Estimation of metabolism in nutritional assessment

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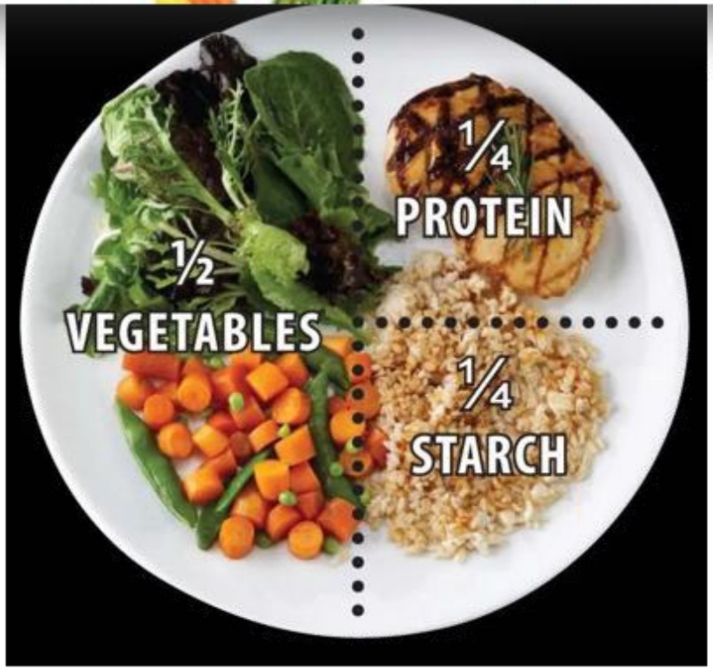
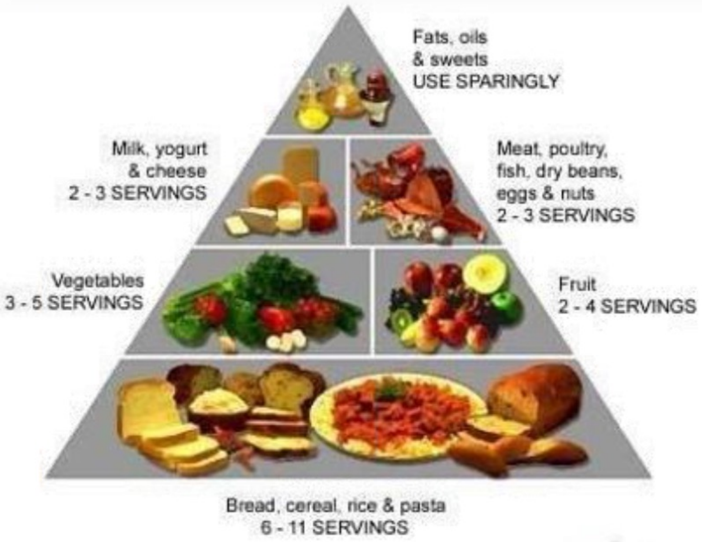
What should I eat?

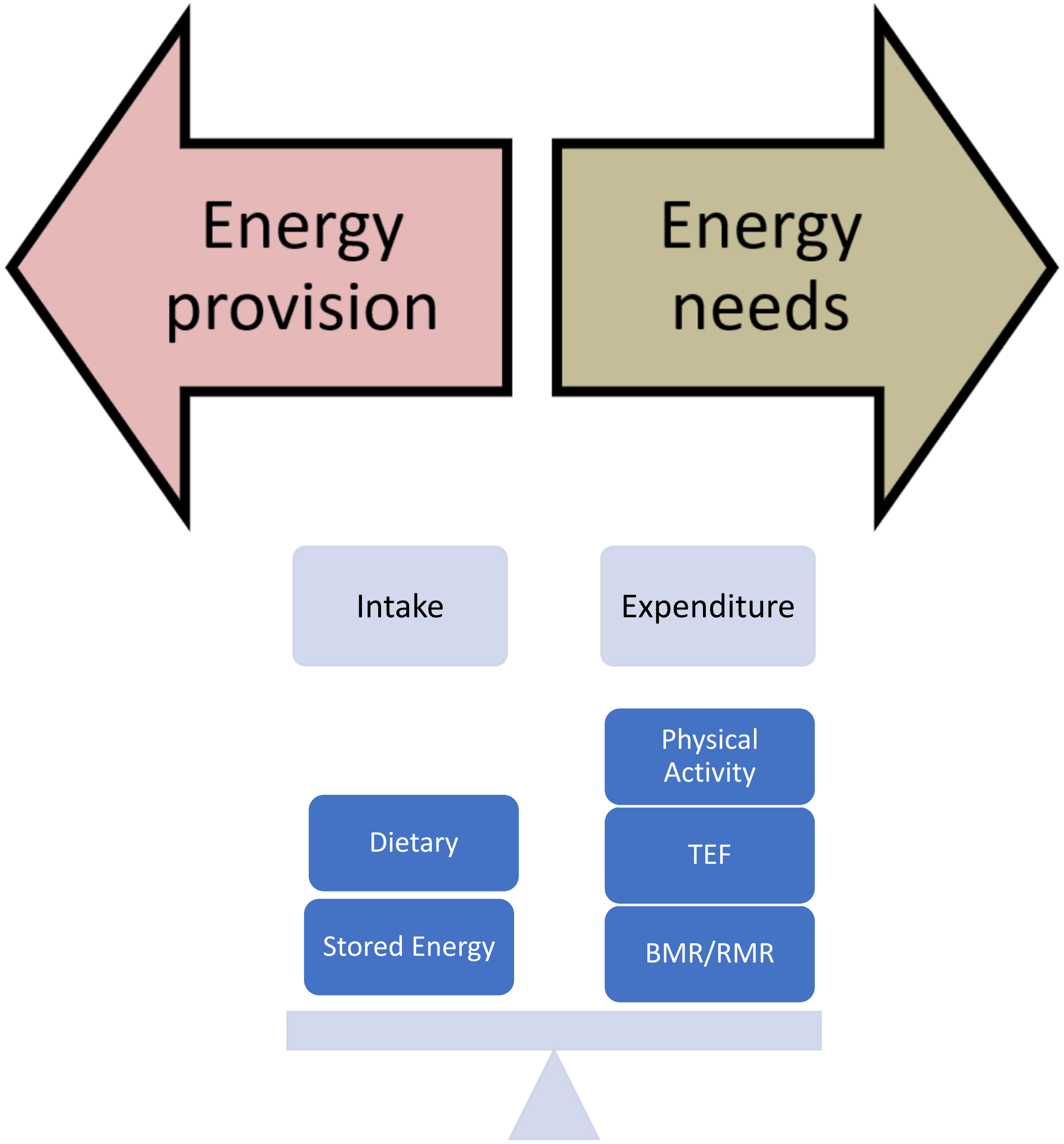




How much should I eat?

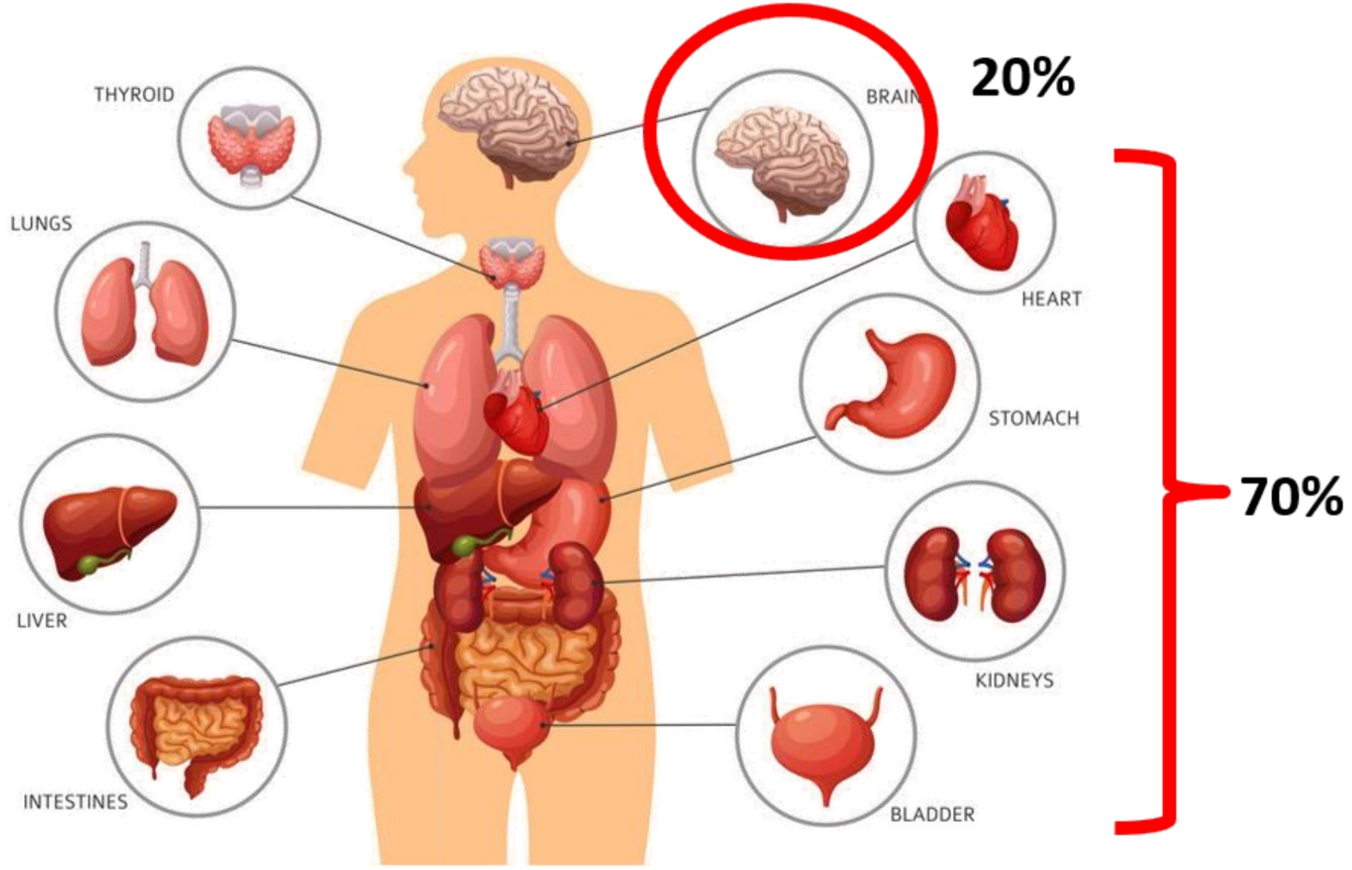
" I ate a burger.."

How much should I eat?



Why should we care about energy?

Utilization of energy in humans



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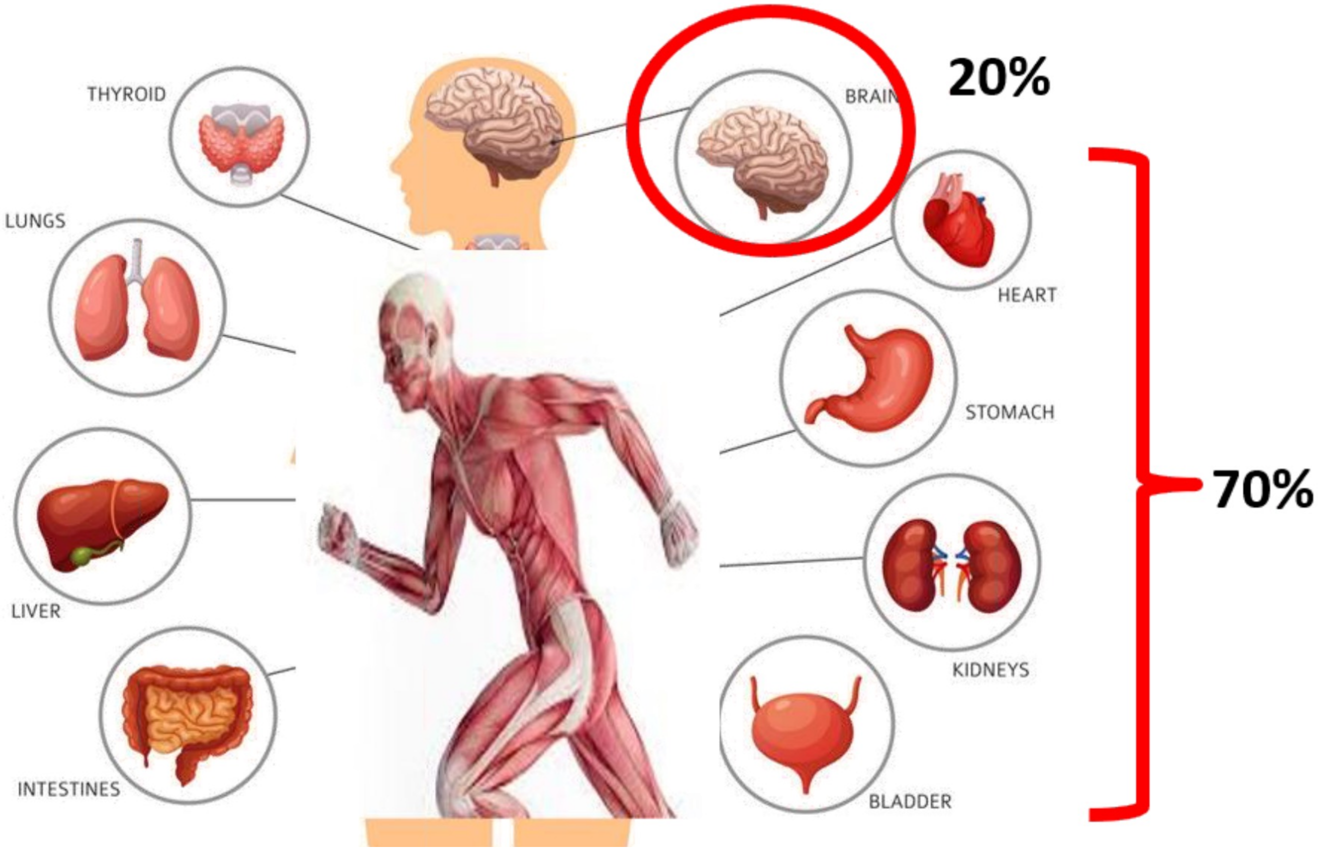
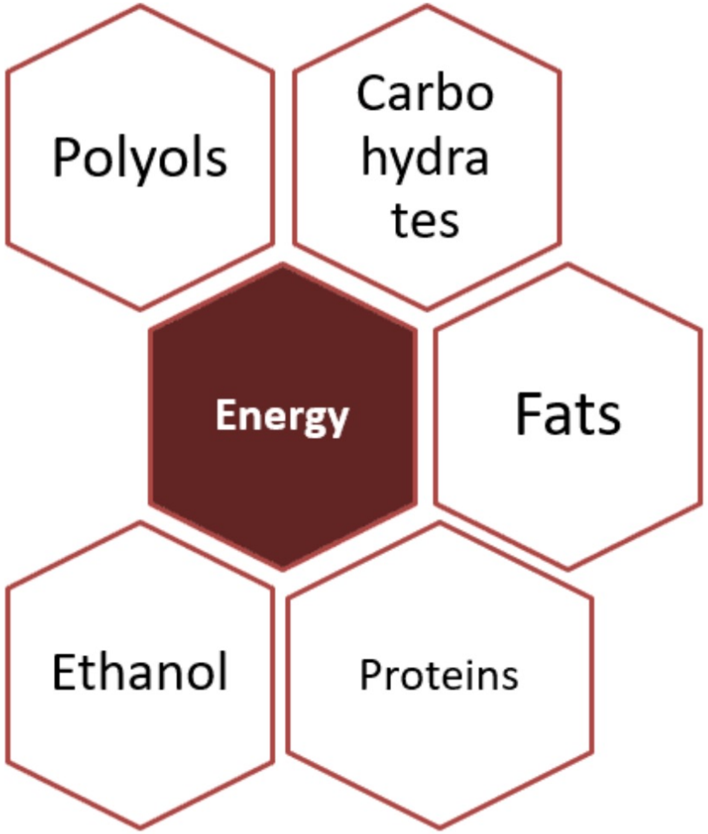


Where do we get energy?

