BASAL METABOLIC RATE

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OUTLINE

- **1. Calorific value**
- **2. Respiratory quotient**
- **3. Basal metabolic rate (BMR)**
- **4. Specific dynamic action (SDA)**

BODY WEIGHT

- Body composition is the proportion of muscle, bone, fat and other tissues that make up body weight.
- Achieving and maintaining a healthy weight is about managing energy balance and increasing the proportion of lean to fat tissue.
- Energy balance = energy in – energy out.

ENERGY BALANCE

- Energy in = calories consumed per day.
- Energy out = basal metabolic rate (BMR) + thermic effect of foods, + physical activity per day.
- Small increments in calories consumed per day or week can contribute to weight gain over time.

WHAT MAKES US EAT?

- Hunger: physiological need to eat
- **Appetite** initiates eating. It is a desire to eat that accompanies sight, smell or thought of appealing foods.
- Appetite is learned behaviour.

WHAT MAKES US STOP EATING?

- **Satiation**: the perception of fullness that gradually builds throughout a meal.
- When the stomach stretches, chemical messengers are sent to the brain to indicate fullness.
- The brain releases neurotransmitters that suppress food intake in response.
- Satiation occurs, the persons feels full and stops eating.

SATIETY

- **Satiety** continues to suppress hunger for several hours. Satiety determines the length of time between meals.
- Satiation tells the body when to stop eating, satiety allows the body to stay stopped for awhile.
- **Leptin,** a hormone produced by the adipose tissue, controls satiety.

SATIETY CONTINUED

- Protein foods most satiating
- CHO next especially if high in fibre
- Foods high in fat have low satiety.
- Overriding satiety and satiation cues leads to overeating.

NUTRITION & ENERGY

- **Energy content of foods**

  The calorific value (energy content) of a food calculated from the heat released by the total combustion of food in a calorimeter.

- **Unit of heat** : Calorie is the unit of heat. One calorie represents amount of heat required to rise the temperature of one gram of water by 1^0C

A calorie is too small a unit. Therefore, it is more conveniently expressed as kilocalories

ENERGY REQUIREMENT OF A NORMAL PERSON

- While calculating the energy requirements, we have to consider the energy required for:

i. Maintenance of basal metabolic rate (BMR)

ii. Specific dynamic action or thermogenic effect of food

iii. physical activities Extra energy expenditure.

- **i. The Basal Metabolic Rate (BMR) is the energy**
- required by an awake individual during physical, emotional and digestive rest. It is the minimum amount of energy required to maintain life or sustain vital functions like the working of the heart, circulation, brain function, respiration, etc. The metabolic rate during sleep is less than BMR.

- **ii. Resting metabolic rate (RMR) is the measure** of energy required to maintain life or vital functions. The subject is awake and non fasting.It is approximately about 3% higher than the BMR.

BMR

- Basal metabolic energy required to support the basic processes of life, including circulation, respiration, temperature maintenance, etc. It excludes digestion and voluntary activities.
- BMR constitutes the largest proportion (2/3) of a person's daily expenditure.

FACTORS THAT AFFECT BMR

- Age – BMR higher in youth. Lean body mass declines with age; physical activity can offset this effect.
- Height – tall people have larger surface area.
- Growth – children & pregnant women have higher BMR's

BMR CONTINUED

- Body composition – more lean tissue, higher BMR
- Fever – raises BMR
- Stress
- Environmental temperature
- Fasting/starvation, lowers BMR
- Malnutrition, lowers BMR
- Thyroxine – regulates BMR

MEASUREMENT OF BMR

- **i. Procedure: Atawater -Benedict-Roth basal metabolism**
- apparatus (closed circuit method) is used.
- The person should be awake, but at physical and mental rest. The temperature of surroundings should be comfortable (about 25˚C). The subject breathes in oxygen from a metal cylinder. The CO2 produced is absorbed in soda lime. The subject is asked to breathe through a mouthpiece for 6 minutes. The oxygen present in the cylinder is utilized during this time. The volume of oxygen consumed is recorded.

