University of Verona,

School of Exercise and Sport Science,

Laurea magistrale in Scienze motorie preventive ed adattate

Metodologia delle misure delle attività sportive

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A class within a four classes module

Some definitions

- Physiology is the scientific study of function in living organisms;
- Metabolism is the set of life-sustaining chemical transformations within the cells of living organisms (also to support energetically locomotion);
- Bioenergetics is the subject of a field of biochemistry (and physiology) that concerns energy flow through living organisms;
- Energy balance is the biological homeostasis of energy in living organisms;
- Energy intake = internal heat produced + external work + storage;
- Biomechanics is the scientific study of how living organisms move (including locomotion).

The two faces of the same coin

- Biomechanics is the physics of exercise/ sport (mechanics, statics/dynamics, kinematics/kinetics):
  biomechanics deals with the correct management of motion, force, momentum, levers and balance, to improve technique and reduce injury risk;
- bioenergetics is the chemistry of exercise/sport (exercise/sport metabolism)

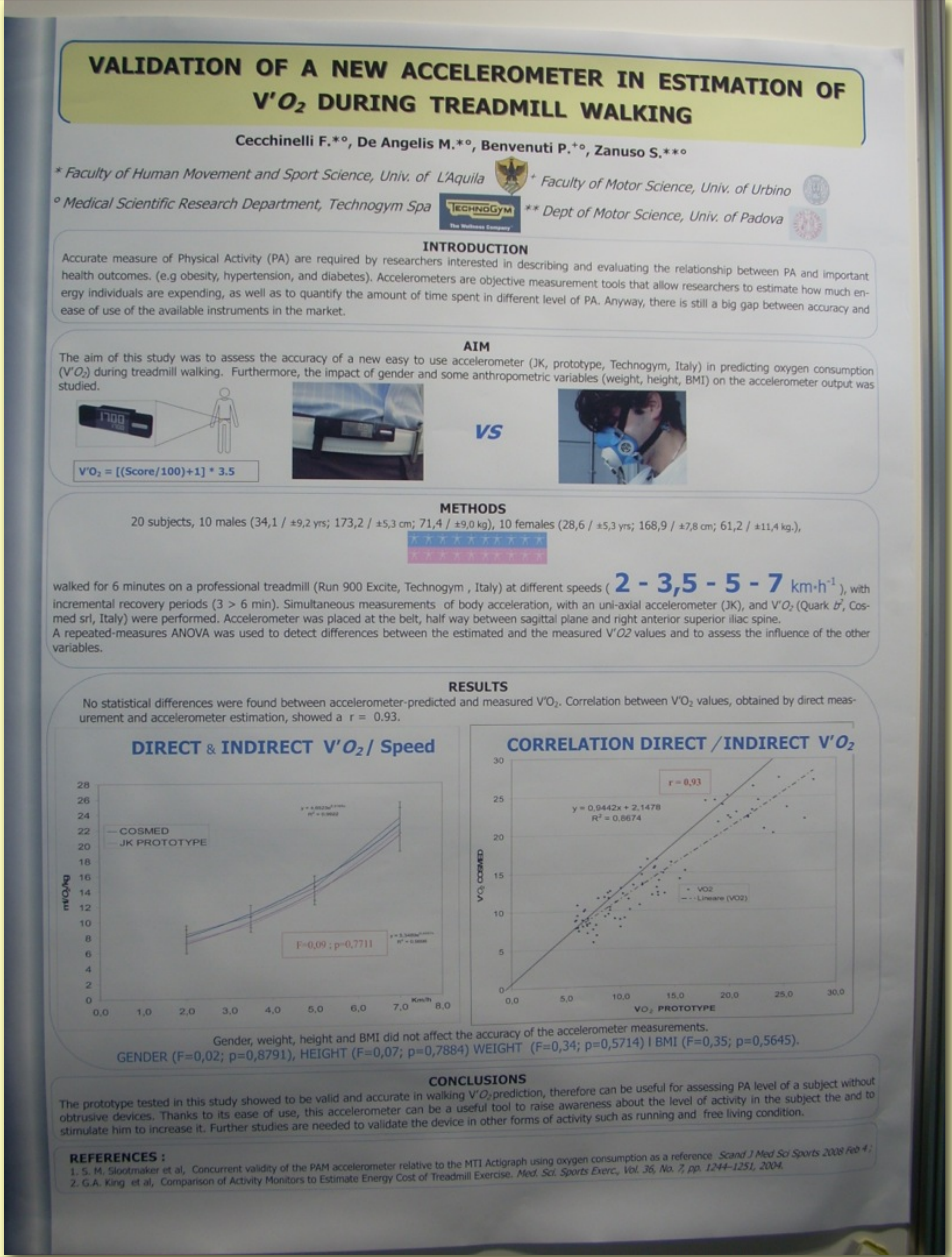
Back to (my) February 2006…

Stato dell'arte degli strumenti portatili di misura della spesa calorica della persona