- Energy in animals and humans derive from food and is obtained through the process of cellular respiration with or without requirement of oxygen



Alberts et al, Mol Biol cell 2002

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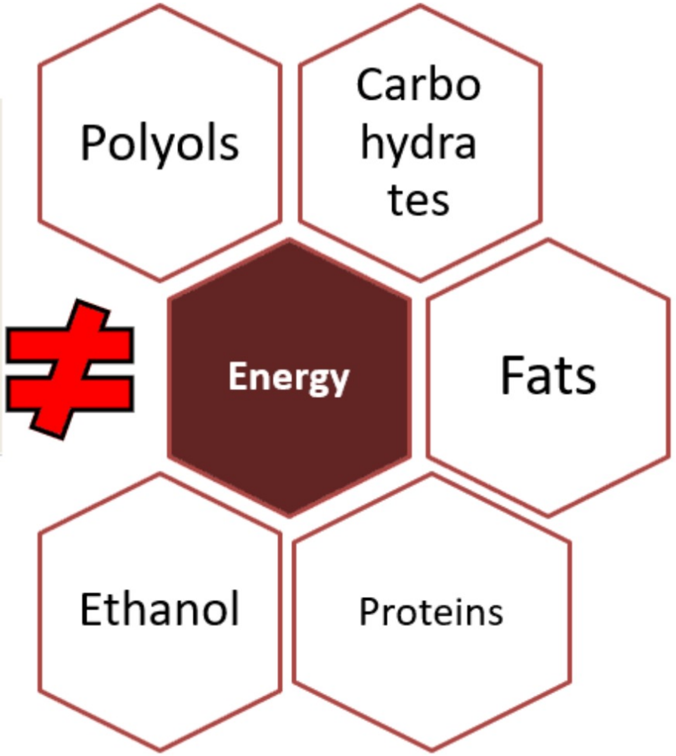
- Energy in animals and humans derive from food and is obtained through the process of cellular respiration with or without requirement of oxygen

minerals,
vitamins,
Insoluble fibre
water



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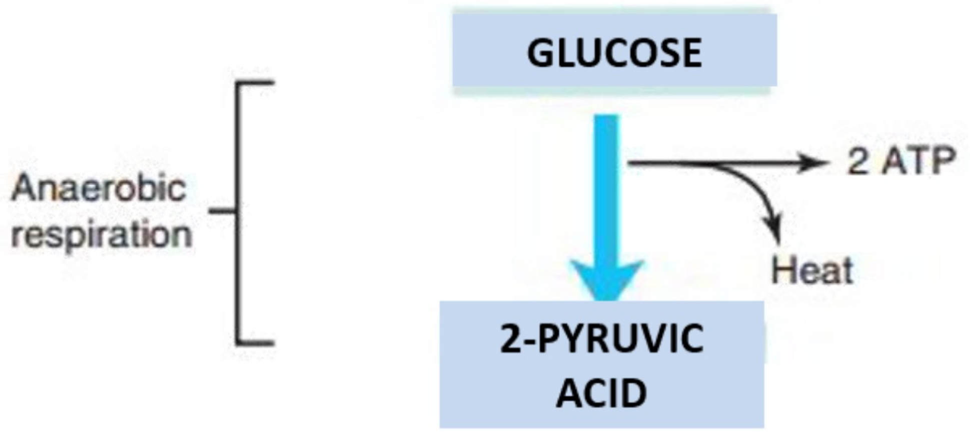

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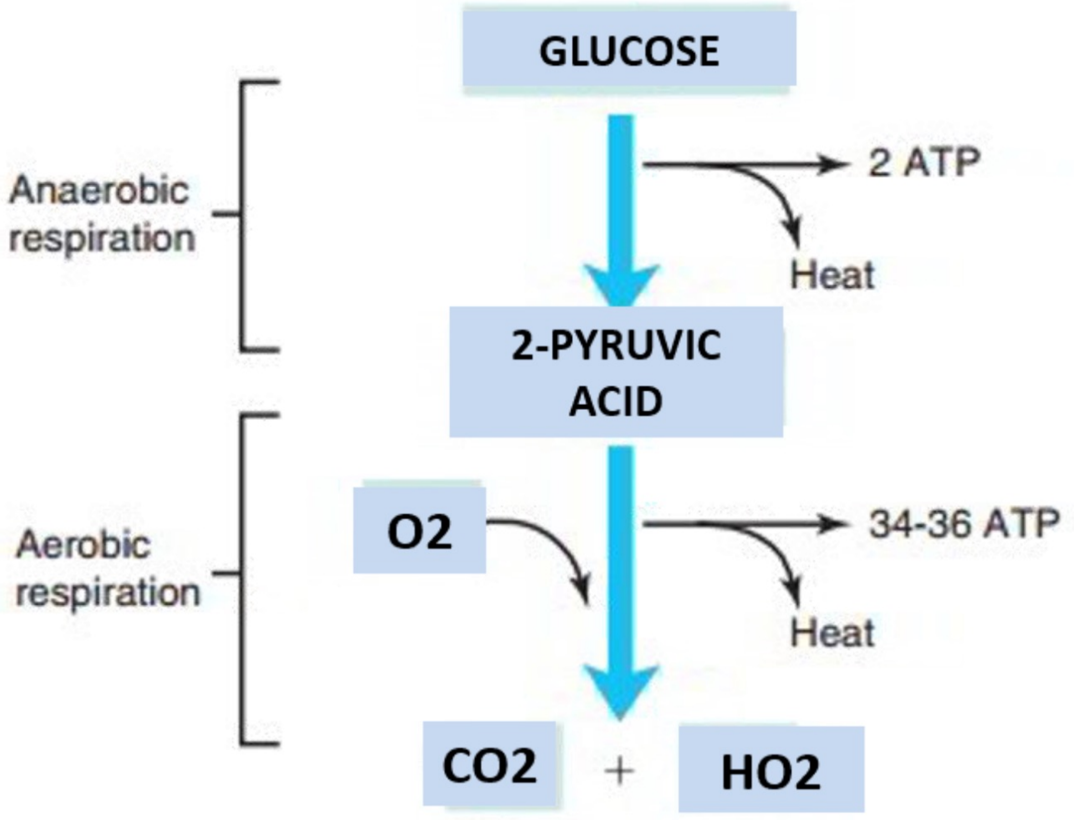

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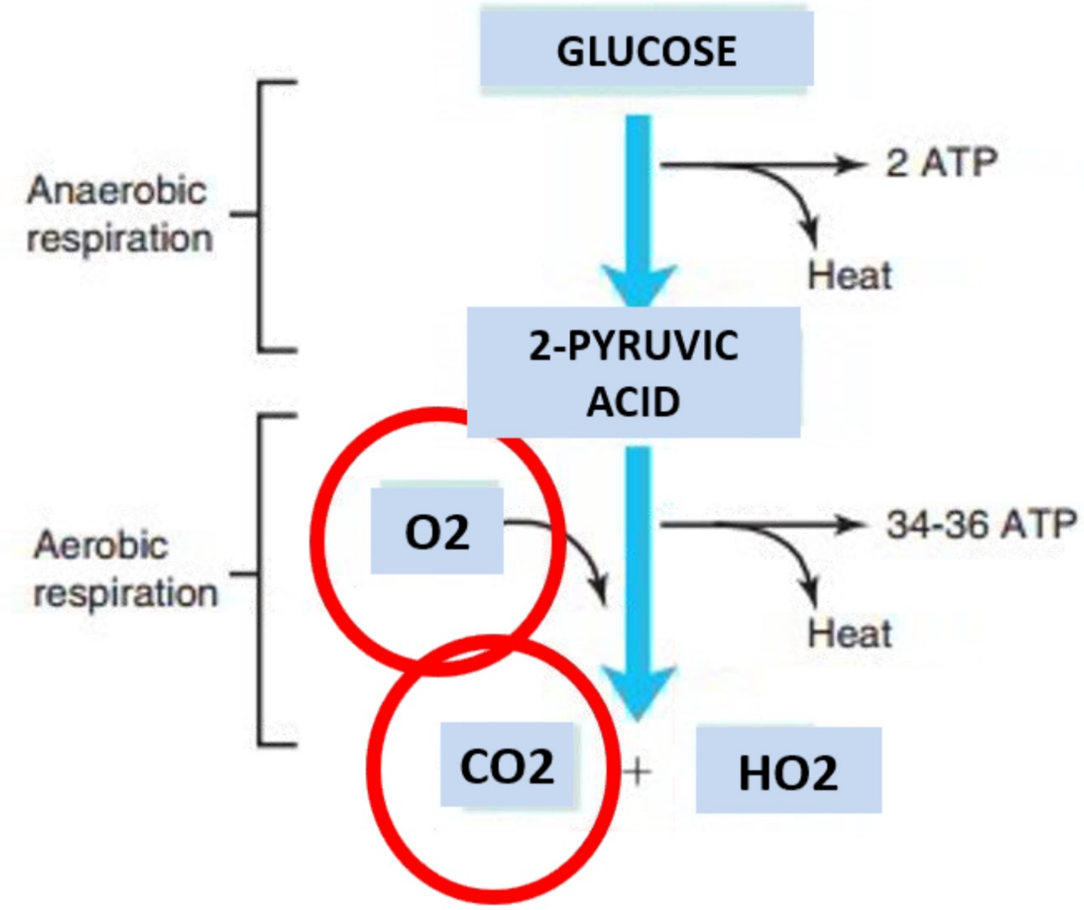
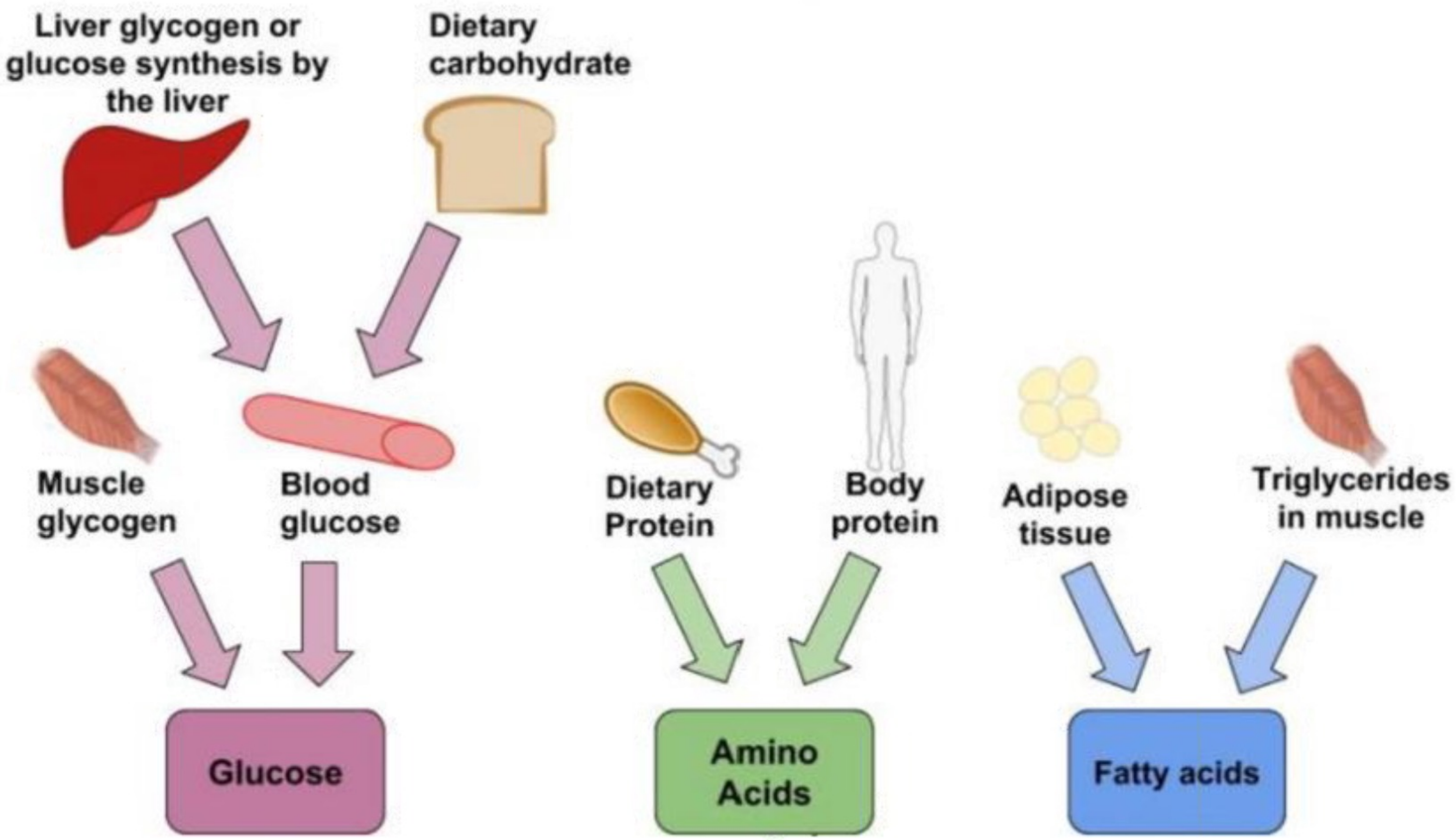
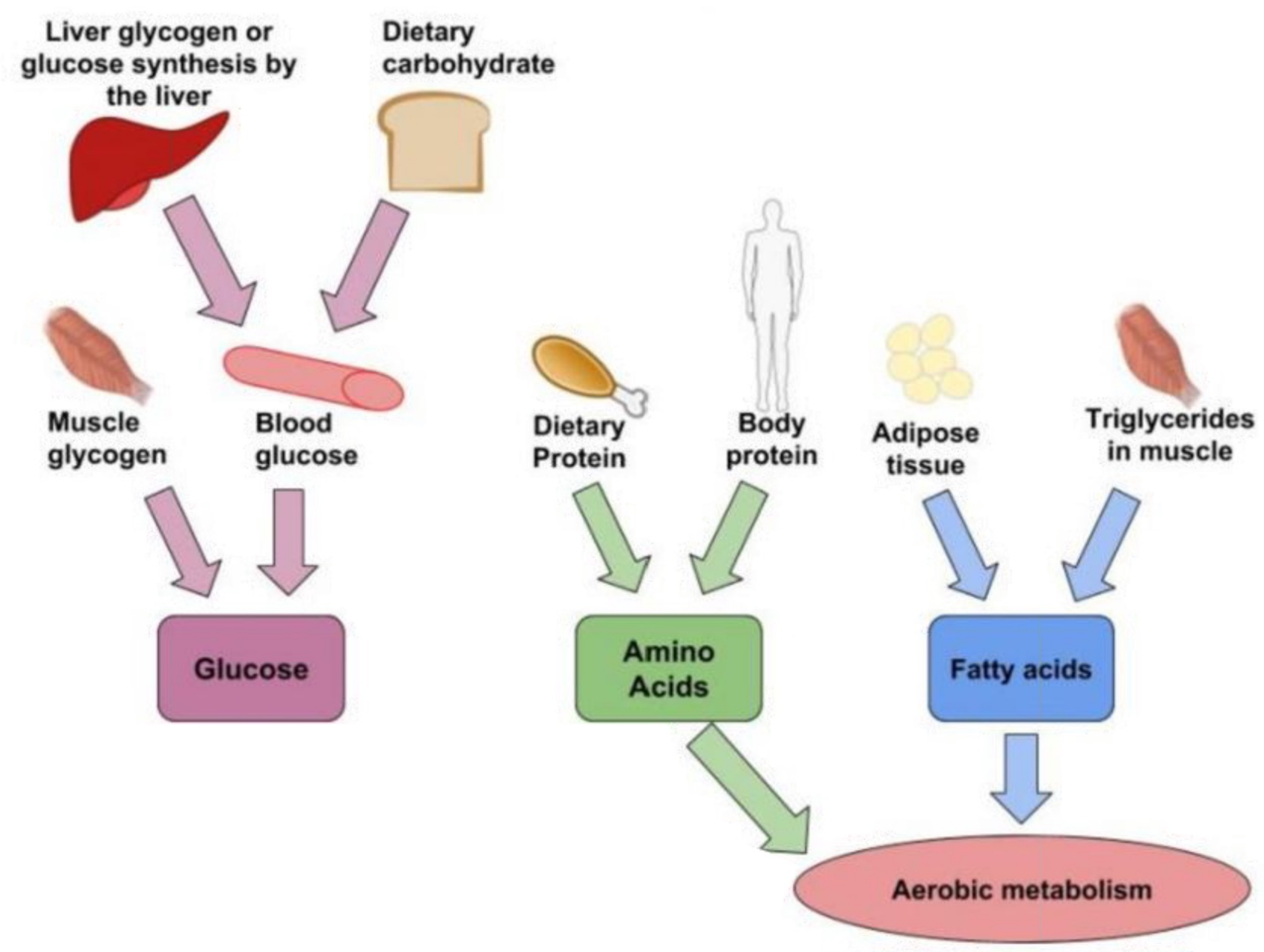


