University of Verona,
School of Exercise and Sport Science,
Laurea magistrale in Scienze motorie preventive ed adattate

Metodologia delle misure delle attività sportive

Monday 10/11/2014 h. 10:30÷12:30

Luca P. Ardigò Ph.D.

A class within a four classes module

30

Pedometer accuracy/reliability

measures

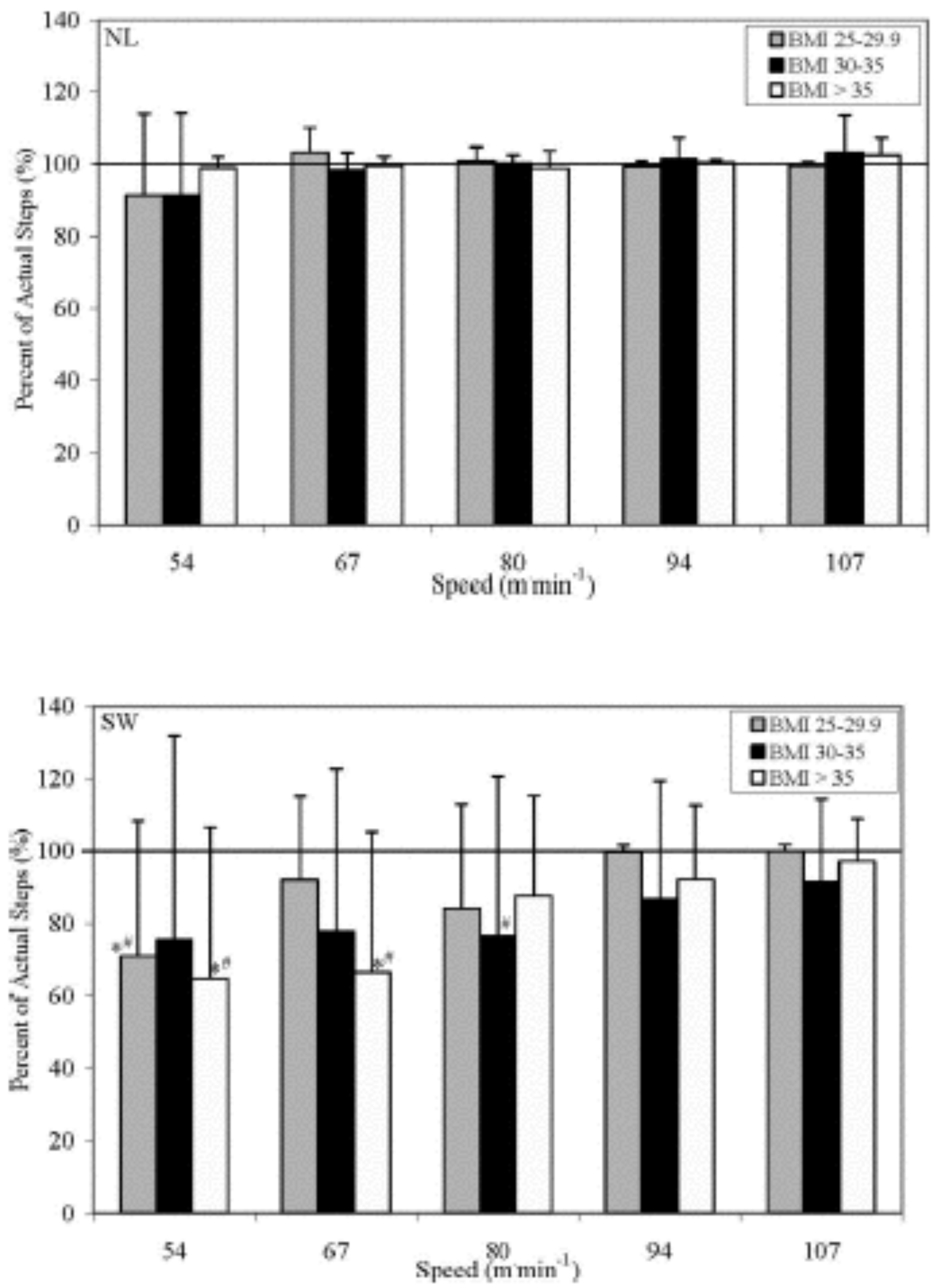


FIGURE 2—Effect of BMI (25–29.9 kg·m^{-2}, 30–35 kg·m^{-2}, and >35 kg·m^{-2}) on the percent of actual steps recorded by the New-Lifestyles NL-2000 (NL) and Yamax Digiwalker SW-200 (SW). Error bars are standard deviation. * Significantly different from actual steps; # significantly different from the NL ($P < 0.05$).

(uniaxially accelerometric)

stride #

(electromechanical circuit based)

Crouter et al., 2005

Pedometer

Final pedometry issues

- no discrimination of weight lifting, gradient legged locomotion, cycling, swimming, rowing;
- shoe or ankle accelerometric pedometer -> stride #

Accelerometer

First generation

Rationale

a <- F (= m x a) <- by paying ME

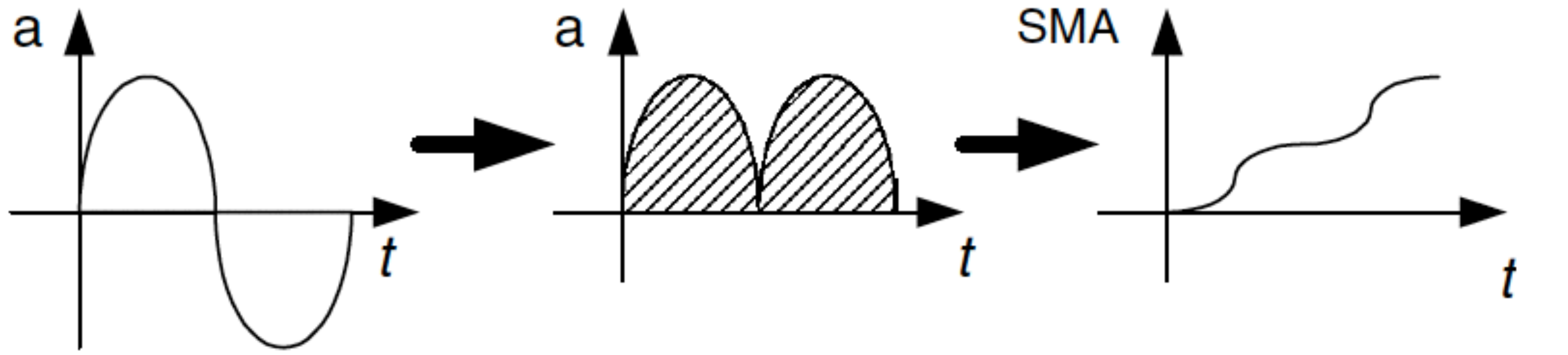


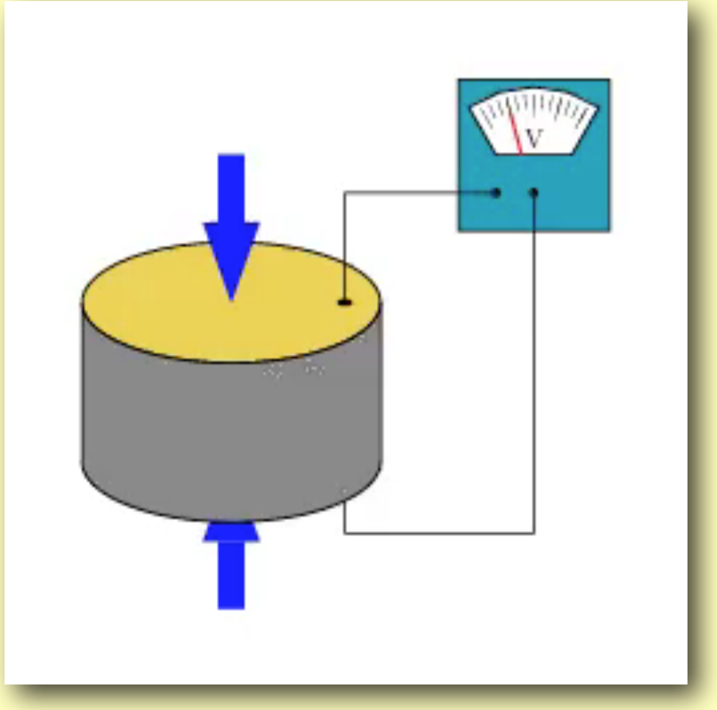
Figure 5. Metabolic energy expenditure (EE) is estimated by computing the signal magnitude area (SMA). The acceleration signal is rectified and then integrated. EE is then estimated by means of a linear regression.