1 Introduzione

Personalmente, penso che attualmente non esista sul mercato alcun sistema portatile di misura della spesa calorica della persona obiettivamente valido in tutte le situazioni più comuni. Ciò è dovuto soprattutto all'ancora limitata richiesta assoluta di questo tipo di prodotto, nonostante il suo sentito bisogno – a costi sostenibili – da parte della comunità scientifica (Trost *et al.*, 2005).

Then what?


VALIDATION OF A NEW ACCELEROMETER IN ESTIMATION OF V'O2 DURING TREADMILL WALKING
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INTRODUCTION
Accurate measure of Physical Activity (PA) are required by researchers interested in describing and evaluating the relationship between PA and important health outcomes. (e.g obesity, hypertension, and diabetes). Accelerometers are objective measurement tools that allow researchers to estimate how much energy individuals are expending, as well as to quantify the amount of time spent in different level of PA. Anyway, there is still a big gap between accuracy and ease of use of the available instruments in the market.
AIM
The aim of this study was to assess the accuracy of a new easy to use accelerometer (JK, prototype, Technogym, Italy) in predicting oxygen consumption (V'O2) during treadmill walking. Furthermore, the impact of gender and some anthropometric variables (weight, height, BMI) on the accelerometer output was studied.
V'O2 = [(Score/100)+1] * 3.5
VS
METHODS
20 subjects, 10 males (34,1 / ±9,2 yrs; 173,2 / ±5,3 cm; 71,4 / ±9,0 kg), 10 females (28,6 / ±5,3 yrs; 168,9 / ±7,8 cm; 61,2 / ±11,4 kg.),
walked for 6 minutes on a professional treadmill (Run 900 Excite, Technogym , Italy) at different speeds (2 - 3,5 - 5 - 7 km·h-1), with incremental recovery periods (3 > 6 min). Simultaneous measurements of body acceleration, with an uni-axial accelerometer (JK), and V'O2 (Quark b2, Cosmed srl, Italy) were performed. Accelerometer was placed at the belt, half way between sagittal plane and right anterior superior iliac spine.
A repeated-measures ANOVA was used to detect differences between the estimated and the measured V'O2 values and to assess the influence of the other variables.
RESULTS
No statistical differences were found between accelerometer-predicted and measured V'O2. Correlation between V'O2 values, obtained by direct measurement and accelerometer estimation, showed a r = 0.93.
DIRECT & INDIRECT V'O2 / Speed
COSMED
JK PROTOTYPE
ml/O2/kg
F=0,09 ; p=0,7711
Km/h
CORRELATION DIRECT / INDIRECT V'O2
r = 0,93
y = 0,9442x + 2,1478
R² = 0,8674
VO2 COSMED
VO2 PROTOTYPE
Gender, weight, height and BMI did not affect the accuracy of the accelerometer measurements.
GENDER (F=0,02; p=0,8791), HEIGHT (F=0,07; p=0,7884) WEIGHT (F=0,34; p=0,5714) I BMI (F=0,35; p=0,5645).
CONCLUSIONS
The prototype tested in this study showed to be valid and accurate in walking V'O2 prediction, therefore can be useful for assessing PA level of a subject without obtrusive devices. Thanks to its ease of use, this accelerometer can be a useful tool to raise awareness about the level of activity in the subject the and to stimulate him to increase it. Further studies are needed to validate the device in other forms of activity such as running and free living condition.
REFERENCES :
1. S. M. Slootmaker et al, Concurrent validity of the PAM accelerometer relative to the MTI Actigraph using oxygen consumption as a reference. Scand J Med Sci Sports 2008 Feb 4
2. G.A. King et al, Comparison of Activity Monitors to Estimate Energy Cost of Treadmill Exercise. Med. Sci. Sports Exerc., Vol. 36, No. 7, pp. 1244-1251, 2004.

