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)

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measures

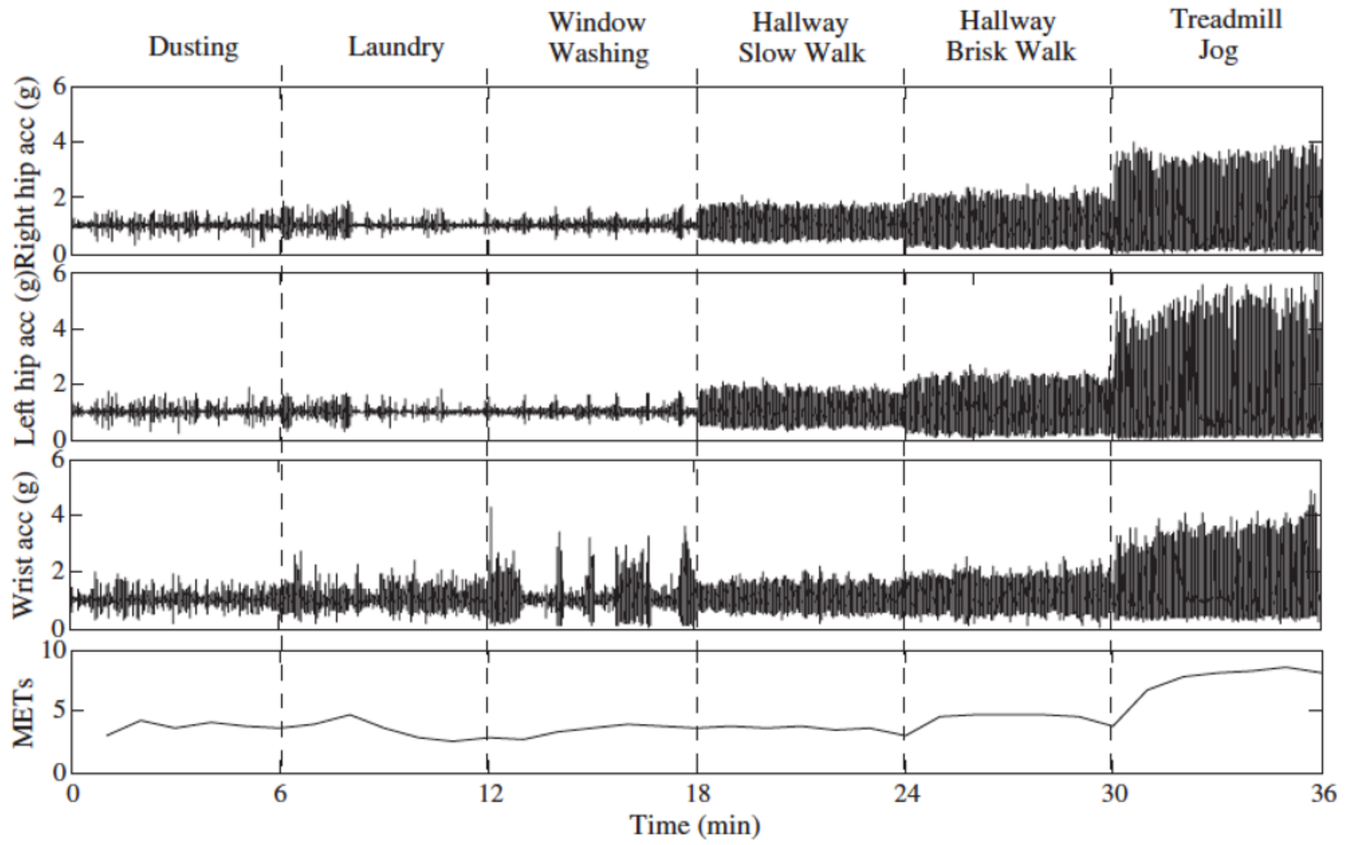

Figure 1. An example of accelerometer and MET measurements for one participant performing an activity routine. Data was not captured between activities.