Fuel Sources for Aerobic and Anaerobic Metabolism



https://chem.libretexts.org/nutrition *metabolism*

Fuel Sources for Aerobic and Anaerobic Metabolism



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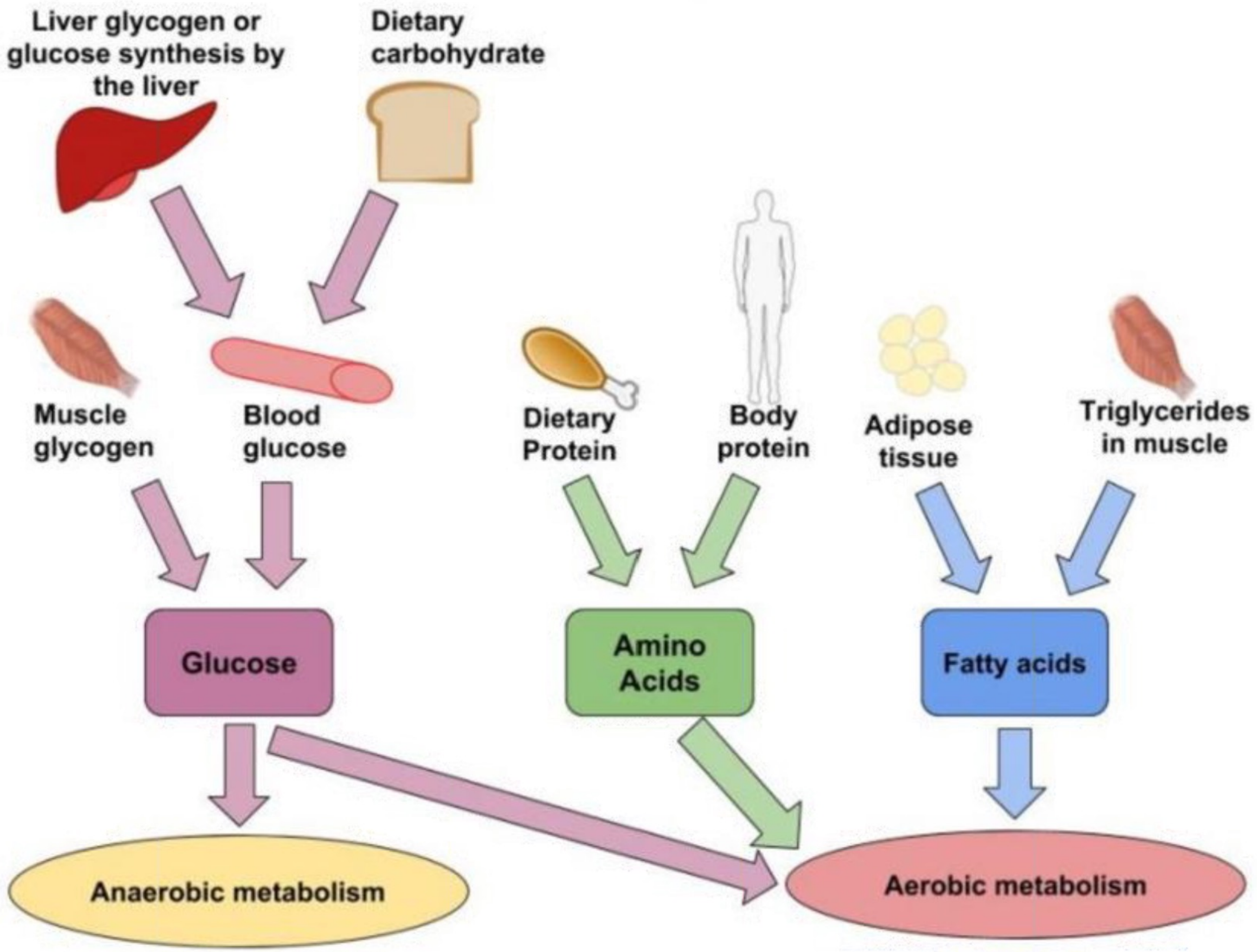


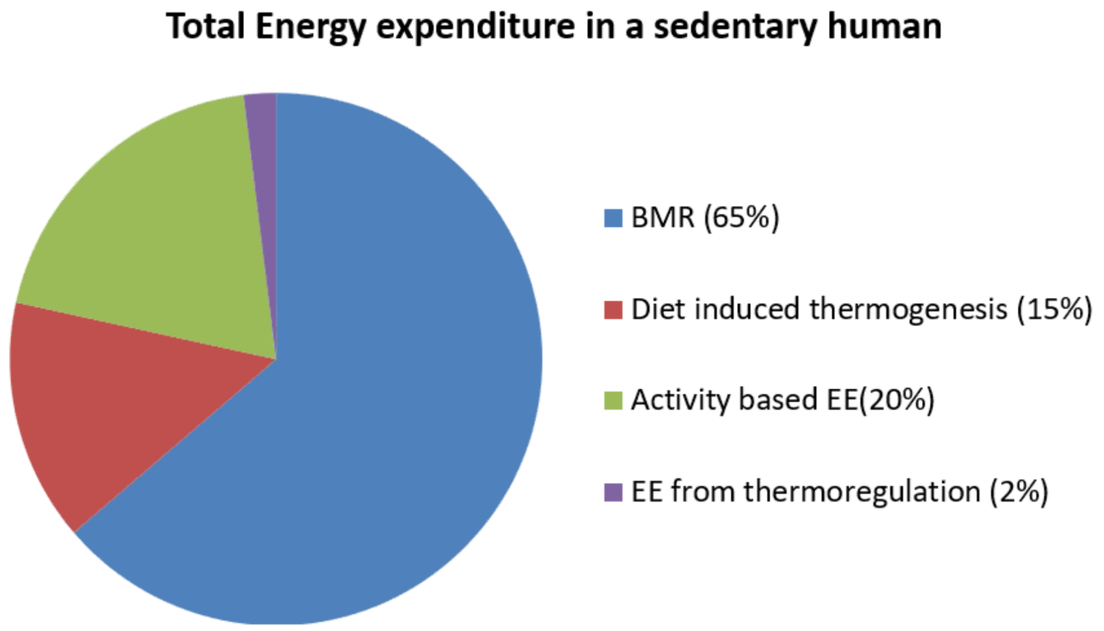
https://chem.libretexts.org/nutrition *metabolism*

Energy measurement

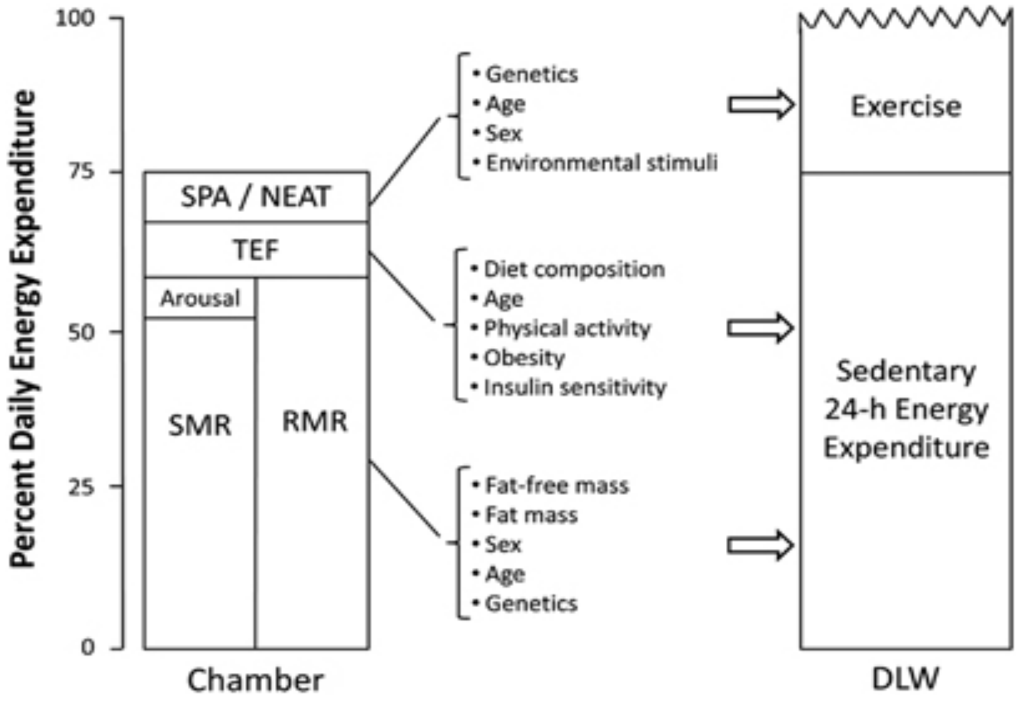
Calories provision will depend on the source of food

Food component	ENERGY DENSITY	
	kJ/g	kcal/g
Fat	37	9
Ethanol(drinking alcohol)	29	7
Proteins	17	4
Carbohydrates	17	4
Organic acids	13	3
Polyols (sugar alcohols, sweeteners)	10	2.4
Fibre	8	2

How do we know how much calories/energy our body is burning (expenditure) and how much energy should provide?



Rigaud D , Rev Prat 2009



How do we know how much calories/energy our body is burning (expenditure) and how much energy should provide?

- ***Basal metabolic rate:*** is the rate of energy expenditure per unit time that a person needs to keep the body functioning at rest (breathing, blood circulation, controlling body temperature, cell growth, brain and nerve function, and contraction of muscles).

