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Introduction to Biophysical Aspects of Human Movement (APA-1161)

Exercise physiology (Energy system)

November 13, 2012

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Exam

- December 12, 2012 (14h)

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Lab reports

- Intro
  - Pass tense – No "I"
  - Provide background – Why
- Results
  - Table and graph – need description
- Discussion
  - Refer to the intro + results
- References
  - APA – None received 100%
  - Owl WEB site
    - www.owl.english.purdue.edu
  - No WIKIPEDIA !

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TODAY

Lesson Plan

- Energy (creation)
- Muscle contraction
- Energy source
- Resting metabolisim

Objectives

- Introduction to exercise physiology
- Understand the principle of energy prodution
- Identify the common usage of ATP
- Define muscle contraction
- Introduced to energy expendature

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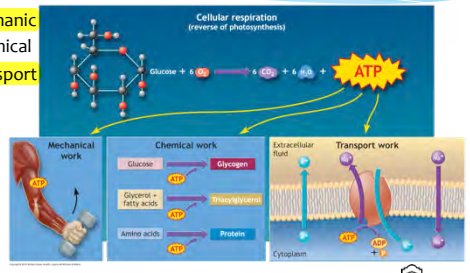
Energy management

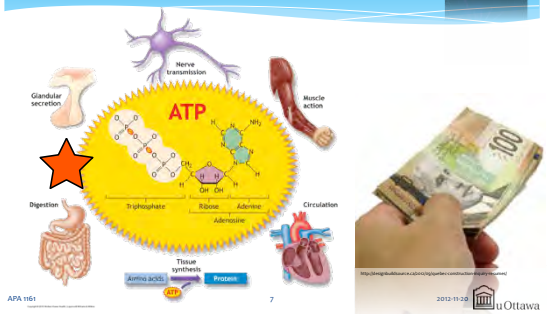
- ATP
- Role
- Production

Biologic work

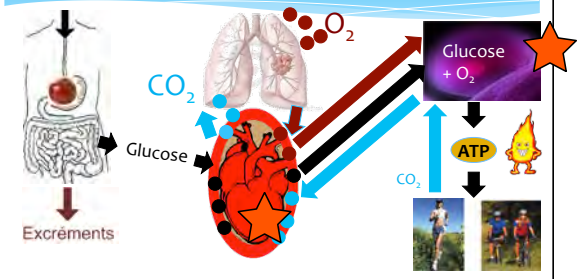
- Mechanic
- Chemical
- Transport



Energy currency
(Adenosine triphosphate-ATP)



How is ATP produced



How is APT produced ?

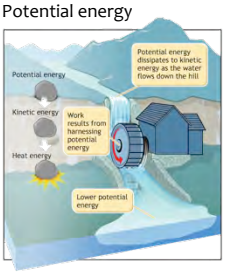
- Derived from degradation of:
  - Glucose
  - Protein
  - Lipids

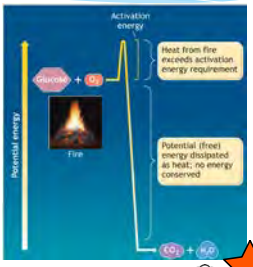
Nutrition Facts

Amount Per Serving	
Calories 402	Calories from Fat 205
	% Daily Value*
Total Fat 24.95 g	38%
Saturated Fat 17.24 g	86%
Trans Fat 0.1 g	
Cholesterol 32.50 mg	4%
Sodium 11.04 mg	2%
Potassium 221.76 mg	6%
Total Carbohydrate 42.61 g	21%
Dietary Fiber 0.56 g	4%
Sugars 40.73 g	
Sugar Alcohols	
Protein 6.25 g	
Vitamin A 72.76 IU	2%
Vitamin C 0 mg	0%
Calcium 120 mg	12%
Iron 0.90 mg	5%

How is APT produced ?

- Potential energy



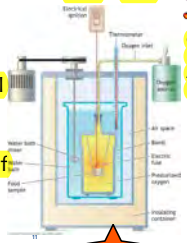


How is APT produced ?