Ellis et al., 2014

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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);

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- 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;

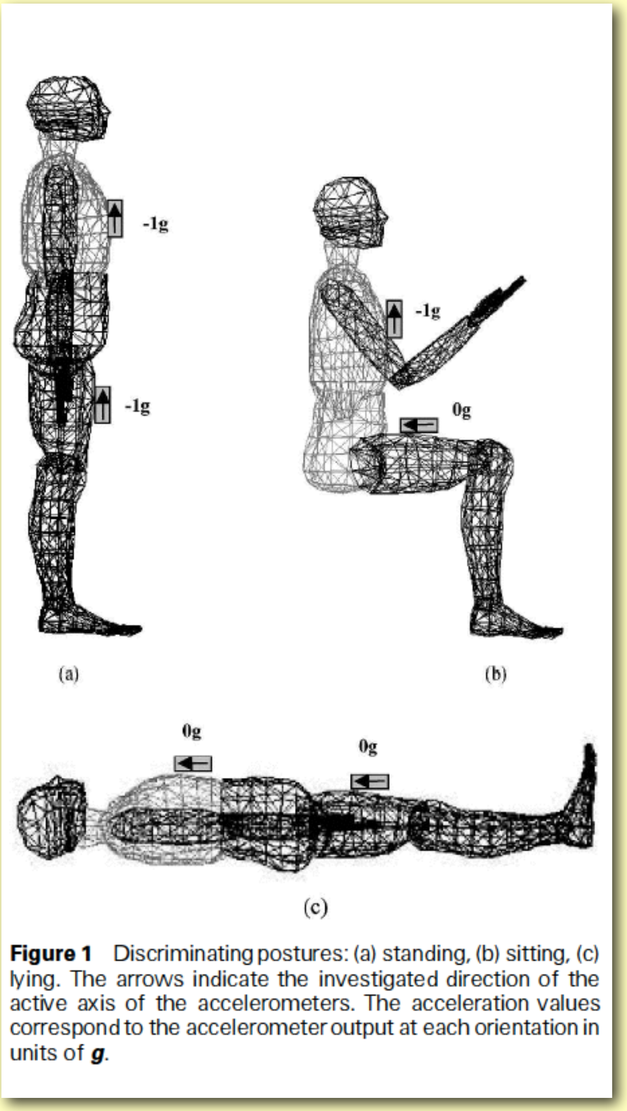

Figure 1 Discriminating postures: (a) standing, (b) sitting, (c) lying. The arrows indicate the investigated direction of the active axis of the accelerometers. The acceleration values correspond to the accelerometer output at each orientation in units of ***g***.

Culhane et al., 2004

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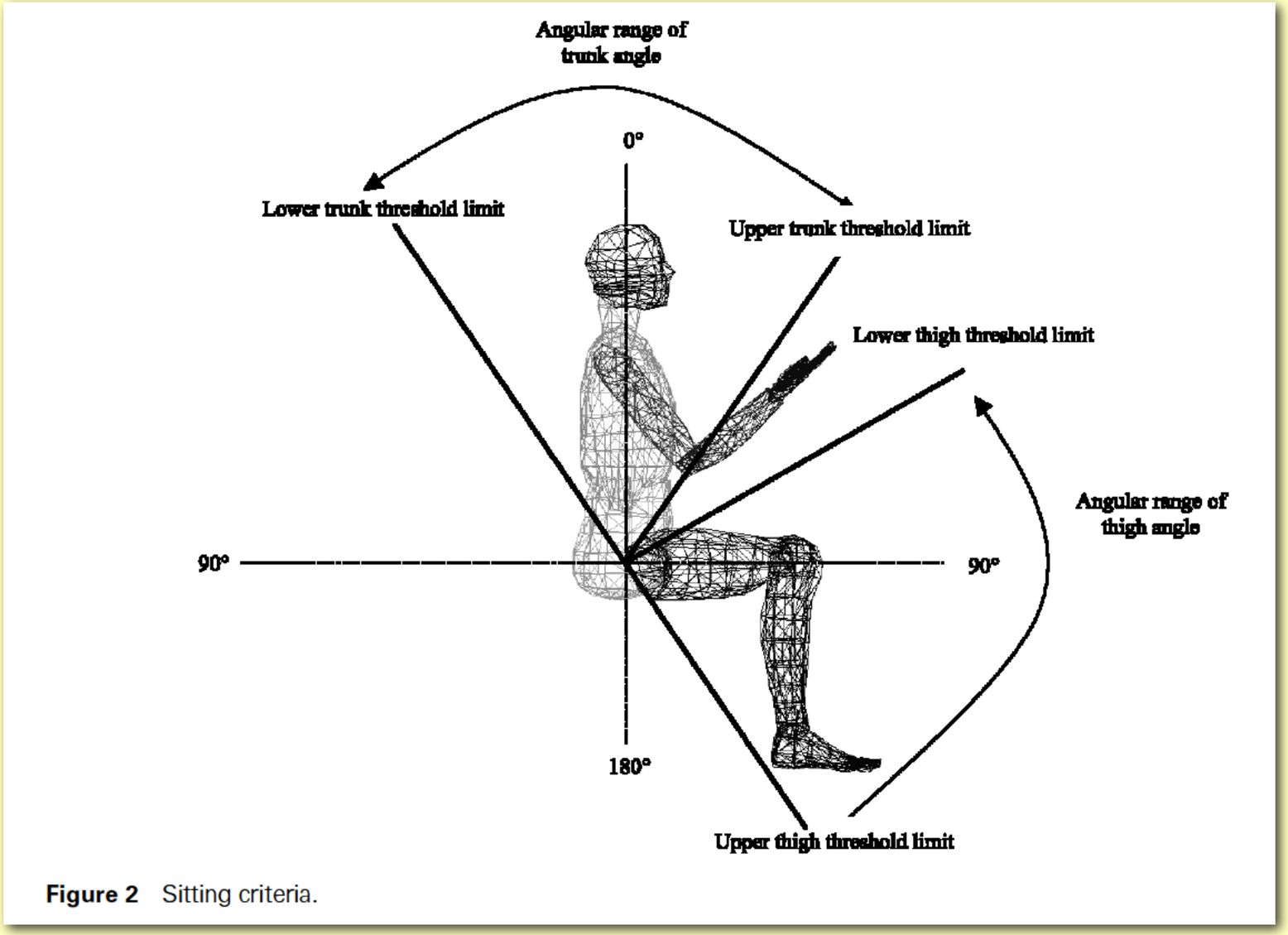