CALCULATION OF BMR

- **The BMR is calculated from oxygen** consumption, calorific value and surface area.

  Let oxygen consumed in 6 minutes be "Y" liters.

  calorific value of oxygen is 4.8, that is,

  when 1 liter of oxygen is utilized, 4.8 kilocalories are generated.

  Heat produced in 6 minutes = 4.8 × Y or

  Heat produced in 24 hours = 4.8Y × 10 × 24 kilocalories

- **Normal Value for BMR**
- **i. Since BMR is affected by body surface area, it is usually** expressed in kilocalories per hour/square meter of body surface. Body surface area is calculated using the formula (Eugene DuBois and Delafield DuBois, 1915).
- $A = W^{0.425} \times H^{0.725} \times 71.84$
- where A = area in sq cm,

  H = height in centimeters and

  W = weight in kilograms.
- The BMR is then calculated from the values of oxygen consumption, calorific value and surface area.

NORMAL VALUE FOR BMR

For adult men normal value for BMR is 34-37 kcal/square meter/hour, and

For adult women, 30-35 kcal/Sq.m./hour.

For easier calculations, BMR for an adult is fixed as **24 kcal/ kg body weight/day.**

- **SPECIFIC DYNAMIC ACTION(SDA)**
- **i. This refers to the increased heat production** or increased metabolic rate following the intake of food **(thermogenic effect of food) (dietinduced thermogenesis).**
- **ii. Part of this is due to the expenditure of energy** for digestion; absorption and active transport of products of the digestion.
- **iii. Another reason** for this expenditure of energy is that reserve materials such as glycogen, triacyl glycerol, protein, etc. are synthesized from small molecules available after digestion.
- Iv. SDA can be considered as the
- activation energy needed for a chemical
- reaction. This activation energy is to be
- supplied initially.

EXPLANATION OF SDA

- Suppose a person takes 250 g of carbohydrates;
- this should produce 250 × 4 = 1000 kcal. But before this energy is trapped, about 10% energy (=100 kcal) is drawn from the reserves of the body. Thus the net generation of energy is only 1000 minus 100 = 900 kcal.
- **If the person wants to get 1000 kcal, he should** take food worth 1100 kcal.

SPECIFIC DYNAMIC ACTION (THERMIC EFFECT OF FOOD)

- **Specific dynamic effect of food** – estimated energy used in digestion and absorption of food.
- **Diet induced thermogenesis** is ↑ energy due to ↑ in metabolic rate due to overeating
  - CHO 5-10%
  - Fat 0-5%,
  - Protein 20-30%
  - Alcohol 20%

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- **iii. This energy is trapped from previously** available energy, so that the actual energy from the food is lesser than that of theoretical calculation. SDA can be considered as the activation energy needed for a chemical reaction. This activation energy is to be supplied initially.

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  v. If the person wants to get 1000 kcal, he should take food worth 1100 kcal. Thus additional calories, equivalent to SDA have to be added in diet.

CALCULATED VALUES OF SDA

- The values of SDA are:
- **For proteins 30%,**
- **For lipids 15%, and**
- **For carbohydrates, 5%.**
- **For a mixed diet, 10%**

- This means that out of every 100 grams of proteins consumed, the energy available for doing useful work is 30% less than the calculated value.

PHYSICAL ACTIVITY AND ENERGY

- Most variable and changeable
- Voluntary
- It can be significant in weight loss and weight gain
- The energy requirements would depend on the occupation, physical activity and lifestyle of the individual

CLASSIFICATION OF PHYSICAL ACTIVITY

- **The activity level may be divided into 3** groups—sedentary, moderate and heavy. Additional calories are to be added for each category:

- **For sedentary work, +30% of BMR;**
- **For moderate work,** +40% of BMR; and
- **For heavy work**, +50% of BMR should be added .

- **iv. Requirement for energy**
- **During pregnancy is** +300 kcal/day, and
- **During lactation** is + 500 kcal/day, in addition to the basic requirements.