Placement

waist but also chest, back, wrist, ankle

Accelerometer

- A piezo-electric or -resistive sensor;
- -> “counts” number, intensity;
- no isometric force



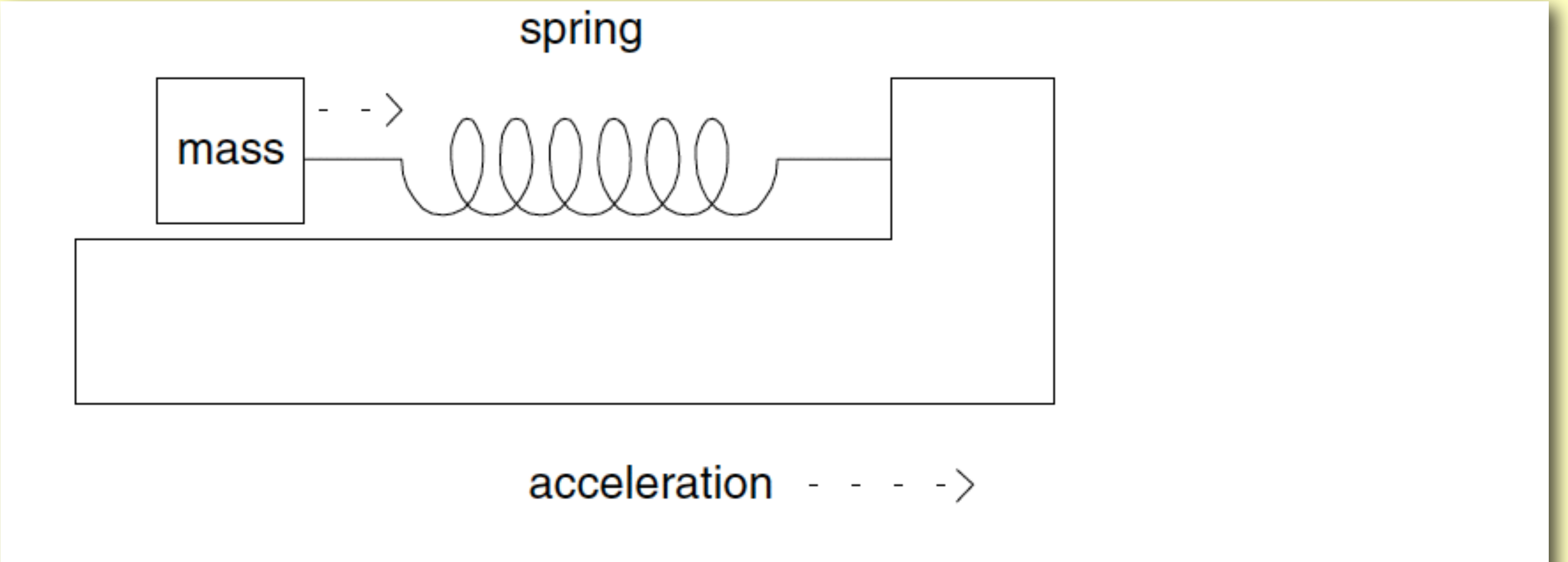
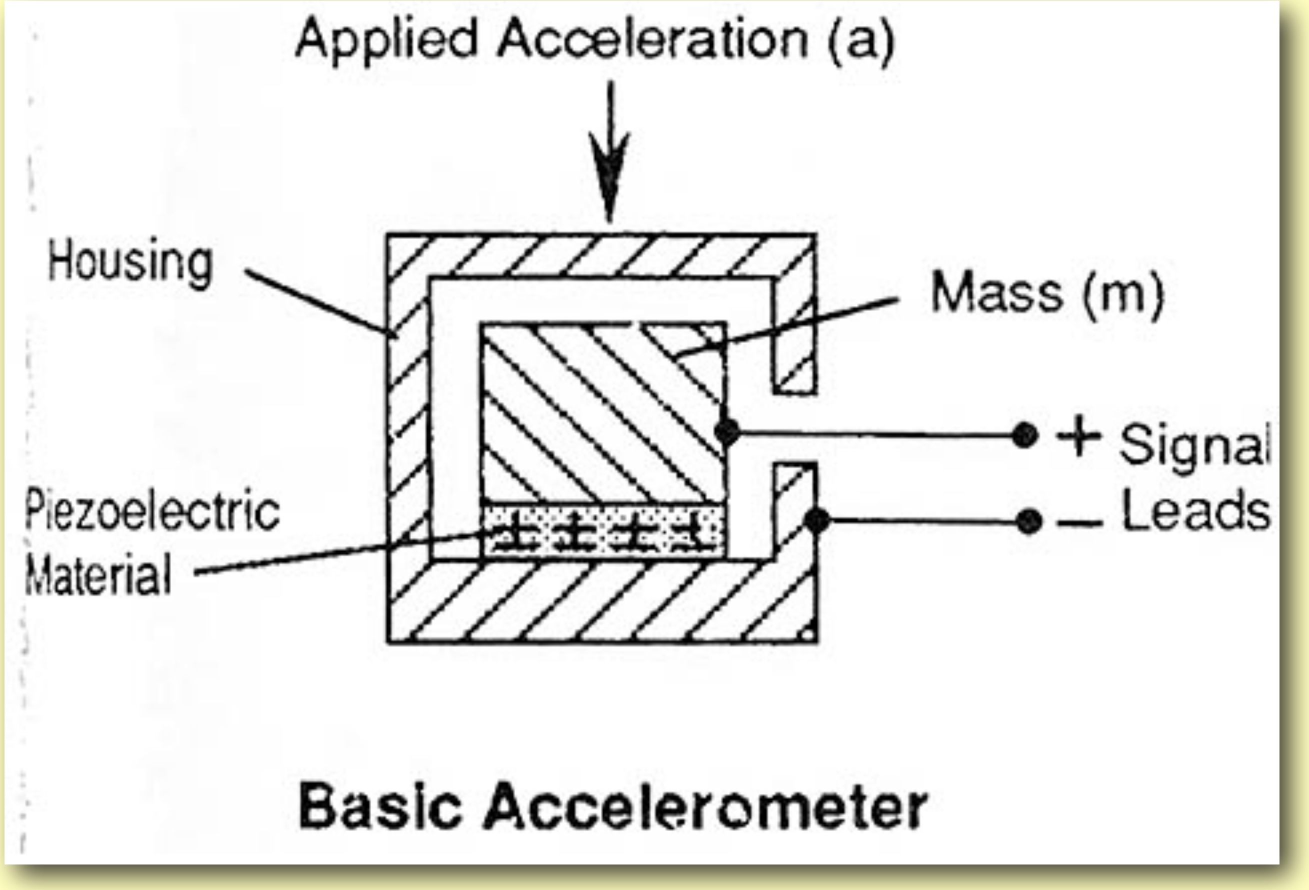


Figure 1. A piezoelectric accelerometer works like a simple mass spring system.



Accelerometer

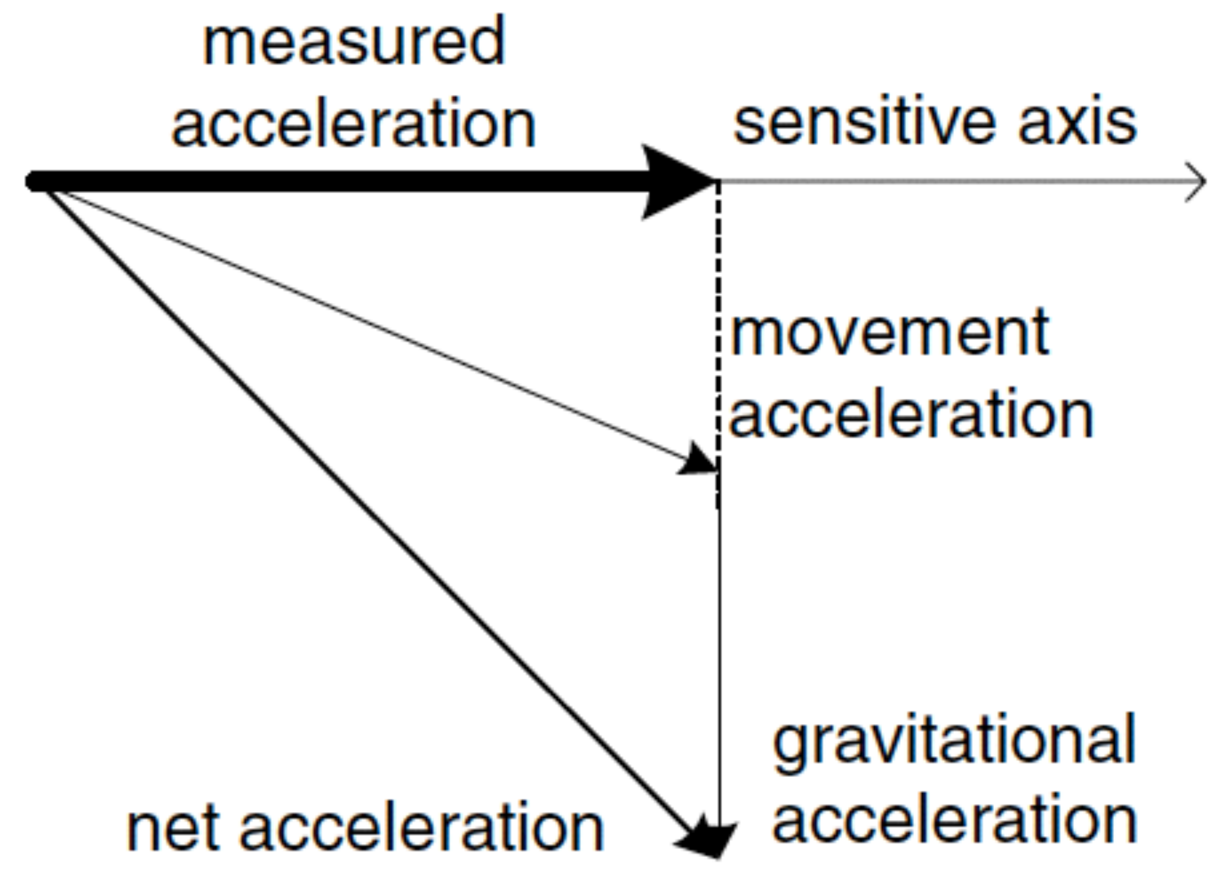


Figure 2. Piezoelectric accelerometers measure the sum of the acceleration due to movement and gravitational acceleration acting along the sensitive axis.

