University of Verona,
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(Laurea magistrale in Scienze dello sport e della prestazione fisica)

Metodologia delle misure delle attività sportive

Monday 11/12/2017 13:30÷15

Luca P. Ardigò Ph.D.

A class within a six-class module

73

Pedometer accuracy/validity

measures

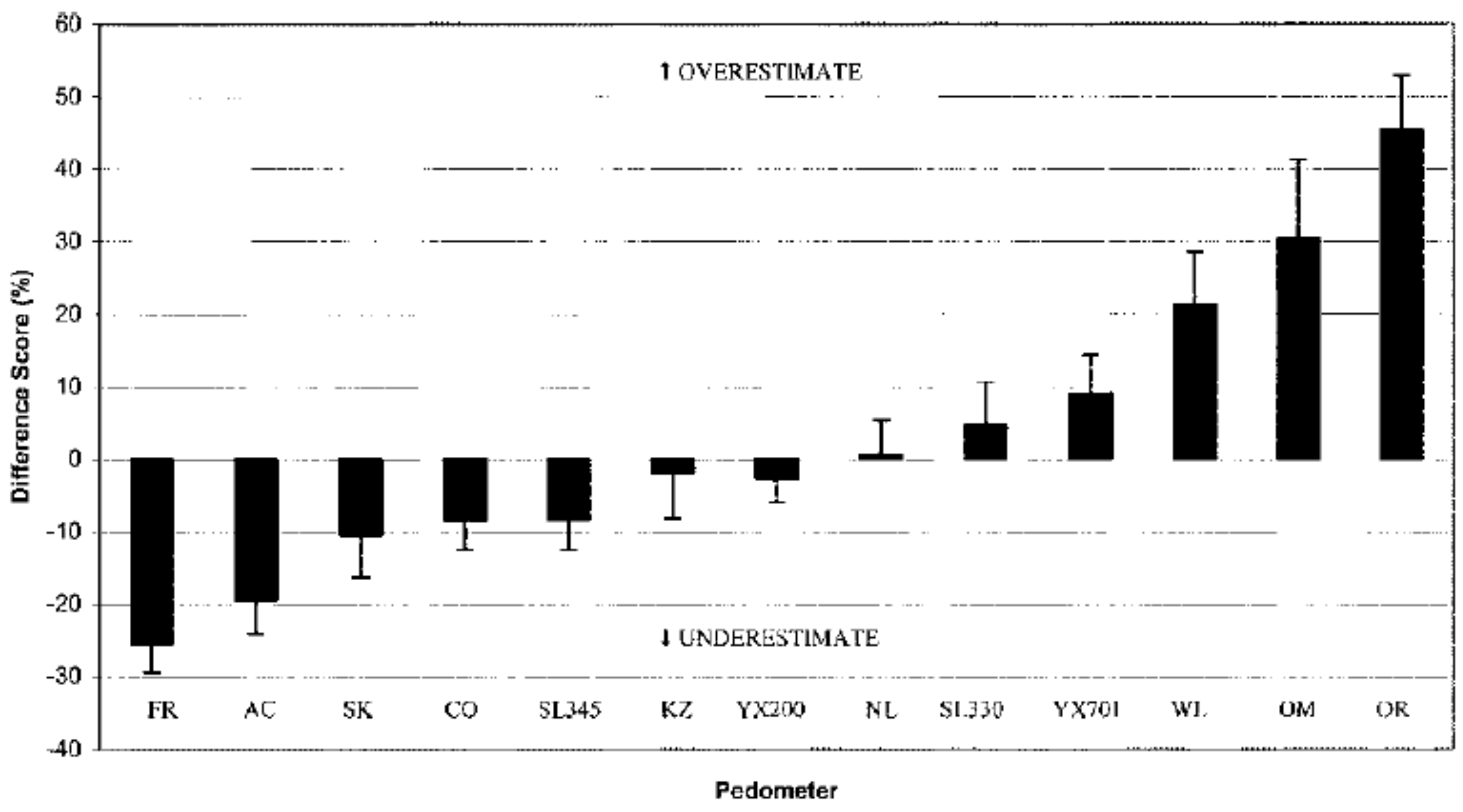

FIGURE 1—Mean difference scores [(comparison − criterion pedometer)/criterion] ± SE as a percentage of the criterion estimated steps over a 24-h period. Positive difference scores represent overestimations, and negative difference scores indicate underestimations of steps compared with the criterion pedometer.

step/day #

Schneider et al., 2004

Pedometer accuracy/validity

measures

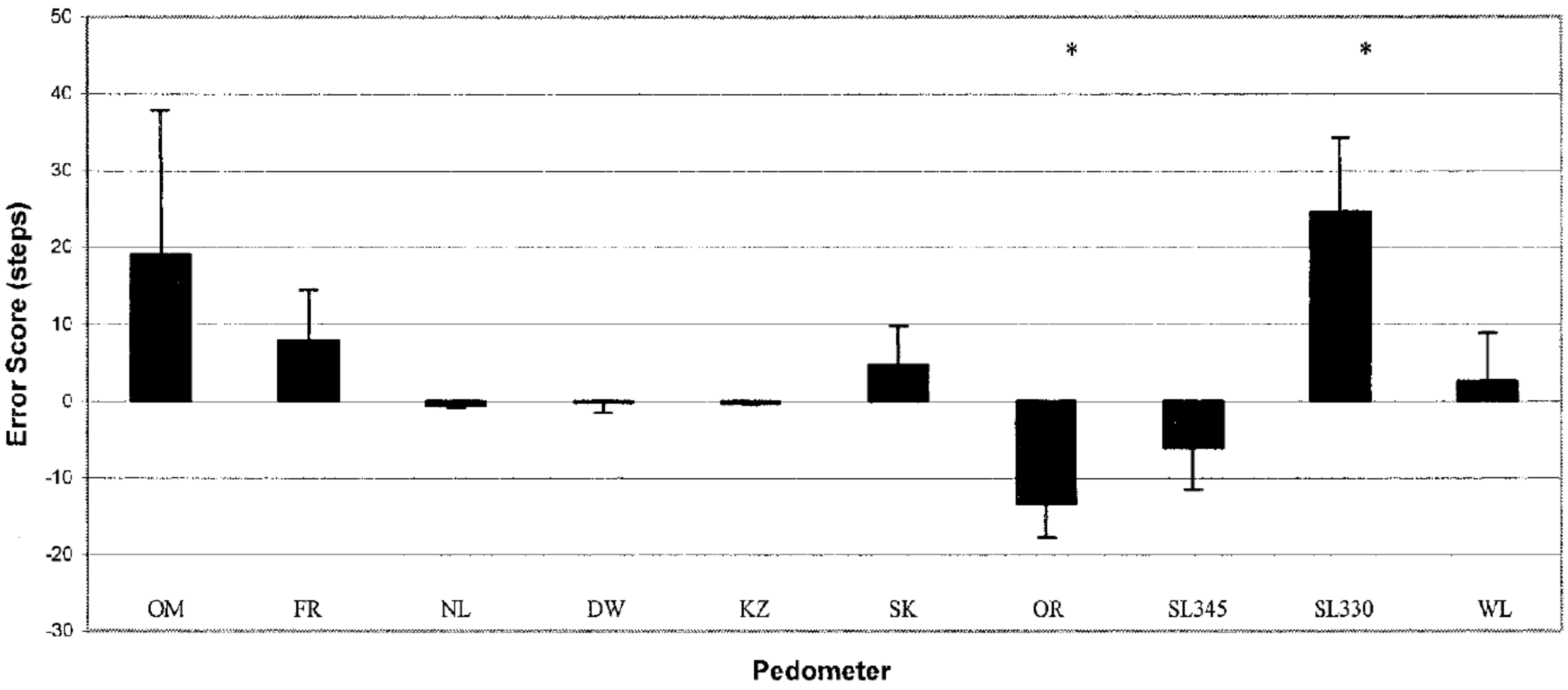

FIGURE 1—Mean error scores (actual − pedometer) ± SE in number of steps during a 400-m track walk at self-selected speeds. * $P < 0.05$.

400-m step #

Schneider et al., 2003

Pedometer accuracy/validity

measures

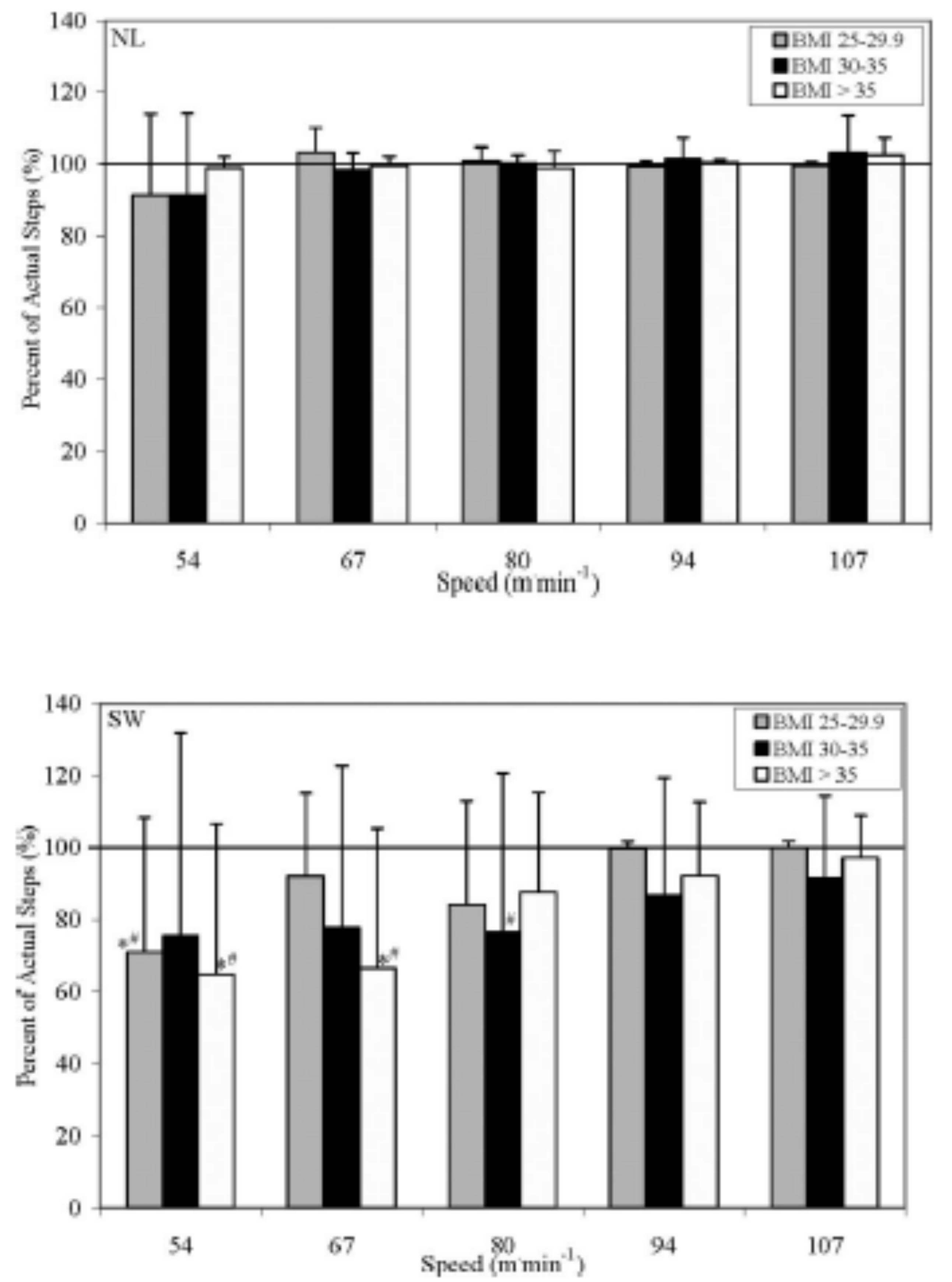

FIGURE 2—Effect of BMI (25–29.9 kg·m^{-2}, 30–35 kg·m^{-2}, and >35 kg·m^{-2}) on the percent of actual steps recorded by the New-Lifestyles NL-2000 (NL) and Yamax Digiwalker SW-200 (SW). Error bars are standard deviation. * Significantly different from actual steps; # significantly different from the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