CALCULATION FOR ENERGY REQUIREMENT FOR A 55 KG PERSON, DOING MODERATE WORK

- **1)For BMR = 24 × 55 kg = 1320 kcal**

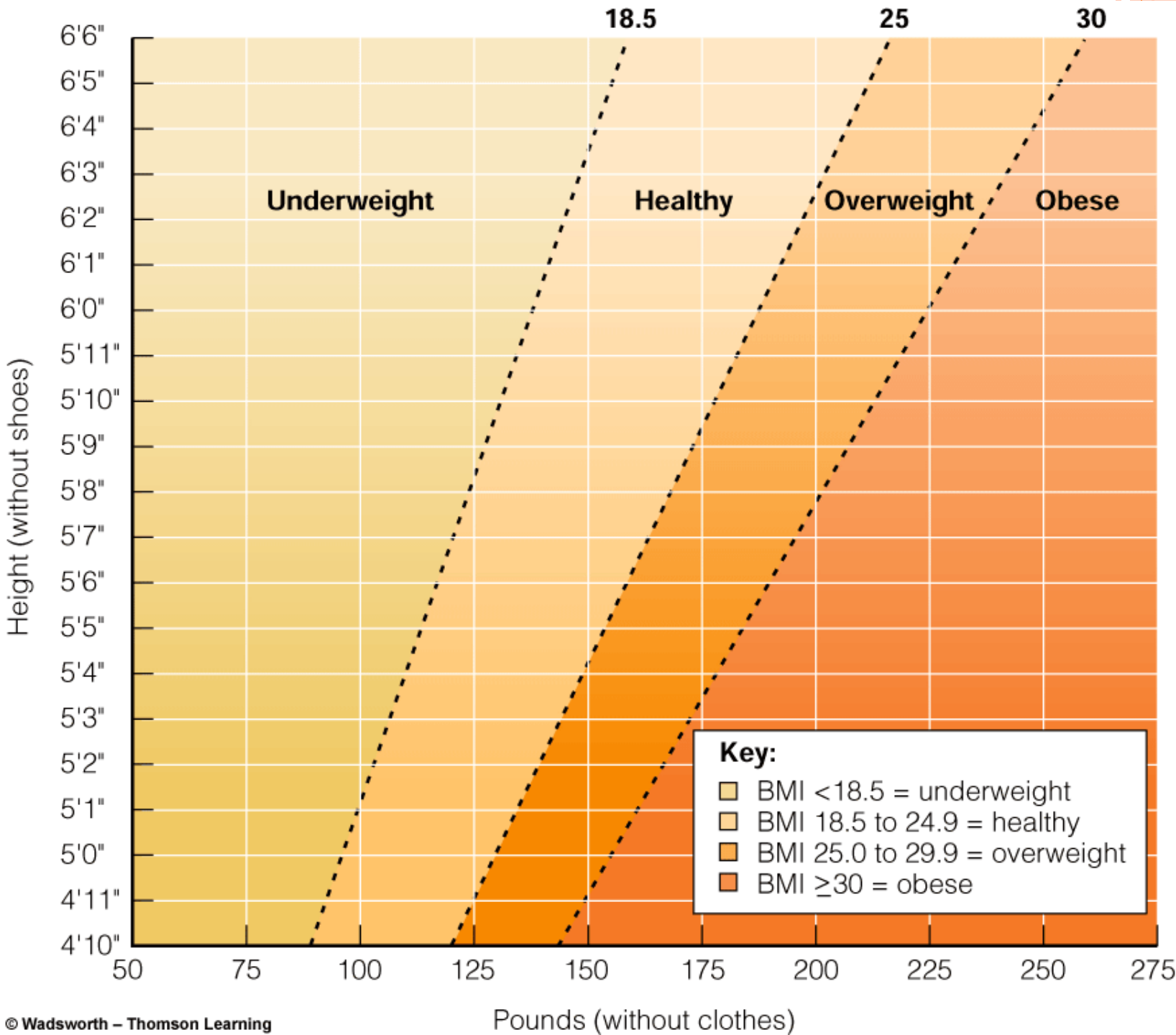
2)+ For activity = 40% of BMR = 528 kcal