The two faces of the same coin/2

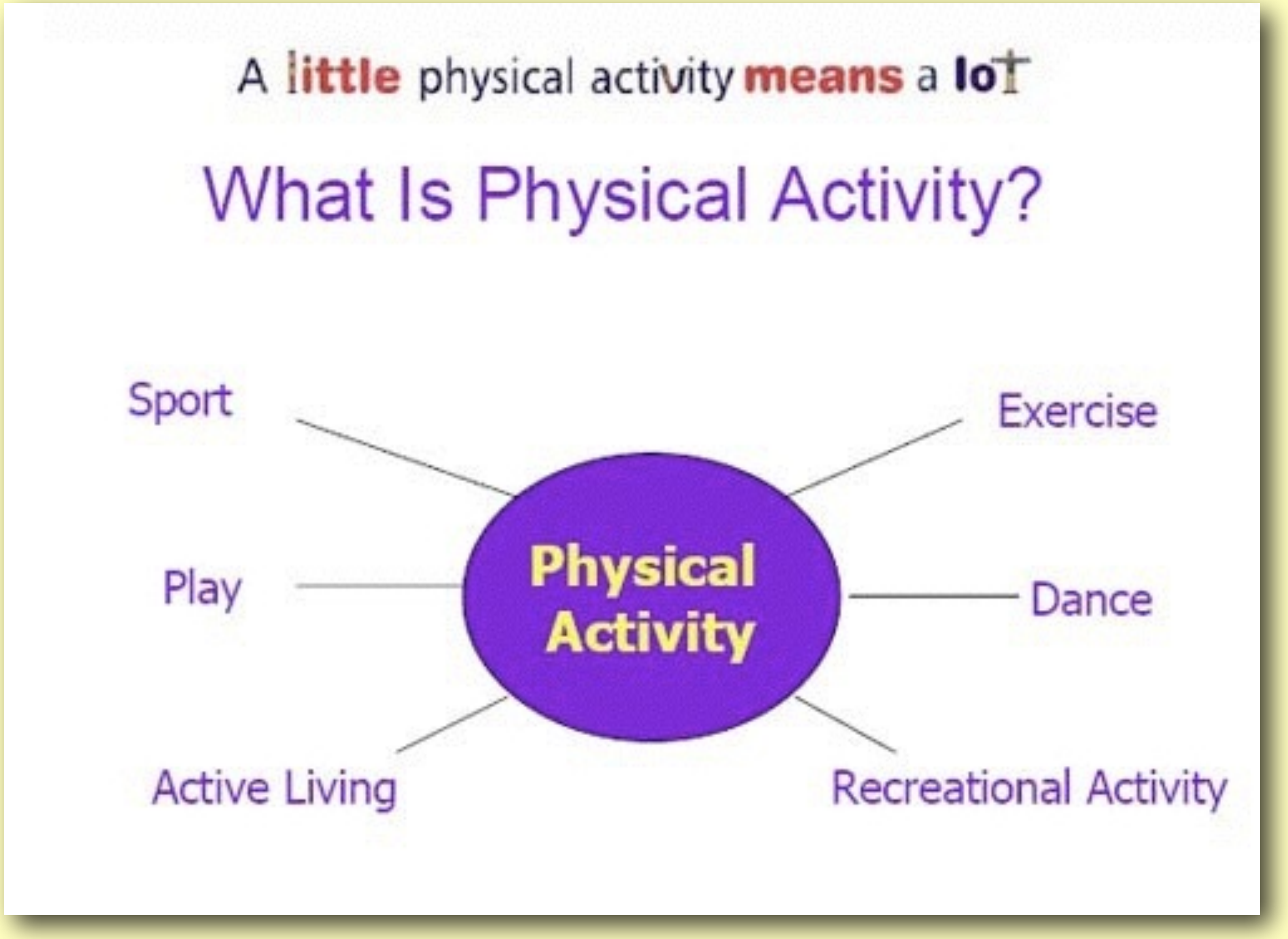
- 'coin' = any specific exercise/sport action;

physical activity (PA) 'face' = biomechanics/ mechanics of action;