Factors influence BMR:

Increase BMR	Decrease BMR
Higher lean body mass	Muscle wasting/atrophic
>surface area (taller)	Short stature
Young age	Female
Male	Older age
Pregnancy lactation	low amount of kcals/starvation/fasting
Stress	Decrease amount of thyroid hormones
Increased Thyroid hormones	Heat
Cold	Medications: sedatives, Bblockers, analgesics
Medications: stimulants, caffeine, tobacco	barbiturate, coma

**BMR=Reported as joule/second; ml O2/min or J/hr/kg body mass.*

Cunningham JJ , Am J clin Nutr 1980

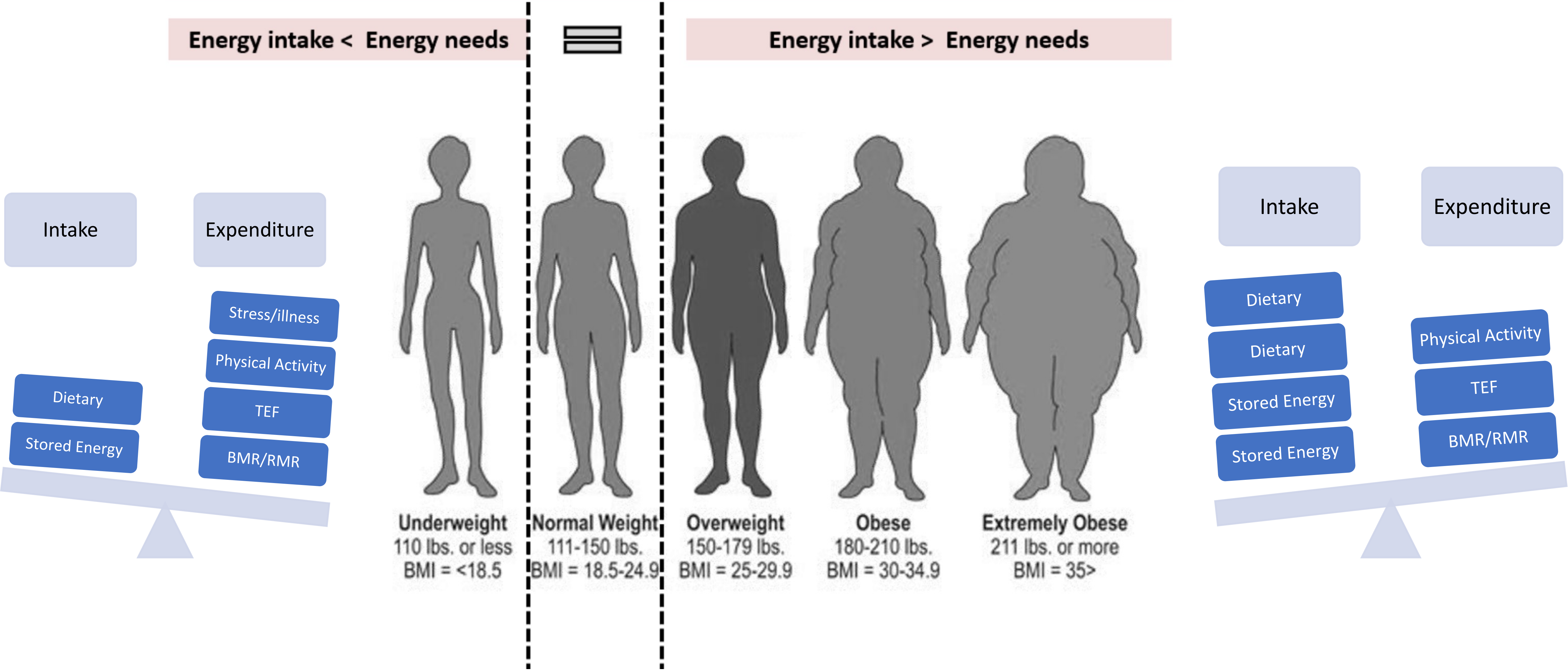
Resting Energy expenditure(REE)

- REE Is the energy expenditure of an individual who is not fasting and is the number of calories required for a 24 h period by the body during a non-active period

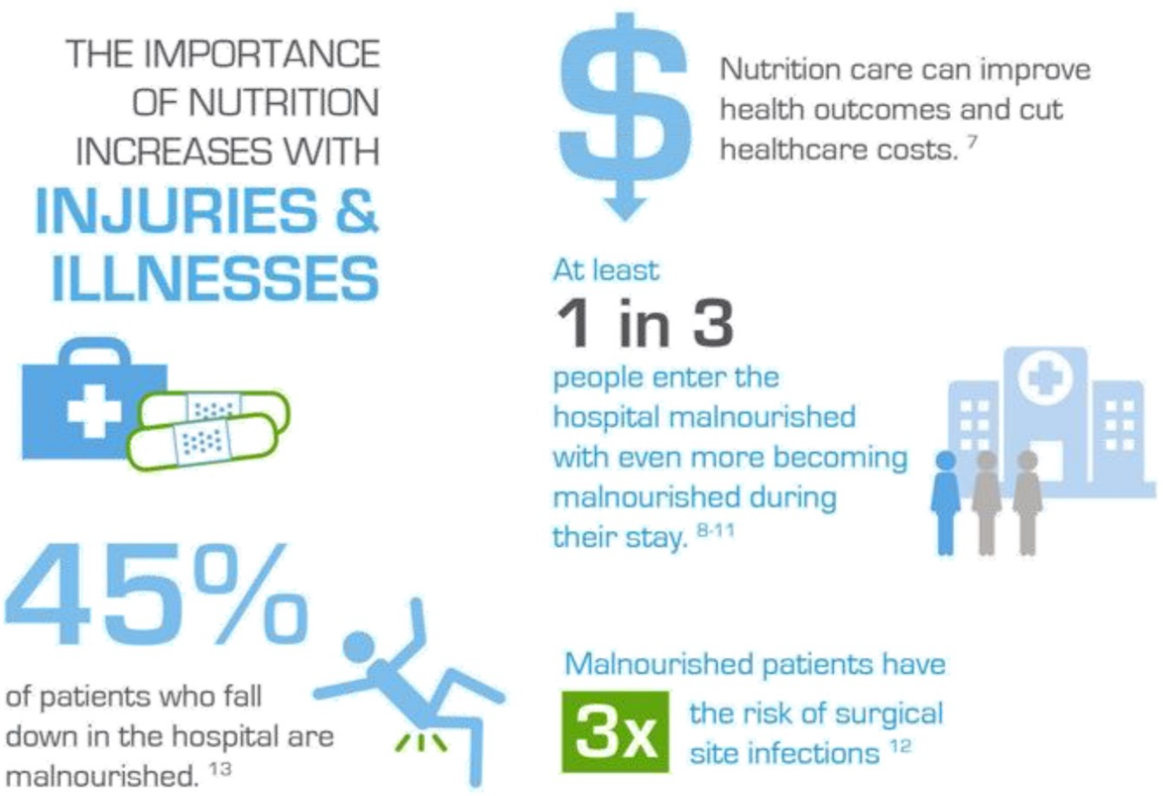
- Accounts for more than 60% of the total energy expenditure and is directly related to the amount of fat-free mass, which is more active metabolically than fat mass

- Is useful to avoid or prevent underfeeding and/or overfeeding of individuals, especially in clinical care,

Resting Energy expenditure(REE)



Malnutrition is a serious concern



Malnutrition affects negatively outcomes in ICU

1. Malnutrition is frequent in admission to ICU (66%)

2. Critically ill patients are frequently hypermetabolic, catabolic and at risk of underfeeding

3. MN affects negatively outcomes:

   a- increase mortality (33 vs 21%)
   b- more days on ventilator and
   c- length of stay in ICU

Table 4 Relationship between complications and cumulated energy deficit by regression analysis.

Variables	*F*	*P*
Length of stay	25.18	0.0001
Complications	15.15	0.0003
Infections	9.14	0.0042
Days on antibiotics	17.48	0.0003
Start of nutrition	17.17	0.0002
Days of mechanical ventilation	17.12	0.0002

Proper nutrition assessment is crucial to recognize malnutrition early and initiate timely nutritional therapy.

Shpata V, Eur J Anest 2013; villet et al, Clin Nutr 2005

Subjective Global Assessment Form

MEDICAL HISTORY

Patient name: ______________________________ Date: ______/______/__________

NUTRIENT INTAKE

1. ☐ No change; adequate
2. Inadequate; duration of inadequate intake ______
   ☐ Suboptimal solid diet ☐ Full fluids or only oral nutrition supplements ☐ Minimal intake, clear fluids or starvation
3. **Nutrient Intake in past 2 weeks***
   ☐ Adequate ______ ☐ Improved but not adequate ______ ☐ No improvement or inadequate ______

WEIGHT

Usual weight ______ **Current weight** ______

1. **Non fluid weight change past 6 months** Weight loss (kg) ______
   ☐ <5% loss or weight stability ☐ 5-10% loss without stabilization or increase ☐ >10% loss and ongoing
   If above not known, has there been a subjective loss of weight during the past six months?
   ☐ None or mild ☐ Moderate ☐ Severe
2. **Weight change past 2 weeks*** Amount (if known) ______
   ☐ Increased ☐ No change ☐ Decreased

SYMPTOMS (Experiencing symptoms affecting oral intake)

1. ☐ Pain on eating ☐ Anorexia ☐ Vomiting ☐ Nausea ☐ Dysphagia ☐ Diarrhea
   ☐ Dental problems ☐ Feels full quickly ☐ Constipation
2. ☐ None ☐ Intermittent/mild/few ☐ Constant/severe/multiple
3. **Symptoms in the past 2 weeks***
   ☐ Resolution of symptoms ☐ Improving ☐ No change or worsened

FUNCTIONAL CAPACITY (Fatigue and progressive loss of function)

1. No dysfunction
2. Reduced capacity; duration of change ______
   ☐ Difficulty with ambulation/normal activities ☐ Bed/chair-ridden
3. **Functional Capacity in the past 2 weeks***
   ☐ Improved ☐ No change ☐ Decrease

METABOLIC REQUIREMENT

High metabolic requirement ☐ No ☐ Yes

PHYSICAL EXAMINATION

Loss of body fat	☐ No	☐ Mild/Moderate	☐ Severe
Loss of muscle mass	☐ No	☐ Mild/Moderate	☐ Severe
Presence of edema/ascites	☐ No	☐ Mild/Moderate	☐ Severe

SGA RATING

☐ **A** Well-nourished
Normal

☐ **B** Mildly/moderately malnourished
Some progressive nutritional loss

☐ **C** Severely malnourished
Evidence of wasting and progressive symptoms

CONTRIBUTING FACTOR

☐ **CACHEXIA** - (fat and muscle wasting due to disease and inflammation) ☐ **SARCOPENIA** - (reduced muscle mass and strength)

*See page 2 SGA Rating for more description.

April 2017

Canadian Malnutrition Task Force | Le Groupe de travail canadien sur la malnutrition

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How do we know if the energy intake is adequate or inadequate??

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Presence of edema/ascites	☐ No	☐ Mild/Moderate	☐ Severe

Risk	A= No risk	B= mild/mod malnutrition	C= severe malnutrition

☐ **CACHEXIA** - (fat and muscle wasting due to disease and inflammation) ☐ **SARCOPENIA** - (reduced muscle mass and strength)

*See page 2 SGA Rating for more description.

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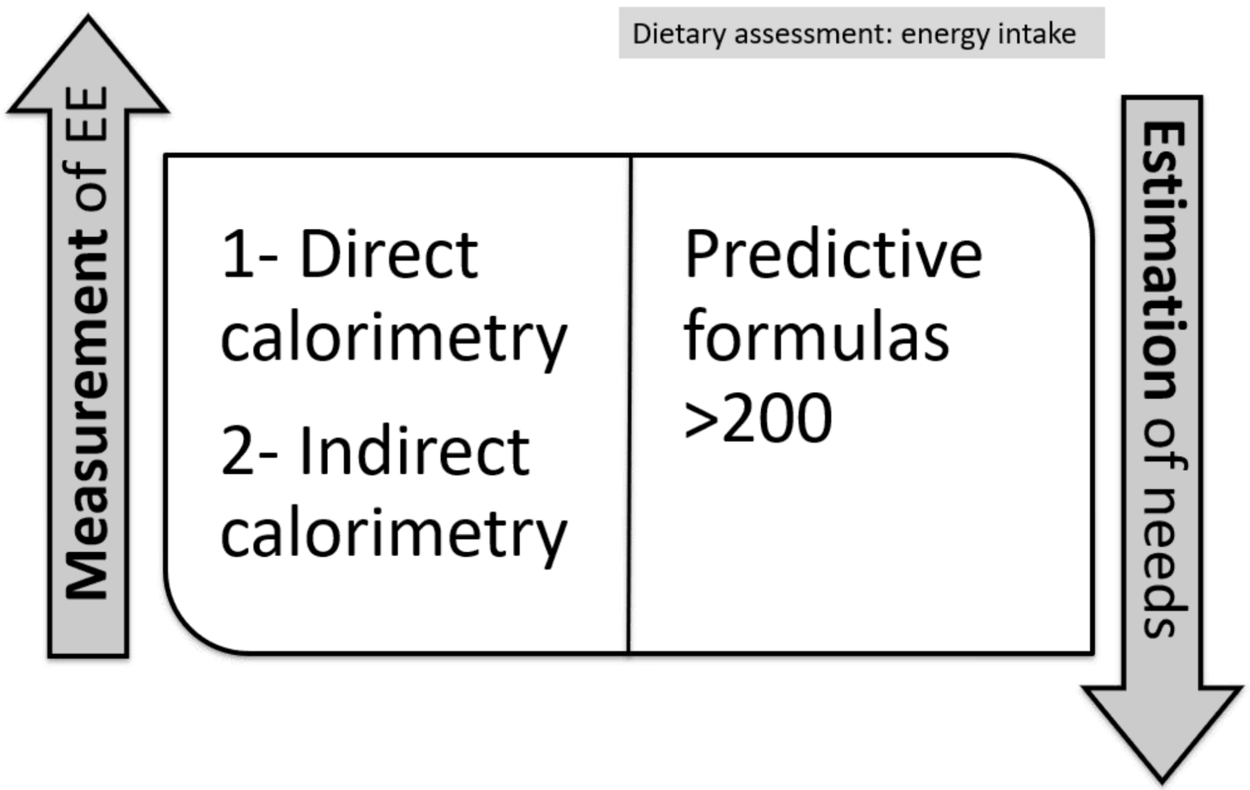
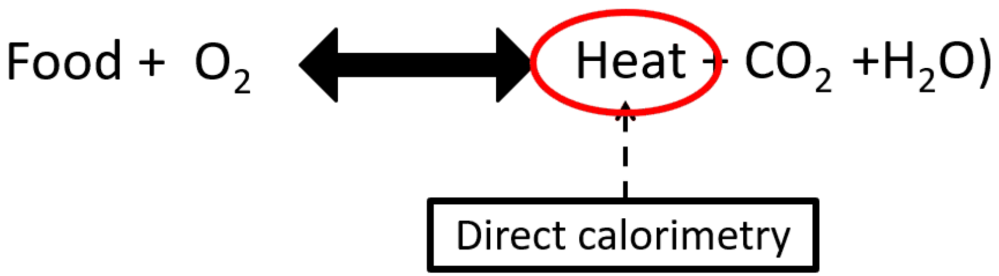
Measurement of energy expenditure/requirements



Measurement of energy expenditure/requirements

***Calorimetry**: Calor(latin) = heat / Metrion(greek)= measure*



The rate of heat production in an individual is directly proportional to energy expenditure and therefore, metabolic rate

Kenny G et al, Eur J Appl Physiol 2017

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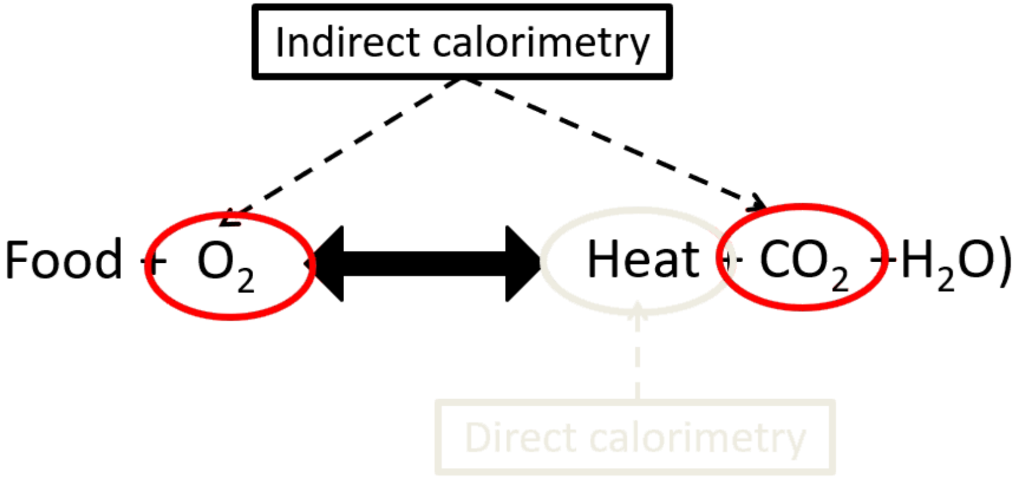