3.Subtotal = 1320 + 528 = 1848 kcal

4)+ Need for SDA = 1848 × 10% = 184 kcal

5)Total = 1848 + 184 = 2032 kcal

BMI VALUES USED TO ASSESS WEIGHT



MEASURING WEIGHT & BODY FAT

- Weight for height tables
- Body Mass Index (BMI) weight in kgs divided by height in metres squared
- Waist to hip ratio/ waist circumference
- Anthropometric measures – skinfold tests
- Bioelectrical impedance
- Underwater weighing

ESTIMATING BODY FATNESS

- Anthropometry: skinfold measurements and waist circumference.
  - Skinfold test measures level of fat under skin at several places: triceps muscle, subscapular, suprailiac and back of the thigh. Measurements are added and compared to a standardized chart for men and women.
  - Waist measurement done with tape measure. Men 102 cm (40”) Women 88 cm (35”). Measure of visceral fatness and distribution of fat at abdomen.

ESTIMATING BODY FATNESS CONTINUED

- Underwater weighing – measures body density and volume. Lean tissue is denser than fat tissue, so the denser a person's body is the more lean tissue it contains.
- Bioelectrical impedance measures how a small, harmless electrical charge is conducted through the lean tissue of the body and reflects the body's contents of lean tissue and water.

ESTIMATING BODY FAT CONTINUED

- Combination of non-invasive measures of BMI with waist circumference gives a good overall estimate of body fat for most of the adult population under 65.
- Average body fat for men is 15% of body weight and 20% for women.
- Obesity when body fat exceeds 22% in young men, 25% in older men; 32% in younger women and 35% in older women. Age 40 dividing line between younger and older.

METHODS USED TO ASSESS BODY FAT

Fatfold measures estimate body fat by using a caliper to gauge the thickness of a fold of skin on the back of the arm (over the triceps), below the shoulder blade (subscapular), and in other places (including lower-body sites) and then comparing these measurements with standards.

Air displacement plethysmography estimates body composition by having a person sit inside a chamber while computerized sensors determine the amount of air displaced by the person's body.

Hydrodensitometry measures body density by weighing the person first on land and then again while submerged in water. The difference between the person's actual weight and underwater weight provides a measure of the body's volume. A mathematical equation using the two measurements (volume and actual weight) determines body density, from which the percentage of body fat can be estimated.

Dual energy X-ray absorptiometry (DEXA) uses two low-dose X-rays that differentiate among fat-free soft tissue (lean body mass), fat tissue, and bone tissue, providing a precise measurement of total fat and its distribution in all but extremely obese subjects.

Bioelectrical impedance measures body fat by using a low-intensity electrical current. Because electrolyte-containing fluids, which readily conduct an electrical current, are found primarily in lean body tissues, the leaner the person, the less resistance to the current. The measurement of electrical resistance is then used in a mathematical equation to estimate the percentage of body fat.

BODY FAT DISTRIBUTION

- Fat needed for fuel, insulation and protection of organs
- Fat assists in nerve impulse transmission
- Fat supports normal hormone activity
- Fat distribution –abdominal –central obesity- increases health risks
- apple versus pear shape

RISKS OF BEING UNDERWEIGHT

- Inadequate fat stores to support life in event of famine or illness.
- Low blood pressure
- Susceptibility to cold
- Anaemia in women

RISKS OF BEING OVERWEIGHT

- Increased risk of:
  - Cardiovascular disease
  - High blood pressure
  - Diabetes
  - Osteoarthritis
  - Sleep apnea
  - Gout, gallbladder disease, varicose veins
  - Abdominal hernias, complications in surgery and pregnancy.