Figure 2 Sitting criteria.

Culhane et al., 2004

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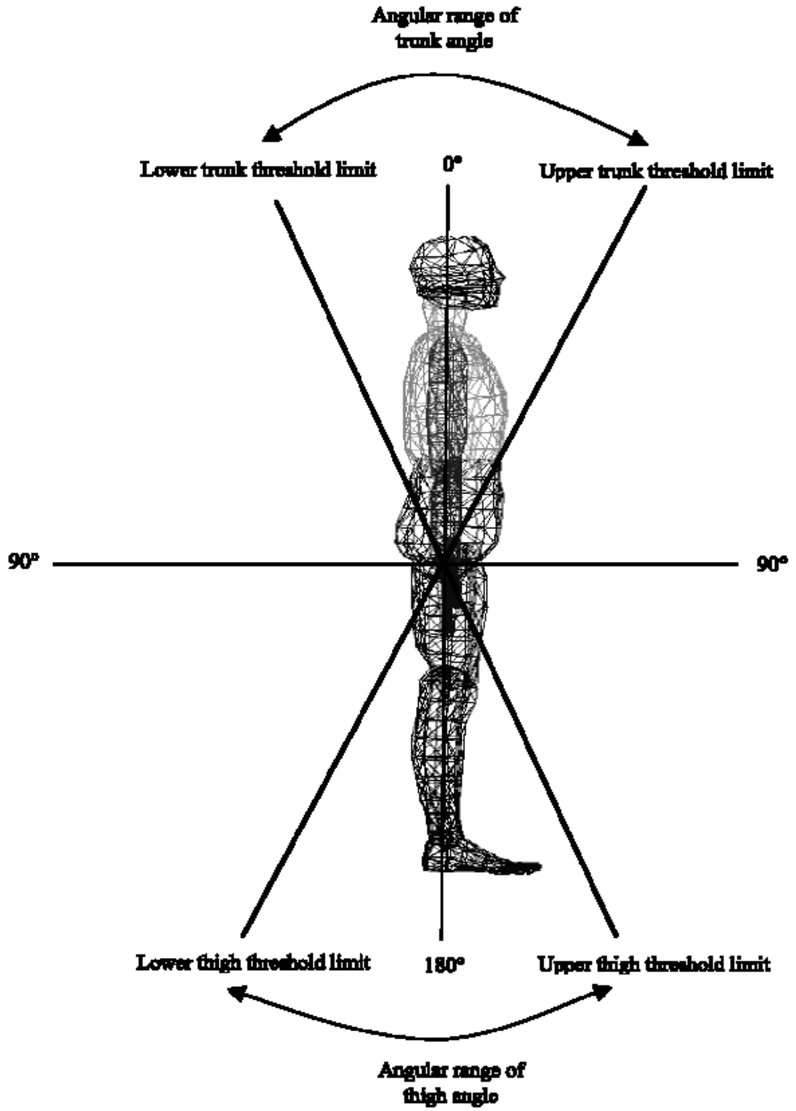

Figure 3 Standing criteria.