(uniaxially accelerometric)

step #

(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 #

Accelerometers

Actiwatch

-> Actical

Actitrac

Biotrainer

Accelerometers

Nokia N79

Carlson Jr et al., 2012

Accelerometers

measures

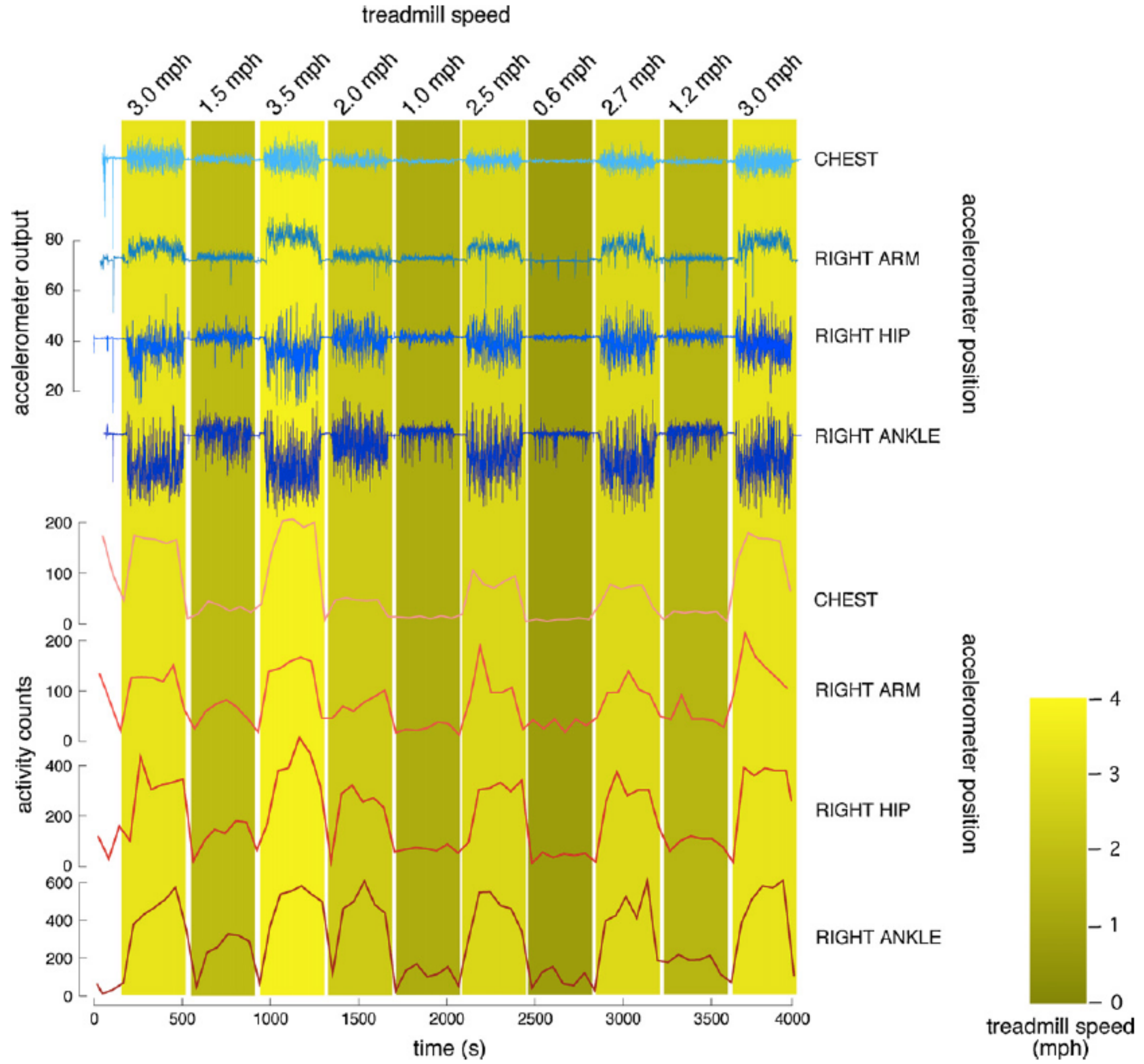

Fig. 1. Activity counts from cell-phone accelerometers provide an accurate measure of treadmill gait speed regardless of where the sensor is worn. The top four traces depict raw data from a representative trial (43 y/o man) showing acceleration magnitude *versus* time for sensors worn at the chest, right 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

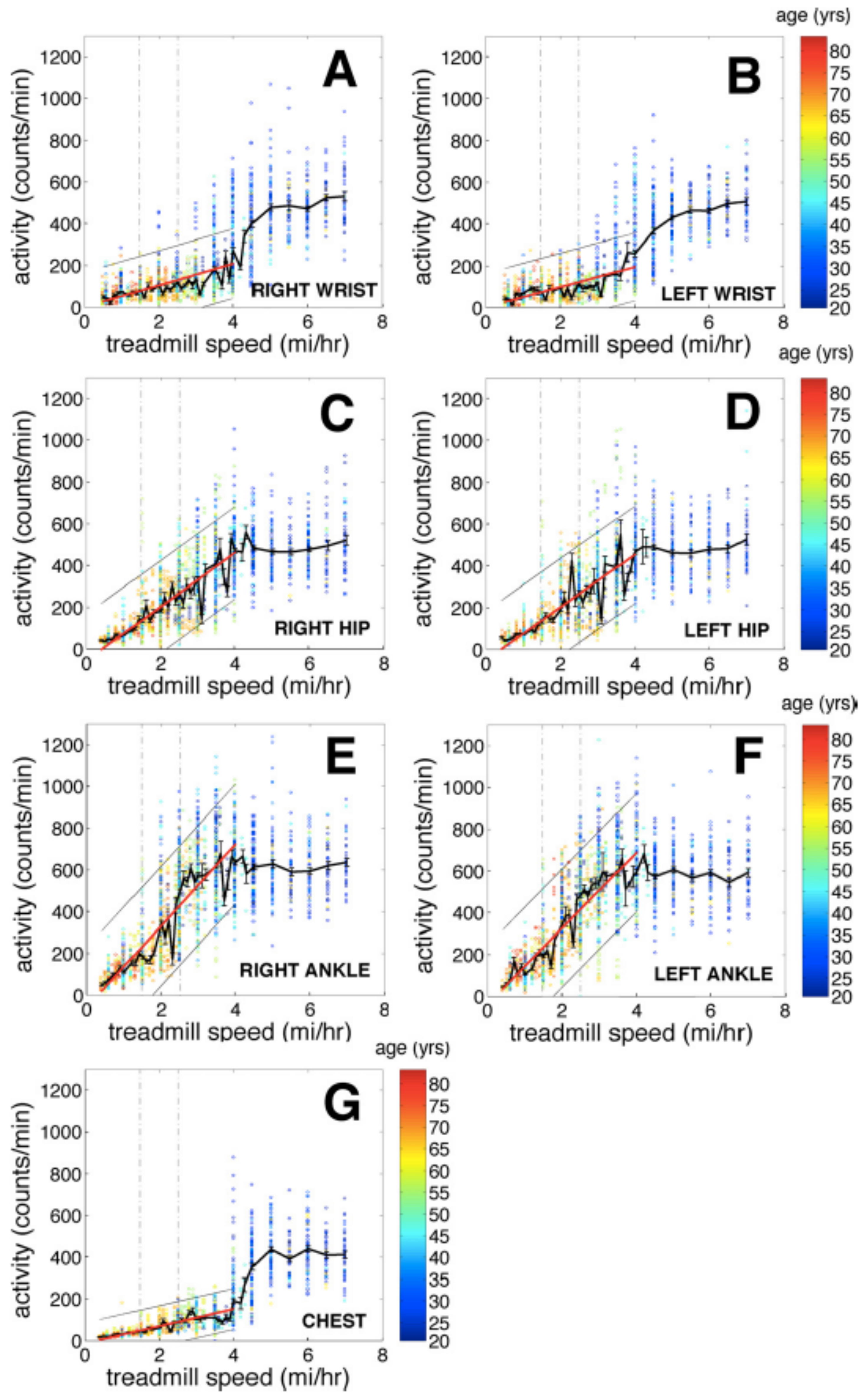

Fig. 3. Activity count versus treadmill speed relationships for all sensor locations. For all figures, the solid red line shows the linear regression between treadmill speed and activity counts (fit for all data between 0.0 and 6.4 km/h (0–4 mi/h) gait speeds); the thin surrounding black lines are 95% 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).

Accelerometers

Apple iPod Touch
(iPhone)

Ellis et al., 2015

Accelerometers

measures

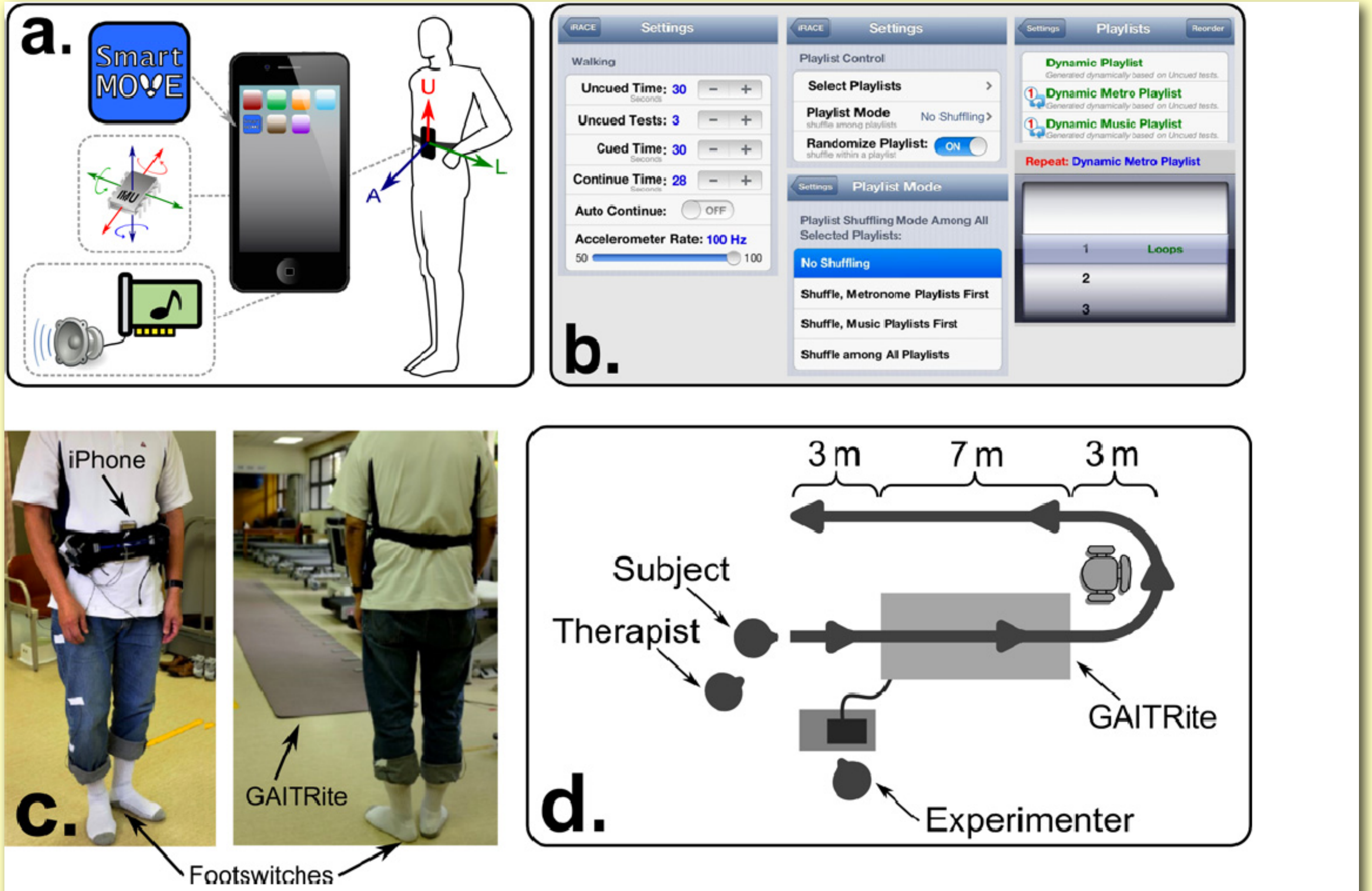

Fig 1. Key experimental features. The SmartMOVE mobile app (a.) utilizes the smartphone's inertial measurement unit to record gait movements during walking. Flexible parameter settings (b.) enable precise control over testing parameters. SmartMOVE outcome measures were validated against heel-mounted footswitches and a GAITRite sensor walkway (c.) while subjects walked along a prescribed path (d.).