Mathiee et al., 2004

Accelerometer

measures

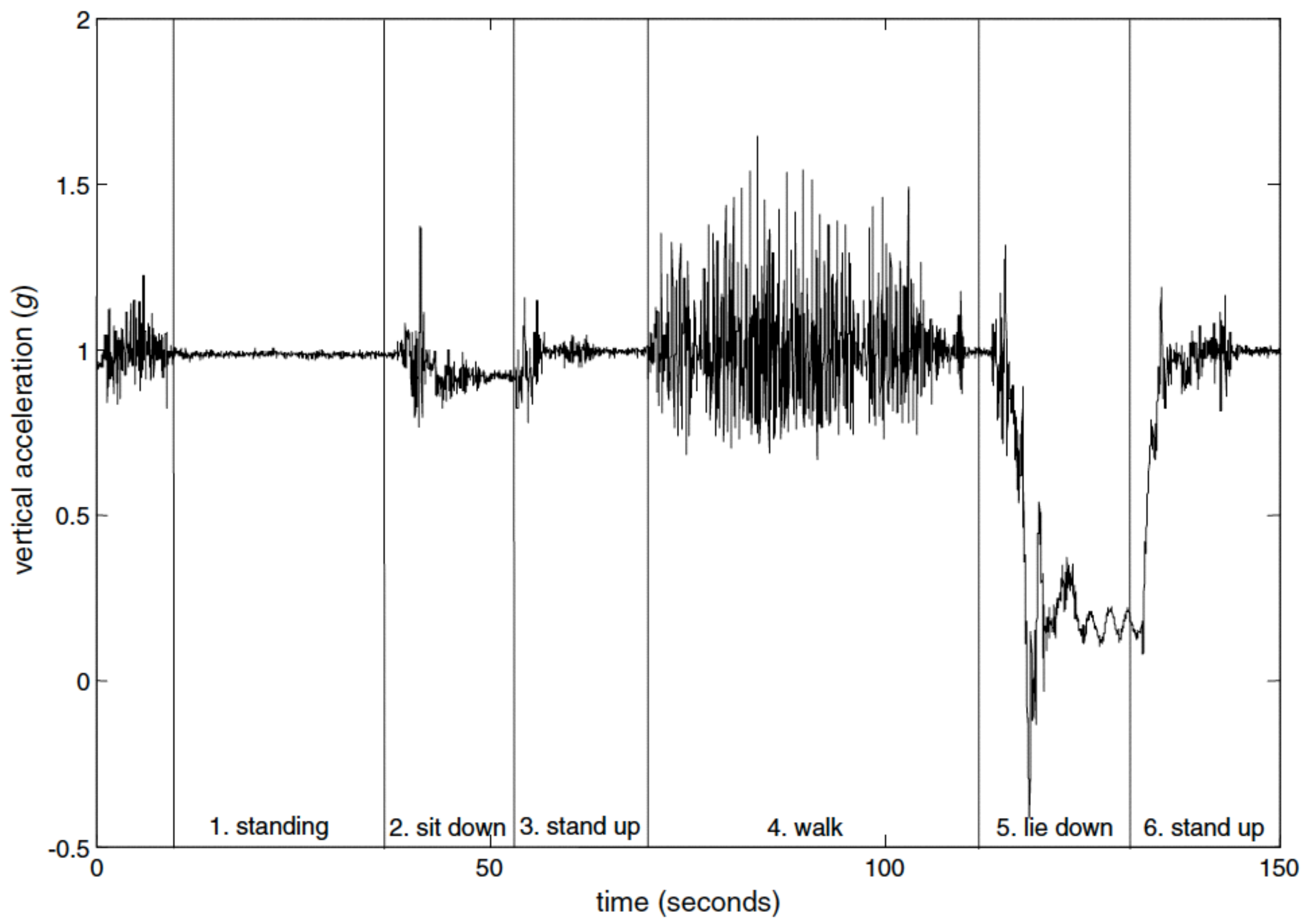


Figure 4. Acceleration signal produced by a waist-mounted accelerometer aligned in the vertical (gravitational) direction, during a selection of basic daily movements. The acceleration signal is composed of the gravitational acceleration due to the posture of the subject and the acceleration due to body movement. g is the acceleration due to gravity, approximately 9.81 m s^{-2}. The measured accelerations are dependent on the activity being performed. If the accelerometer was attached at a different point on the body, different acceleration signals would be recorded.

Mathiee et al., 2004

Accelerometer

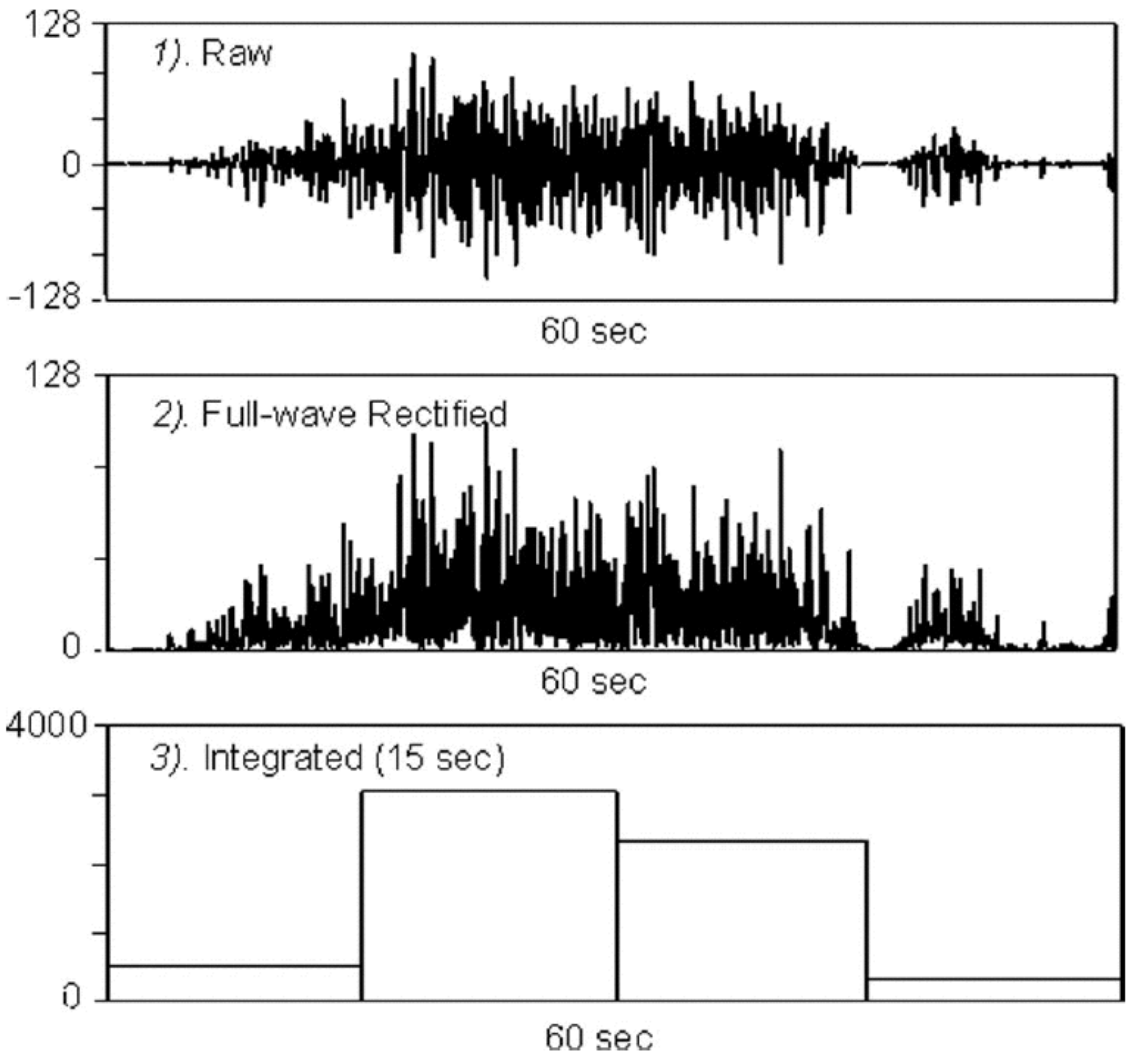


FIGURE 2—Analytical processing of the acceleration data. 1. Raw: a 60-s window of a digitized raw signal collected at 32 Hz and using a 8-bit A/D conversion. 2. Rectification: all negative signal from (1) was turned into positive. 3. Integration: 15-s epochs.