Culhane et al., 2004

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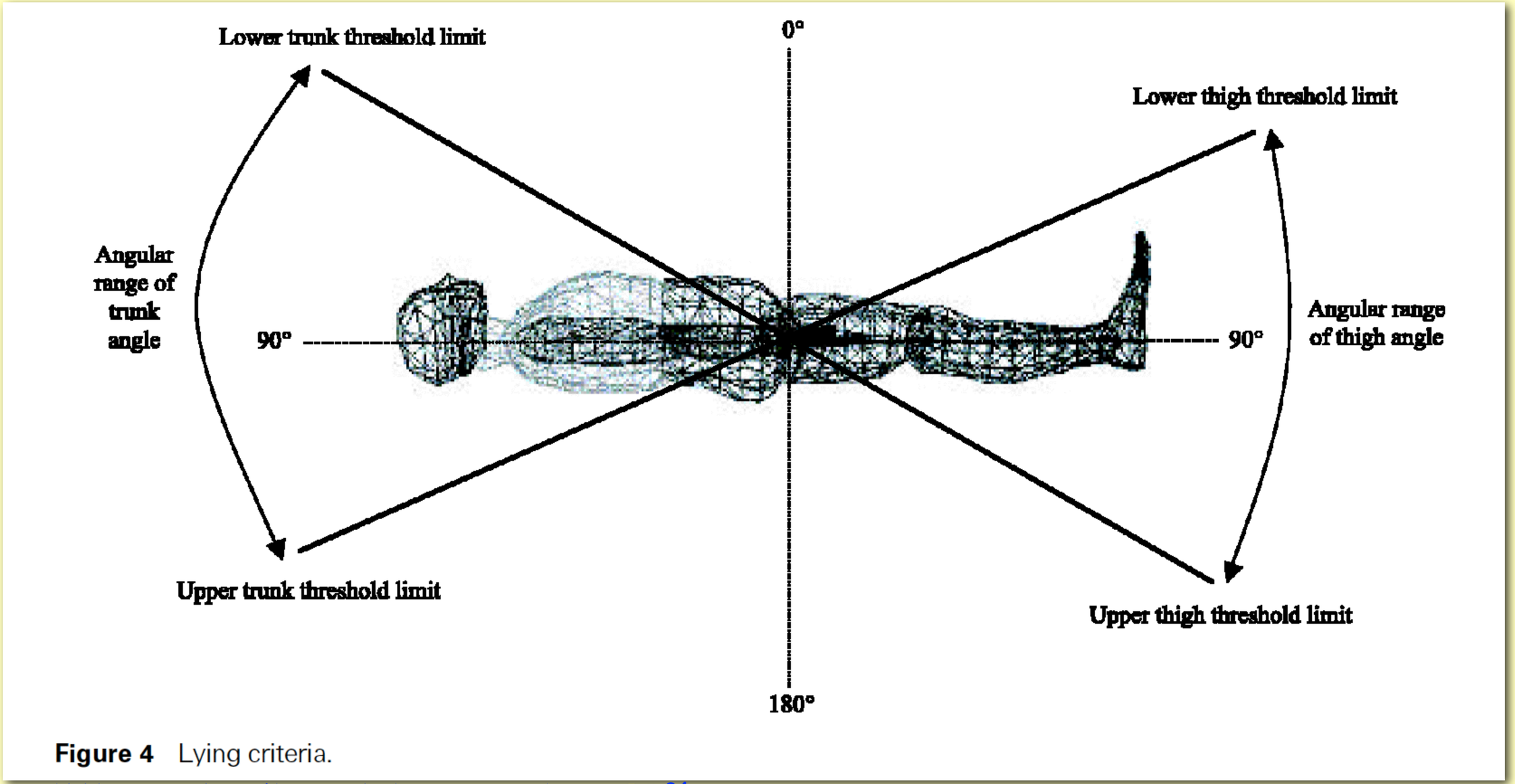

Figure 4 Lying criteria.