$Nutient + O_2 \rightarrow Energy + H_2O + CO_2 +$

Unit of measure :
Calorie
1000 calories = 1 kcal

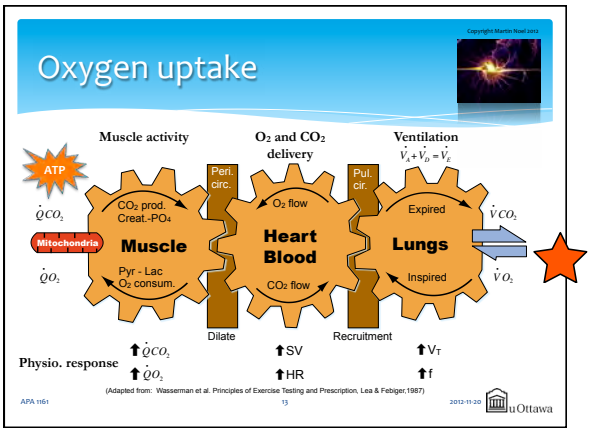
kcal = Quantity of heat needed to raise 1 liter of water by 1 degree Celsius



Glucose =4 kcal/g
Protein =4 kcal/g
Alcohol =7 kcal/g
Lipids =9 kcal/g

How is APT produced ?

- Transformation of energy in ATP


Oxygen uptake
Muscle activity
O2 and CO2 delivery
Ventilation
ATP
Peri. circ.
Pul. cir.
CO2 prod. Creat.-PO4
Muscle
Mitochondria
Pyr - Lac
O2 consum.
O2 flow
Heart
Blood
CO2 flow
Expired
Lungs
Inspired
Dilate
Recruitment
Physio. response
SV
HR
VT
f
(Adapted from: Wasserman et al. Principles of Exercise Testing and Prescription, Lea & Febiger,1987)
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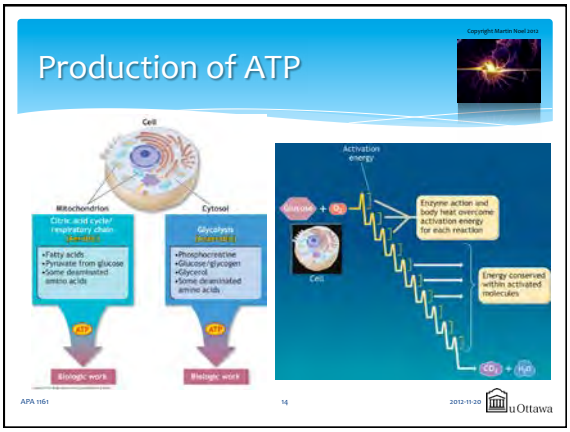
Production of ATP
Cell
Mitochondrion
Cytosol
Activation energy
Enzyme action and body heat overcome activation energy for each reaction
Energy conserved within activated molecules
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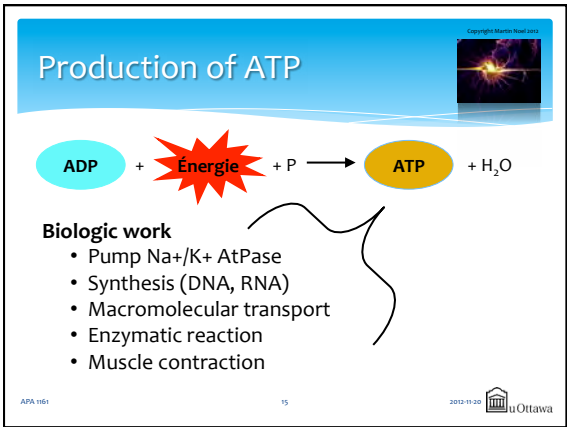
Production of ATP
ADP
+
Énergie
+ P
ATP
+ H2O
Biologic work
Pump Na+/K+ AtPase
Synthesis (DNA, RNA)
Macromolecular transport
Enzymatic reaction
Muscle contraction
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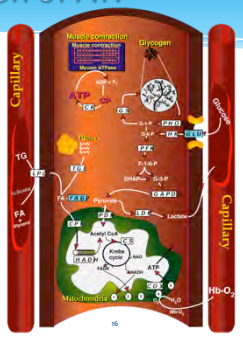
Production of ATP

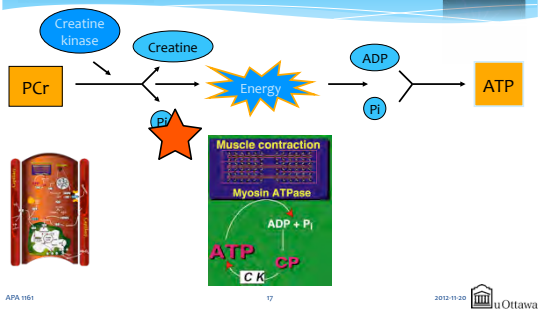


Muscle (PCr)

