Ahl Al Bayt University
College of Medical & Health Technologies
Department AnesthesiaTechniques and laser
Medical Physics/ First Stage
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Third Lecture

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Energy, work and power of the body.

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What we study in this lec.:

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By Ass. Lec. Maher Hadi

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- Energy Metabolism (BMR) Unit of energy
- Factors affecting basal metabolic rate
- Energy Expenditure
- Components of Daily Energy Expenditure
- Energy Changes In The Body:

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• Factors affecting basal metabolic rate
• Energy Expenditure
• Components of Daily Energy Expenditure
· Energy Changes In The Body:

Energy: is defined as the ability to do work

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- The body is constantly using energy to perform tasks such as breathing, digesting food, and maintaining a constant body temperature.

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- This energy is obtained from the food we consume, which is converted into chemical energy through a process called metabolism.

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All activities in the body, including energy changes.

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The body uses the food energy to:

The body uses the food energy to:

1-Operate its different organs.

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2-Keep a constant body temperature.

2-Keep a constant body temperature.

3-Do external work.

3-Do external work.

Metabolism (BMR): is the set of biochemical reactions that occur in the

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body to maintain life and sustain bodily functions.

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- Factors affecting basal metabolic rate:

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1. **Basal metabolic rate depends on the function of the thyroid gland.** A person with hyperthyroidism has a higher basal metabolic rate

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than a person with normal thyroid function.

than a person with normal thyroid function.

2. **Basal metabolic rate is related to the surface area or mass of the body.** The energyused in basal metabolism is converted into heat

2. Basal metabolic rate is related to the surface area or mass of the body. The energyused in basal metabolism is converted i

that is dissipated from theskin.

that is dissipated from theskin.

3. **Metabolic rate depends largely on body temperature.**

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Any energy that is left over is stored as body fat.

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Mifflin-St Jeor Equation

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This equation is used to estimate the Basal Metabolic Rate (BMR), which is the number of calories the body needs at rest to maintain basic physiological functions such as breathing and circulation.

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Formula:

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1. **For Men:**

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$$\mathrm{BMR}=10\times \textbf{mass}\ (\mathrm{kg})+6.25\times \mathrm{height}\ (\mathrm{cm})-5\times \mathrm{age}\ (\mathrm{years})+5\,BMR=10\times \mathrm{weight}\ (\mathrm{kg})+6.25\times \mathrm{height}\ (\mathrm{cm})-5\times \mathrm{age}\ (\mathrm{years})+5$$

BMR=10× mass (kg)+6.25×height (cm)·5×age (years)+5BMR=10×weight (kg)+6.25×height (cm)·5×age (years)+5

2. **For Women:**

2. For Women:

$$BMR=10\times \textbf{mass}\ (\mathrm{kg})+6.25\times \mathrm{height}\ (\mathrm{cm})-5\times \mathrm{age}\ (\mathrm{years})-161$$

BMR=10× mass (kg)+6.25×height (cm)·5×age (years)·161

Mifflin-St Jeor Equation

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2. **For Women**

2. For Women:

$$BMR=10\times\ \mathbf{mass}\ \text{(kg)}+6.25\times \text{height (cm)}-5\times \text{age (years)}-161$$

BMR=10× mass (kg)+6.25×height (cm)·5×age (years)·161

Example1: Calculate the basal metabolic rate (BMR) using the Mifflin-St. Jour equation for a 30-year-old man, weighing 70 kg and standing 175 cm tall.

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Solution:

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Gender: Male // ((**mass**: 70 kg) //(Height: 175 cm)//(Age: 30 years))

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$$\mathbf{BMR=10\times\ mass\ (kg)+6.25\times height\ (cm)-5\times age\ (years)+5}$$

BMR=10× mass (kg)+6.25×height (cm)·5×age (years)+5

$$BMR=(10\times70)+(6.25\times175)-(5\times30)+5 \longrightarrow (700)+(1093.75)-(150+5\ )$$

BMR=(10×70)+(6.25×175)·(5×30)+5 (700)+(1093.75)·(150+5)

BMR ≈ 1649 calories/day (approximately) This is your basal metabolic rate (calories your body burns at rest).

BMR · 1649 calories/day (approximately) This is your basal metabolic rate (calories your body burns at rest).

Example2:

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Calculate the Basal Metabolic Rate (BMR) using the Mifflin-St Jeor equation for a 30-year-old woman, weighing 70 kg and standing 175 cm tall.

Calculate the Basal Metabolic Rate (BMR) using the Mifflin-St Jeor equation for a 30-year-old woman, weighing 70 kg and standing 175 cm tall.