Accelerometers

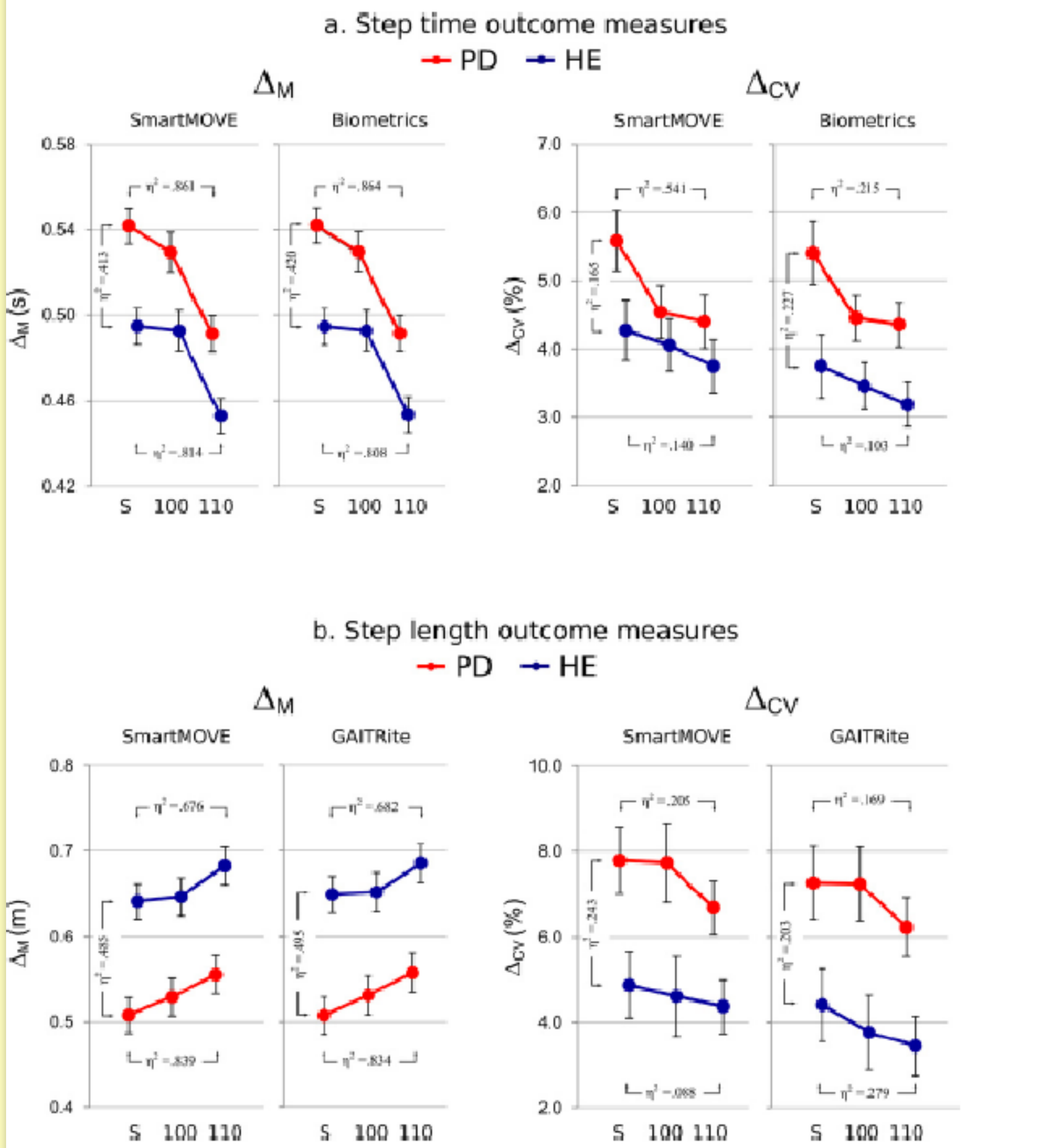

Fig 2. Outcome measure results. Results of the *Group* (separate lines: PD vs. HE) x *Condition* (x-axis: self-paced, 100% RAC, 110% RAC) x *Device* (separate panels: SmartMOVE vs. heel contact-based) ANOVAs for step time (a.) and step length (b.) outcome measures.

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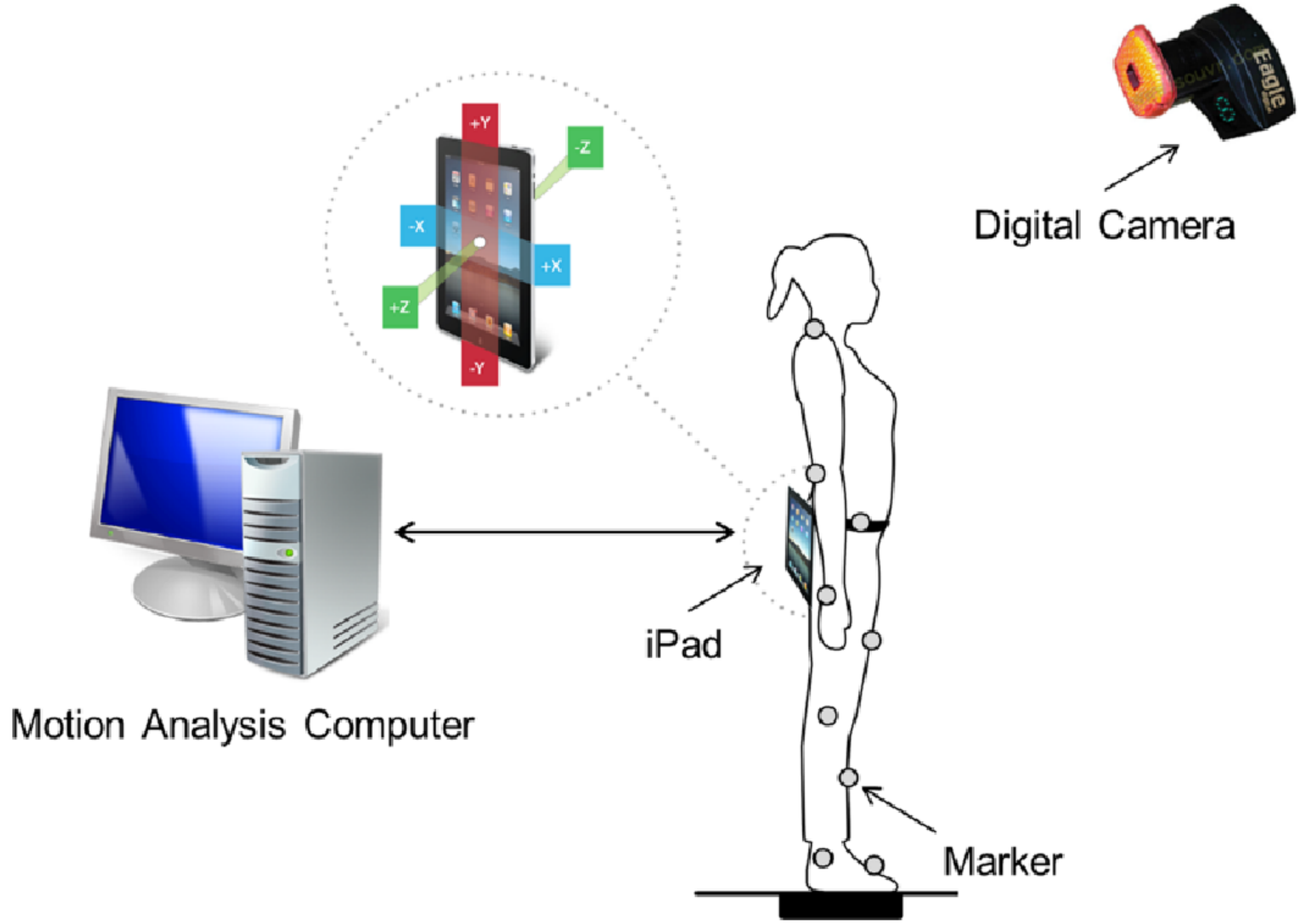
Accelerometers

iPad (third generation)

Ozinga et al., 2014

Fig. 1 Illustration of experimental paradigm and measurement setup



Accelerometers

OZINGA ET AL

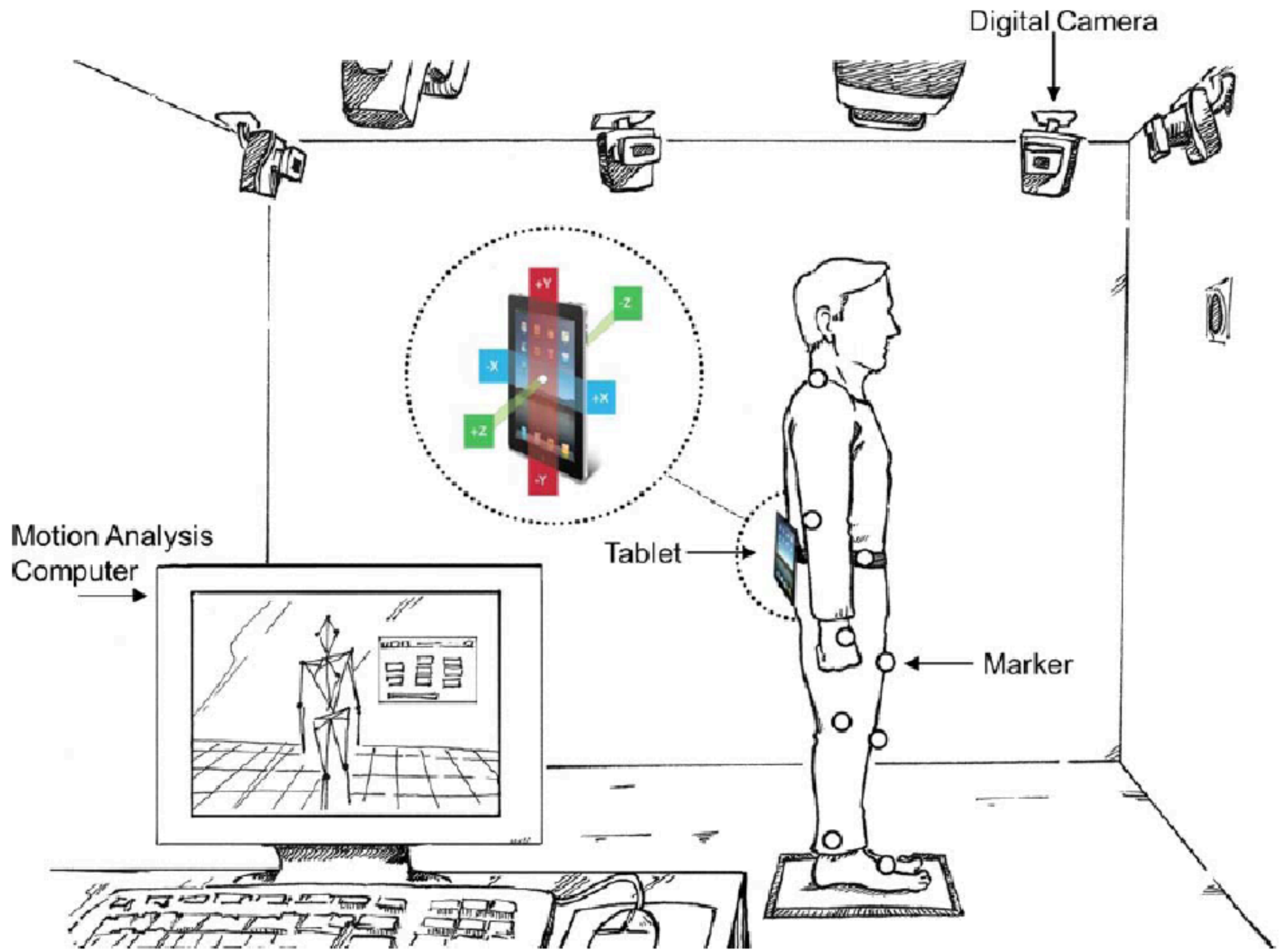


FIG. 1. Illustration of experimental paradigm and measurement setup. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Ozinga et al., 2015

Accelerometers

Samsung Galaxy II

Zhang et al., 2014

Accelerometers

measures

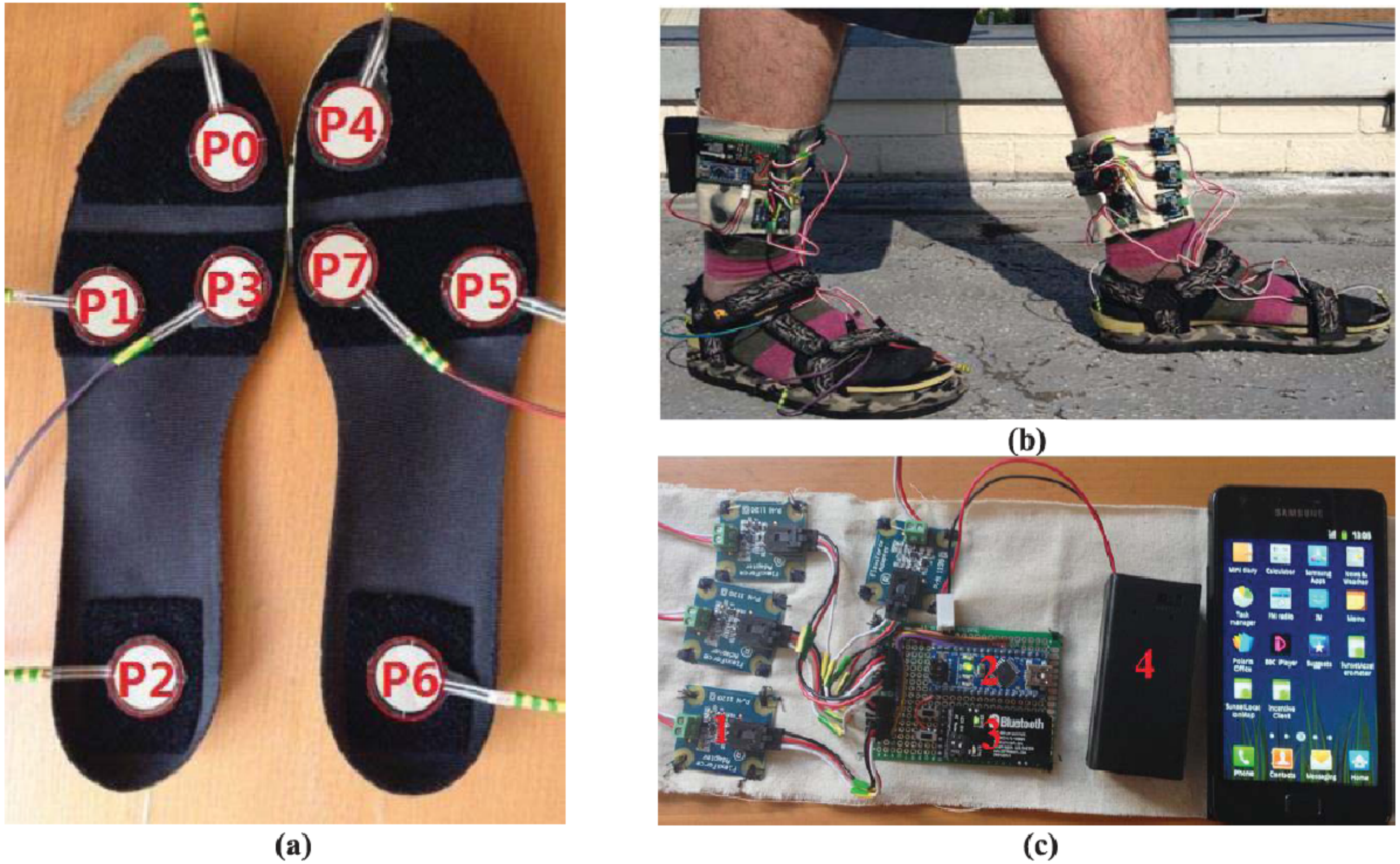


Fig. 2. Experiment equipment: (a) experimental insoles with 8 Flexiforce sensors instrumented; (b) the scene of foot force measurements; and (c) the foot force sensing system and a Samsung galaxy II smart phone.