Chen et al., 2005

Accelerometer

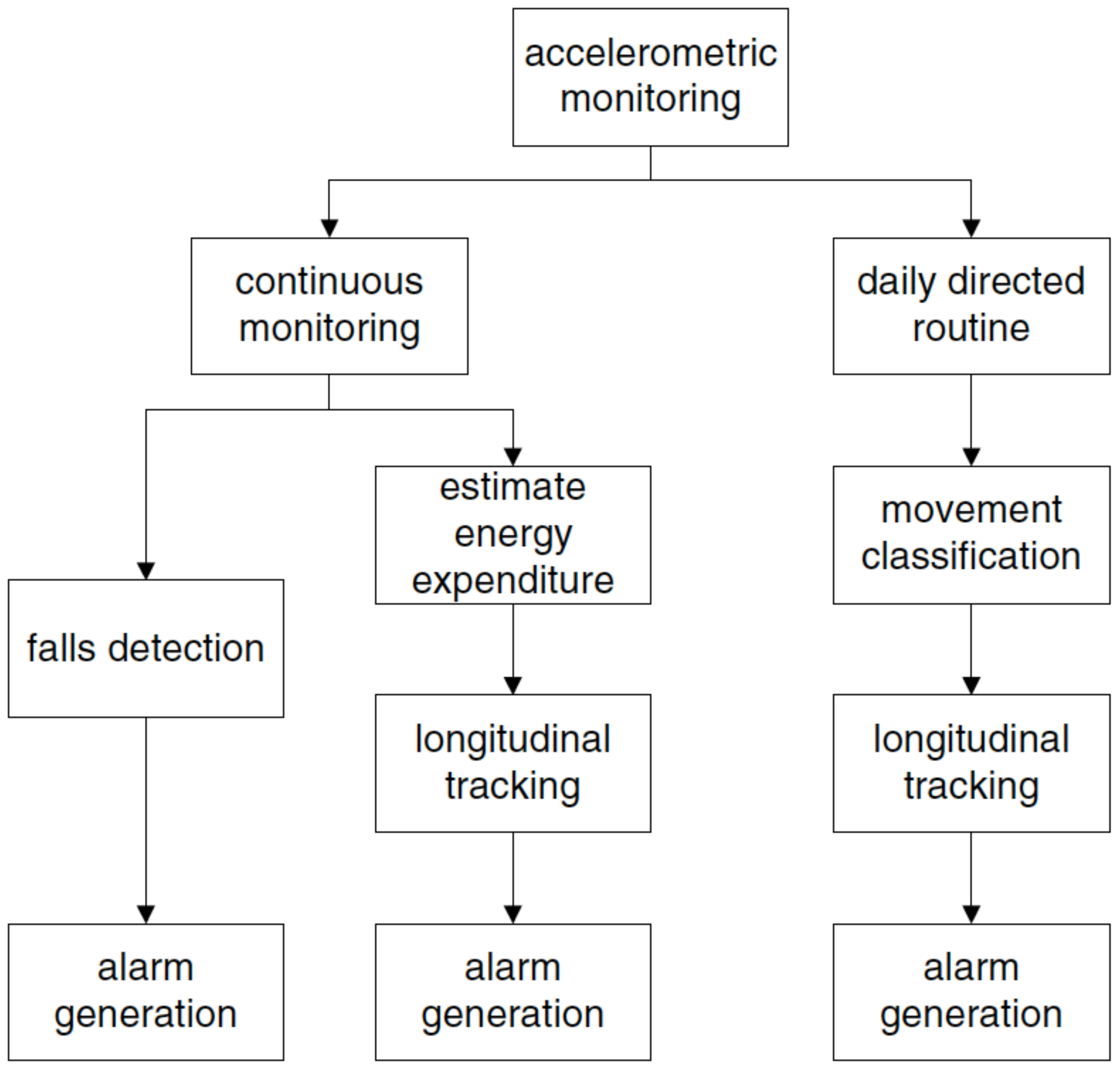


Figure 6. The three modes of monitoring.

Mathiee et al., 2004

Accelerometer

- Uniaxial accelerometer -> -59% children DLW ME;
  -59÷-50% old men DLW ME;
  +50÷+60% old claudicants DLW ME;
  -59% young women weekly DLW nME;
- Triaxial accelerometer -> +12÷+49% V'O2 locomotion ME;
  -21÷-8% V'O2 gradient walking ME;
  -68÷-53% V'O2 cycling ME;
  -45÷-35% V'O2 daily activity ME;
  -35% young women weekly DLW nME

HR wrist monitor

HR wrist monitor

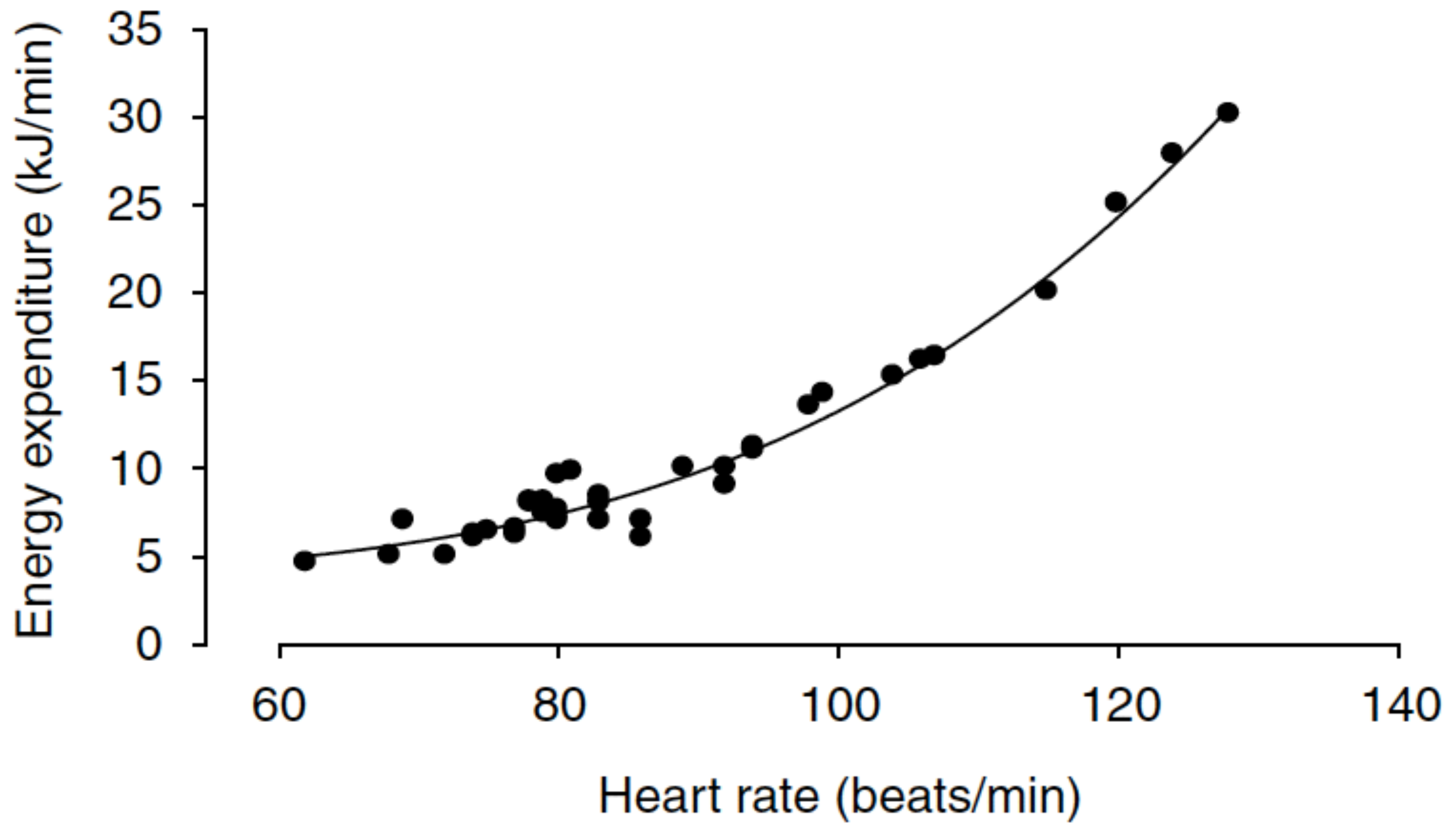


Fig. 2. The relationship between heart rate and energy expenditure in a healthy male study participant (unpublished data).

HR wrist monitor

HR measure issues

- HR <- environmental temperature and humidity, hydration status, posture, illness, stress, type of exercise (w/upper limbs or lower ones, continuous or intermittent), gender, age, body mass;
- w/≈3′ latency

but…

- pedometer/accelerometer -> level legged locomotion;
  no exercise with upper limbs, walking and running on soft ground or on slopes, cycling, swimming, rowing;
- pedometer/uniaxial accelerometer -> no over 9 km/h running

HR wrist monitor

HR measure issues

- (HR ≥ 90 bpm or ≥ 60% HRMax) ME = k HR;
- -30% daily ME;

(partial) answer:

- FLEX HR method (Spurr et al., 1988): ME = k HR (subject, activity specific) use only @external load/HR > FLEX HR, i.e., average between maximum value during rest or sedentary activity, and minimum value during light activity;
- i.e., (HR < FLEX HR) ME = rME, (HR > FLEX HR) ME = k HR;
- -17÷+20% daily DLW ME