Solution: Gender: feMale // ((**mass**: 70 kg) //(Height: 175 cm)//(Age: 30 years))

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Equation for Women:

Equation for Women:

$$BMR=10\times \textbf{mass} \text{ (kg)}+6.25\times\text{height (cm)}-5\times\text{age (years)}-161$$

BMR=10× mass (kg)+6.25×height (cm)·5×age (years)·161

$$BMR=(10\times70)+(6.25\times175)-(5\times30)-161$$

BMR=(10×70)+(6.25×175)·(5×30)·161

$(700+1093.75)=\mathbf{1793.75}$ → $\mathbf{1793.75}-150=\mathbf{1643.75}$ → $\mathbf{1643.75}-161$

)700+1093.75(=1793.75 1793.75·150=1643.75 1643.75·161

BMR≈1483 kcal/day

BMR·1483 kcal/day

This reflects the natural physiological differences in body composition, as men generally have a higher muscle mass and a higher basal metabolic rate compared to women of the same weight, height, and age.

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Unit of energy

Unit of energy

- \- A convenient unit for expressing the rate of energy consumption of the body is the met. The met is defined as 50 kcal/m^2 of body surface area per hour.

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defined as 50 kcal/m2 of body surface area per hour.

- \- The most widely accepted physics units for energy is Newton-meter or joule (J).

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- **summarized as follows:**

· summarized as follows:

1 kcal = 4184 J

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1 J = 107 ergs

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1 kcal/hr = 1.162 W

1 kcal/hr = 1.162 W

1 met = 50 kcal/m^2

1 met = 50 kcal/m2

$$1 \frac{\text{kcal}}{\text{min}} == 69.7 \text{ W}$$

1
== 69.7 W

Example:1

Example:1

Convert **2 kilocalories (kcal)** to **joules (J).**

Convert 2 kilocalories (kcal) to joules (J).

Solution:

Solution:

We know the conversion factor:

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2kcal=2×4184=8368J.

2kcal=2×4184=8368J.

Example:2

Example:2

Convert 5000 joules (J) to kilocalories (kcal).

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Sol: We know that: 1 kilocalorie (kcal) = 4184 joules (J).

···: We know that: 1 kilocalorie (kcal) = 4184 joules (J).

To convert from joules to kilocalories, divide the number of joules by 4184.

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$$4184 \quad \frac{5000}{4184} \approx 1.195$$

kcal

kcal

The first law of thermodynamics can be written as

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$$\Delta U = \Delta Q - \Delta W$$

·· = ·· - · W

Where, ΔU Is the change in stored energy.

Where, ·· Is the change in stored energy.

ΔQ Is the heat lost or gained.

·· Is the heat lost or gained.

ΔW Is the work done by the body

·· Is the work done by the body

Work of the body

Work of the body

From the description of energy (ability to do work), we can conclude that where energy

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resides, there is an ability to do work. Therefore, because cells of the body store energy,

resides, there is an ability to do work. Therefore, because cells of the body store energy,

they can do work.

they can do work.

The internal energy stored (ΔU) during break down of a molecule can do work (ΔW)

The internal energy stored (··) during break down of a molecule can do work (·W)

and release heat (ΔQ) which can be given according to the first law of thermodynamics

and release heat (·Q) which can be given according to the first law of thermodynamics

as follows:

as follows:

change in stored energy in the body = heat lost or gained – work done by

change in stored energy in the body = heat lost or gained · work done by

(i.e. food energy, body fat and body heat) of the body

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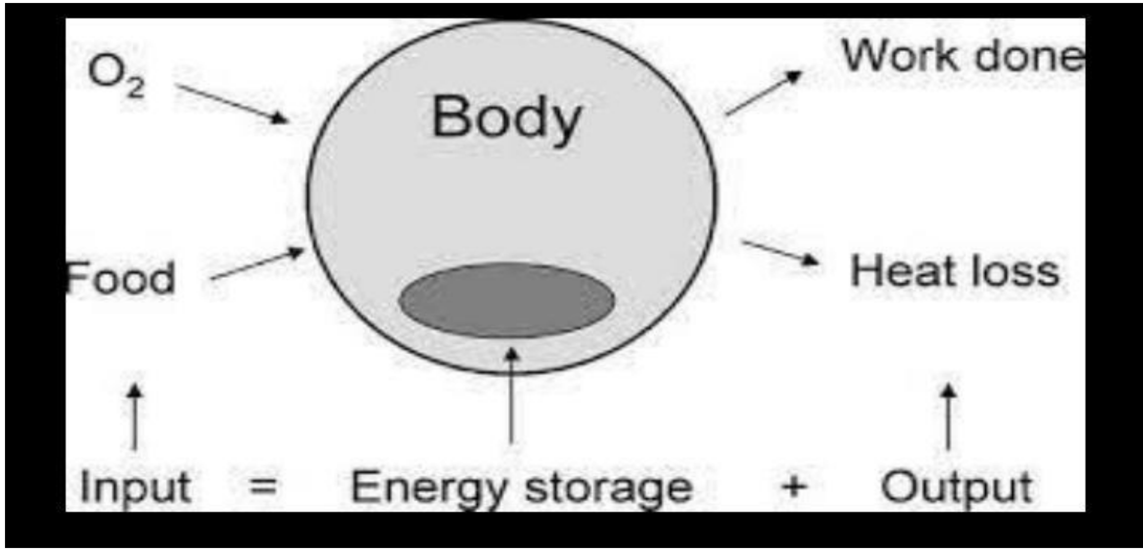
الطاقة واستهلاكها في الجسم



Energy in the Human Body

Energy in the Human Body

What is Energy Expenditure?