Accelerometers

measures

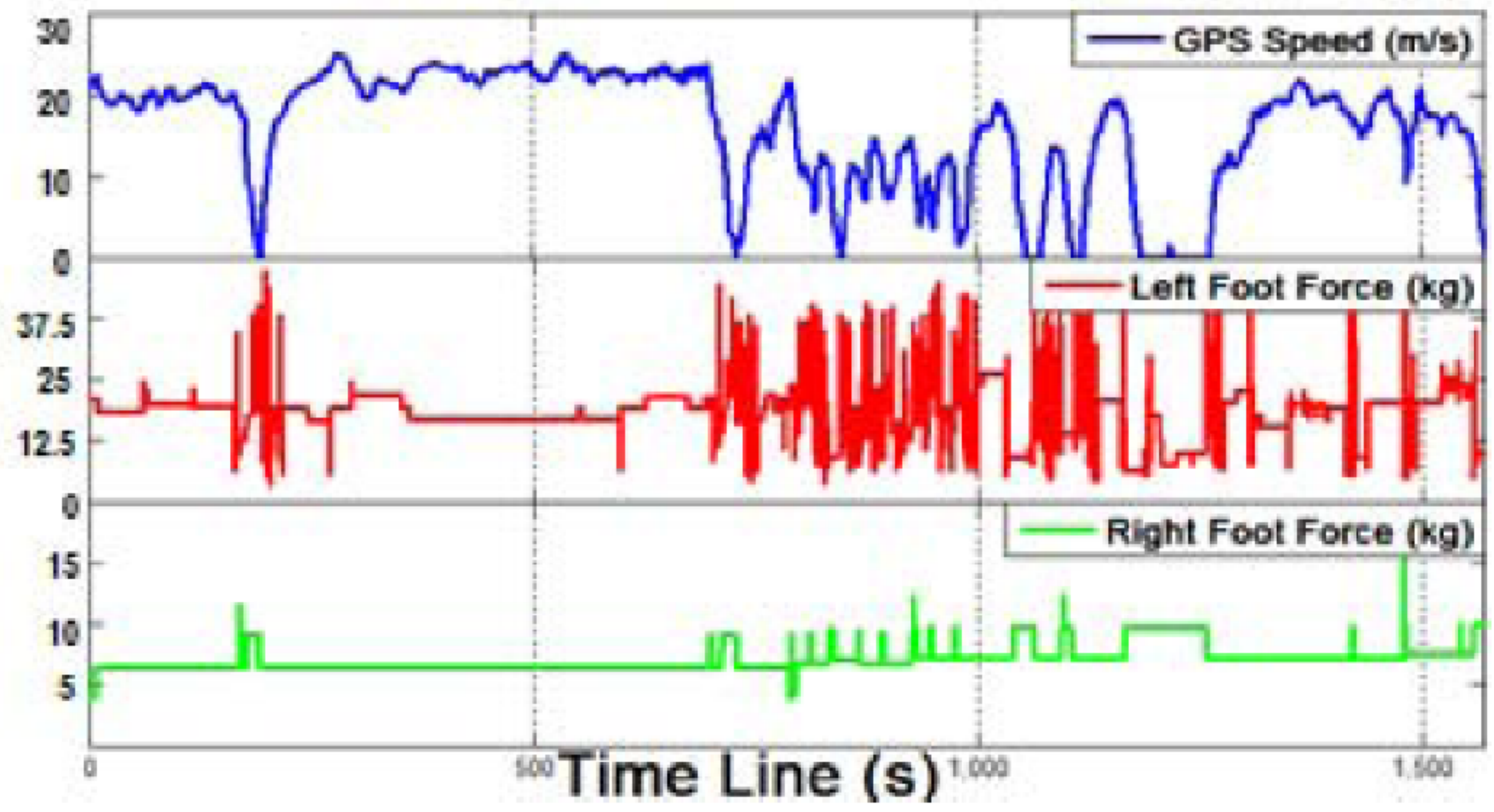


Fig. 8. GPS speed, foot force variations during a 30 minutes driving process.

Accelerometers

iPhone 4s

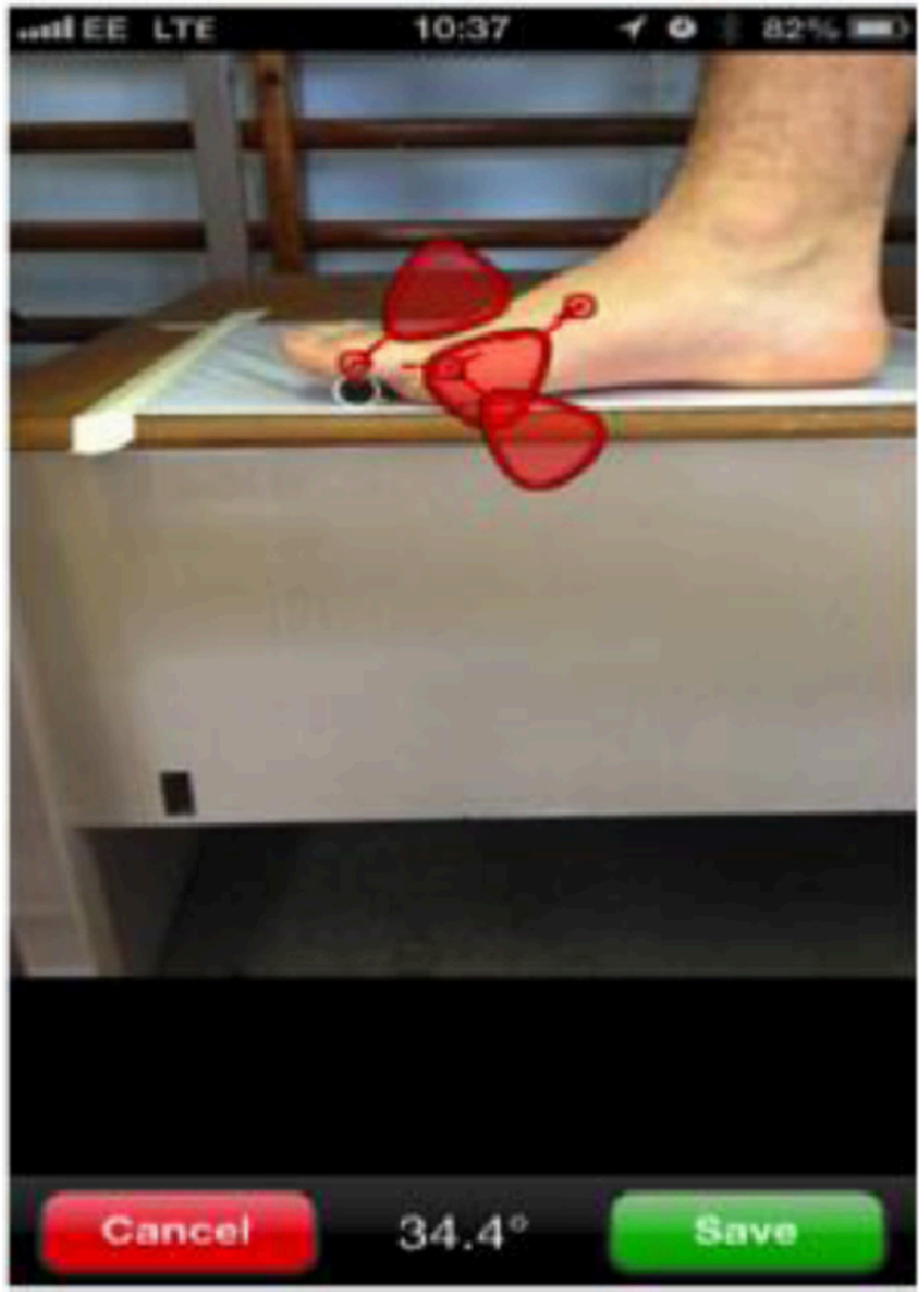
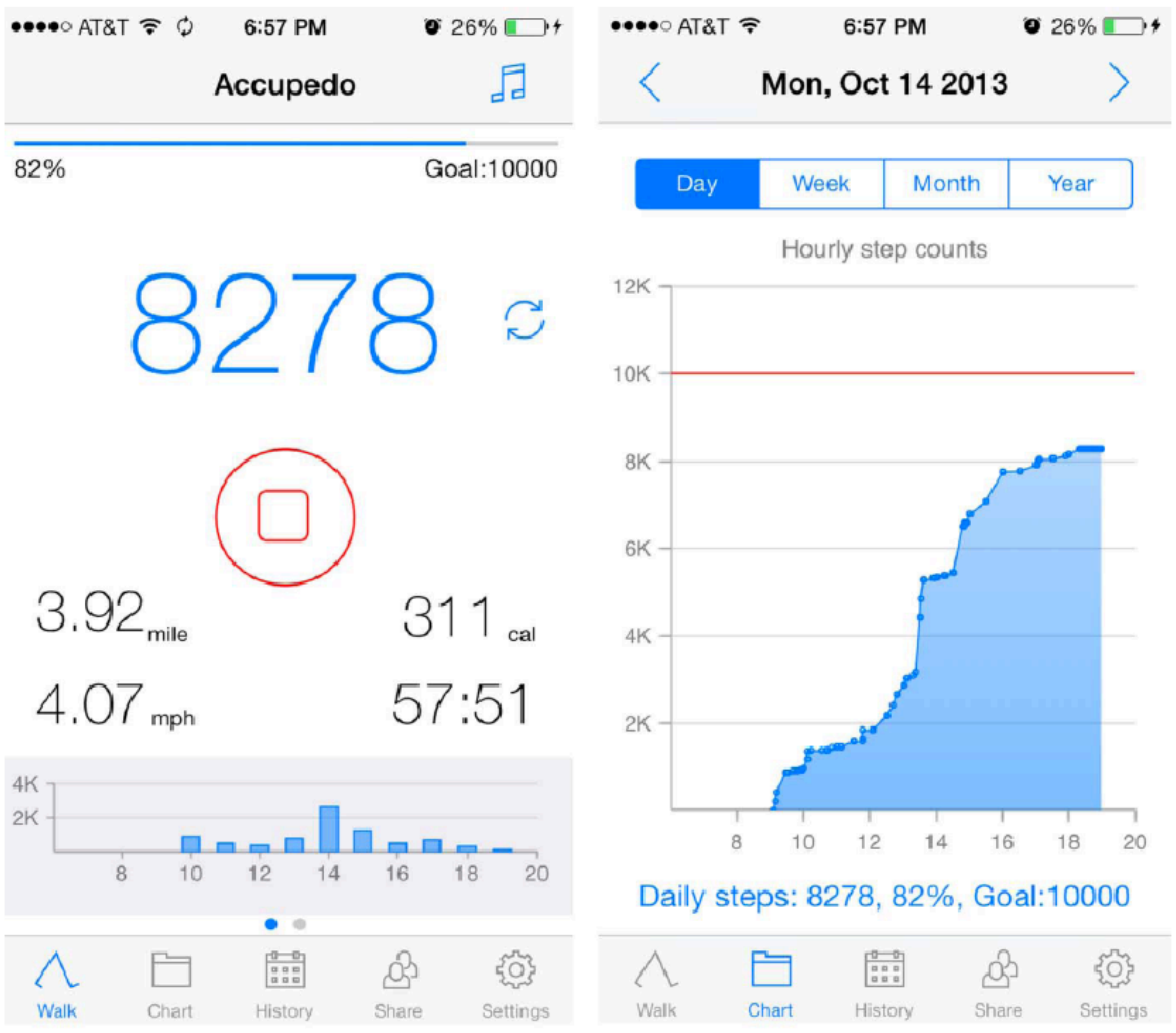


Fig. 2 Screenshot of smartphone app

Otter et al., 2015

Pedometer



A B

Figure 1 Screenshot of iOS Accupedo-Pro Pedometer user interface: (A) daily log history (step counts, distance, calories and walking time) and (B) charts (daily, weekly, monthly and yearly step counts).