HR wrist monitor

-> beat to beat recording -> HRV

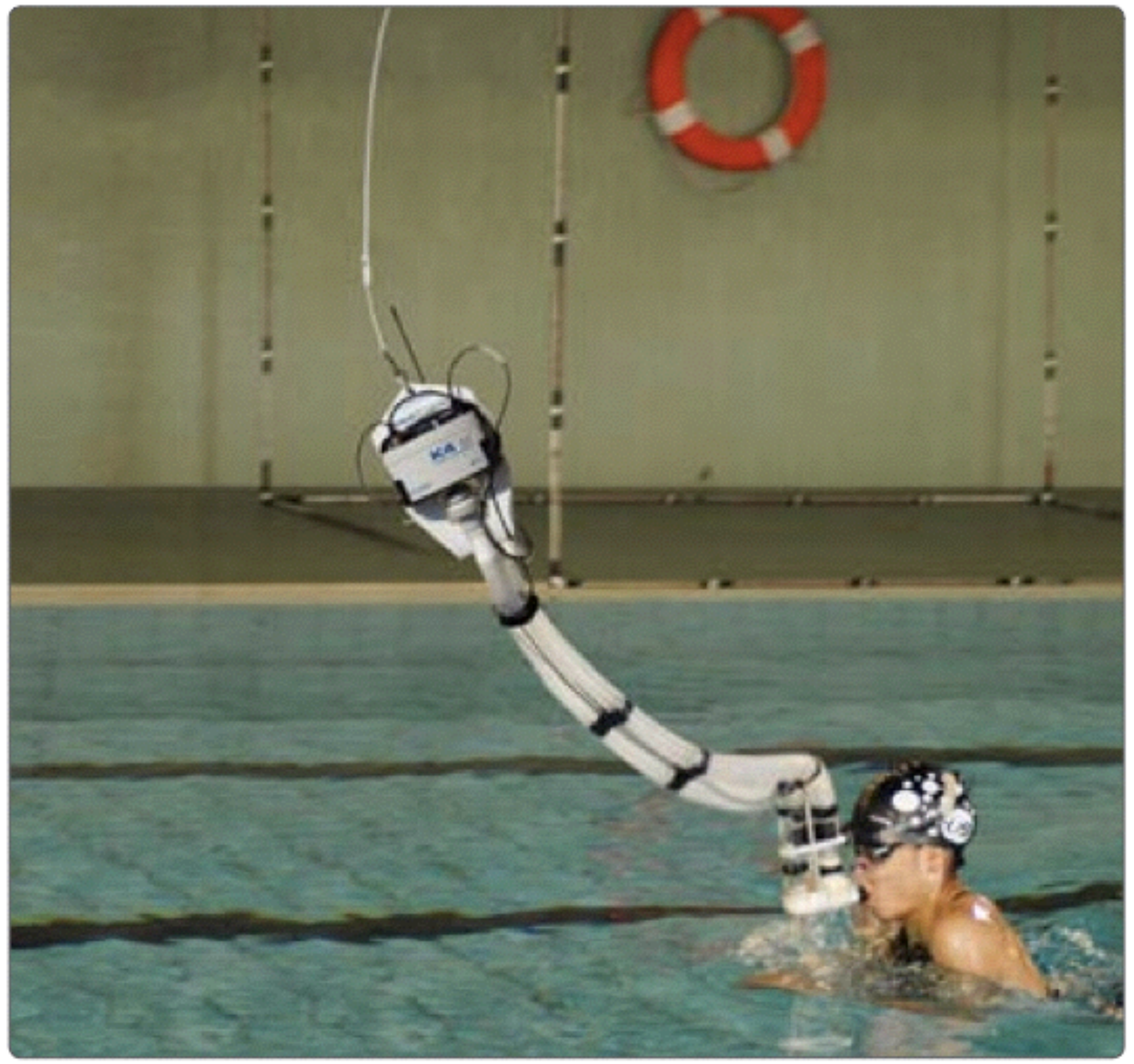
V'O2 measure

- direct calorimetry in metabolic chamber;
- indirect calorimetry, respirometry @closed/open circuit -> V'O2, V'CO2, ...;
- < 8h

V'O2 measure

V'O2 measure

Option 1:
An operator can follow the swimmer by holding the K4b2 using a special rod (rod and harness are included in the standard packaging)

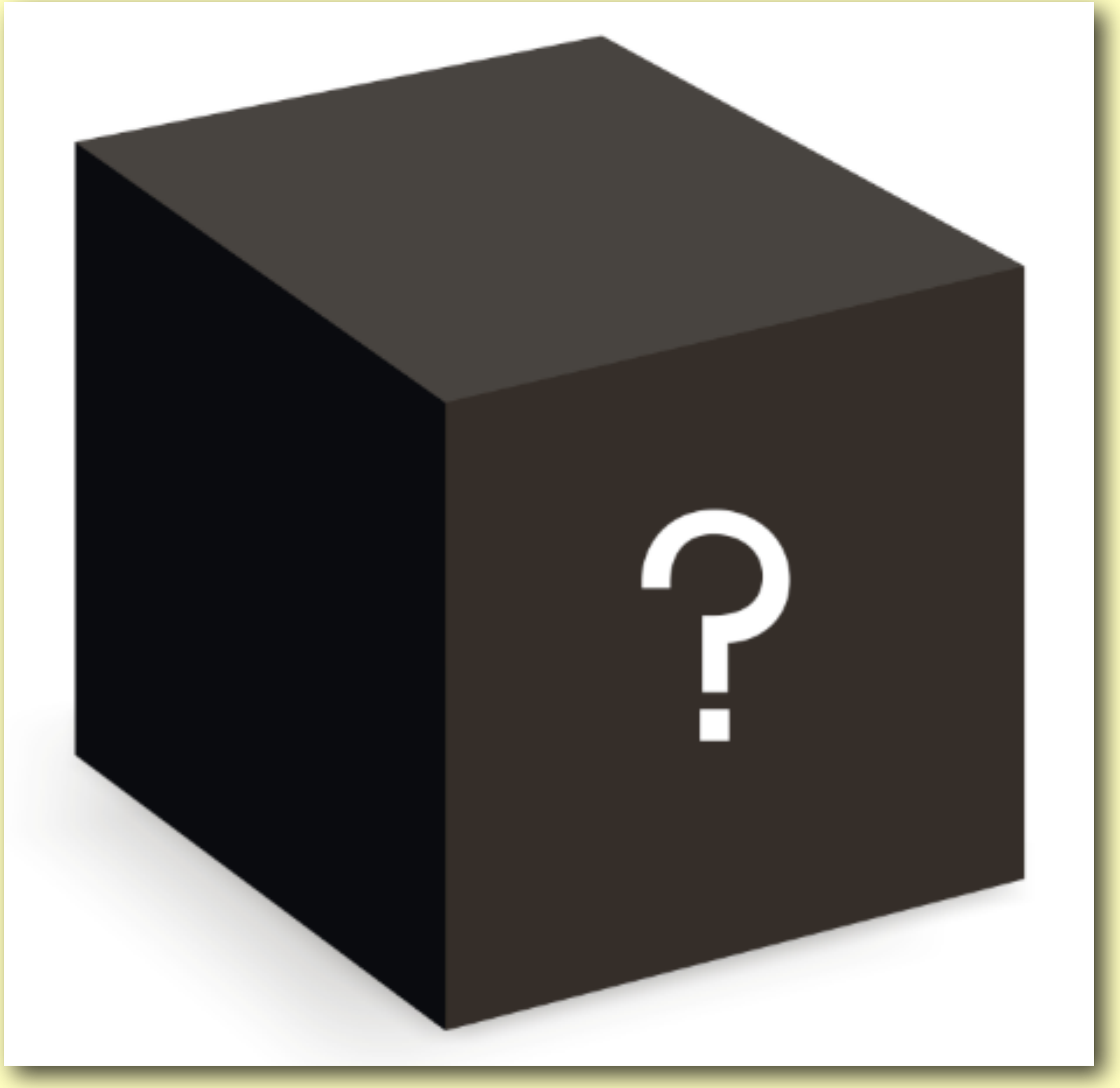


Option 2:
The K4b2 can be hung on a cable to be placed above the swimming pool lane

Accelerometer

Accelerometer issues

- PROPRIETARY ALGORITHM (i.e., "how from counts to ME?");
- need for custom developed software…