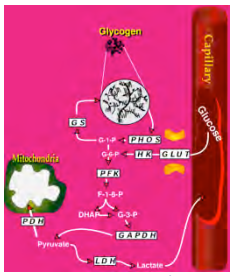
Glycolysis

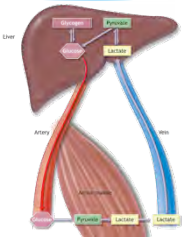
Oxidation

Production of ATP
(PCr to ATP)

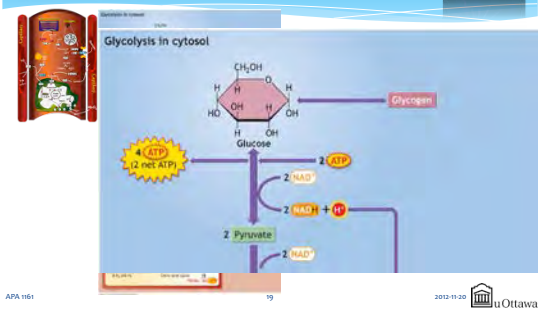


Production of ATP
(Glycolysis)

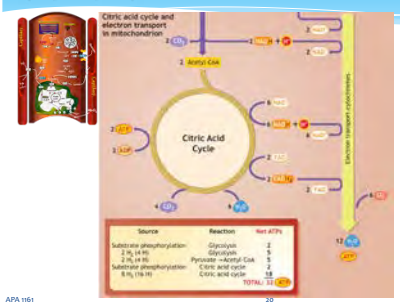




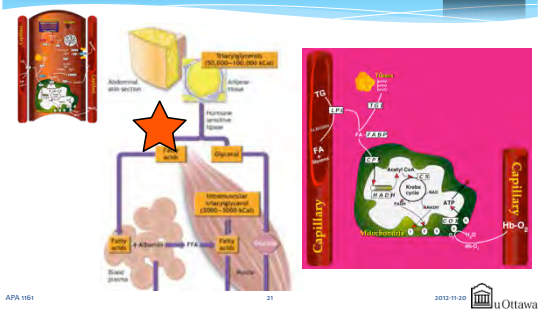
Production of ATP
(Glycolysis)



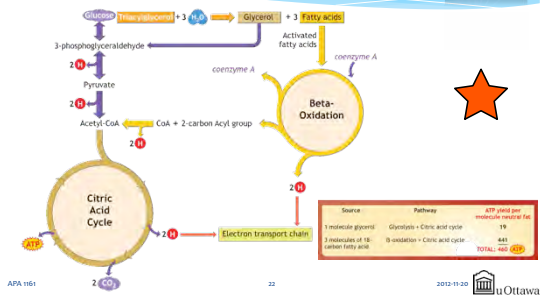
Production of ATP
(Glycolysis)



Production of ATP
(Oxydation)



Production of ATP
(Oxydation)



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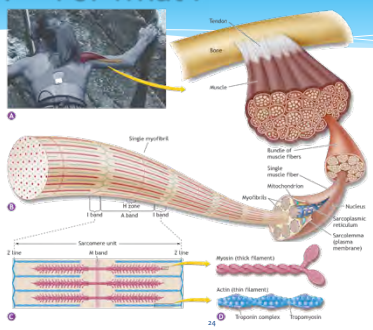
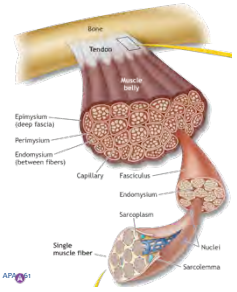
Muscles

- Anatomy
- Contraction
- Fibres

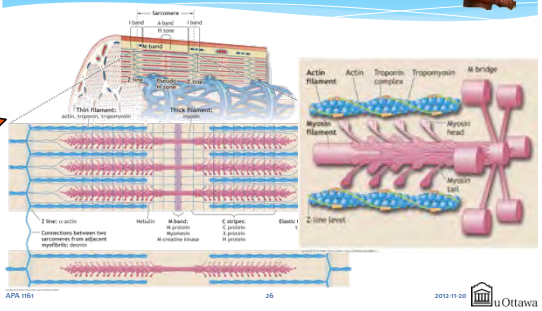
ATP – For what ?