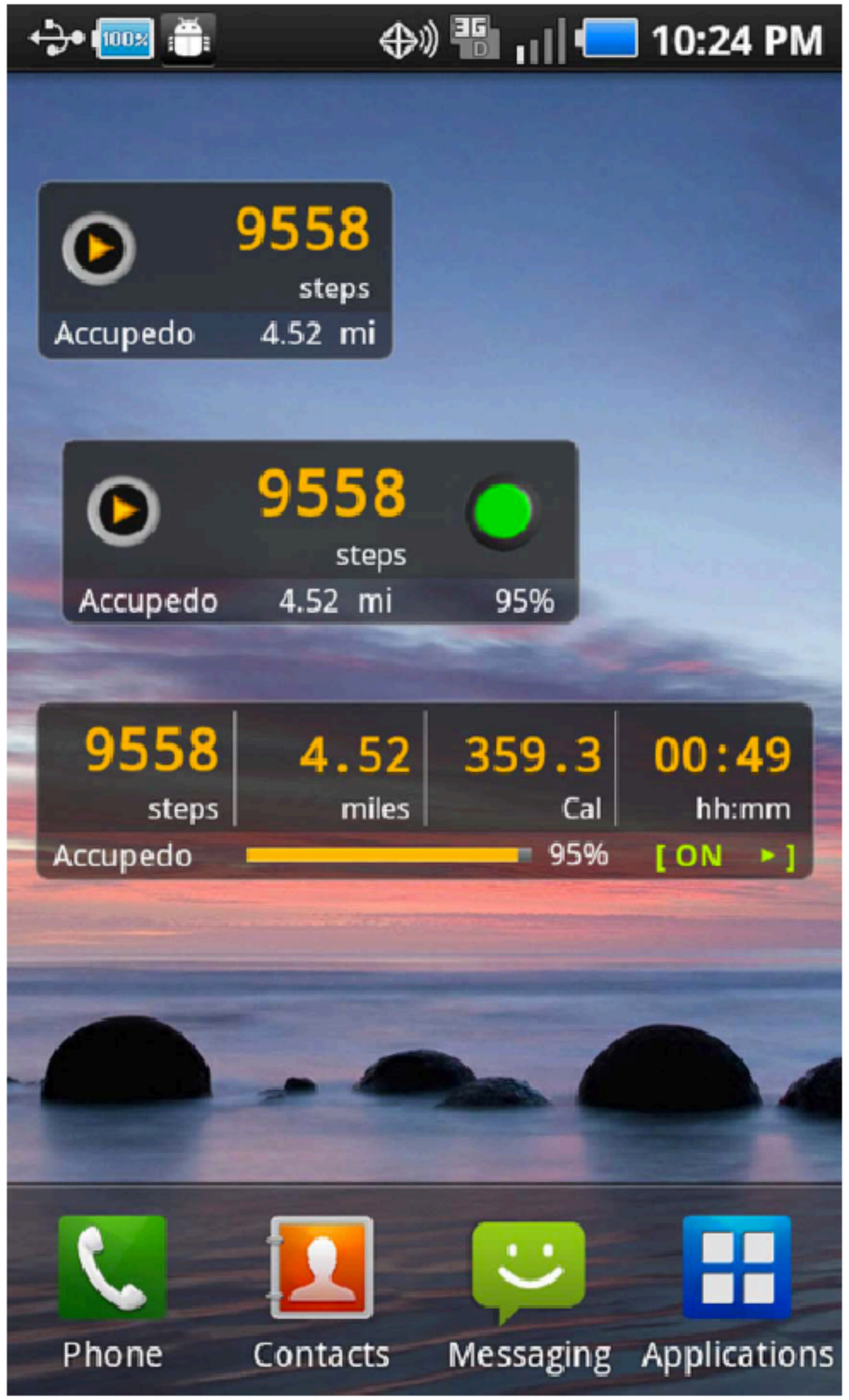


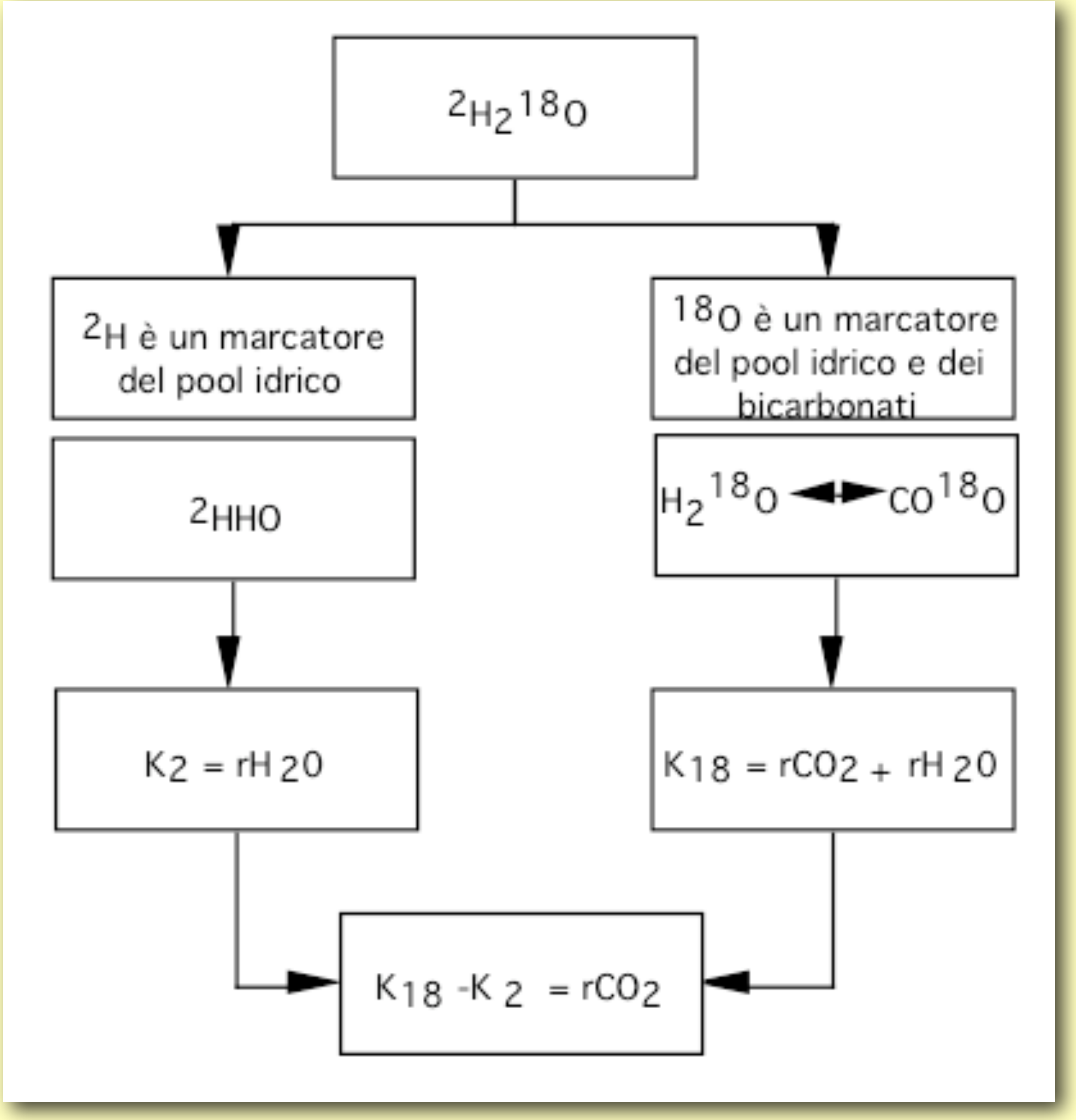
Figure 2 Screenshot of Android Accupedo-Pro Pedometer widget.

Milanović et al., 2016

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

DLW method



$^2H_2{}^{18}O$
^2H è un marcatore del pool idrico
^{18}O è un marcatore del pool idrico e dei bicarbonati
^2HHO
$H_2{}^{18}O$ ⟷ $CO^{18}O$
$K_2 = rH_20$
$K_{18} = rCO_2 + rH_20$
$K_{18} - K_2 = rCO_2$

DLW method

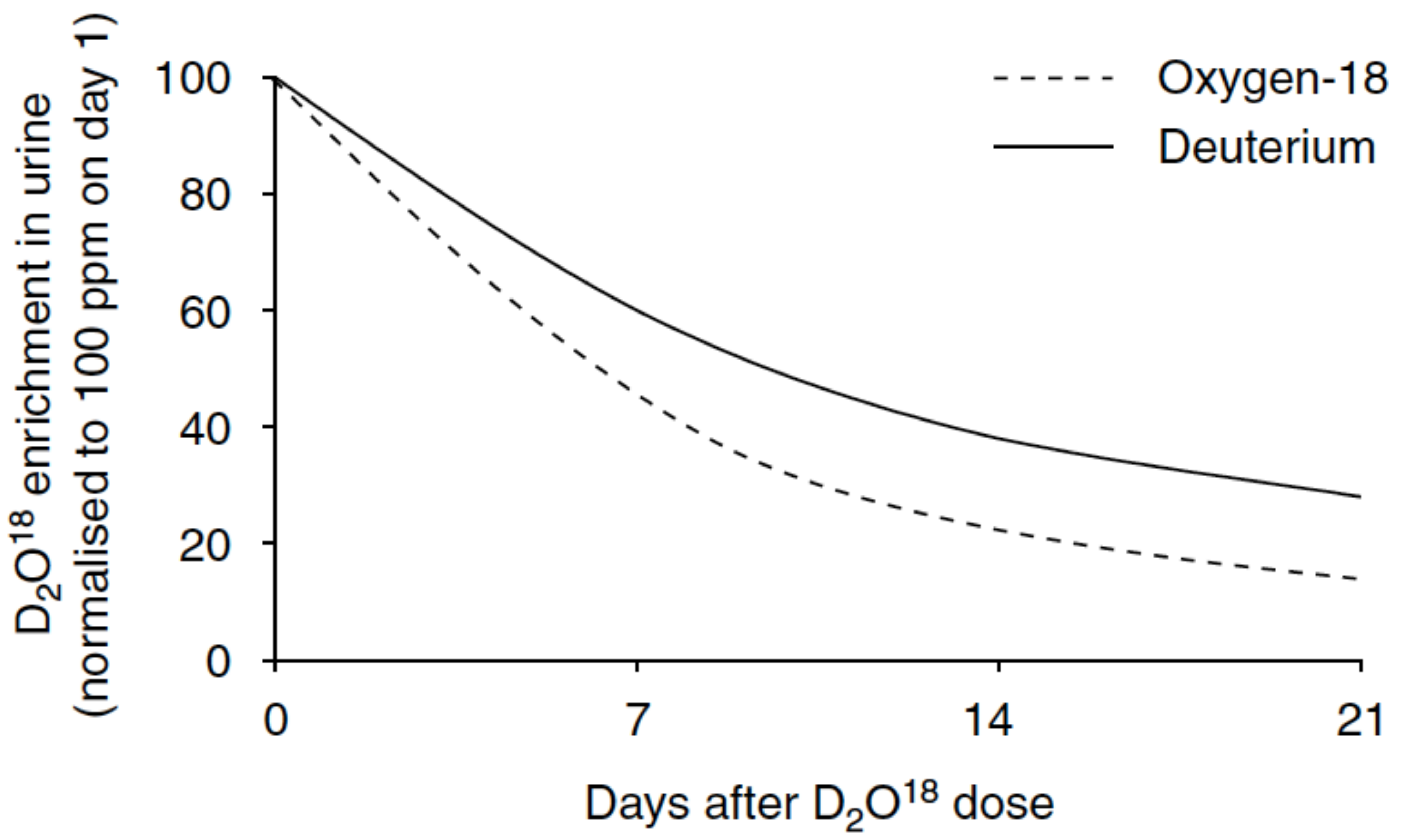


Fig. 1. Decline of ^{2}H (deuterium [D]) and ^{18}O in body fluids (urine, plasma or saliva) during a hypothetical doubly labelled water experiment.

DLW method

- RQ (= V'CO2 / V'O2) estimate -> accuracy:
  . standard Western diet -> RQ estimate;
  . food intake diary -> RQ estimate (i.e., food quotient ≈ RQ);
  . indirect calorimetry -> RQ

$$FQ = 1.0 \times CA + 0.7 \times F + 0.79 \times P + 0.66 \times A \quad (7)$$

where CA is the percent of energy in the diet consisting of carbohydrates, F is the percent that is fat, P is the percent protein, and A is the percent alcohol. Data on human macronutrient intake for the USA, based

DLW method

DLW method issues

- inability to discriminate the contribution of individual PAs (types, amount, intensity of each type) to ME;
- costs: isotopes and tools to detect them (i.e., mass spectrophotometers) still have considerable costs;
- -> only 3-4 ÷ 21 d ME;
- unknown RQ -> 5% e