BMI: HEALTH RISK FOR DIABETES, HYPERTENSION, HEART DISEASE

- <18.5 Underweight
- 18.5 – 24.9 Normal
- 25. – 29.9 overweight
- 30 – 34.9 class I obesity
- 35. – 39.9 class II obesity
- 40 or above class III obesity

- Lower BMI, greater risk to health
- Very low risk
- Increased risk/high risk
- High risk/very high risk
- Very high risk
- Extreme risk

OVERWEIGHT VERSUS OVERFAT

- BMI not suitable for athletes. Muscle weights more than fat, therefore may be classified as overweight but have lots of muscle not fat.
- Pregnant & lactating women
- Adults over 65, (shrink with age)

CAN YOU BE OVER-FAT AND HEALTHY?

- Yes, if you are fit.
- Physical fitness improves cardiovascular health –circulation and blood lipids; lowers blood sugar, decreases hypertension and strengthens muscles including the heart.
- Cardiovascular fitness may be more important than body weight in maintaining health.

WHY DO PEOPLE GET FAT?

- Overeating
  - Availability of food
  - Eating out
  - Portion distortion
- Physical inactivity
- Genetics

PREFERENCE FOR HIGH-FAT FOODS

- Fat delivers 2 x the calories of protein or CHO
- Fat is stored preferentially by the body and with great efficiency
- Of the 3 energy nutrients, fat stimulates the least energy expenditure in diet thermogenesis.
- Of the 3 energy nutrients, fat is the least satiating thus leading to over-consumption.

PHYSICAL INACTIVITY

- Overweight people spend more energy in daily activities than normal weight people, however, engage in less physical activity.
- Physical activity burns calories, builds lean tissue which is more metabolically active so assists with weight loss.
- One study found that TV watching increases obesity in children by 2% per hour of watching TV per day.
- One study found that watching TV expends less energy than doing nothing!

GENETIC CAUSES

- Genetics affect tendency to obesity.
  - 1 parent overweight -60% chance of offspring becoming overweight.
  - 2 parents overweight – 90% chance for offspring
  - Supported by studies on twins raised apart, & adopted children who weigh similar to biological parents.

GENETIC FACTORS

- Leptin –protein that acts as hormone to increase energy expenditure and decrease appetite.
- Ghrelin – protein that acts like hormone to decrease energy expenditure and increase appetite
- Uncoupling proteins –white fat/brown fat

LEPTIN

- Leptin suppresses neurotransmitter NPY, the strongest appetite stimulator in the brain.
- Injections of leptin to reduce obesity?
- No. Most obese people already have high levels of leptin, only a very few do not produce leptin.

LEPTIN CONTINUED

- As body fat increases and leptin increases, the brain's receptors may become less receptive to leptin
- Leptin has other roles: e.g., may inform the female reproductive system about fat reserves, stimulates growth of new blood vessels, acts on bone marrow cells to enhance their maturation into specialized cells, etc. Therefore, cannot inject leptin freely.

SET-POINT THEORY

- The theory that the body tends to maintain a certain weight by means of its own internal controls. Appetite and satiety regulators are manipulated by the body to maintain a specific weight.
- Enzyme theory: LPL or **lipoprotein lipase** enables fat cells to store triglycerides. Concentrations of LPL increase as fat cells become enlarged with fat.

BEHAVIOURAL CAUSES OF OBESITY

- External cue theory: people override signals of satiety and hunger when presented with circumstances that stimulate them to do so. E.g., going into a chocolate shop; friend offering bag of chips. People eat even though not hungry.
- Stress can trigger over-eating
- Poor self-esteem can trigger over-eating

SOCIAL CONSEQUENCES OF OBESITY

- Prejudices and discrimination
- Judged on appearance rather than character or ability
- Stereotyped as lazy and lacking self-control

KETONE BODIES

- Are acidic compounds derived from fat and certain amino acids that can be used by the brain for energy when CHO not available.
- After about 10 days, the brain and nervous system can meet most of their energy needs from ketones.
- Ketones are toxic to system and must be removed in the urine.