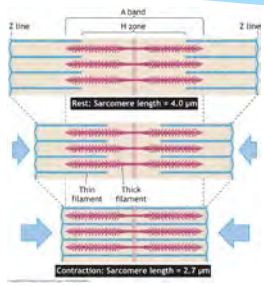
Muscle anatomy

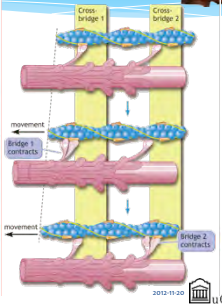


Muscle anatomy

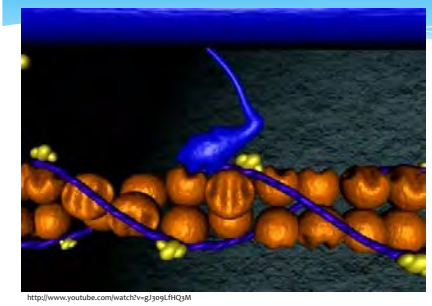


Muscle contraction



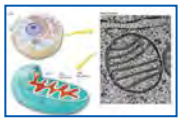


Muscle contraction



http://www.youtube.com/watch?v=gJ309LfHQ3M

Muscle fibres (Biopsie)



Muscle fibres (Biopsie)

Muscle fibres
(Biopsie)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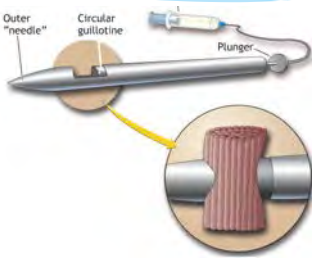
Muscle fibres
(Biopsie)





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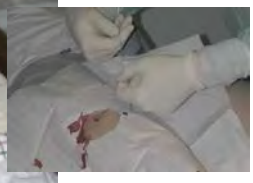
Muscle fibres
(Biopsie)

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Muscle fibres
(Biopsie)

- Fibre types
  - I, IIA, IIB

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Energy systems

- PCr
- Glycolysis
- Oxidation

Energy systems

Mitochondria

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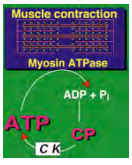
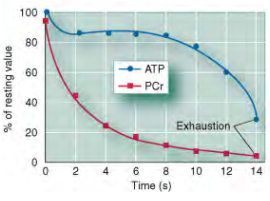
Energy systems

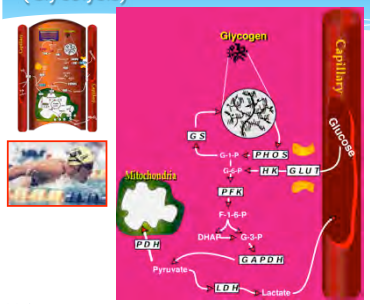
Energy systems

Energy systems
(Phospho creatine)



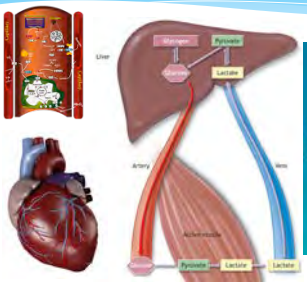


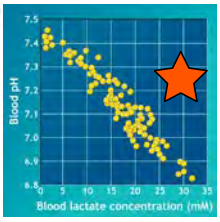
Energy systems
(Glycolysis)



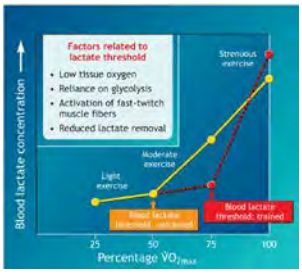
Lactate

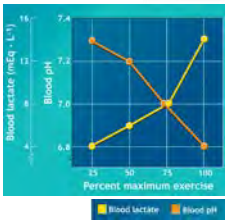
Energy systems
(Glycolysis)





Energy systems
(Glycolysis)

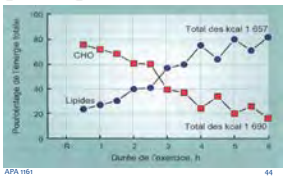




Energy systems
(Oxydation)

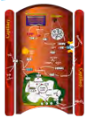
Type of fuel
- Blood glucose
- Hep + intramuscular glucose
- Fat
- Little protein

Energy systems
(Oxydation)