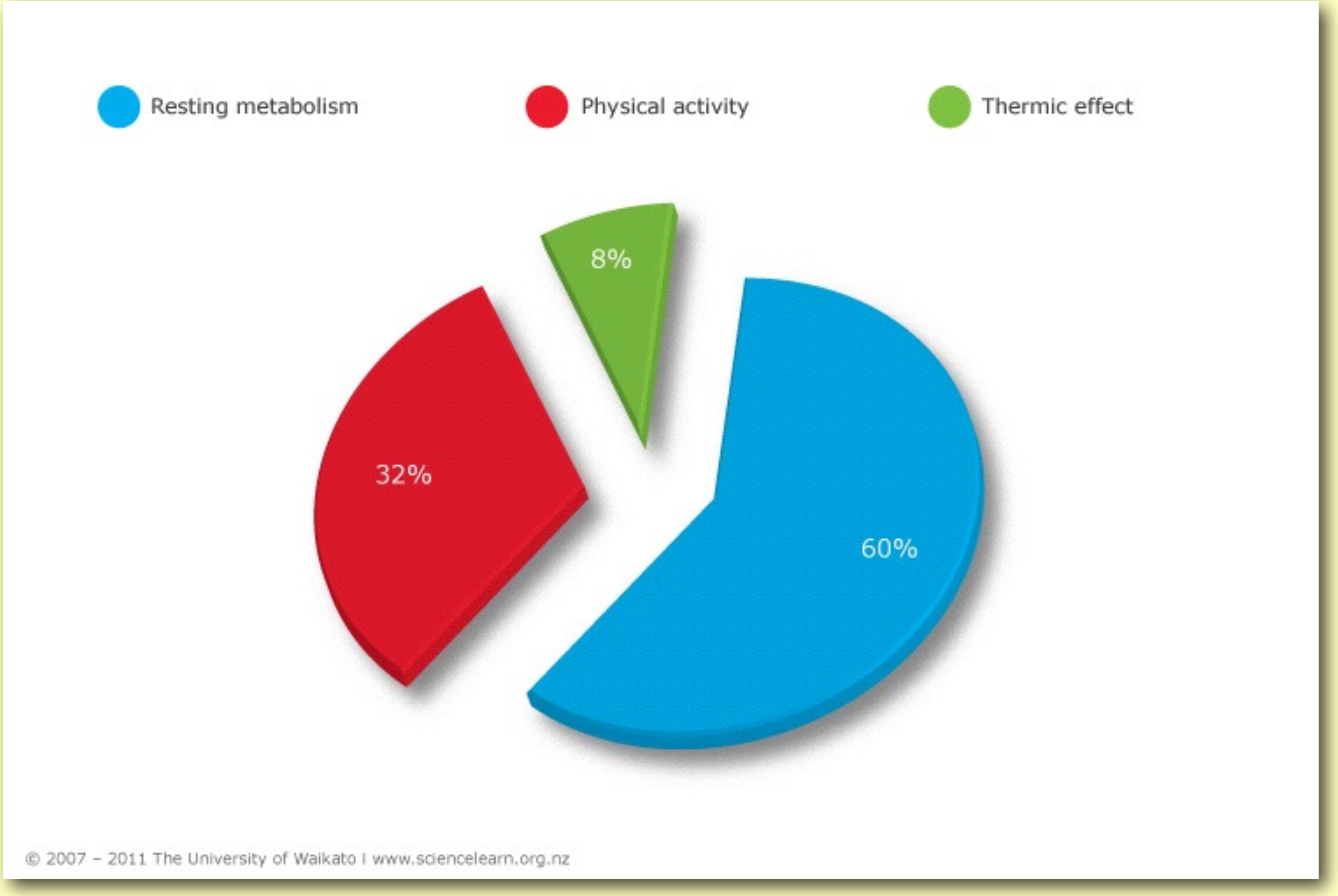
metabolic expenditure (ME) 'face' = chemistry/ metabolism of action

