Basal metabolism

Introduction

- BMR – basal metabolic rate
- Minimal caloric necessity to ensure the basic vital function in resting state
  - Breathing, circulation, body temperature
  - The amount of energy [calories, jouls], which a man uses if he lay down whole day
- 70% of daily energy expenditure
  - Depends on several conditions

Basal metabolism

- The amount of energy which is needed to ensure the basic functions during basal conditions:
  - Awakened, psychic and physical rest
  - Postabsorbtive time – SDE of food
  - Termoneutral zone - 18-22 °C
  - Body normal temperature

Influence on basal metabolism

- Genetic factors
- Gender
- Age
- Body weight
  - % of fat
- Body surface
- Diet
- Body temperature
- Hormons
- Exercise and physical activity

How to count basal metabolism

- William McArdle a Frank Katch
- Total daily energy expenditure (TDEE)
- Women - 2000-2100 calories/day
- Men - 2700-2900 calories/day
- Athletes – up to 6000 calories/day

- Several methods
  - Quick, Harris-Benedict equation,Katch-McArdle equation, calorimetric methods (direct, indirect)

Quick method

- Fast method based only on body weight
- **Lose weight** = 22 - 26 kcal/kg
- **Basal** (TDEE) = 30- 32 kcal/kg
- **Gain weight**: = 36- 40 kcal/kg
- Inaccurate in extreme values

Equations based on factors

- BMR
  - State when all necessary vital functions are ensured – such is circulation, breathing, digesting, formation of new cells, etc.
  - It considers age, gender, weight, height x
  - x factor of physical activity =
  - = TDEE
    - total daily energy expenditure

Harris-Benedict equation (BMR based on total body weight)

- Men: BMR = 66 + (13.7 x weight [kg]) + (5 x height [cm]) - (6.8 x age [years])
- Women: BMR = 655 + (9.6 x weight [kg]) + (1.8 x height [cm]) - (4.7 x age [years])
    - x factor of physical activity

Factor of physical activity

- Sitting = BMR x 1.2
  - (little or none work)
- Light = BMR x 1.375
  - (light work or sport 1-3 days/week)
- Medium/Moderate = BMR x 1.55
  - (3-5 days/week)
- Heavy = BMR x 1.725
  - (6-7 days/week)
- Extreme = BMR x 1.9 (heavy daily work/sport – exercise e.g. 2 times a day,maraton, competition)

BEE Correction Factors for Physical Activity and Clinical Status

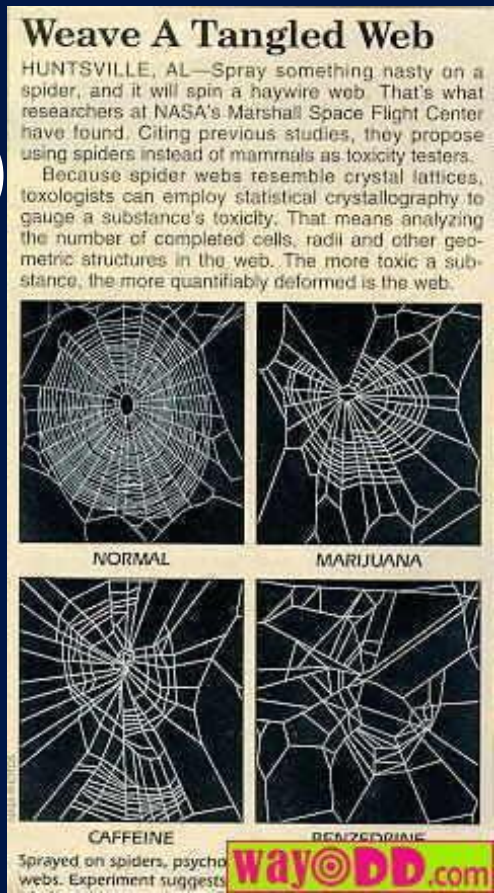
Physical activity	*Factor*	*Clinical state*	*Factor*
Resting in bed	1.2	Febrility	1.0 + 0.13/°C
Resting out of bed	1.3	Elective surgery	1.0-1.1
Tremor	1.3	Peritonitis	1.2-1.5
Quadruparesis	0.8	Trauma of soft tissues	1.1-1.4
Paralysis	0.9	Multiple fracture	1.2-1.4
Hemiparesis	1.2-1.3	Closed wound of smooth muscles	1.5-1.8
		sepsis/heavy infection	1.4-1.8
		Cancer	1.1-1.3
		COPD	1.2-1.3
		Burns	1.5-2.0
		AIDS	1.5-1.8