Accelerometer

Accelerometer issues

- From linear to non-linear ME=f(counts) -> 3D accelerom. -50->-3% nME

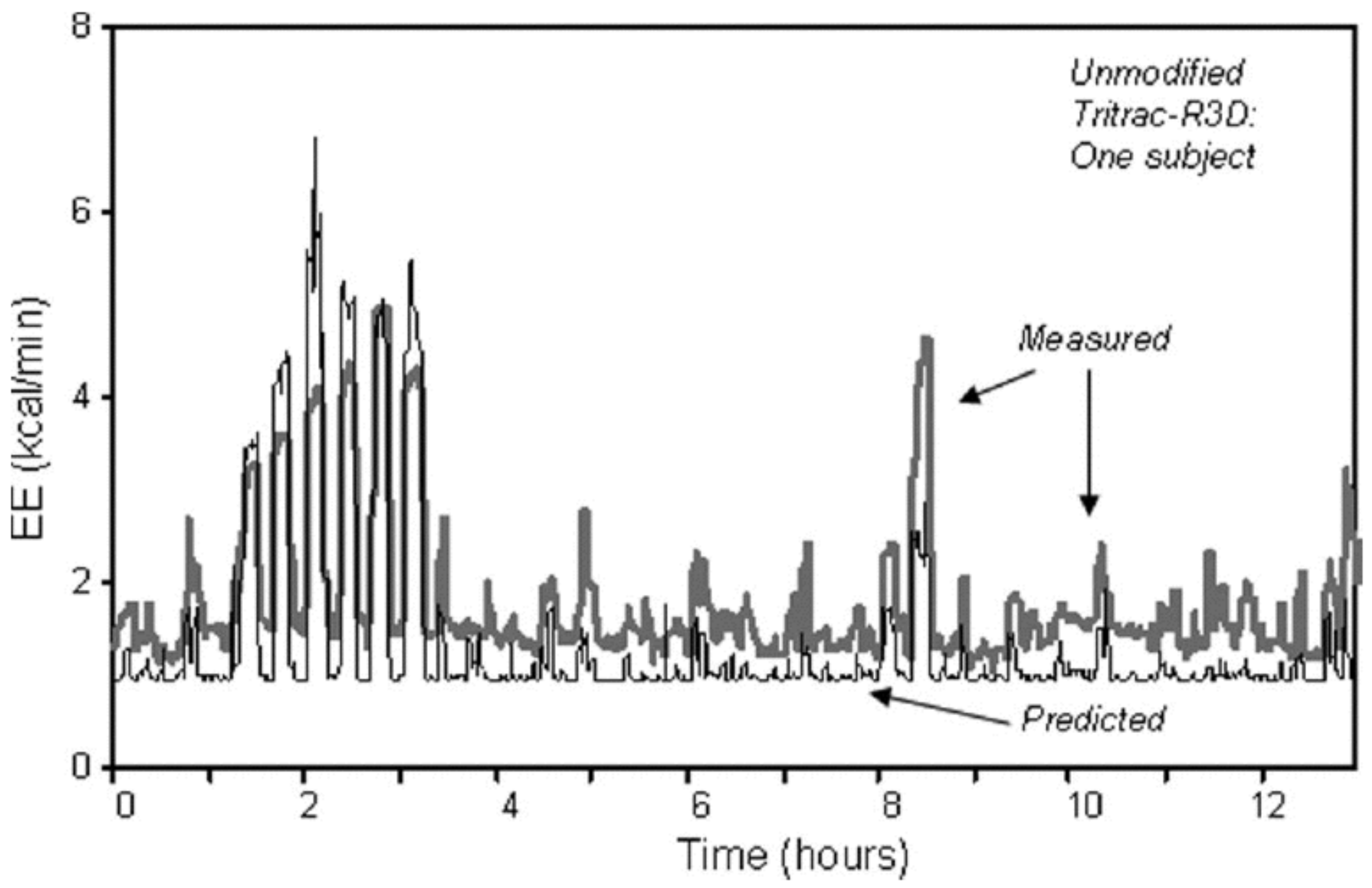


FIGURE 4—Subject: a woman age 32 yr, body mass 67.4 kg, resting EE = 1.06 $kcal \cdot min^{-1}$. Tritrac-predicted EE (*thin black line*) vs the calorimeter-measured EE (*thick black line*) during the waking period of a 24-h stay in the room calorimeter. r = 0.88, SEE = 0.48 $kcal \cdot min^{-1}$.

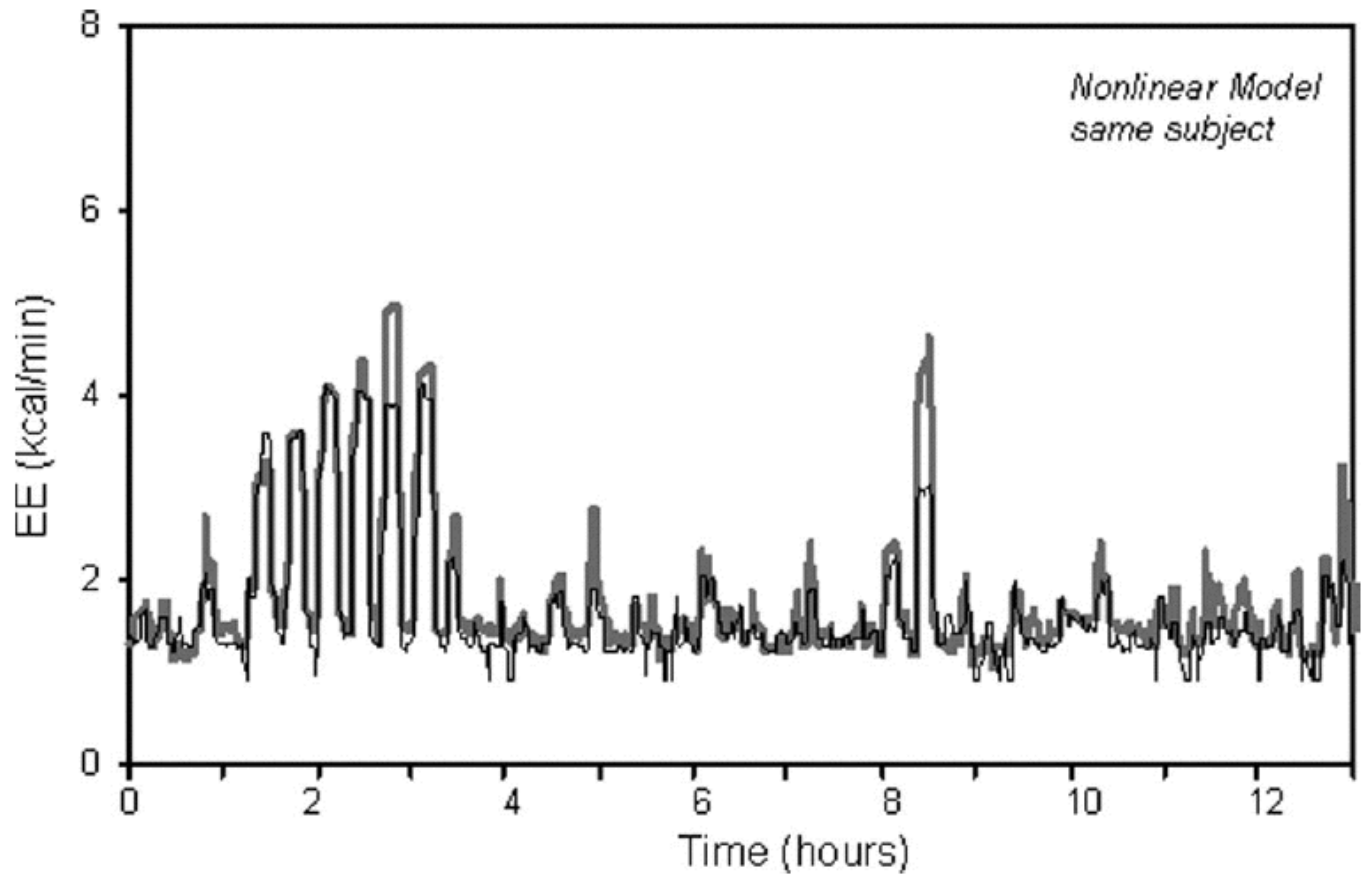


FIGURE 5—.Same subject as in Figure 4. Predicted EE using the modified two-component nonlinear model (*thin black line*) vs the calorimeter-measured EE (*thick black line*). r = 0.94, SEE = 0.27 $kcal \cdot min^{-1}$.

Chen et al., 2005

Accelerometers

Caltrac

-> TriTrac-R3D -> RT3

ActiGraph 71-64/-256

-> ActiGraph GT1M

->

-> ActiGraph GT3X

Accelerometers

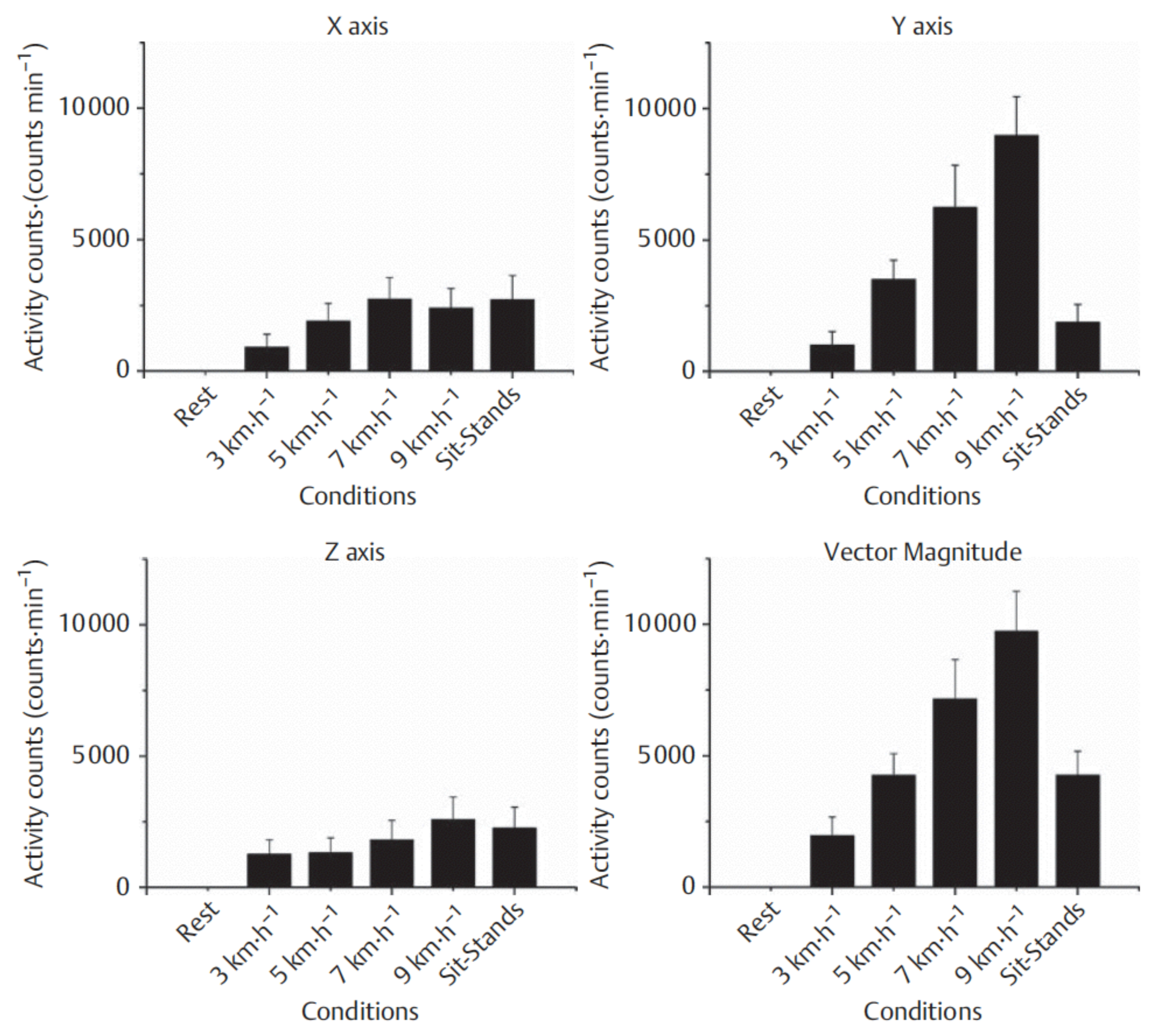


Fig. 1 Activity counts (counts · min^{-1}) (mean ± standard deviation) per axis and activities for all participants.