Type of fuel
- Blood glucose
- Hep + intramuscular glucose
- Fat
- Little protein

Energy systems
(Recovery)

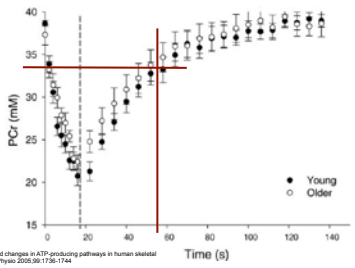


Recovery time (seconds)	PPO recovery (%)
15	68,7
30	73,6
45	78,1
60	81,0
120	88,2
180	92,2

Holmyard et al. (1994)[4] with a group of subjects who performed 6 second sprints with recovery intervals from 15 to 180 seconds found that there is a 81% recovery in peak power output (PPO) with a 1 minute recovery and a 92% recovery of PPO in 3 minutes.

HOLMYARD, D.J. et al. (1994) *Effect of recovery on performance during multiple treadmill sprints.* London: E&FN Spon

Energy systems (Recovery)



ATP synthesis rates from these pathways during maximal voluntary isometric contractions

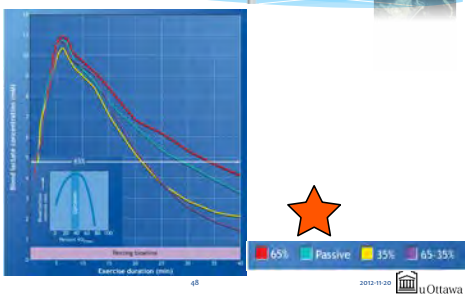
8 (20–35 yr), 8 (65–80 yr) men

Lanza et al. Age-related changes in ATP-producing pathways in human skeletal muscle in vivo J Appl Physio 2005;99:1736-1744

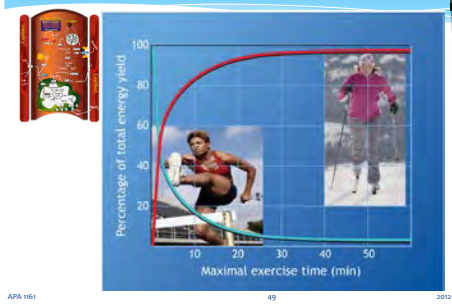
Energy systems (Recovery)

	Recuparation time			
	Minimum	**Incomplete**	**90-95%**	**Complete**
PCr	2 min			5 min
Glycolisis	5 hrs		18 hrs	72 hrs
Oxidative	30min-1h	2-3 hrs	18 hrs	48 hrs

Energy systems (Recovery)



Energy systems
(In brief)

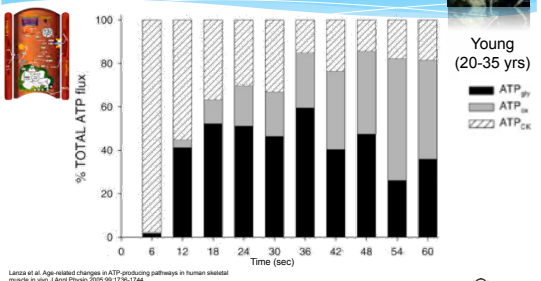


Energy systems
(In brief)

Duration of maximal exercise

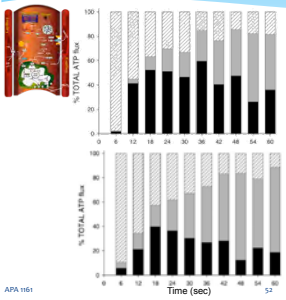
	Seconds			Minutes					
	10	30	60	2	4	10	30	60	120
Percentage anaerobic	90	80	70	50	35	15	5	2	1
Percentage aerobic	10	20	30	50	65	85	95	98	99

Energy systems
(Recovery)



Lanza et al. Age-related changes in ATP-producing pathways in human skeletal muscle in vivo. J Appl Physiol 2005;99:1736-1744

Energy systems
(Recovery)

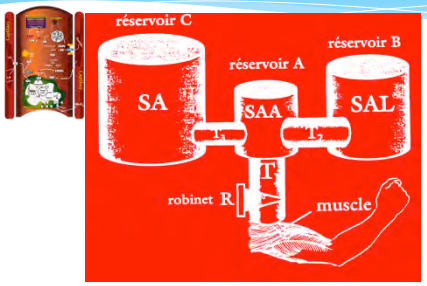


Young
(20-35 yrs)