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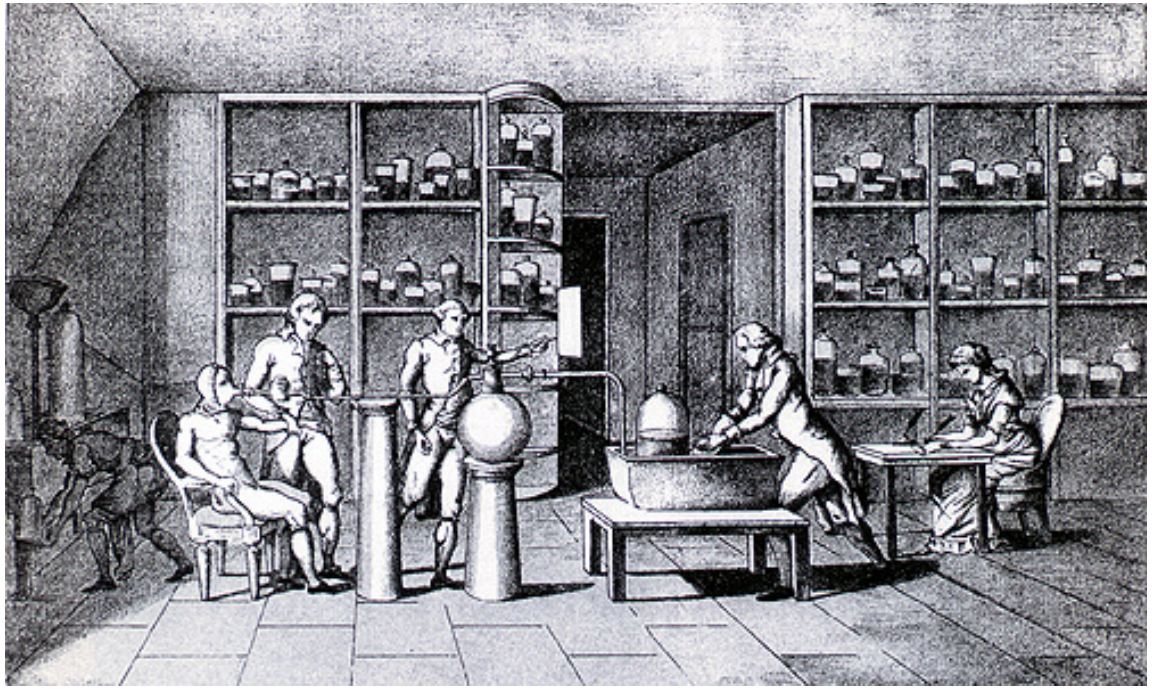
Antoine Lavoisier
1775



- Father of Modern Chemistry
- First to define combustion with modern terminology
- First to measure human energy expenditure by analysis of respiratory gases

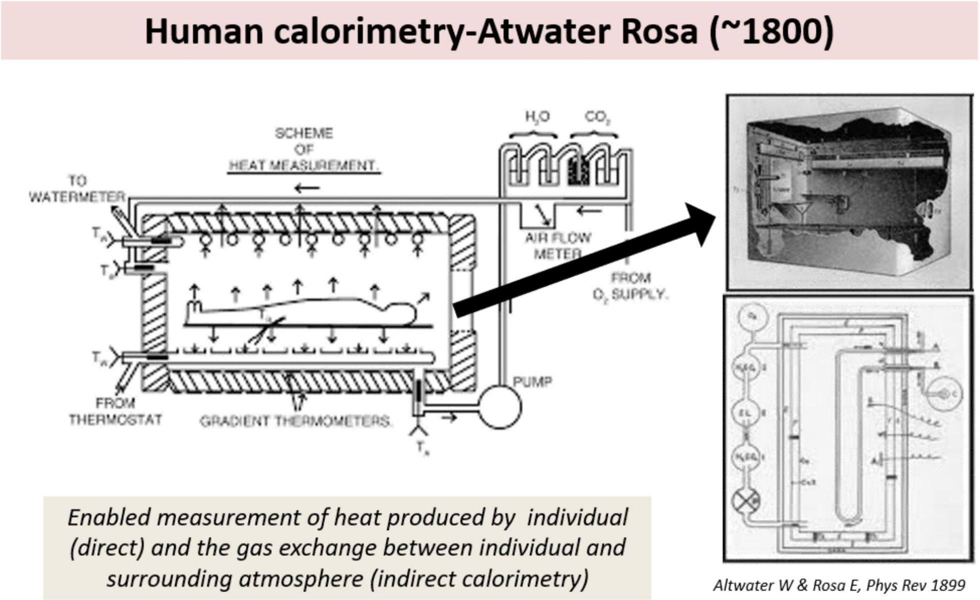
Direct calorimetry

- In direct calorimetry the measurement of the heat produced by metabolic processes to quantify total energy expenditure (TEE).

- Total body heat production is directly measured via a thermally sealed chamber.
  - Although accurate, this method is expensive, not readily accessible, and requires technical expertise.

7Nutr Clin Pract Heather A. Haugen et al, 2007, Calorimetry: A Practical Guide for Clinicians

Direct Calorimeter



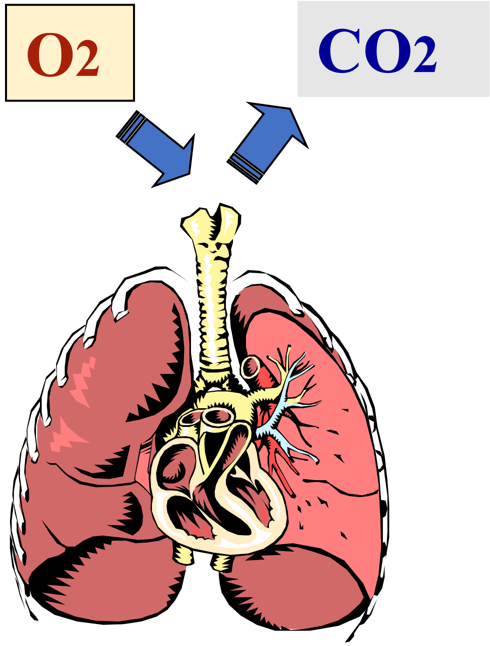
Indirect Calorimetry (IC)

- Indirect calorimetry is the quantification of REE, which is the major constituent of total daily energy expenditure (TDEE).
- It is based on the non-invasive measurement of VO_2 , the greater component of REE, and VCO_2.
- These primary parameters are derived precisely by the application of gas dynamics physics, for the correct measurement of inspired and expired gas concentrations and volumes.

Indirect calorimetry: methodology, instruments and clinical application, Eduardo E. , et al. 2006

Indirect Calorimetry (IC)

❖ O2 & CO2 Measured at the Airway



❖ Urinary nitrogen excretion should be measured

Indirect calorimeter

Use of Indirect calorimetry (IC)

- Clinical application of the measurement of REE : guiding nutrition support different conditions
- In critical illnesses such as major trauma and sepsis, for the healthy or sick obese patient
- IC can measure EE in both mechanically ventilated and spontaneously breathing patients (capy or facemask or mouthpiece)

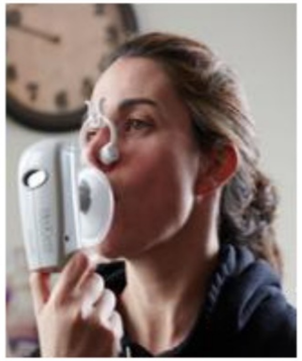
ventilator

canopy

Face mask

Mouth-piece

Hand-held



Delsoglio M..,Pichard J Clin Med 2019; Kenny G et al, Eur J Appl Physiol 2017

Definitions and abbreviation

- **VO_2:** Oxygen consumption
- **VCO_2:** Carbon dioxide production
- **RQ**: Respiratory quotient = VCO_2 / VO_2 for the cell
- **RER:** Respiratory exchange ratio = VCO_2 / VO_2 measured from expired air
- **FIO_2** = fraction of oxygen in inspired air = 0.2095
- **FEO_2** = fraction of oxygen in expired air = variable

The Respiratory Quotient and Substrate Oxidation

$$C_6H_{12}0_6 + \mathbf{6O_2} \longrightarrow \mathbf{6CO_2} + 6H_20 + \text{Energy}$$

RQ = VCO2/VO2 = 1.0

Heat + Work

$$2\ C_{57}H_{110}O6 + \mathbf{163\ O2} \longrightarrow \mathbf{114CO_2} + 110H20 + \text{Energy}$$

RQ=114CO2/163O2=0.7

$$C_{72}H_{112}N_{18}O_{22}S + \mathbf{77\ O_2} \longrightarrow \mathbf{63\ CO_2} + 38H2O + SO3 + 9CO(NH2)2 + \text{Energy}$$

RQ= 63CO2/77O2=0.818

Respiratory Quotients for Various Substrates - RQ = VCO2 ÷ VO2

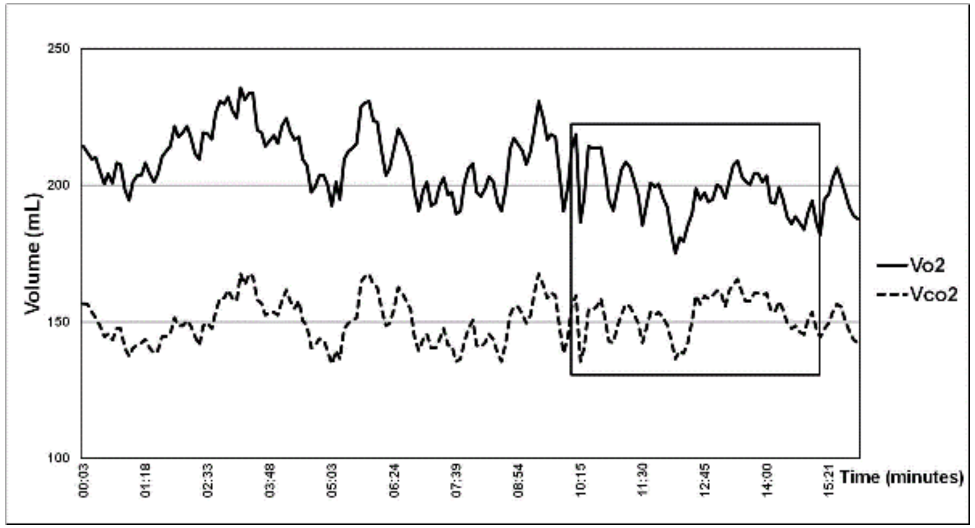
Fuel Oxidation	RQ
Protein	0.8
Fat	0.7
CHO	1

- The normal range for critically ill patient is 0.65 to 1.25, depending on the blend of nutrients metabolized.
- RQ values less than 0.65 or greater than 1.25 are suspect and usually indicate non-steady state conditions.

Steady-State condition

- A steady state has been achieved when the average minute Vo2 and Vco2 changes by <10% (over a 10 minute interval).
- IC results not consistent with a steady state are not to be used.
- Under steady state conditions, the RER and RQ are assumed to be equal.
- a steady state condition exists when the exchange of gases (O_2 & CO_2) at cellular level and those measured at the airway are similar.

Steady-State condition



Variable	Acceptable Range
RQ	0.65-1.25 consistent with nutritional intake
VO2	± 5% from baseline value
VCO2	± 5% from baseline value
Minute ventilation	±10% from baseline value

Marina M. Reeves, Peter S. W. Davies, Judith Bauer, Diana Battistutta
Journal of Applied Physiology Published 1 July 2004 Vol. 97 no. 1, 130-134 DOI: 10.1152/japplphysiol.01212.2003

Indirect Calorimetry, Normal Values

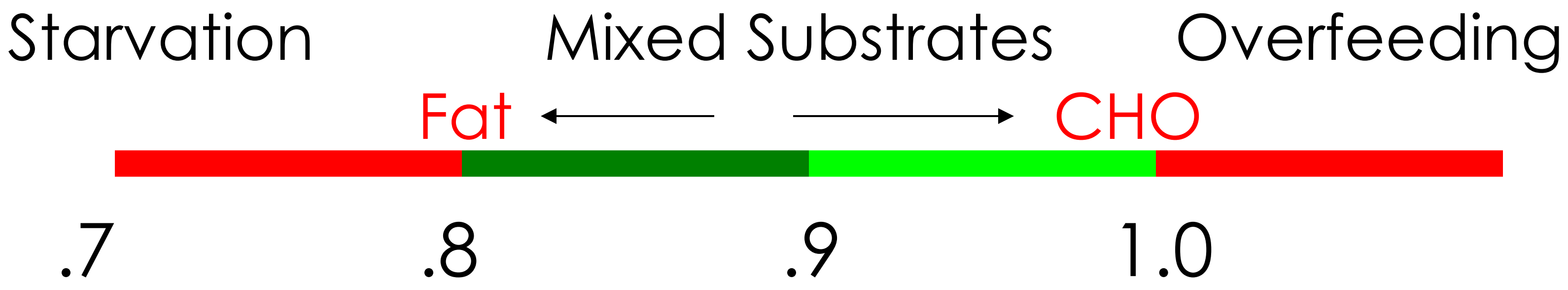
Variable	Symbol	Normal value*
Oxygen consumption	VO2	250 ml/min (3.6 mL/min/kg IBW)
Carbon dioxide production	VCO2	VCO2 200 ml/min(2.9 mL/min/kg IBW)
Respiratory quotient	RQ	0.65-1.25
Respiratory exchange ratio	RER	0.65-1.25 (assumes steady-state conditions)
Energy expenditure	EE	Depend on measurement condition
Basal Energy Expenditure	BEE	Not applicable
Resting Energy Expenditure	REE	1800-2000 kcal/24h (25-35kcal/kg)

*represents critically ill adults patient; values will vary with sepsis, trauma, and burns
IBW = ideal body weight

Using RQ Ratio to Determine Substrate Utilization

RQ	Condition
1.0	Carbohydrate metabolism
0.71	Lipid metabolism
0.80	Protein metabolism
0.85	Mixed substrate metabolism
<0.65	Nonsteady-state condition---hypoventilation/Ketosis
>1.25	Nonsteady-state condition---hyperventilation/Isocapenic buffering

INTERPRETATION OF RQ



Hypoventilation

ETOH or Ketones

Hyperventilation

Metabolic Acidosis

The objectives of indirect calorimetry:

1. To accurately **measure the REE and RQ** to guide nutritional support
2. To allow **determinations of substrate utilization** in conjunction with UN measurements
3. To determine VO2 as a guide for **monitoring the work of breathing** and targeting adequate oxygen delivery
4. To assess the contribution of **metabolism to ventilation**.