Santos-Lozano et al., 2013

Accelerometers

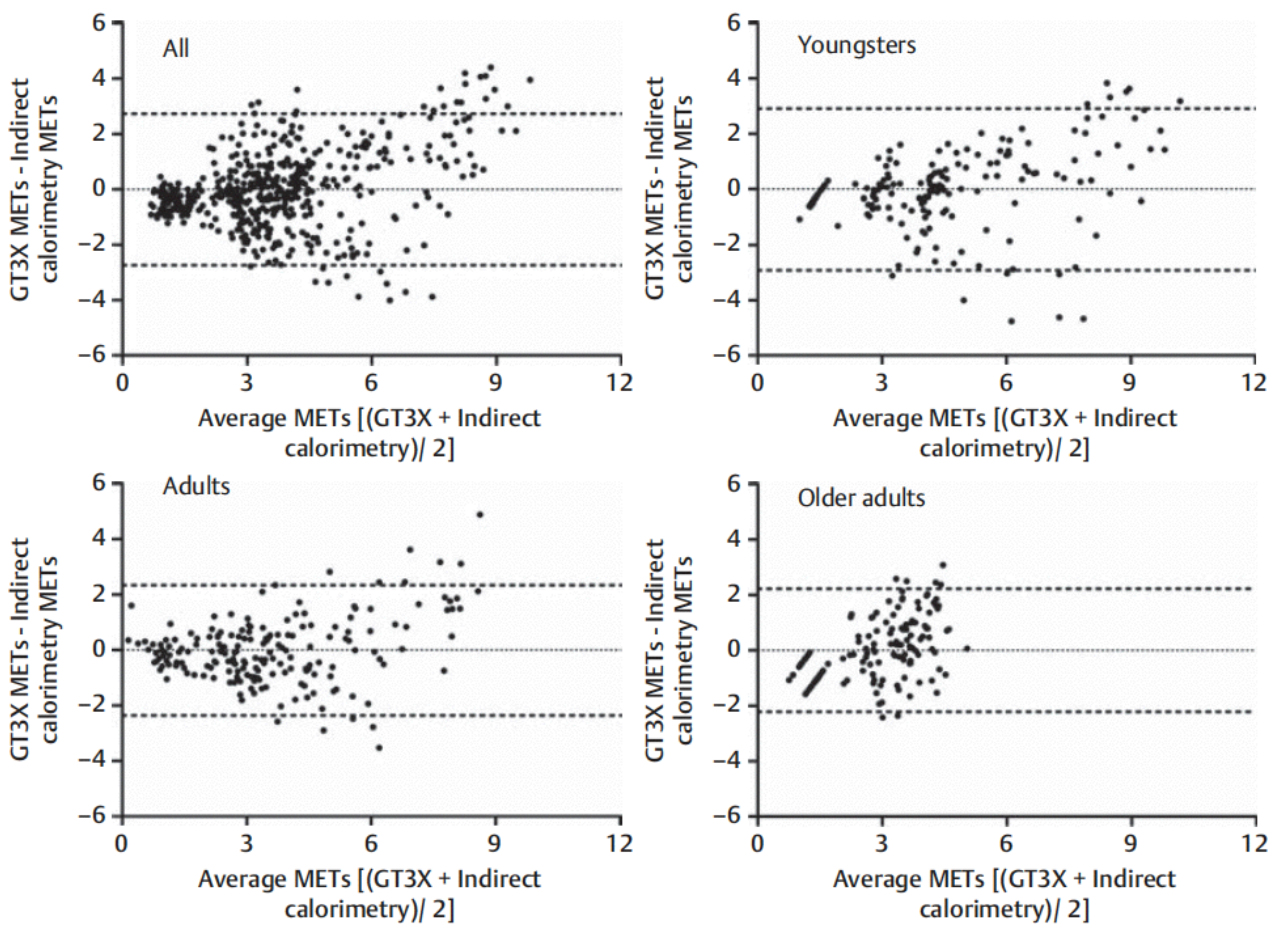


Fig. 3 Bland and Altman Plots in each group (energy expenditure (EE, in METs) determined with indirect calorimetry – EE (METs) predicted with GT3X).

Santos-Lozano et al., 2013

Accelerometers

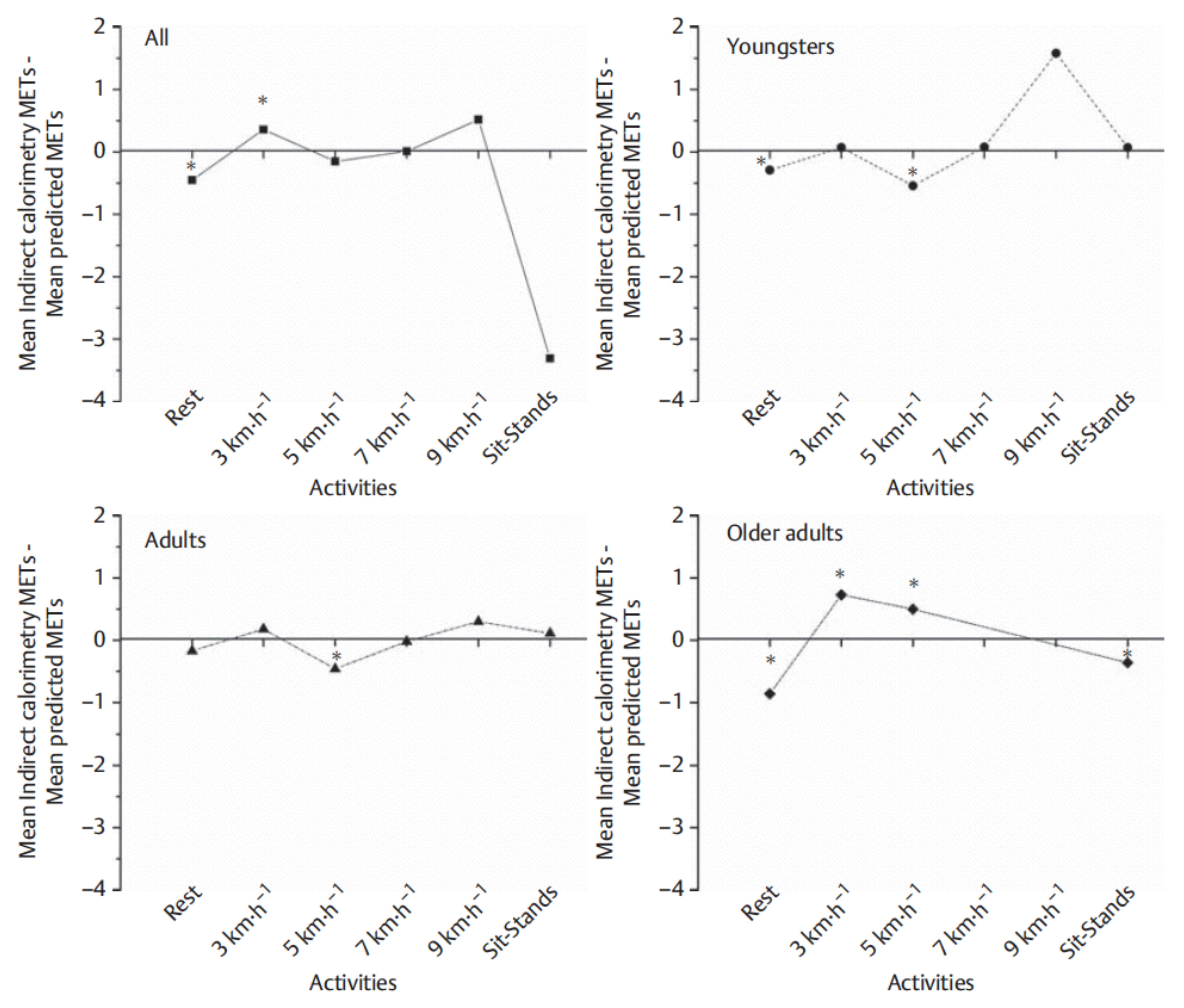


Fig. 4 Energy expenditure (EE, in METs) from indirect calorimetry vs. EE predicted with the GT3X for each age-group. *Significantly different from indirect calorimetry vs. predicted, same activity and age-group, $P<0.05$.