Physical activity

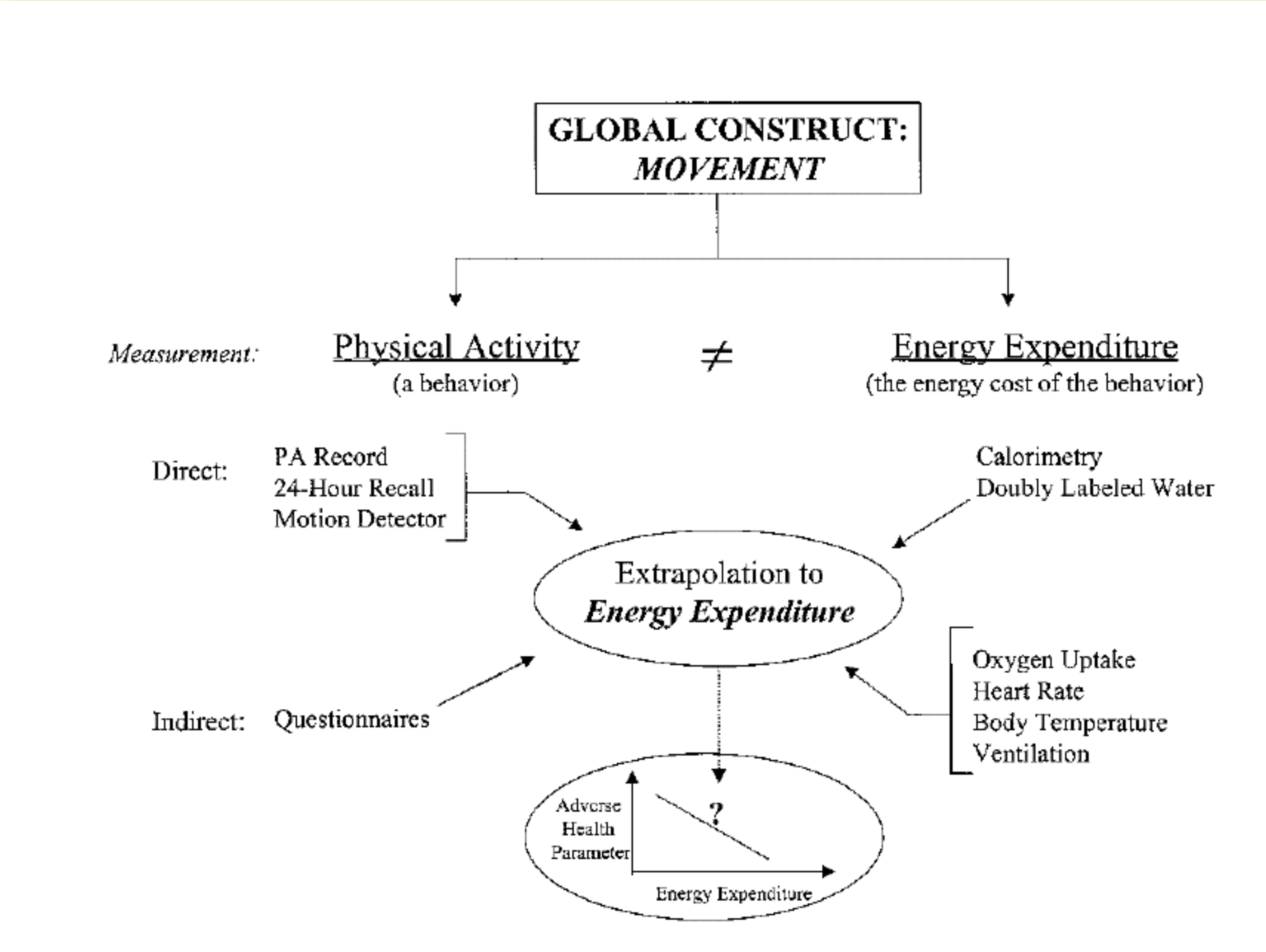
Any bodily movement produced by the contraction of skeletal muscle;
but... isometric contraction?
therefore: bodily movement + isometric contraction = PA



Physical activity **requires** metabolic expenditure



PA & ME



Lamonte et al., 2001

PA & ME

TABLE 1. Methods of assessing physical activity or energy expenditure.

Direct	
	Observation
	Room calorimetry (e.g., body heat production)
	Doubly labeled water
	Biomechanical forces
	Acceleration vectors (e.g., accelerometry)
	Motion sensors (e.g., pedometry)
	PA records or diaries, recall interviews
Indirect	
	Indirect calorimetry (e.g., O_2 uptake, CO_2 production)
	Physiologic measures (e.g., heart rate, ventilation, temperature, estimated cardiorespiratory fitness)
	PA surveys or questionnaires
	Surrogate reports (e.g., energy intake)

Lamonte et al., 2001

PA & ME

Measures

- accelerometry (counts/u.t.);
- HR:
  - HR (bpm), nHR (bpm), HRR (%);
- V'O2 (metabolic chamber or open circuit):
  - V'O2, nV'O2, PAL.