Indications

(a) clinical conditions that significantly alter REE;

(b) when patients fail to respond to presumed adequate nutrition support

(c) in order to individualize and fine-tune the nutrition support in the ICU, in critically ill patients:

- **Severe sepsis**
- **Multiple trauma**
- **COPD**
- **Exhibiting hyper or hypometabolic symptoms**
- **Failure to wean from mechanical ventilation**
- **Flow dependency oxygen consumption**
- **Increased oxygen cost of breathing**
- **Failure in responding to traditional nutritional support regimens**

Clinical Benefits of IC in hospital settimg

- Both **underfeeding and overfeeding** may have a negative impact on recovery and healing
- Minimizing negative energy balance has a positive effect on survival and may reduce complications in hospitalized patients.
- <u>Serial IC measurements</u> should be considered to more accurately tailor nutrition support regimens at different stages of illnesses to facilitate patient recovery

Indirect Calorimetry (IC) Measurement

How do you do the test?

1. Individual should rest for at least 30 minutes in bed or a recliner before the test, however, the person should not be asleep.
2. No food for at least 4 hours before the test (>4 and <12h).
3. Maintain quiet surroundings when the test is in progress and normal temperature. The individual should not move arms or legs during the test.
4. Normal room temperature should be maintained, avoid drafts or any condition that might result in shivering.
5. Medications taken should be noted, such as stimulants or depressants.

How do you do the test?

- Steady state should be achieved, which would be identified clinically by the following:
  - 5 minute period when average minute VO2 and VCO2 changes by less than 10% and the average RQ changes by less than 5%.
- Stable interpretable measurements should be obtained in a 15 to 20 minute test

Special consideration

Using IC in diseases

Special Considerations

Severe obese:

The most accurate method to adjust for excessive body weight in the predictive equations for severely obese patients remains unclear.

- Data validating methods of weight adjustment in patients with BMI > 40 kg/m2, especially in extremely obese (class III) non-Caucasians, are very limited.
- The only accurate approach to determine energy expenditure to optimize nutrition support regimens in these patients is through IC.
- IC becomes the only way to provide a more reasonable assessment of energy balance to optimize nutrition support regimens in patients undergoing bariatrics surgery.

Special Considerations

Patients infected with human immunodeficiency virus (HIV)

- As much as a 30% difference has been observed between the measured REE and predicted REE using the Harris-Benedict Equation (HBE) in HIV-positive patients with lipodystrophy.
- One of the most common reasons for hospitalization of these patients is severe opportunistic infection, which further alters energy expenditure.

Special Considerations

Patients receiving hemodialysis or continuous renal replacement therapy

- To accurately assess energy expenditure in patients receiving intermittent hemodialysis, IC should be performed preferably 24 hours after the end of the hemodialysis session.

Special Considerations

Patients who receive continuous infusion of sedatives and paralytic drugs

- A recent study suggests that in the absence of fever, the disease-specific or injury-specific variations in energy expenditure may be abolished with **deep sedation** among demographically matched medical and surgical ICU patients.
- Therefore, to prevent overfeeding, IC should be performed in patients who are deeply sedated.
- Additionally, the measurement should be repeated when the dose of sedation medication is changed.

Additional considerations for hospitalized individuals:

1. If the individual is on specialized nutrition support (enteral or parenteral nutrition) continuous 24-hour infusion does not need to be stopped. The nutrients infused should be constant for at least 12 hours. If feedings are intermittent or cyclic, the feeding should be held for at least 2-4 hours.
2. Discontinue any supplemental sources of oxygen if the individual is on room air, which includes nasal cannulas, masks or tracheostomy collars.
3. If the individual is on a ventilator, the settings should remain constant for at least 1-1/2 hours before the test.
4. No recent chest therapy or physical procedures.
5. Renal failure patients requiring hemodialysis should not be tested during dialysis therapy.

ASPEN criteria for the use of IC measurements in children in the PICU

- Oncologic diagnoses (including children with stem cell or bone marrow transplant)
- Children with thermal injury
- Children requiring mechanical ventilator support for > 7 d
- Children suspected to be severely hypermetabolic (status epilepticus, hyperthermia, systemic inflammatory response syndrome, dysautonomic storms, etc.) or hypometabolic (hypothermia, hypothyroidism, pentobarbital or midazolam coma,…)
- Any patient with ICU LOS > 4 wk may benefit from IC to assess adequacy of nutrient intake.

IC vs HB vs predictive formula

Aim: Quality assessment to guide decision making and implementation of a process to target energy provision.

✓ IC was performed in adult patients admitted to an ICU or the clinical ward.

✓ Energy expenditure measured by IC was compared to the estimation of energy needs by: **1)** Predictive formula (25kcal/kg) **2)** Harris Benedict formula.

✓ Change in energy provision: increase or decrease >10%

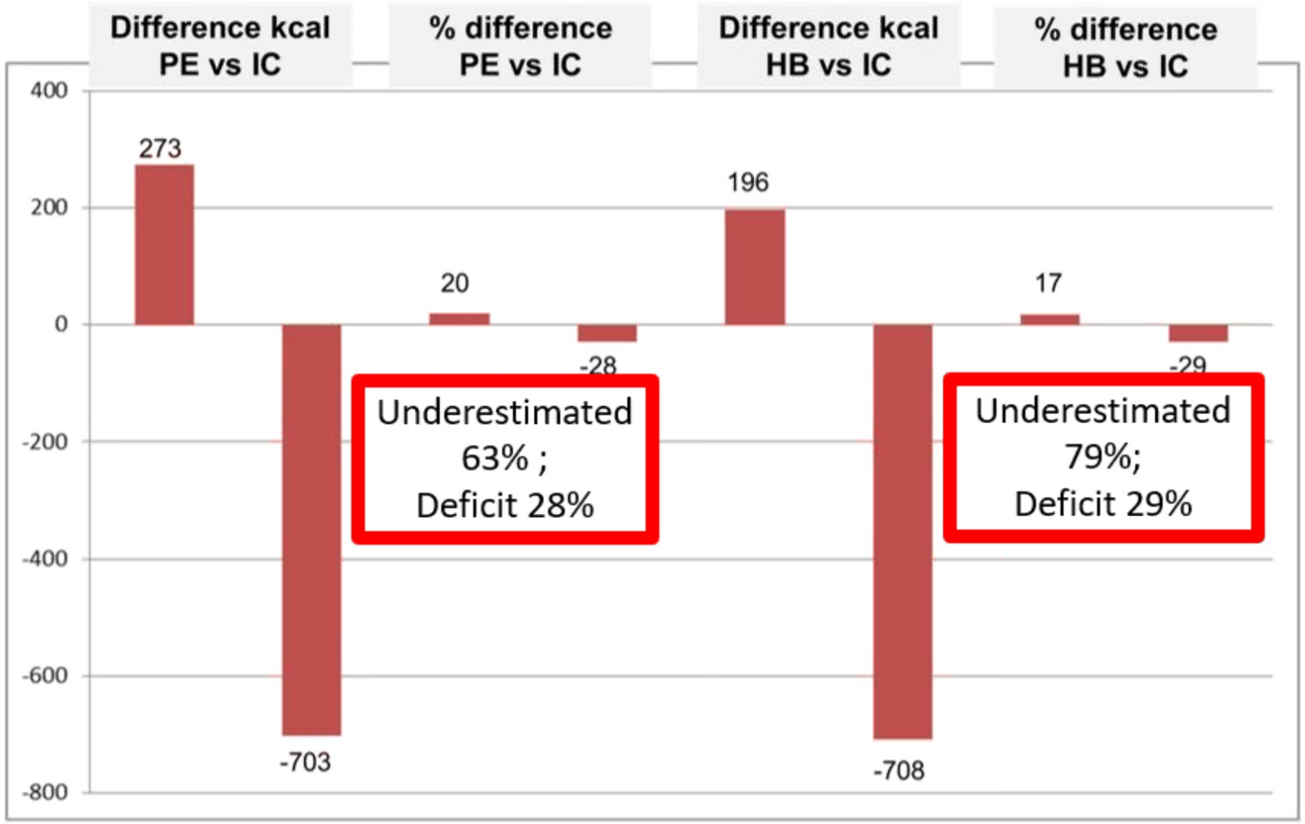
✓ The most common reasons for admission

1. ICU sepsis (32%) and post-surgery (24%), followed by trauma and respiratory or cardiac failure.
2. Ward: IBD or surgery

Hamilton sciences institute, 2020

Indirect calorimetry inpatients

From 6/ 2018 to 1/2019 : 329 IC tests performed in 293 patients



PE: Predictive Equation; HB: Harris-Benedict Equation ; IC: Indirect Calorimetry

Unpublished data, CNS 2020

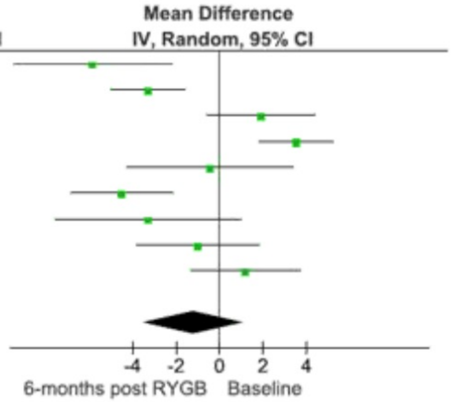
Using IC In Bariatric surgery

- 12 studies – Fu 6 months and 1 yr.

a

Study or Subgroup	6-months post RYGB Mean	SD	Total	Baseline Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Algahin et al 2010	27.57	4.83	9	33.41	2.74	9	10.0%	-5.84 [-9.47, -2.21]
Carrasco et al 2007	30.1	2.6	31	33.4	4.1	31	12.5%	-3.30 [-5.01, -1.59]
Carrasco et al 2008	34.2	4.7	23	32.3	3.9	23	11.6%	1.90 [-0.60, 4.40]
de Cleva et al 2018	29.44	4.14	45	25.91	4.04	45	12.5%	3.53 [1.84, 5.22]
Faria et al 2012	33.8	5.51	16	34.23	5.58	16	9.8%	-0.43 [-4.27, 3.41]
Golzarand et al 2018	34.5	4.6	22	39	3.2	22	11.8%	-4.50 [-6.84, -2.16]
Moehlecke et al 2016	30.9	6.4	30	34.2	10.1	30	9.2%	-3.30 [-7.58, 0.98]
Oliveira et al 2016	37.3	3.2	13	38.3	4.1	13	11.1%	-1.00 [-3.83, 1.83]
Rabl et al 2014	32.1	4	14	30.9	2.6	14	11.6%	1.20 [-1.30, 3.70]
Total (95% CI)			**203**			**203**	**100.0%**	**-1.18 [-3.48, 1.11]**

Heterogeneity: $Tau^2 = 10.25$; $Chi^2 = 58.64$, $df = 8$ ($P < 0.00001$); $I^2 = 86\%$
Test for overall effect: $Z = 1.01$ ($P = 0.31$)



b

Study or Subgroup	12 -months post RYGB Mean	SD	Total	Baseline Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Carrasco et al 2008	32.7	5.1	23	32.3	3.9	23	9.4%	0.40 [-2.22, 3.02]
Faria et al 2012	31.15	3	13	31.33	4.76	13	7.2%	-0.18 [-3.24, 2.88]
Sans et al 2017	28.74	4.33	103	31.25	6.15	103	23.7%	-2.51 [-3.96, -1.06]
Simonen et al 2012	29.7	3.1	30	32.1	3.6	30	19.0%	-2.40 [-4.10, -0.70]
Wilms et al 2017	29.57	3.75	167	31.85	4.47	167	40.7%	-2.28 [-3.16, -1.40]
Total (95% CI)			**336**			**336**	**100.0%**	**-1.95 [-2.82, -1.09]**

Heterogeneity: $Tau^2 = 0.28$; $Chi^2 = 5.58$, $df = 4$ ($P = 0.23$); $I^2 = 28\%$
Test for overall effect: $Z = 4.42$ ($P < 0.00001$)

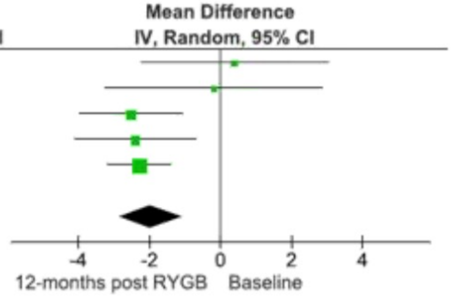


Fig. 3 Forest plot of changes in REE/FFM over (a) 6 months and (b) 12 months post-surgery by RYGB

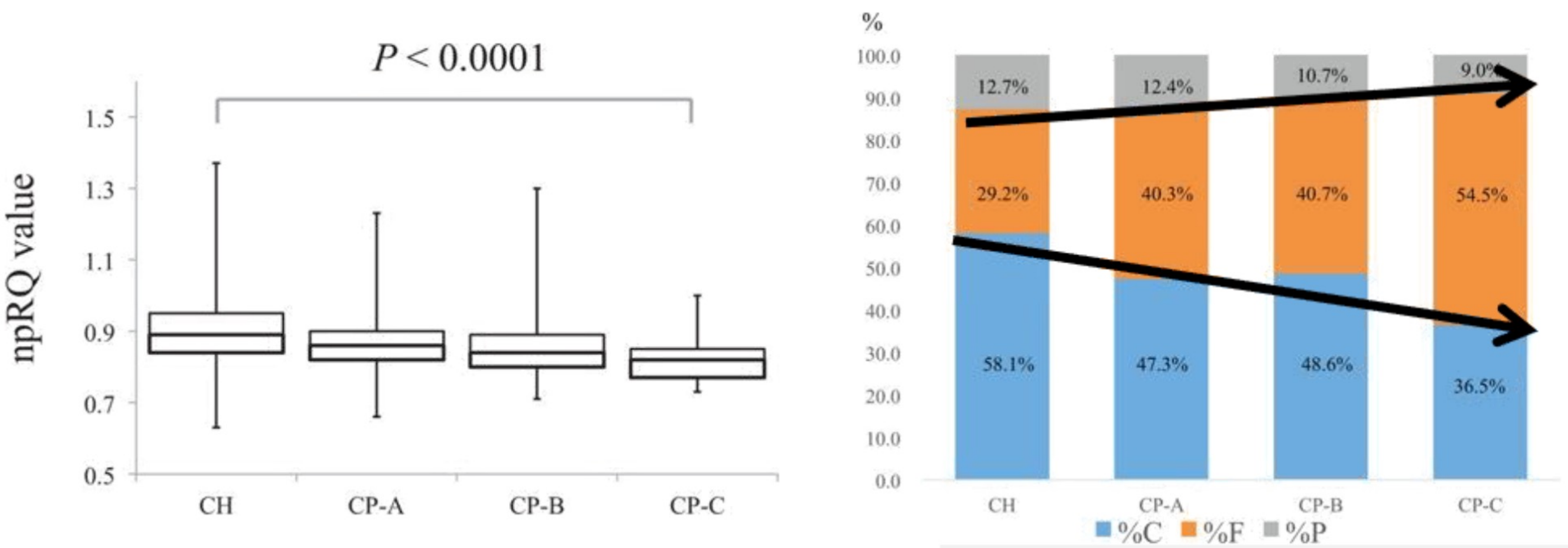
Decrease REE after 1 yr of bariatric surgery Roux in Y may influence outcomes