DLW method

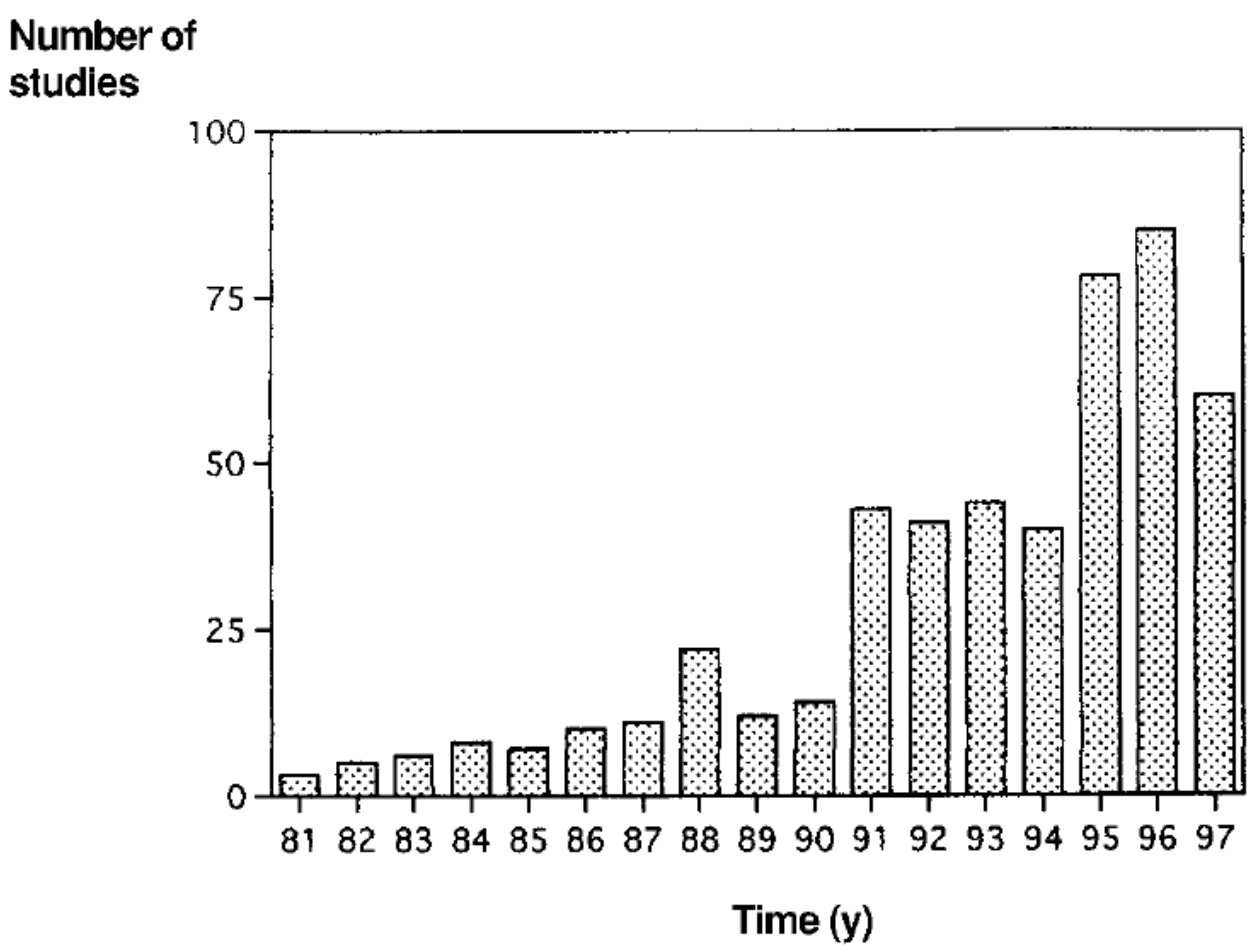


FIGURE 1. Number of studies in peer-reviewed journals (excluding abstracts) that used the doubly labeled water technique in the years 1981–1997 (through June) from the *Science Citation Index* (Institute for Scientific Information, University of Aukland, New Zealand). Since the first study in humans in 1982 the use of the technique has continued to grow.

Second generation accelerometers

Accelerometer issues

- SINGLE-SITE PLACEMENT;
- waist placement -> PA underestimate during upper limb movement, standing, vertical activity (i.e., climbing stairs, uphill walking), pushing or pulling objects, carrying loads (e.g., books or laptops), body-supported exercise (e.g., cycling), water PA (e.g., swimming), running faster than 9 km/h, horizontal speed rapid changes activities (e.g., tennis)

Second generation accelerometers

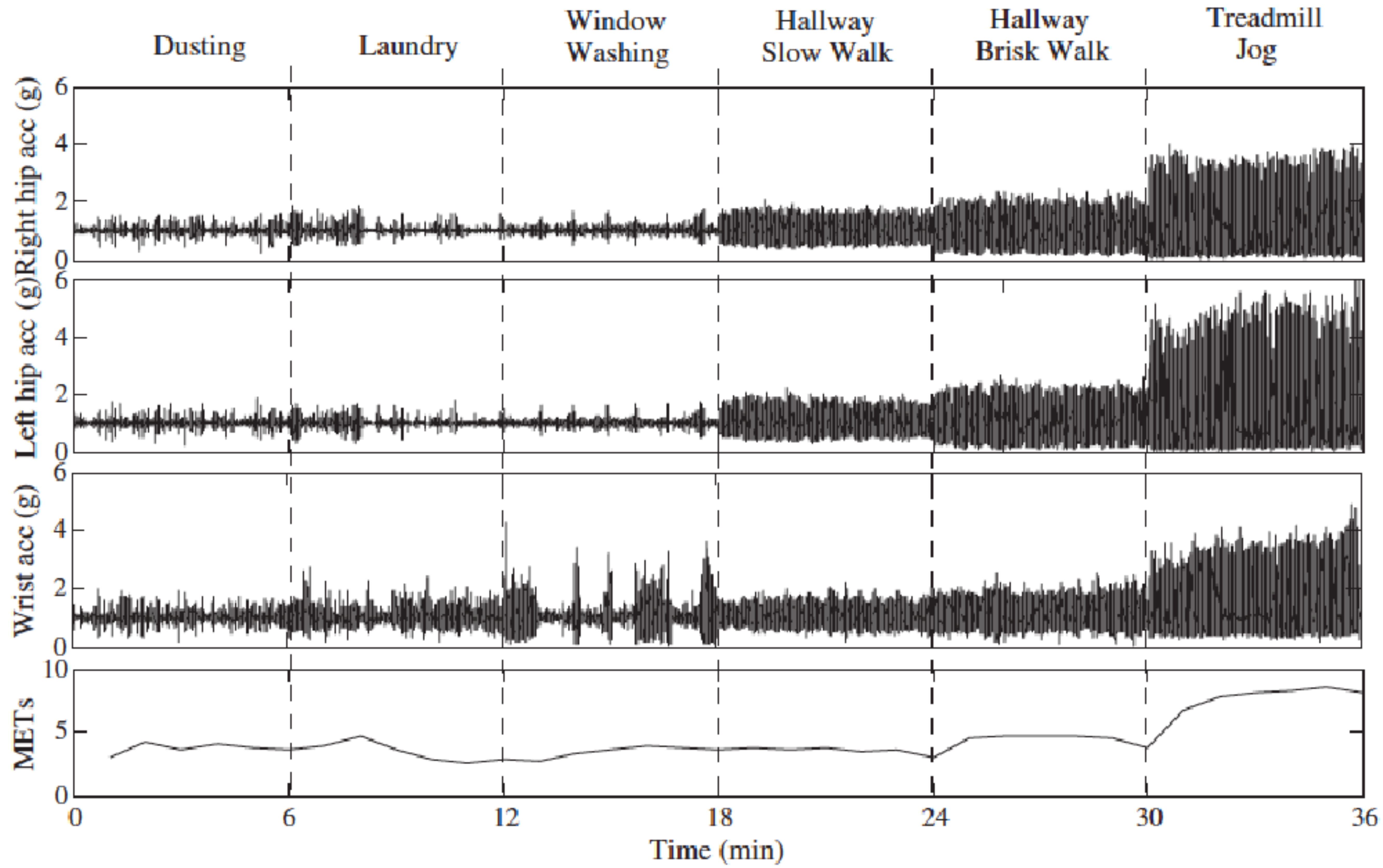


Figure 1. An example of accelerometer and MET measurements for one participant performing an activity routine. Data was not captured between activities.

Ellis et al., 2014

Second generation accelerometers

Solution?

- A combination of variables describing:
    1) upper limbs-focused high frequency components (upper limbs movements feature sedentary PA);
    2) a trunk-focused posture variable featuring locomotion;
    3) lower limbs-focused high intensity components (lower limbs have largest, most powerful muscles);

Second generation accelerometers

- More than ONE accelerometer together, as well (e.g., waist TriTrac-R3D + dominant arm wrist Actiwatch, Actiwatch + Actical, ...);
- accelerometers based activity logger:
  . two (@sternum, front thigh) biaxial accelerometers + analog data-logger;

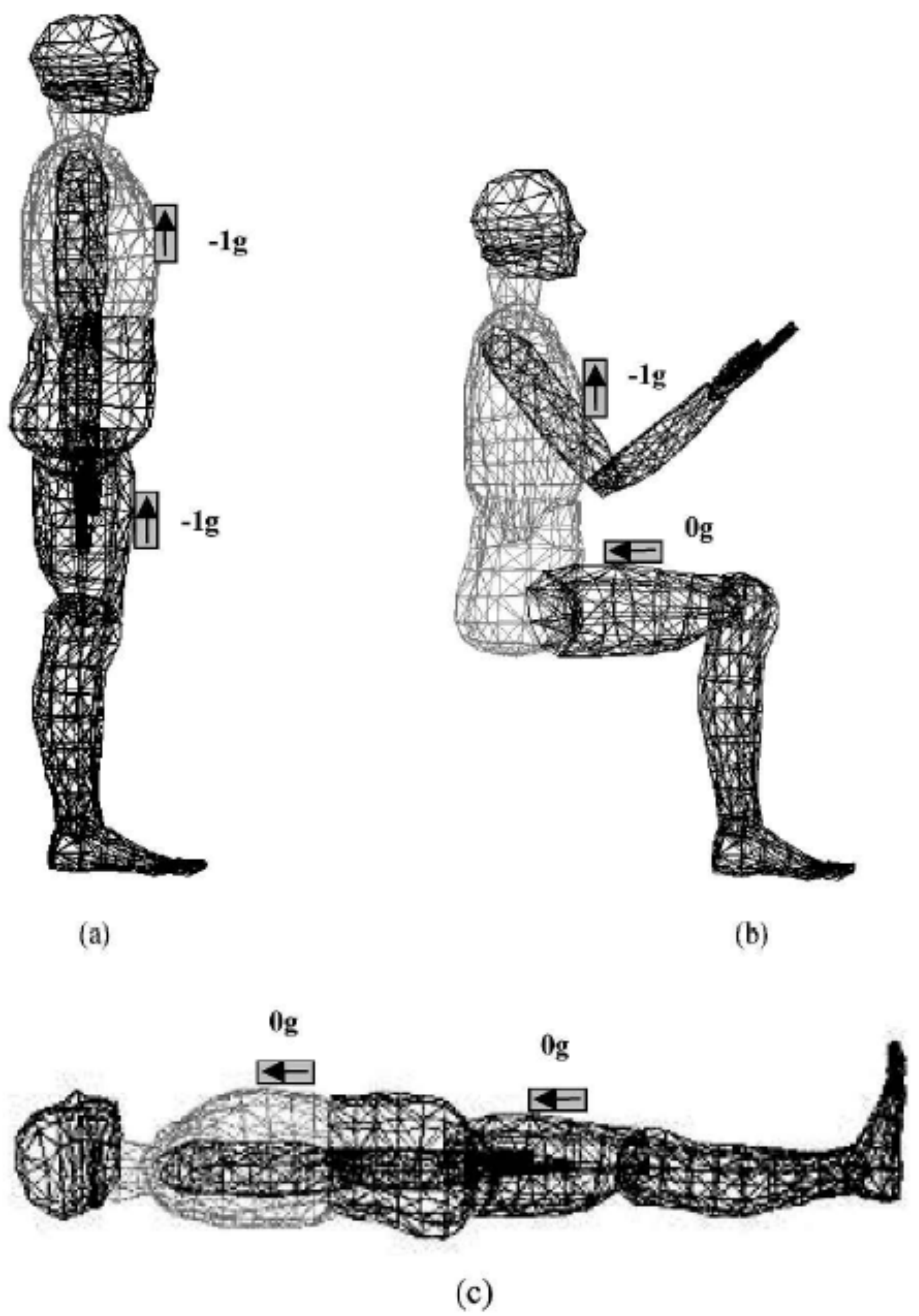


Figure 1 Discriminating postures: (a) standing, (b) sitting, (c) lying. The arrows indicate the investigated direction of the active axis of the accelerometers. The acceleration values correspond to the accelerometer output at each orientation in units of ***g***.

Culhane et al., 2004

Second generation accelerometers

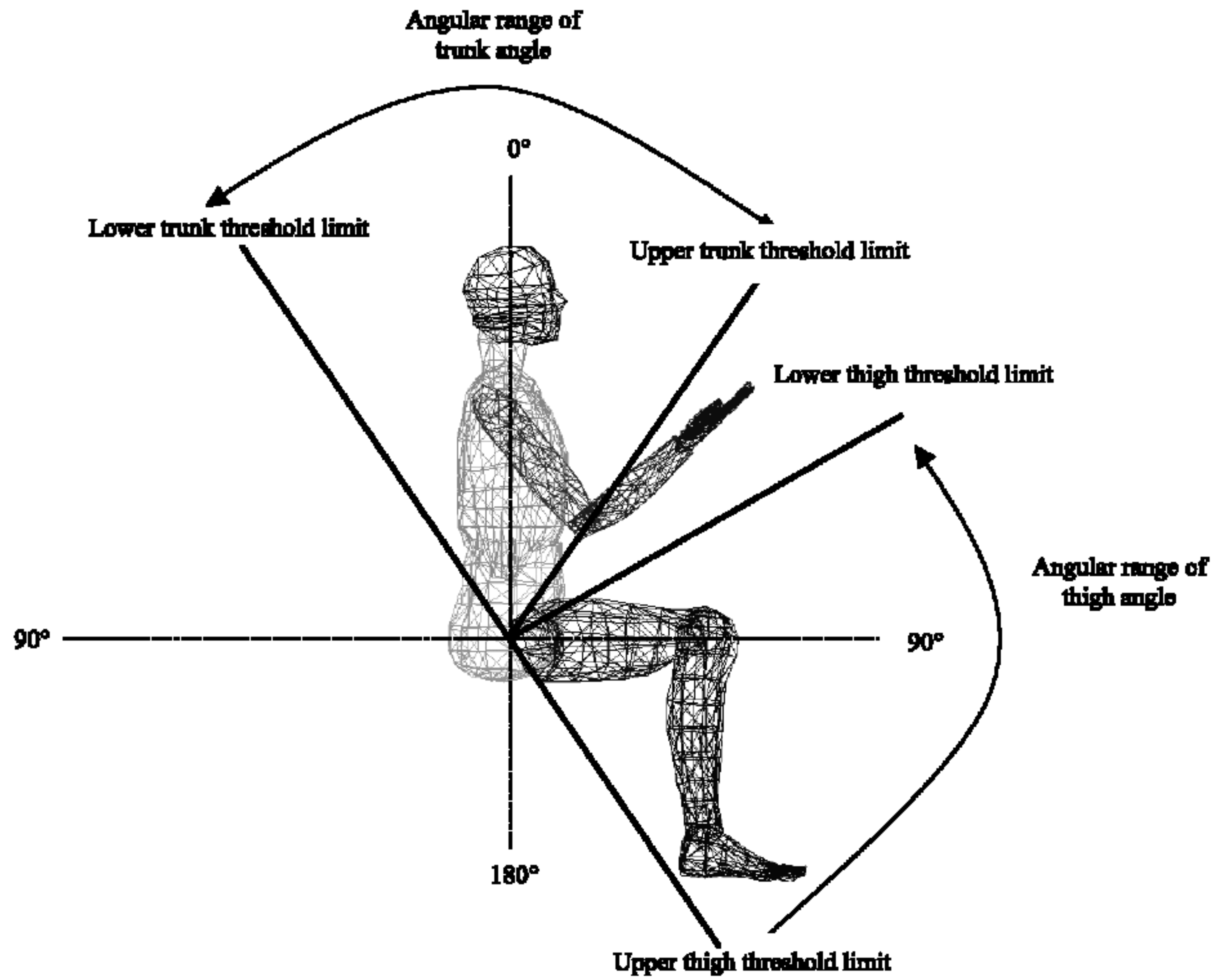


Figure 2 Sitting criteria.