Schutz et al., 2001

PA & ME

measures

Table 2. Representative values obtained for currently available and proposed new measures to assess physical activity: values are based on two hypothetical subjects of the same sex, age, and height, but different weights and activity levels*

Parameter (units)		Subject 1 (lighter, more active) Female, age = 40 yr BMI = 25 kg/m² (67 kg, 1.63 m) REE = 1480 kcal/d (1.0 kcal/min) 24-hr EE = 2150 kcal/d	Subject 2 (heavier, less active) Female, age = 40 yr BMI = 30 kg/m² (80 kg, 1.63 m) REE = 1550 kcal/d (1.1 kcal/min) 24-hr EE = 2200 kcal/d
Parameters based on EE or O_2 uptake			
AEE	Activity EE (kcal/d or kcal/kg · d)	450 kcal/d 6.7 kcal/kg/d	450 kcal/d 5.6 kcal/kg/d
PAL*EE*	Physical activity level (24-hr EE/REE) (ratio)	1.45 (2150/1480)	1.42 (2200/1550)
PAL*EEday*	Daytime physical activity level (daytime EE/REE) (ratio)	1.65 (2450/1480)	1.58 (2450/1550)
MET*EE*	Metabolic equivalent [exercise O_2 uptake (O_2/kg · min)/standard resting O_2 uptake (O_2/kg · min)] (ratio)	3.4 (12.0/3.5)	3.4 (12.0/3.5)
PAR*EE*	Physical activity ratio (reference exercise EE [kcal/min]/REE [kcal/min]) (ratio)	4.0 (4.0/1.0)	4.5 (5.0/1.1)
ARTE*EE*	Activity-related time equivalent (min/d) (24-hr EE [kcal/d] · 0.9 − REE [kcal/d])/(reference exercise EE [kcal/min] − REE [kcal/min])	152 min/d (2150 · 0.9 − 1480)/(4.0 − 1.0)	110 min/d (2200 · 0.9 − 1550)/(5.0 − 1.1)
Parameters based on HR			
HR*net*	Net HR (beats/d) (average 24-hr HR [beats/min] − resting HR [beats/min]) · 1440 min/d	21,600 beats/d (80 − 65) · 1440	21,660 beats/d (85 − 70) · 1440
PAL*HR*	Physical activity level (24-hr HR/resting HR) (ratio)	1.23 (80/65)	1.21 (85/70)
PAL*HRday*	Daytime physical activity level (daytime HR/resting HR) (ratio)	1.31 (85/65)	1.29 (90/70)
PAR*HR* (MET*HR*)	Physical activity ratio (exercise HR/resting HR) (ratio)	1.85 (120/65)	1.86 (130/70)
ARTE*HR*	Activity-related time equivalent (min/d) (24-hr HR [beats/d] − resting HR [beats/d])/(reference exercise HR [beats/min] − resting HR [beats/min])	393 min/d (115,200 − 93,600)/(120 − 65)	360 min/d (122,400 − 100,800)/(130 − 70)

* Subject characteristics and physiological data, although hypothetical, are based on actual data of similar subjects studied in our laboratory (14,25). The reference exercise task used for each parameter = steady-state response to bicycle ergometry at 60 rpm, 50-W workload, 4 minutes. Calculation of MET*EE* is based on assumption that 1 MET = 3.5 mL O_2/kg · min.

Schutz et al., 2001

PA & ME

Direct measures

- pedometry;
- accelerometry;
- V’O2;
- DLW;
- observation;
- self-report diaries

Indirect measures

- HR;
- anthropometry;
- questionnaires;
- oth. metabolic measures;
- oth. fitness measures

Tudor-Locke et al., 2001

PA & ME

Golden standard
- V'O2 (middle term);
- DLW (long term);
- observation

Secondary measures
- pedometry;
- accelerometry;
- HR

Subjective measures
- self-report diaries;
- questionnaires

Tudor-Locke et al., 2001

PA & ME

Accelerometry issues
- ->PA;
- activity kind? (e.g., gradient locomotion, cycling);
- specific activity efficiency? (PA/[ME-rME])

Pedometry issues
- ->(most of) PA (i.e., walking);
- other activities?