Lamarca et al, Obes Surg 2019

Use of IC in Liver Diseases

- ✓ Malnutrition is prevalent among patients with cirrhosis,
- ✓ Assessment of nutritional status and identifying adequate energy requirements are complicated in cirrhosis.
- ✓ Predictive equations not accurate as they rely in weight management

Energy metabolism changes with liver function



- Less protein and fat
- Increase carboh. utilization

Nishikawa et al, Medicine 2016

Use of IC in Liver Diseases

- ✓ To assess the accuracy of REE with a MedGem® handheld IC, compared to the Harris Benedict Equation (HBE), the Mifflin St. Jeor equation (MSJ), and the gold standard Vmax Encore® (Vmax)
- ✓ Only 21% of REE measures by MedGem® were within ±5% of Vmax measures

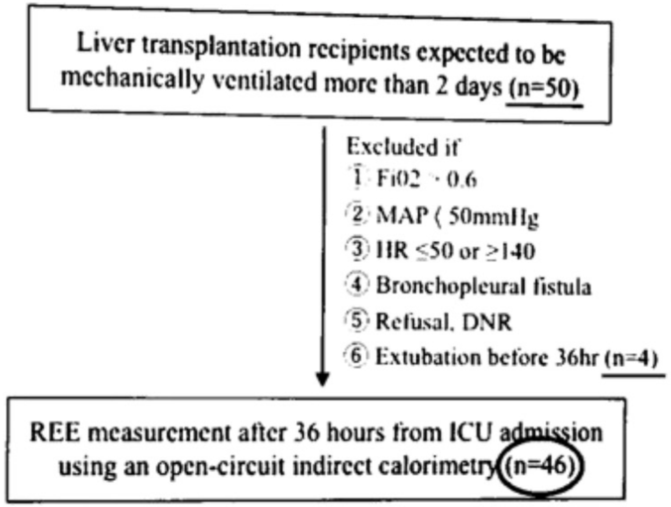
Table 3. Mean REE using different devices compared to Vmax.

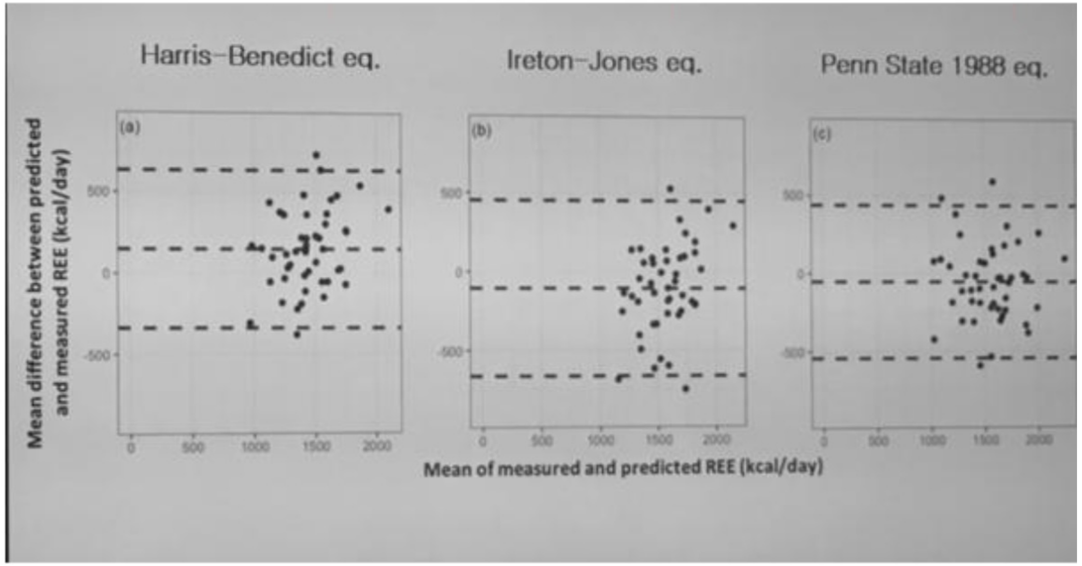
Comparison Group	Lin's Concordance Correlation Coefficient (ρC) (95% CI)	Mean Underpredicted kcal Differences (% difference)	Mean Overpredicted kcal Differences (% difference)
MedGem®–Vmax	0.80 (0.55–0.92)	−188.4 ± 110.8 (n = 7) (13%)	145.6 ± 138.2 (n = 7) (10%)
HBE–Vmax	0.56 (0.19–0.79)	−220.3 ± 112.2 (n = 8) (18%)	150.2 ± 44.9 (n = 6) (9%)
MSJ–Vmax	0.47 (0.07–0.75)	−261.1 ± 132.3 (n = 5) (20%)	132.1 ± 58.1 (n = 9) (8%)

- ➢ Wide variability limits the use of MedGem® at an individual level;
- ➢ More accurate and feasible method for determination of REE in patients with cirrhosis and malnutrition is needed.

Schock L et al,Nutrients 2019

Predicted equations are incurred in liver translation





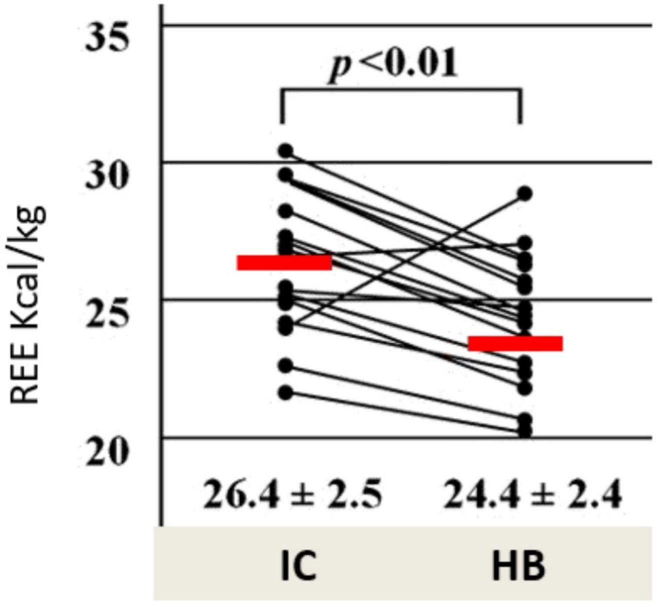
Overestimated **Underestimated**

The use of IC may be helpful in patients with liver transplant

Jong-Kwan , ESPEN 2019

IBD

- Increased energy expenditure associated with active inflammation has been thought to be one cause of weight loss in patients with Crohn's disease[1]
- Studies have investigated resting energy expenditure (REE) measured by IC in CD[1-6]
- REE was greater than the predicted energy expenditure (PEE) calculated from the Harris-Benedict formula [3]



1-Chan AT et al, Gastroenterology 1986; 2-Gong J JPEN 2015; 3-Sasaki et al, Clin Biochem Nutr. 2010; 4- Kushner et al, Am J Clin Nutr. 1991: 5- Zoli G et al. Dis Sci. 1996 :6 -Schneeweiss B et al Hum Nutr Metabol 1999

Crohn's Disease

REE measured (IC) was higher in CD patients with moderate disease activity compared with healthy controls, however, this has been controverted by others

Anthropometric measurements, body composition and REE of untreated (group 1) and treated (group 2) clinically stable CD patients.

		CD Immunosupp.		CD –No Tx	
		n.12		n.24	
		Mean	SD	Mean	SD
Age	*years*	33.3	8.8	33.2	13.1
Weight	*kg*	56.9*	7.4	62.3	8.3
Height	*cm*	168	11	170	8
BMI	*kg/m²*	20.3	2.3	21.5	2.5
FFM	*kg*	40.4*	5.73	48.2	7.06
FAT	*kg*	17.0*	3.55	13.9	5.54
PA	*degrees*	5.6*	1.4	6.5	1.0
REE	*kcal/die*	1383*	266	1583	253
REE/FFM	*kcal/kg*	34.8	4.9	33.0	4.3

*$p < 0.05$ group 1 vs group 2.

In non- treated CD, REE is increased compared to predicted, and is higher when adjusted for fat free mass. REE decreases with treatment , possible due to decrease activity and body composition

Sammarco R, Clin Nutr 2017

Celiac

- ✓ Celiac disease patients are at high risk of undernutrition because of nutrient malabsorption
- ✓ REE and substrate oxidation rates were assessed in 39 adult CeD at the moment of diagnosis and 1 yr after GFD; 63 healthy controls

	Control subjects		Untreated patients		Treated patients	
	Women (n = 34)	Men (n = 29)	Women (n = 23)	Men (n = 16)	Women (n = 23)	Men (n = 16)
Age (y)	32.8 ± 7.0	33.6 ± 9.3	31.4 ± 7.8	27.8 ± 7.0	32.4 ± 7.8	28.8 ± 7.0
Weight (kg)	63.1 ± 4.5	71.5 ± 5.7	55.9 ± 5.9[2,3]	61.6 ± 6.4[2,3]	58.7 ± 5.5[2]	64.0 ± 5.9[2]
Height (cm)	165 ± 4.8	172 ± 4.7	164 ± 4.7	170 ± 5.8	164 ± 4.7	170 ± 5.8
Fat mass						
(kg)	16.9 ± 2.8	17.0 ± 3.3	13.9 ± 3.0[2,4]	8.4 ± 2.7[2]	15.9 ± 2.6[5]	10.7 ± 2.7[2]
(%)	26.8 ± 3.8	23.7 ± 3.5	24.7 ± 3.8[3,5]	13.5 ± 3.9[2,3]	27.1 ± 2.9	16.7 ± 4.0[2]
Fat-free mass						
(kg)	46.3 ± 4.5	54.7 ± 4.6	42.0 ± 4.2[5]	53.3 ± 5.9[5]	42.8 ± 4.1[5]	53.3 ± 5.6[5]
(%)	73.4 ± 4.3	76.4 ± 3.5	75.3 ± 3.8[5]	86.5 ± 3.9[2]	73.0 ± 2.9	83.3 ± 3.9[2]

- ✓ *Untreated CeD preferentially utilized carbohydrates as a fuel substrate, probably as a consequence of both lipid malabsorption and a high carbohydrate intake,*
- ✓ *Lipid utilization increased with the restoration of the intestinal mucosa*

Capristo E et al, Am J Nutr 2000

Interpretation of Indirect Calorimetry

Presented by Charles McArthur, Mankato, MN

Interpretation Steps

- Patient Information
  - Demographics
  - Medications
- Quality of Measurement
  - Length of measurement
  - CV of VO2 & VO2
  - REE & RQ

Energy Equivalents and RQ's

SUBSTRATE	Kcal/LO2	RQ
CHO	5.05	1.0
Protein	4.46	0.8
Fat	4.74	0.7

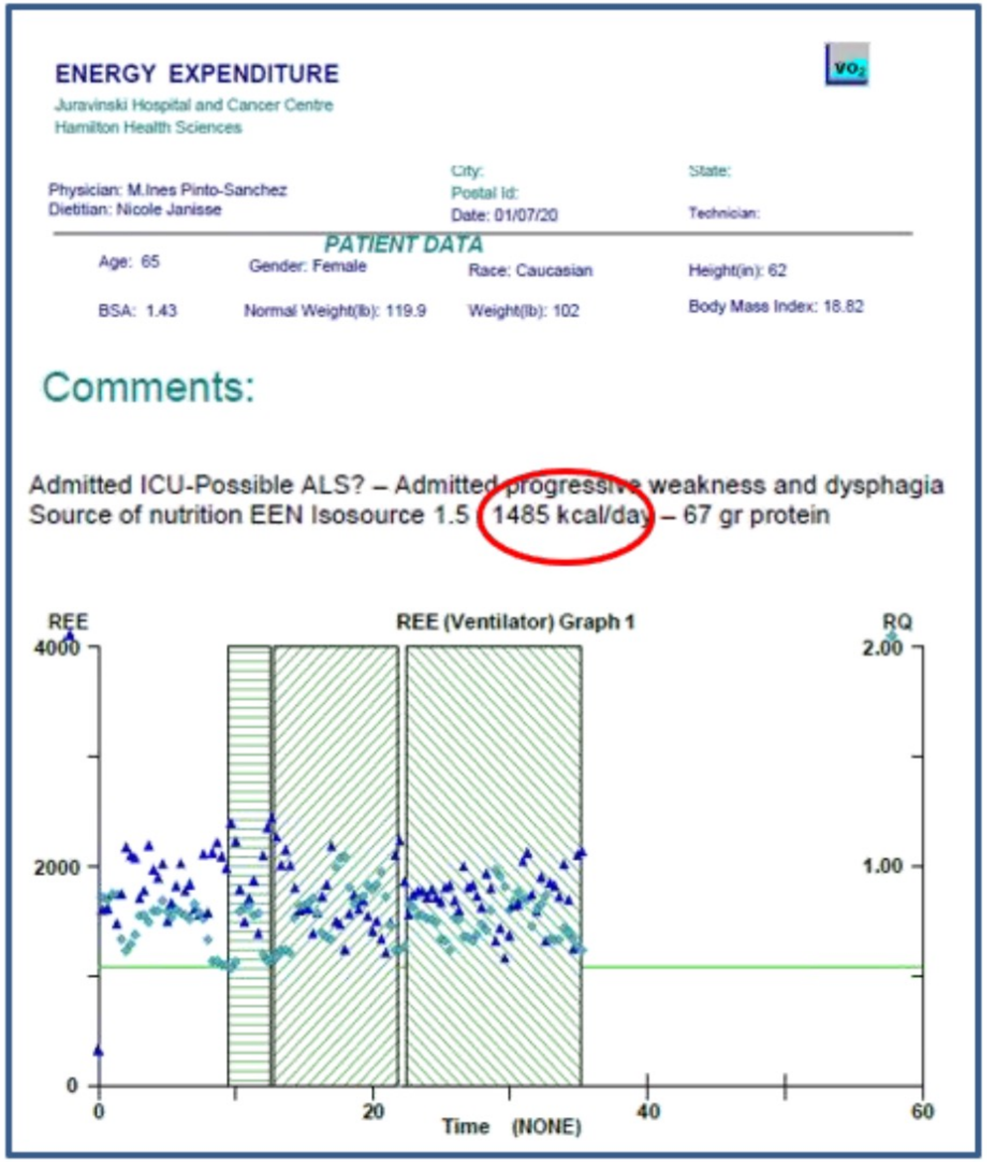
Interpretation of RQ

- RQ consistent with fasting state
- RQ consistent with nutritional intake
- RQ higher than expected for nutritional intake
- RQ lower than expected for nutritional intake

