightly with the type and combination of food stuffs being oxidized.
- The ratio of vol. of CO<sub>2</sub> produced to vol. of O<sub>2</sub> used is measured. This ratio is referred to as the respiratory quotient ( RQ).

## RQ of Carbohydrate



$$\text{RQ} = \frac{\text{QCO}_2}{\text{QO}_2} = \frac{6}{6} = 1$$

RQ of fat - tristearin



$$\text{RQ} = \frac{114}{163} = 0.7$$

- Proteins vary in their chemical structure and hence their RQ is very difficult to calculate.
- Indirect measurements give the RQ of 0.8 for most of the proteins.
- For a mixed diet the measurements give a RQ of 0.85. The RQ under basal conditions are estimated to be 0.82.
- The value of R.Q provides an approximate clue to the nature of the food stuffs being metabolized in the body.
- During decreased CO<sub>2</sub> elimination as in metabolic acidosis due to diabetes, kidney failure or alcoholism the R.Q is 0.8

# Daily calorie requirement

- It is estimated that the calorie requirement of a sedentary man is about 2,500 K.cal per day.
- The total calorie requirements are generally assessed by calculating, on the basis of BMR, surface area, the energy required to perform the usual patterns of activity during the day.
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- Correction for the energy value lost in the preparation of food and during digestion and absorption are made to the extent of 10% of the total energy value.
- The pattern of work usually varies and even the food intake of an individual alters from day to day.
- example – to include protein foods like \* eggs, meat, fish and granular\* foods. Fresh fruits and vegetables.