Culhane et al., 2004

Second generation accelerometers

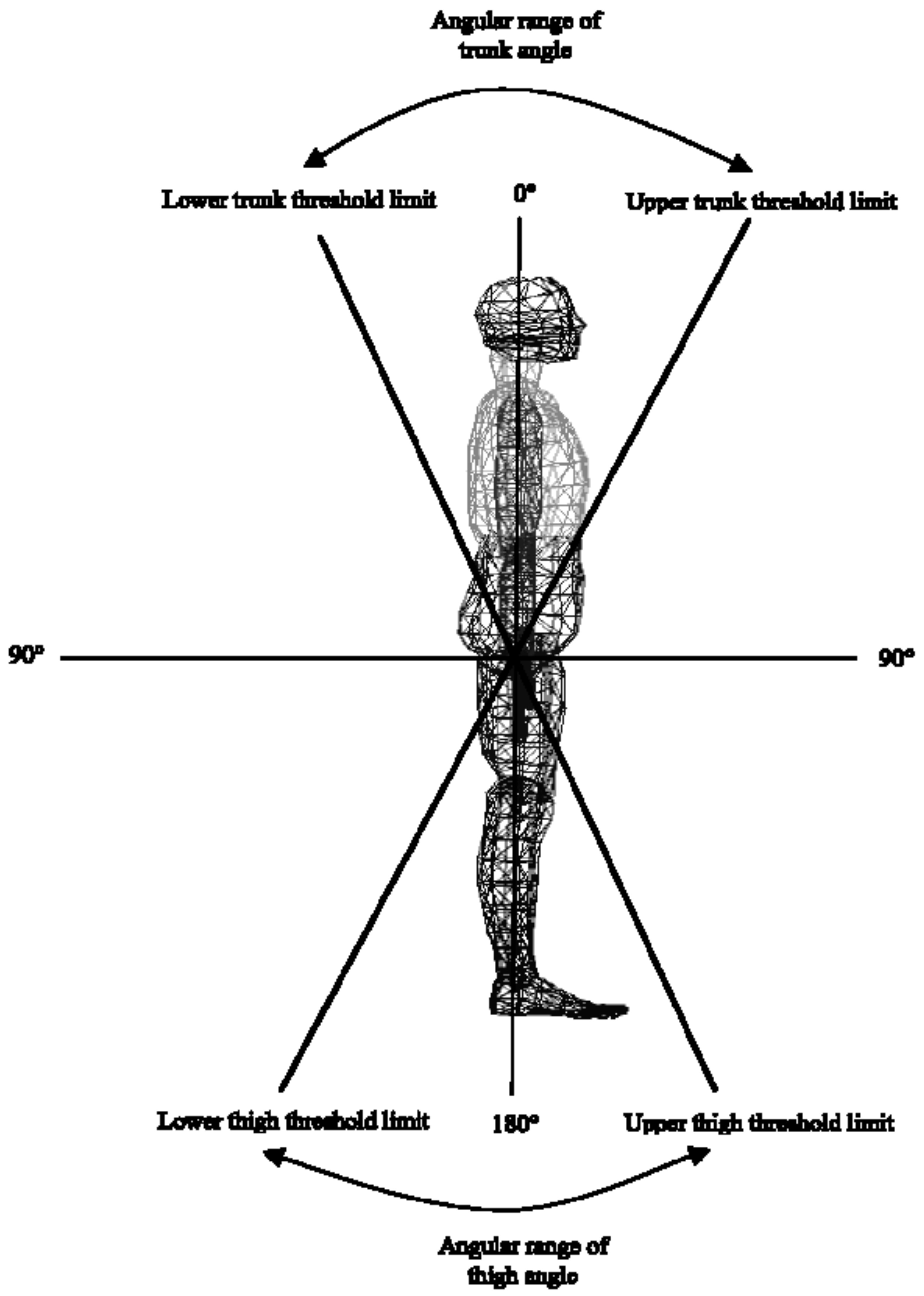


Figure 3 Standing criteria.

Culhane et al., 2004

Second generation accelerometers

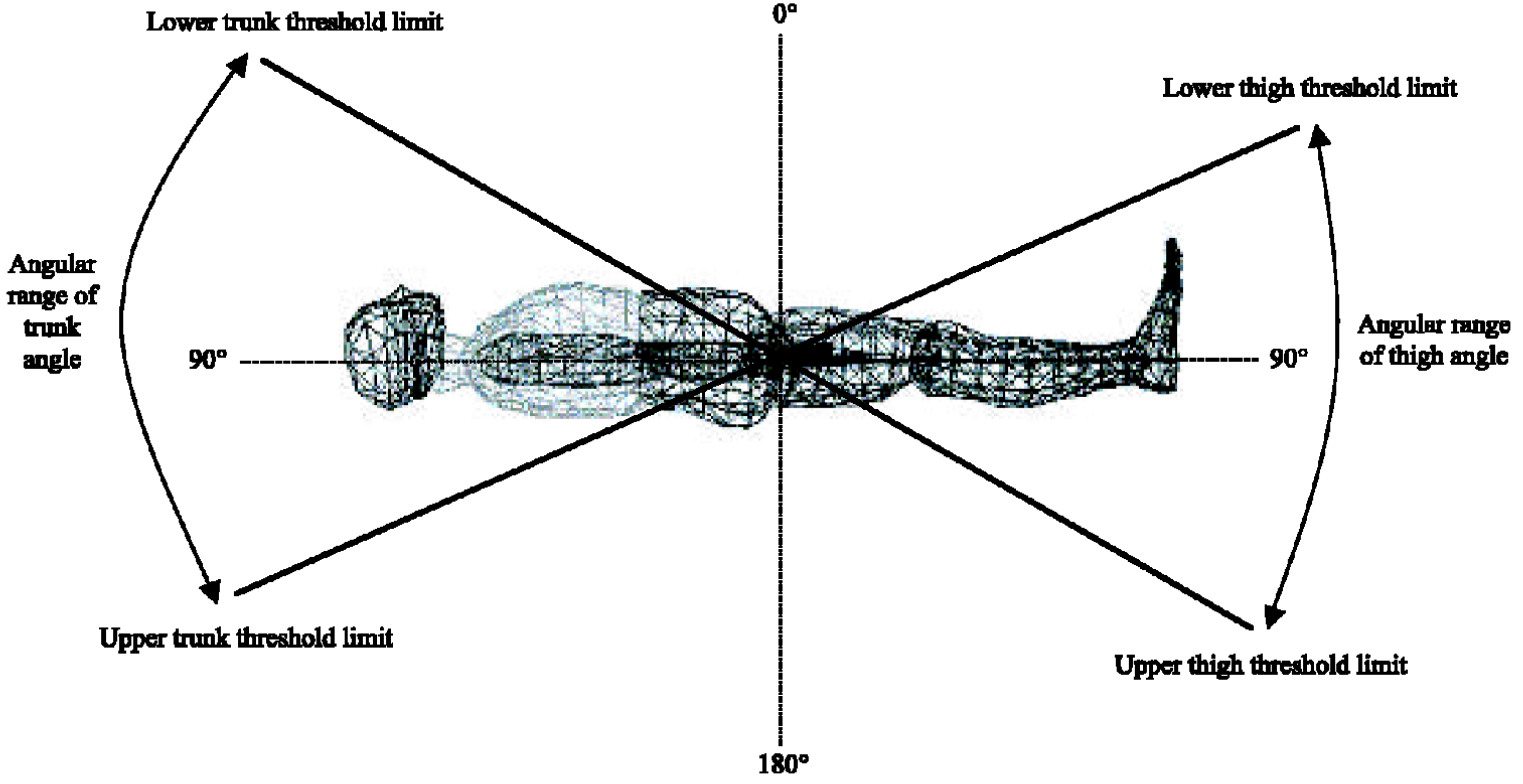


Figure 4 Lying criteria.

-> sitting, standing, lying, moving 83% detection;

Culhane et al., 2004

Second generation accelerometers

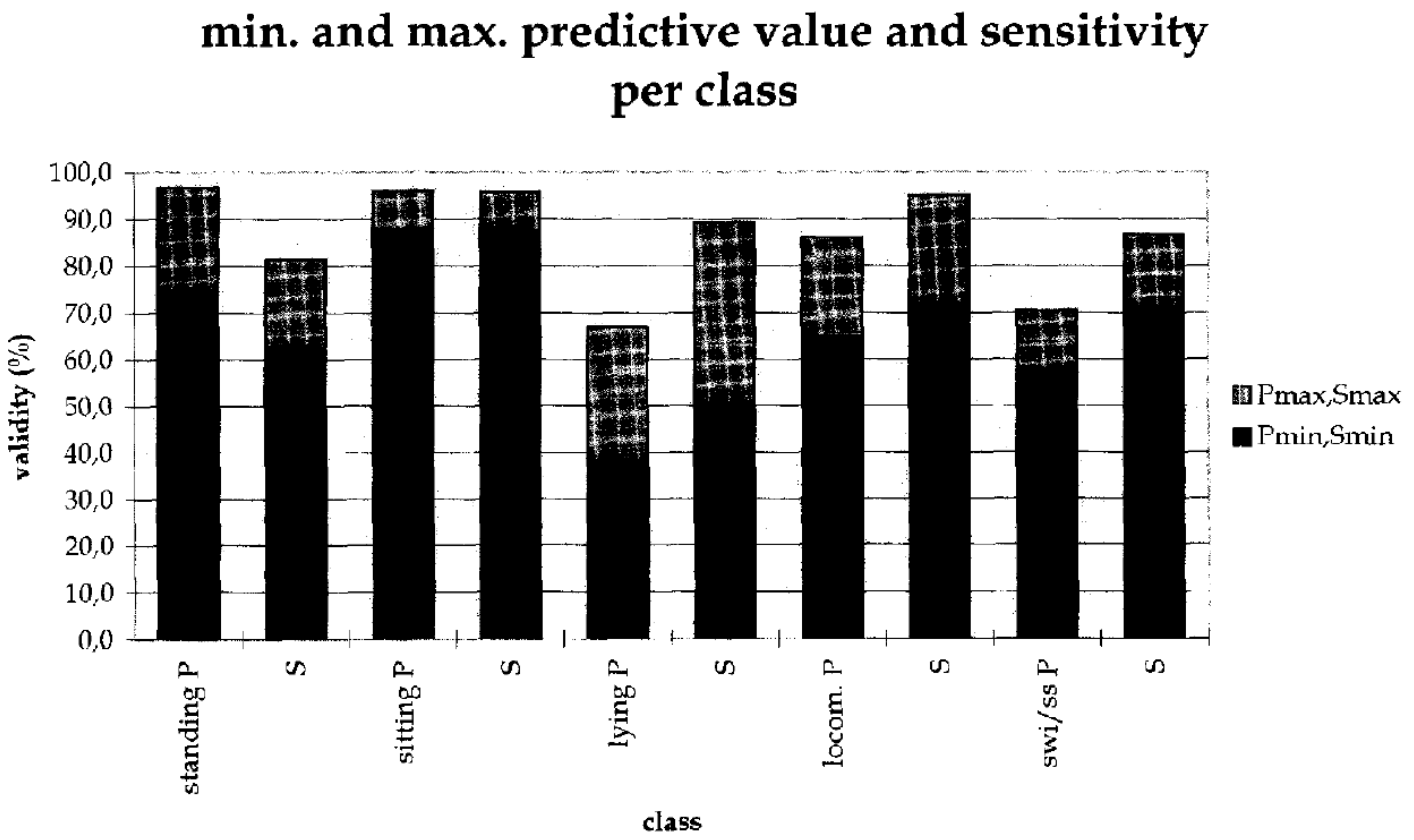


Figure 6 Minimal and maximal validity of the individual ADL categories based on the monitor's sensitivity (S_{min} and S_{max}, respectively) and predictive value (P_{min} and P_{max}, respectively). Sensitivity indicates how often the monitor recognizes a category; the predictive value indicates how often the decision of the monitor is correct. A lack of sensitivity indicates a false negative; a lack of predictive value indicates a false positive.