Metabolic States

- Lower than expected <90% predicted
- Expected Range 90% - 110 % predicted
- Higher than expected > 110% predicted

IC in Inpatients



Hamilton sciences institute, 2020

IC in Inpatients

ENERGY EXPENDITURE
Juravinski Hospital and Cancer Centre
Hamilton Health Sciences

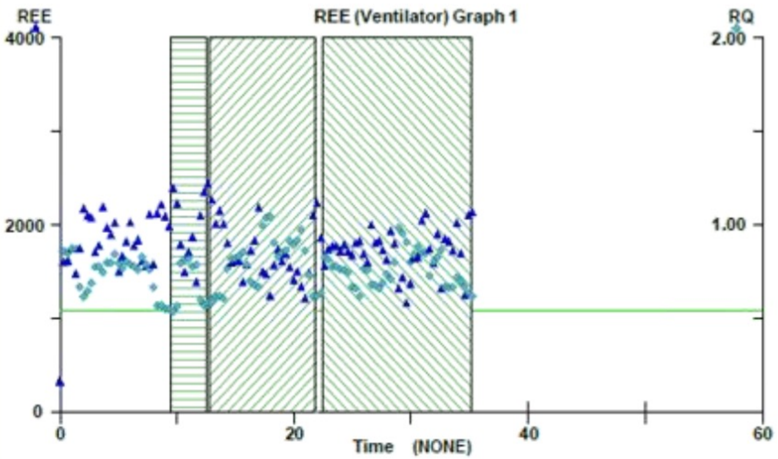
Physician: M.Ines Pinto-Sanchez
Dietitian: Nicole Janisse
City:
Postal Id:
Date: 01/07/20
State:
Technician:

PATIENT DATA

Age: 65	Gender: Female	Race: Caucasian	Height(in): 62
BSA: 1.43	Normal Weight(lb): 119.9	Weight(lb): 102	Body Mass Index: 18.82

Comments:

Admitted ICU-Possible ALS? – Admitted progressive weakness and dysphagia
Source of nutrition EEN Isosource 1.5 (1485 kcal/day) – 67 gr protein



METABOLIC TEST RESULTS

VO2: 0.254 L/min VO2/kg: 5.5 mL/kg/min VCO2 :0.191 L/min

Respiratory Quotient(RQ) : 0.75

Measured Resting Energy Expenditure (REE): 1745 Kcal/day
Predicted Basal Metabolic Rate (BMR): 1081 Kcal/day

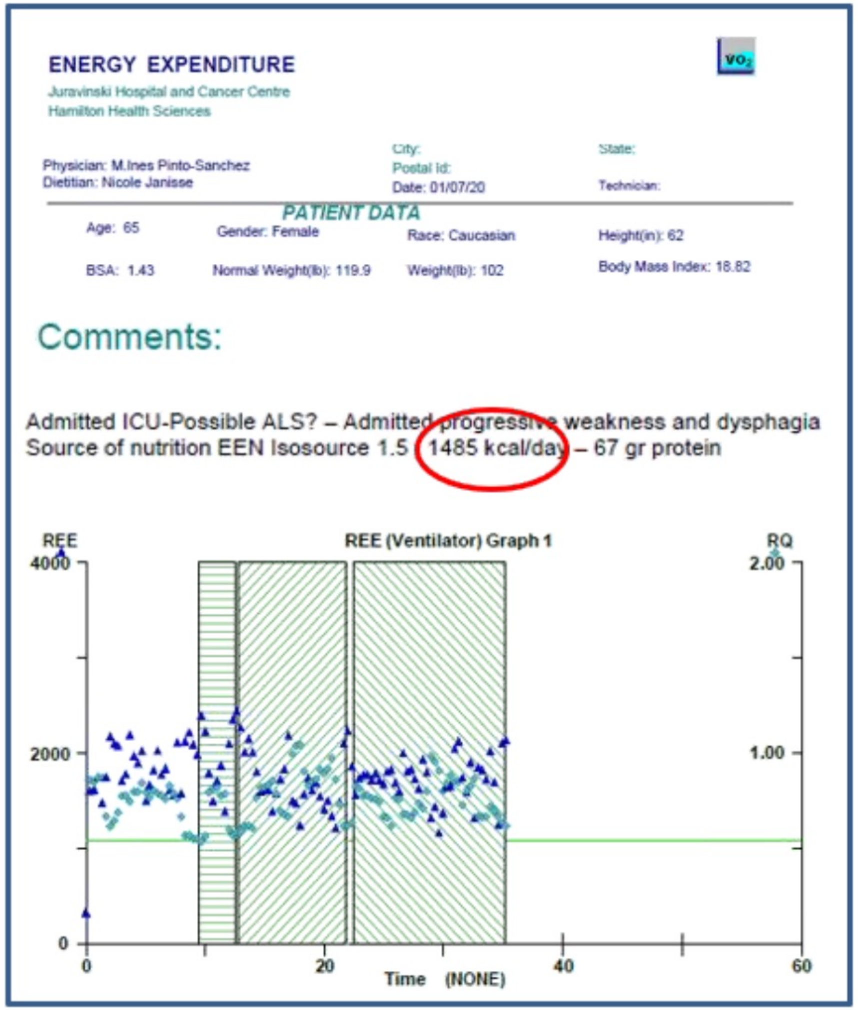
SUBSTRATE UTILIZATION: **REE (%Predicted): 157 %**

Metabolic Interpretation:

Measurement for 35 minutes. Technical difficulty: no.
During the period measured, RQ 0.75; within physiological range. Resting energy expenditure (energy use):1745 Kcal/day; which is above predicted.
Adjust energy provision and new measurement to assess response to change.

Signature

IC in Inpatients



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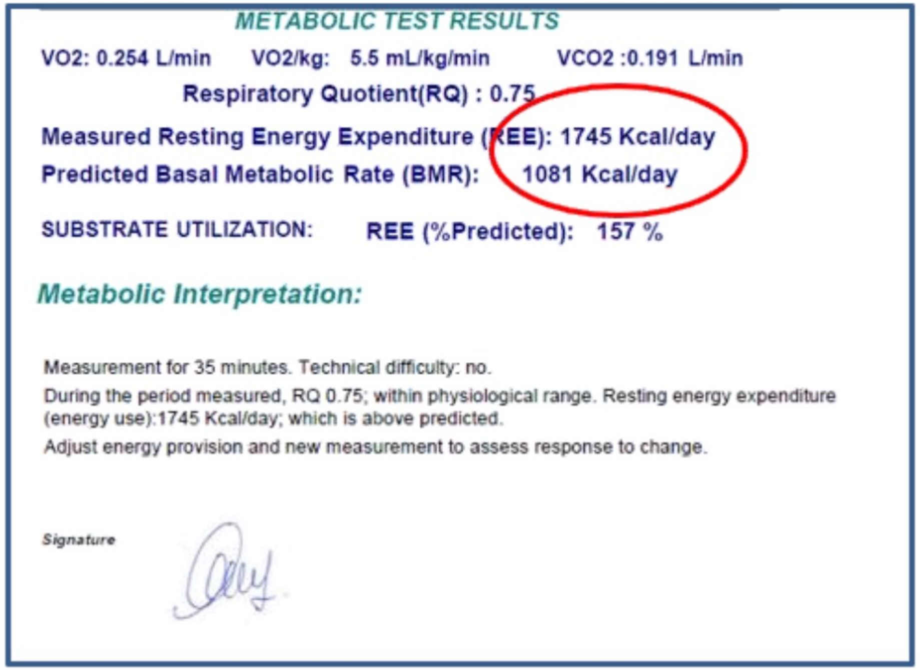

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1081

Predicted

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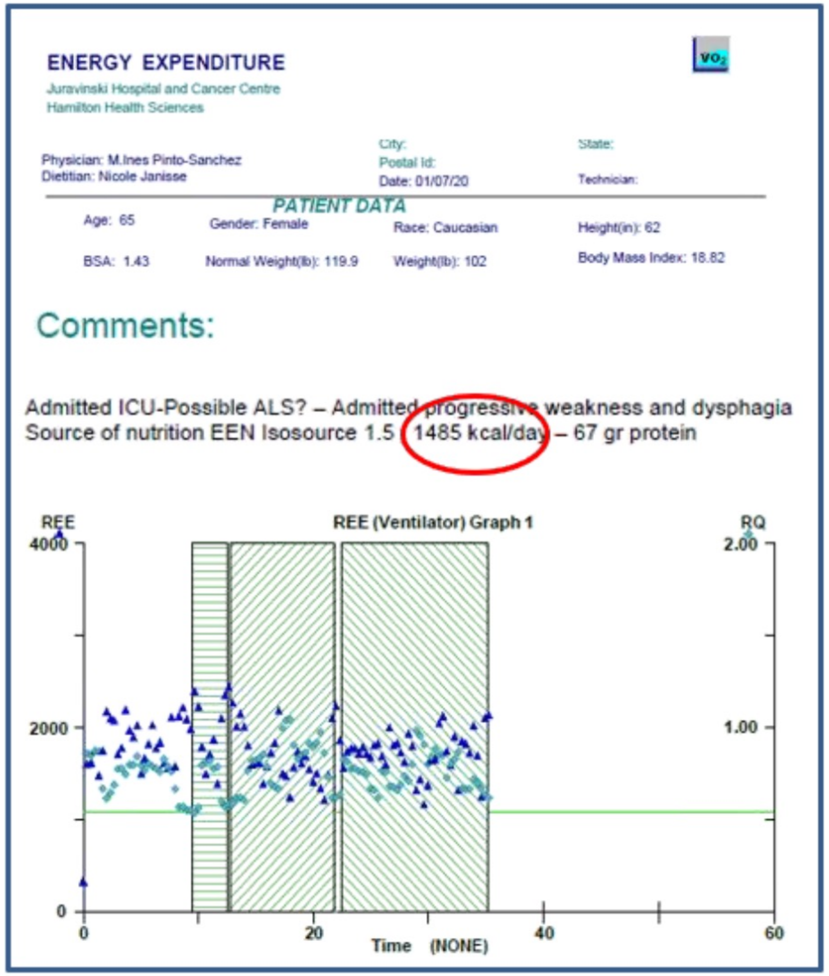

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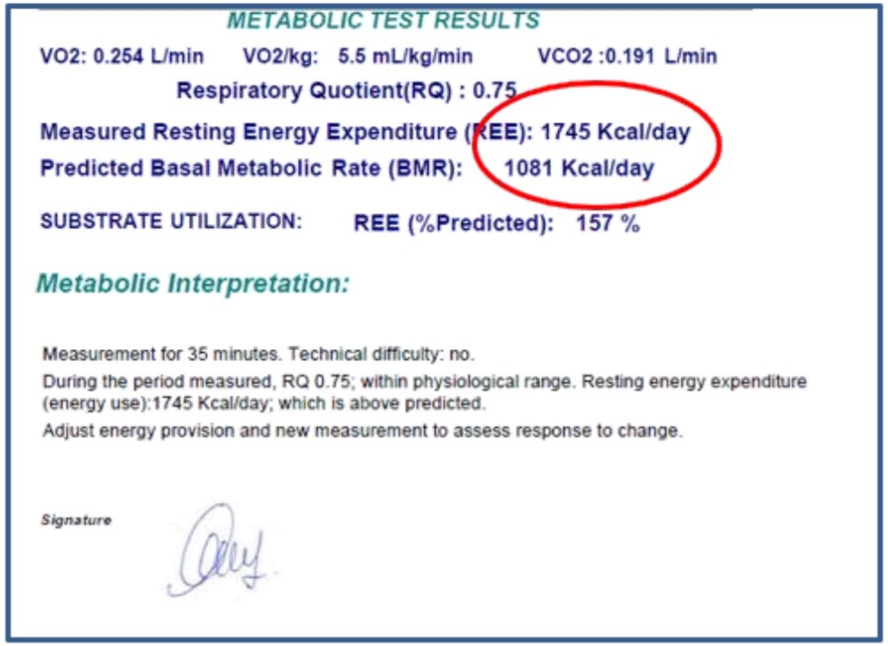

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Signature

1081	1485	1745
Predicted	Before IC	After IC

Case Example

Patient: Outpatient, 46 yr old man , BMI 46, Fasting

Method: Canopy, Room Air

Measurement: 15 min, last 5 min CV 2%

Predicted REE (adjusted body weight) = 1600 kcal/day

Measured REE = 1840 kcal/day

115%predicted

RQ = .75

RQ .70 to .79

- Fasting State
- Starvation
- ETOH or Ketones

Interpretation

- Quality: Good, CV 2%
- Conditions: Canopy study, Fasting State
- Summary: REE is 1840 kcal/day (115% predicted) with an RQ of .75 consistent with a fasting state.

case scenario

A 63yrs old male was admitted to the hospital with a diagnosis of pulmonary emphysema. The patient complained of shortness of breath for the last several days at home, and, on admission, the patient's condition rapidly deteriorated in the emergency department; after several attempts to stabilize his ventilation, the patient was intubated and transferred to the ICU where he was placed on a mechanical ventilator.

On physical exam, the patient exhibited signs of muscle wasting and malnutrition. Enteric feeding were begun using a standard mixture of 10% lipids, 60% CHO, with balance of proteins and minerals that supplied approximately 2100 kcal per 24 h. the patient's condition stabilized during the next 24h. attempts to withdraw ventilator support over the next several days were not successful due to hypercapnia (increased CO2) when support from the ventilator was reduced.

Case scenario, result and interpretation

- On day 4 of admission, indirect calorimetry was ordered with the following results:
- REE 1950 kcal/24 hr
- RQ 0.98
- VO_2 4.1 mL/min/kg
- VCO_2 3.6 mL/min/kg
- The information from the indirect calorimetry study indicated that while the total number of calories being delivered was appropriate, the patient was being given an excessive CHO load.
- This was confirmed by the RQ measurement of 0.98.

INTERPRETATION

- The elevated carbon dioxide production and oxygen consupmtion levels were contributing to the patient's inability to support his ventilation unaided from the ventilator. The patient's feedings were a djusted to reflect a balance of nutrients that would minimize VCO2 levels and encourage ventilator withdrawal. This patient e xhibited the classic response to excessive CHO calories. While the total number of calories was adequate, as measured by the REE, t he mixture of substrates was not appropriate considering the patient's underlying condition

Summary

- ✓ Malnutrition is concerning, and predictive formulas are not accurate to determine energy requirements
- ✓ There is a need for proper nutritional and functional capacity assessments in patients admitted to hospital as well as outpatient setting
- ✓ IC provides reliable, non-invasive and precise measurement of EE in hospitalized patients and outpatients
- ✓ Larger studies to understand whether changes in nutritional practices based on more accurate estimations of individualized EE will impact in patient' outcomes.

Conclusion

- ✓ In the era of personalized medicine…

Nutrition delivery based on IC determination has the potential to provide individualized nutrition assessment and provision in patients with GI conditions

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