What is Energy Expenditure?

The amount of energy used for vital functions & physical

The amount of energy used for vital functions & physical

activities (measured in kcal).

activities (measured in kcal).

Key Factors:

Key Factors:

- Physical activity level

· Physical activity level

- Body weight & composition

· Body weight & composition

- Intensity & duration of activity

· Intensity & duration of activity

Forms of Energy in the Body:

Forms of Energy in the Body:

- Potential Energy (stored: chemical, gravitational)

· Potential Energy (stored: chemical, gravitational)

- Kinetic Energy (motion: muscle work, circulation)

· Kinetic Energy (motion: muscle work, circulation)

Components of Daily Energy Expenditure
Components of Daily Energy Expenditure

The Three Pillars of Energy Expenditure
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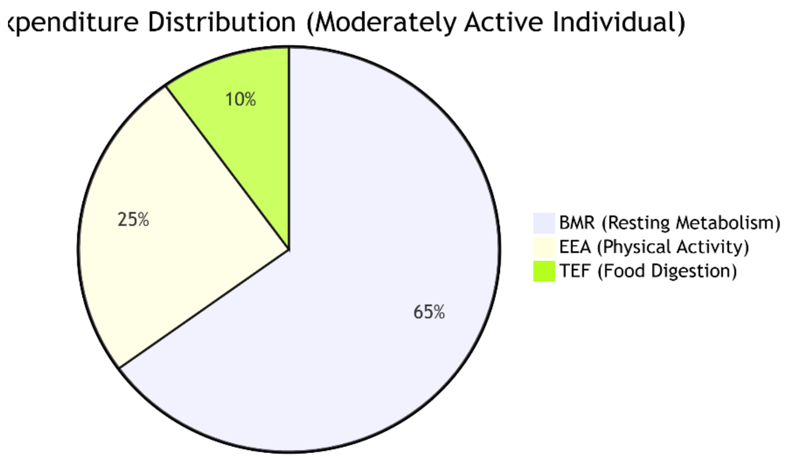
1. Basal Metabolic Rate (BMR) / Resting Metabolic Rate (RMR)
1. Basal Metabolic Rate (BMR) / Resting Metabolic Rate (RMR)



60-70% of total daily energy expenditure
60-70% of total daily energy expenditure

Energy used for essential life functions at complete rest:
Energy used for essential life functions at complete rest:

- Maintaining body temperature
· Maintaining body temperature
- Powering vital organs (heart, lungs, brain)
· Powering vital organs (heart, lungs, brain)
- Cell repair and regeneration
· Cell repair and regeneration
- Basic neurological functions
· Basic neurological functions

2. Thermic Effect of Food (TEF)
2. Thermic Effect of Food (TEF)

Approximately 10% of total daily energy expenditure
Approximately 10% of total daily energy expenditure

Energy required to digest, absorb, and process nutrients:
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• Chewing and swallowing 2• Enzyme production 3• Nutrient absorption & transport 4• Storing excess energ
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3. Energy Expenditure of Activity (EEA)
3. Energy Expenditure of Activity (EEA)

20-30% of total daily energy expenditure (most variable component)
20-30% of total daily energy expenditure (most variable component)

The Complete Energy Equation
The Complete Energy Equation

Total Daily Energy Expenditure (TDEE) Formula:
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TDEE=BMR+TEF+EEATDEE=BMR+TEF+EEA
TDEE=BMR+TEF+EEATDEE=BMR+TEF+EEA

➢ Energy expenditure rates in the body's organs at rest

· Energy expenditure rates in the body's organs at rest

- Under resting conditions about 25% of the body’s energy is being used by the skeletal muscles and the heart,

· Under resting conditions about 25% of the body·s energy is being used by
the skeletal muscles and the heart,

- 19% Is Being Used By The Brain,

19% Is Being Used By The Brain,

- 10% Is Being Used By The Kidneys, And

10% Is Being Used By The Kidneys, And

- 27% Is Being Used By The Liver And The Spleen.

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- . A Small Percent Of About 5% Of Food Energy Being Excreted In Feces And Urine

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Methods of Measuring Energy Expenditure

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- Heart rate monitors.

Heart rate monitors.

- Activity trackers (e.g., smartwatches).

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- Respiratory Gas Analysis:

Respiratory Gas Analysis:

- Measuring oxygen consumption to determine metabolic rate during activity.

Measuring oxygen consumption to determine metabolic rate
during activity.

H.W

H.W

Question 1: **Calculating Basal Metabolic Rate (Mifflin-St Jeor Equation) Problem: Calculate the Basal Metabolic Rate (BMR) for each of the following two cases: Case A: A 35-year-old man, weighing 80 kg, and 180 cm tall Case B: A 28-year-old woman, weighing 65 kg, and 165 cm tall**

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Question2: **An energy drink label states that it provides 85,000 Joules of energy. Calculate how many kilocalories (kcal) this is equivalent to, using the conversion?**

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