Busser et al., 1997

. uniaxial accelerometer (@front thigh) + 2 unixial accelerometer/digital data-logger (backpack)
-> sitting, standing, lying, crawling, walking, running, going on a swing 73÷91% detection;

Second generation accelerometers

. three uniaxial accelerometers (2@sternum, front thigh) + digital recorder;
-> sitting, standing, lying, walking, climbing/going down stairs, cycling 80% detection (Veltink et al., 1996);
. four biaxial accelerometers (@lateral thighs, sternum or front forearms) + HR monitor + digital recorder;
-> more than twenty different postures/locomotions 83÷88% detection;

Figure 1. An extended configuration of the Activity Monitor, with accelerometers at the thighs, trunk, and lower arms.

Bussmann et al., 2001

Second generation accelerometers

- Introduction of another type of physical sensor:
  . (@sternum) two biaxial accelerometers + piezoelectric gyroscope + digital recorder (@wrist);

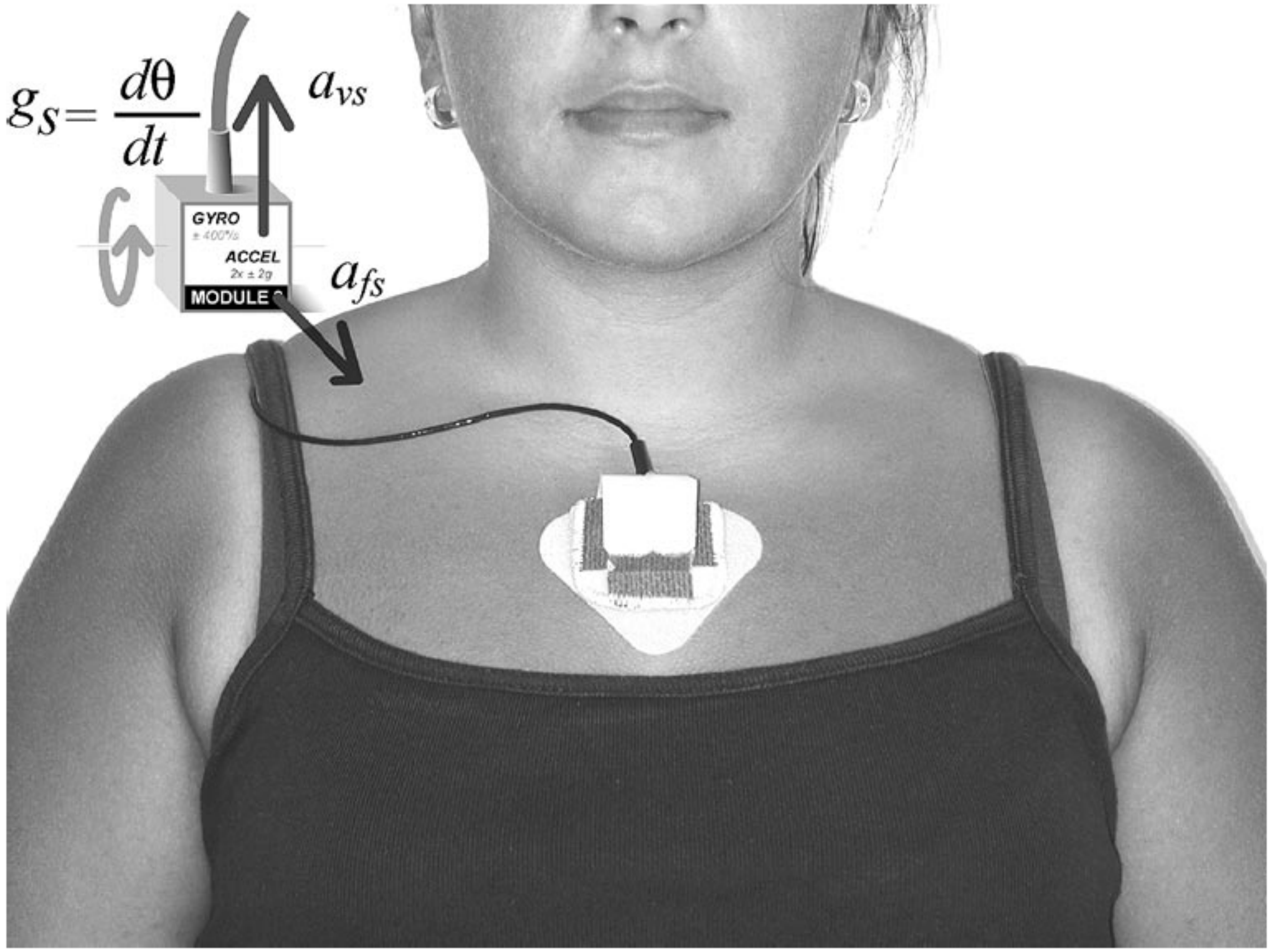


Fig. 1. Sensor attachment. Vertical and frontal acceleration (a_{vs} and a_{fs}) as well as angular velocity (g_s) are measured using a kinematic sensor attached to the subject's chest.

Najafi et al., 2003

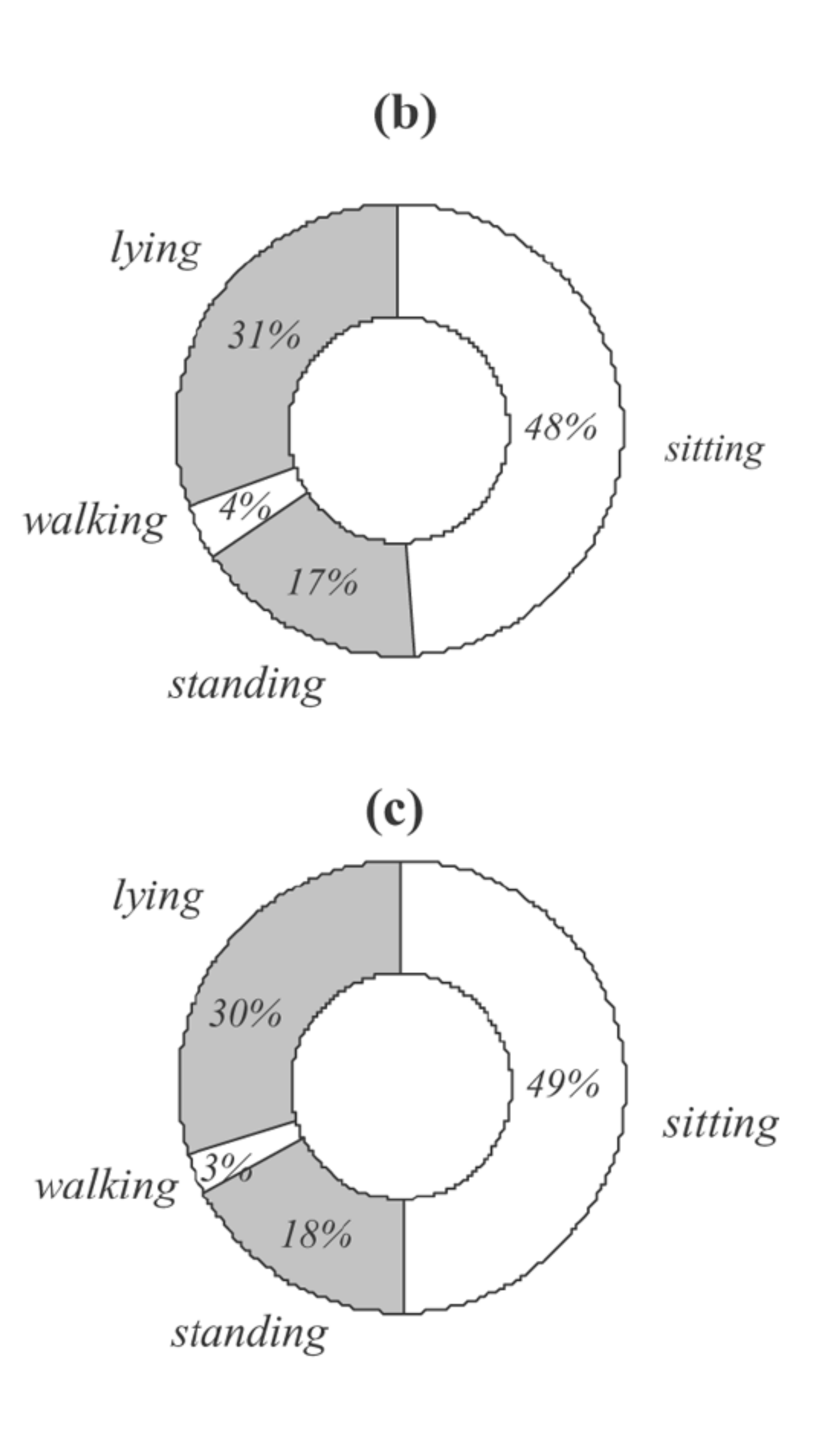
Second generation accelerometers

measures

TABLE II
OVERALL SENSITIVITY AND SPECIFICITY OF TRANSITION DETECTION FOR THE 11 ELDERLY (FIRST STUDY)

# Test	Total PT*	Sensitivity, %					Specificity, %	
		PT	SiSt**	StSi	Lying	Walking	SiSt	StSi
1	40	100	100	100	100	95±4	100	100
2	66	98±5	100	97±10	-	97±3	95±12	100±0
3	58	100	97±10	63±29	-	-	63±29	97±10
4	58	100	88±25	75±29	-	-	75±29	88±25
5	64	96±9	89±18	86±19	-	-	86±19	94±13
6	57	100	85±19	72±24	-	-	72±24	85±19
Mean	***57±9***	***99±2***	***93±7***	***82±15***	***100***	***96±1***	***82±15***	***94±6***

* PT: Postural transition.
** SiSt: sit-to-stand transition.
† StSi: stand-to-sit transition.



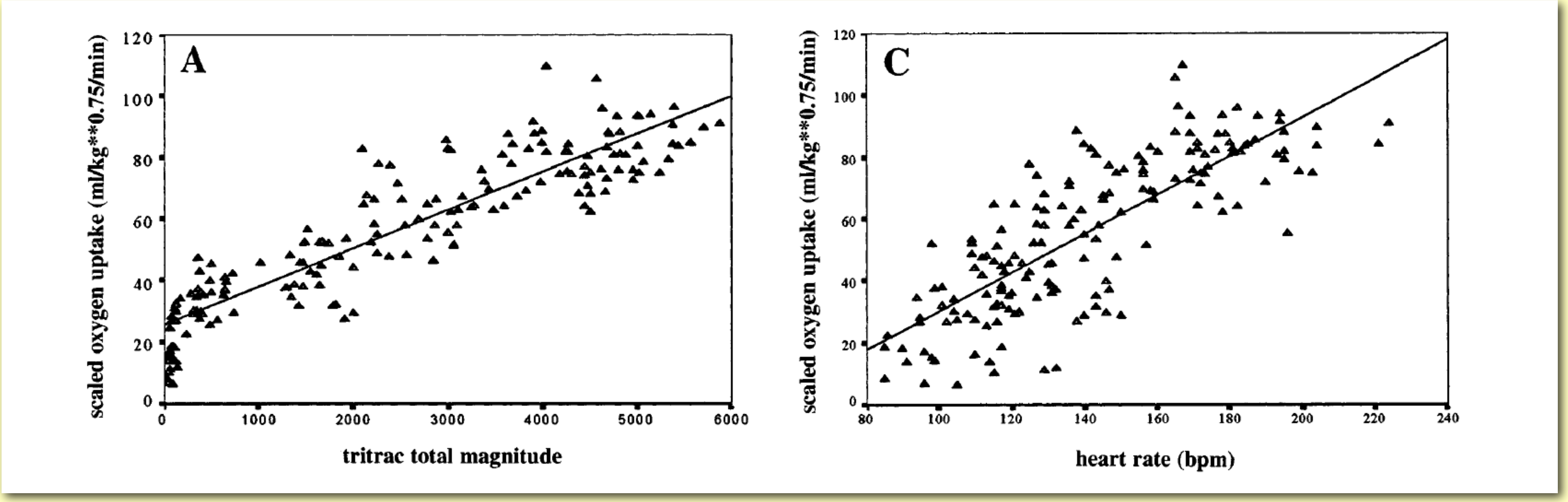
Najafi et al., 2003

-> posture change, walking detection;

Second generation accelerometers

- Accelerometry (-> movement) + physiological measure (e.g., HR measure, thermometry, ventilation measure):
  . e.g., HR monitor (-> ME) + motion sensor(s) (-> motion-sensor-sensitive PA);
- accelerometers + inclinometers -> body position over time -> 85% unstructured exercise thermogenesis estimate:
  . total internal heat produced ≈ 75÷80% energy intake;
  . partial internal heat produced <- sitting, standing, walking, working, any other unstructured exercise;
  . proposal: (during the day) wearing motion sensor, (structured exercise) wearing HR monitor;
  . i.e., motion sensor -> yes/not time to use HR monitor for ME estimate;

Second generation accelerometers



Eston et al., 1998

. exception: children (i.e., V'O2 [ml O2/kg$^{.75}$ min] correlated w/both counts, HR, but w/counts r^2 > w/HR r^2);