Old
(60-80 yrs)

Lanza et al. Age-related changes in ATP-producing pathways in human skeletal muscle in vivo J Appl Physio 2005;99:1736-1744

Energy systems
(In brief)



Energy systems
(In brief)

Type d'énergie	Voie anaérobie		Voie aérobie	
Source énergétique première	ATP produite sans la présence d'O_2		ATP produite avec la présence d'O_2	
Système énergétique	Alactique immédiat	Lactique court terme	Oxygène long terme	
Nutriments	ATP, CP	Glycogène glucose	Glycogène, glucose, lipides, protéines	
Durée	3 s - 10 s	40 s - 2 min	6 min - 25 min	1 h - 3 h
Événement sportif	Sprint (100 m) Lancé Saut Hélicoptère Saut à ski Plongée Gymnastique (saut à la perche)	Piste (200-400 m) Patinage de vitesse (500 m) Gymnastique (exercices divers) Cyclisme piste Natation (50 m)	Natation (100 m) Piste (800 m) Gymnastique (exercices au sol) Ski alpin Cyclisme Piste (1000 m ou poursuite)	Piste (distance moyenne), natation, patinage de vitesse Canoë (1000 m) Boxe Lutte Aviron Patinage artistique Natation synchronisée Cyclisme, poursuite	Piste (longue distance), natation, patinage artistique, canoë Cyclisme, course sur route Triathlon
	La plupart des sports d'équipe/sports de raquette/vole				

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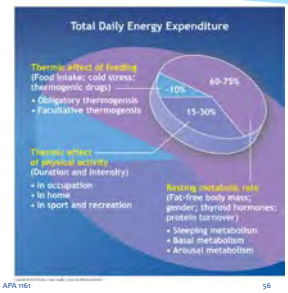
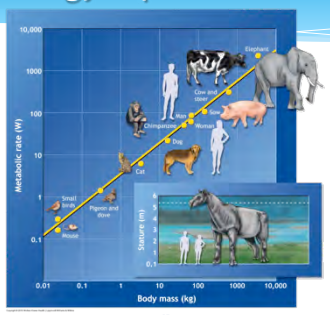
Resting metabolic rate

- Total energy expenditure
- Resting energy expenditure
- MET

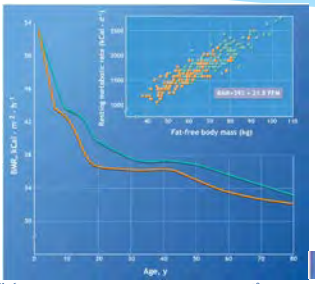
Total energy expenditure



Total energy expenditure

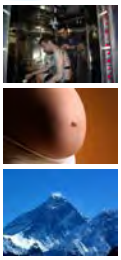


Resting energy expenditure



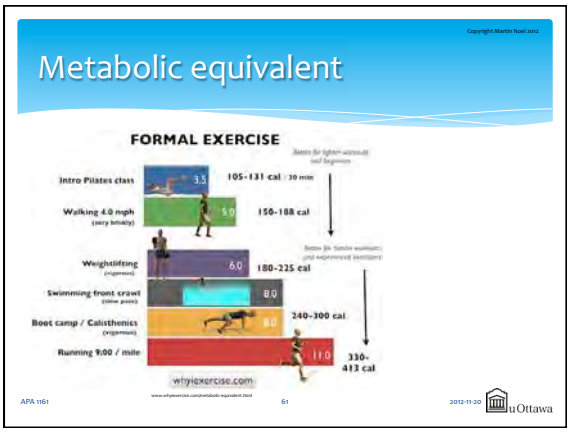
Resting energy expenditure

- Factor affecting
  - Thermic effect of food
  - Climate
    - Hot
    - Cold
    - Altitude
  - Pregnancy



Resting energy expenditure

- MET
  - Metabolic equivalent
  - 3.5 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$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Metabolic equivalent
FORMAL EXERCISE
Intro Pilates class
3.5
105-131 cal / 30 min
Walking 4.0 mph
5.0
150-188 cal
Weightlifting
6.0
180-225 cal
Swimming front crawl
8.0
Boot camp / Calisthenics
8.0
240-300 cal
Running 9:00 / mile
11.0
330-413 cal
whyiexercise.com
APA 1161
61
2012-11-20
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That's all Folks!
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