Santos-Lozano et al., 2013

Accelerometers

Actiwatch

-> Actical

Actitrac

Biotrainer

Accelerometers

Nokia N79

Carlson Jr et al., 2012

Accelerometers

measures

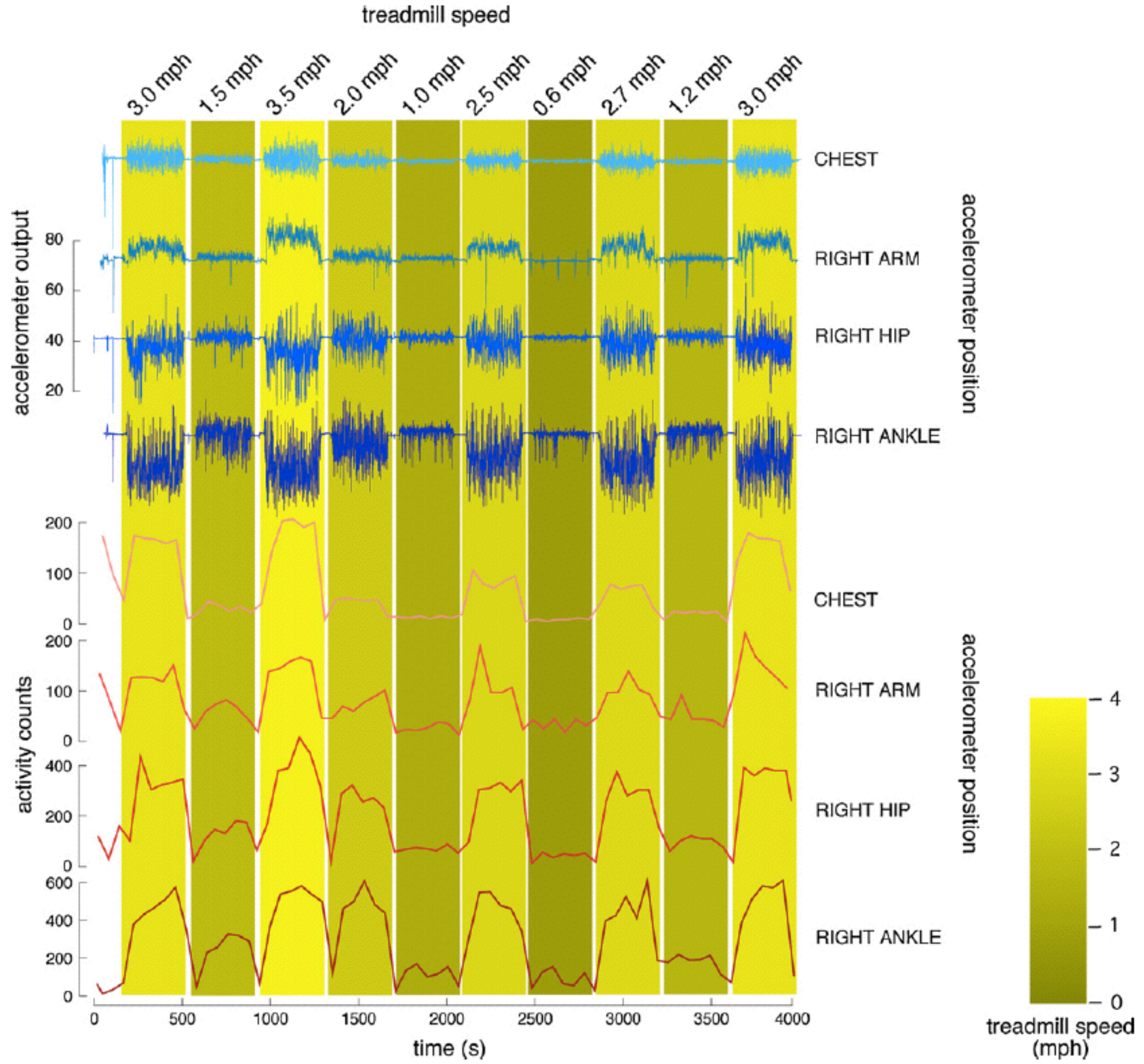


Fig. 1. Activity counts from cell-phone accelerometers provide an accurate measure of treadmill gait speed regardless of where the sensor is worn. The top four traces depict raw data from a representative trial (43 y/o man) showing acceleration magnitude *versus* time for sensors worn at the chest, right arm, right hip, and right ankle (1st through 4th traces from top, respectively). For all traces the baseline is centered at 64 (midscale between sensor output of 0 for −2 g, and 128 for +2 g), the amount of deflection from this baseline is per the common scale provided left of these traces. The bottom four traces show activity counts *versus* time for the sensors worn at the chest, right arm, right hip, and right ankle, respectively. Counts were calculated over 1 min nonoverlapping bins. Treadmill speed is given at the top of each epoch bar.

Accelerometers

measures

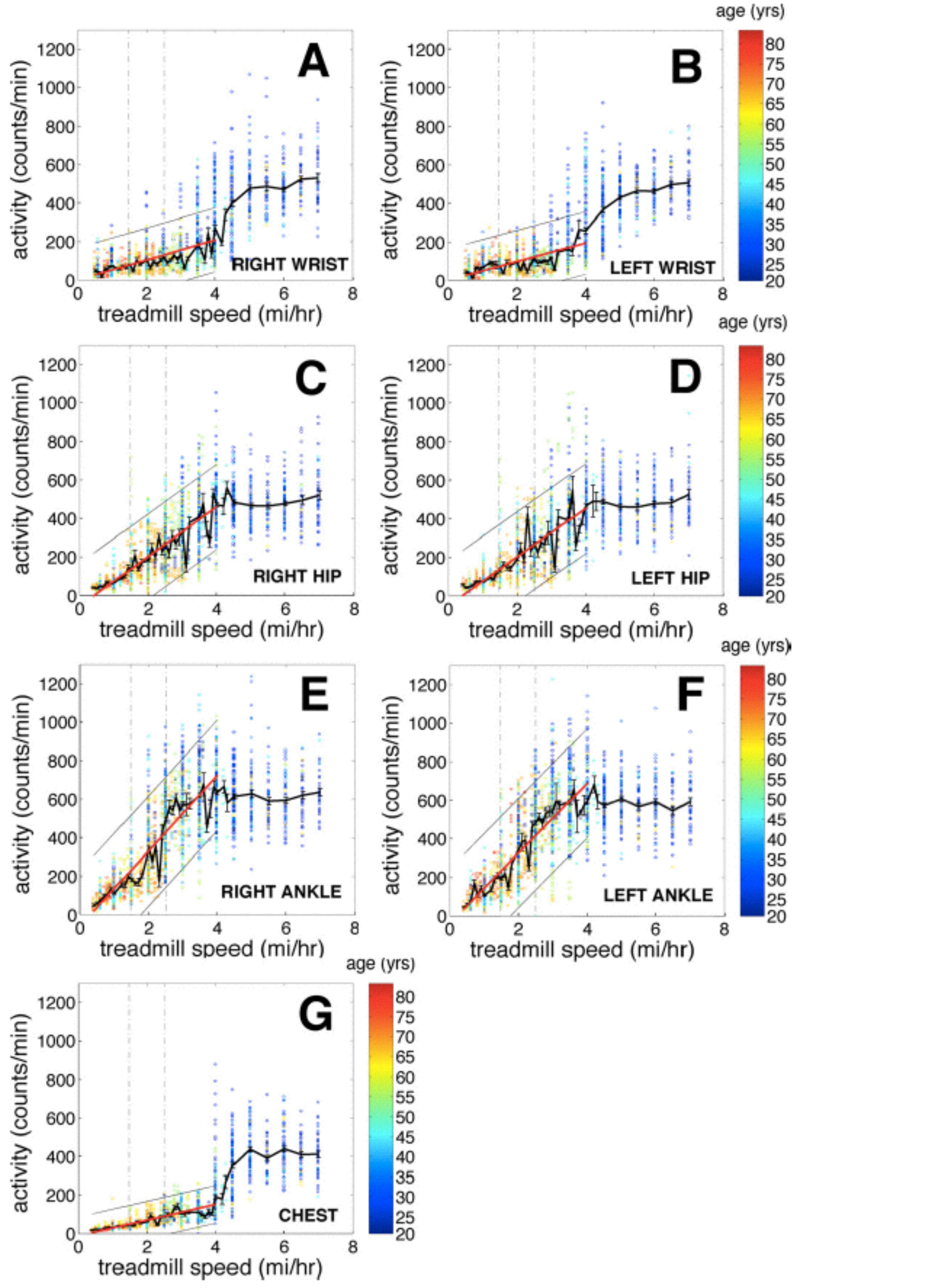


Fig. 3. Activity count versus treadmill speed relationships for all sensor locations. For all figures, the solid red line shows the linear regression between treadmill speed and activity counts (fit for all data between 0.0 and 6.4 km/h (0–4 mi/h) gait speeds); the thin surrounding black lines are 95% confidence boundaries on this regression. The thick black line connects mean activity count values for each of the evaluated treadmill speeds; bars surrounding this point are ±1 standard error of the mean. Individual observations of activity counts are shown as open colored circles. Subject age is color coded as circle color; refer to colorbar at right side for key. The dashed lines at gait speeds of 2.35 km/h (1.46 mi/h) and 4 km/h (2.5 mi/h) highlight system performance at two critical functional thresholds. These relationships come from cell phones placed at the right wrist (A), left wrist (B), right hip (C), left hip (D), right ankle (E), left ankle (F), and neck (G).

DLW method

- Lifson et al., 1955;
- (small animals) 1975;
- validation by Scholler et al., 1982;
- (premature infants, children, pregnant and lactating women, elderly, obese people, hospitalized patients);
- subject is administered a dose of stable isotope $^{2}H_2{}^{18}O$, which (^{2}H, ^{18}O) equilibrates relatively quickly with body water (H, O);
- ^{2}H is eliminated as $^{2}H_2O$ (breath, urine, sweat, perspiratio insensibilis), while the ^{18}O is eliminated either as $H_2{}^{18}O$ (breath, …) and as $C^{18}O_2$ (breathe only);
- difference between the two rates of elimination -> V'CO2 -> ME