Assessing Basal Metabolic Rate in Humans using Indirect Calorimetry

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Daily Energy Expenditure

- **Food Energy**
  - Assimilated Energy
    - Metabolisable Energy
      - Energy Stores (Fat)
      - Glucose
      - Fatty Acids
      - Amino Acids
  - Feces
  - Urine
  - Microbial Heat Dissipation
  - Specific Dynamic Action
    - Basal Metabolic Rate 60-80%
    - Adaptive Thermogenesis 10%
  - Growth
  - Physical Activity 10-30%
  - Adaptive Thermogenesis 10%
Bomb Calorimetry
Basal Metabolic Rate

*Energy to maintain the body function at rest and all vital functions!*

**Definition**

- Postabsorptive (10-12h after last meal)
- Normotherm (Tb ~ 37°C)
- Thermoneutral
- Resting (lying on back)
- No stress, no excitement
- Awake
Relative contribution of organs to BMR

Gallagher et al. 1998
How to measure Resting Metabolic Rate

Direct Calorimetry

• Heat production
  • Bomb calorimetry

Indirect Calorimetry

• Food intake / waste
  • Double labeled water
  • Respirometry
Ice Calorimeter

Leplace and Lavoisier 1780

“Respiration is thus a very slow combustion phenomenon, very similar to that of coal; it is conducted inside the lungs, not giving off light, since the fire matter is absorbed by the humidity of the organs of the lungs. Heat developed by this combustion goes into the blood vessels which pass through the lungs and which subsequently flow into the entire animal body.”
Indirect Calorimetry

Output
RQ, O₂, CO₂

Computer

Gas analyzer
O₂ and CO₂

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Respiratory Quotient (RQ)

**Definition**

Proportion between consumed oxygen \((O_2)\) and produced carbon dioxide \((CO_2)\)

\[
RQ = \frac{V_{CO_2} \ (l/min)}{V_{O_2} \ (l/min)}
\]

The RQ is specific for each metabolized substrate, due to different biochemical characteristics!
Respiratory Quotient to determine the utilized substrate

- Carbohydrates = 1
- Proteins = 0.8
- Fat = 0.7

RQ decreases with dietary fat content!

Schrauwen et al. 1997
Impact of gut microbiota, liver metabolism and PBMC activity on energy expenditure

Part I
Gut microbiota

Part II
Organ-specific metabolic rates

Part III
Mitochondrial activity of Peripheral Blood Mononuclear Cells (PBMCs)
Brain and high metabolic rate organ mass: contributions to resting energy expenditure beyond fat-free mass\textsuperscript{1–4}

Fahad Javed, Qing He, Lance E Davidson, John C Thornton, Jeanine Albu, Lawrence Boxt, Norman Krasnow, Marinos Elia, Patrick Kang, Stanley Heshka, and Dymphna Gallagher

<table>
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<th>Variable</th>
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$\rightarrow$ 30% of the variability in REE are unexplained
Impact of gut microbiota, liver metabolism and PBMC activity on energy expenditure

Part I
Gut microbiota

Part II
Organ-specific metabolic rates

Part III
Mitochondrial activity of Peripheral Blood Mononuclear Cells (PBMCs)
Part I – Fecal Microbiome and Basal Metabolic Rate (BMR)

An obesity-associated gut microbiome with increased capacity for energy harvest

Peter J. Turnbaugh¹, Ruth E. Ley⁴, Michael A. Mahowald¹, Vincent Magrini⁴, Elaine R. Mardis¹,² & Jeffrey I. Gordon¹

Human gut microbes associated with obesity

Ruth E. Ley, Peter J. Turnbaugh, Samuel Klein, Jeffrey I. Gordon
Washington University School of Medicine, St Louis, Missouri 63108, USA
e-mail: jgordon@wustl.edu

Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa

Carlotta De Filippo⁵, Duccio Cavalieri⁶, Monica Di Paola⁶, Matteo Ramazzotti⁵, Jean Baptiste Poullet⁶, Sebastien Massart⁶, Silvia Collini⁵, Giuseppe Pieraccini⁷, and Paolo Lionetti⁵,⁶

The gut microbiota as an environmental factor that regulates fat storage

Fredrik Bäckhed⁵,⁸, Hao Ding⁵, Ting Wang⁵, Lora V. Hooper⁵,⁸, Gou Young Koh⁵, Andras Nagy⁵,⁸, Clay F. Semenkovich⁵,⁸, and Jeffrey I. Gordon⁵,⁸
Human gut microbes associated with obesity

Ruth E. Ley, Peter J. Turnbaugh, Samuel Klein, Jeffrey I. Gordon
Washington University School of Medicine, St Louis, Missouri 63108, USA
e-mail: jgordon@wustl.edu
Summary Part I

- Gut microbiota is influenced by dietary habits
- Increased ratio of Firmicutes to Bacteroidetes in obese people
- Increase in fat mass by colonization of germ-free mice
- Recipients colonized with bacteria from obese compared to lean donors gained more body fat

Hypothesis I

Individual differences in gut microbiota composition affect the BMR
Brain and high metabolic rate organ mass: contributions to resting energy expenditure beyond fat-free mass\textsuperscript{1-4}

Fahad Javed, Qing He, Lance E Davidson, John C Thornton, Jeanine Albu, Lawrence Bost, Norman Krasnow, Marinos Elia, Patrick Kang, Stanley Heshka, and Dymphna Gallagher

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\( \rightarrow \) 25% of the variability in REE are unexplained
Summary Part II

- 70% of BMR variation is explained by sex, age, race, lean mass and fat mass
- Additionally 5% variation of BMR can be explained by HMRO
- Organ metabolic activity may vary between the subjects

Hypothesis II

Specific metabolic activity of liver is associated with the variation of BMR
Part III: Respiratory Capacity of Peripheral Blood Mononuclear Cells (PBMCs) and BMR

Hypothesis III

Oxygen consumption rate of PBMCs correlates with BMR
Thank’s for your attention

AG Klingenspor

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