Example

- Women, 30 years, 167,5cm, 54,5kg

- BMR = 655 + (9.6 x 54,5 kg) + (1.8 x 167,5 cm) - (4.7 x 30 years)
  = 655 + 523 + 302 - 141
  = **1339 kcal/day**

- 1,2 x 1339 = **1606,8 kcal/day**



Katch-McArdle equation (BMR based on net weight)

- **BMR (men and women) = 370 + (21,6 x net weight [kg])**
- Net weight = muscle weight

Example

- Women, 54,5 kg, 20% fat
  - Net weight is 43,6 kg

- BMR = 370 + (21,6 X 43,6)
  = **1312 kcal**

- Factor of physical activity - 1,2
  TDEE = 1,2 x 1312 = **1574 kcal**

Indirect calorimetry – metabolic consumption

- One of the most accurate methods
- REE
  - resting energy expenditure
  - Measures the energy expenditure when resting – basal metabolism
  - Consumption of O_2 vs. expense of CO_2

REE (kcal/day) = [3,9 (VO_2) + 1,1 (VCO_2)] x 1,44

- VO_2 = oxygen consumption [mL/min]
- VCO_2 = expense of carbon dioxide [mL/min]

Fick equation

- The most accurate method, used in ICU patients
  - The need for Swan catheter to arteria pulmonalis

- $CaO_2 - CvO_2 = 1{,}39 \times Hb(g/dL) \times (SaO_2 - SvO_2)$
  - CaO_2 and CvO_2 – content of oxygen in arterial and venous blood [ml/dl]
  - SaO_2 and SvO_2 – saturation with oxygen in arterial and venous blood [fraction...%]

- $VO_2 = [(CaO_2 - CvO_2)] \times 10 \times SV$ [L/min]
- VO_2 [mL/min] x 7 = 24 hod energy expenditure [kcal/day]

Example

- Women, wiht Hb 10,5 g/dL, $SataO_2$ 96%, $SatvO_2$ 65%, heart rate 70 bpm, stroke volume 70ml

- $CaO_2 - CvO_2 = 1,39 \times Hb\ (g/dL) \times (SaO_2 - SvO_2)$
  - $CaO_2 - CvO_2 = 1,39 \times 10,5 \times (0,96 – 0, 65)$
    $= 4,52\ mL/dL$
- $VO_2 = [(CaO_2 - CvO_2)] \times 10 \times SV\ [L/min]$
  - $4,52 \times 10 \times 4,9$
    $= 221,48\ mL/min$
- $VO_2\ [mL/min] \times 7$
  - $221,48 \times 7$
    $=$ **<u>1550,36 kcal/24 hrs</u>**

Energy metabolism

- The amount of energy consumed in a unit of time [kJ, kcal/24hrs]

- *Direct calorimetry* {measuring heat production}
  - Energetic value of food = combustible heat is the amount of heat released after 1g of substance is burnt

- *Indrect calorimetry* {O_2,CO_2}
  - Closed method of Krogh metabolimeter
  - Opened method of Douglas analysis of O_2,CO_2 in expired air
- **Energetic equivalent** of O_2 [EE] is the amount of energy, which is released when 1 L of O_2 is consumed. It depednd on the type of oxiding nutritients
- **Respiratory quotient RQ** = VCO_2/VO_2
- 1kcal = 4,185 kJ

Practicals

- Basal metabolism