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

Culhane et al., 2004

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measures

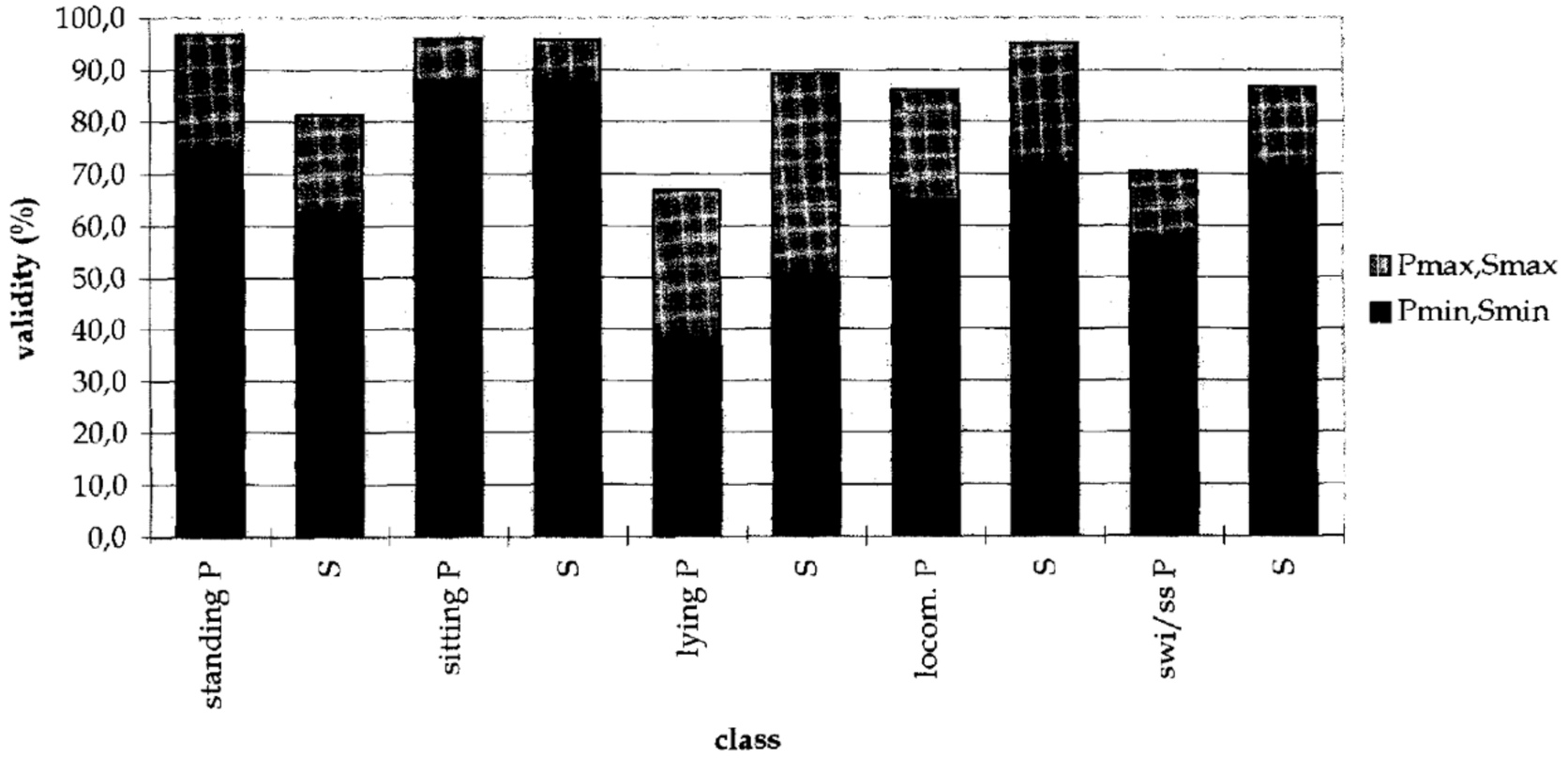

Figure 6 Minimal and maximal validity of the individual ADL categories based on the monitor's sensitivity (S_{min} and S_{max}, respectively) and predictive value (P_{min} and P_{max}, respectively). Sensitivity indicates how often the monitor recognizes a category; the predictive value indicates how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

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. 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

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

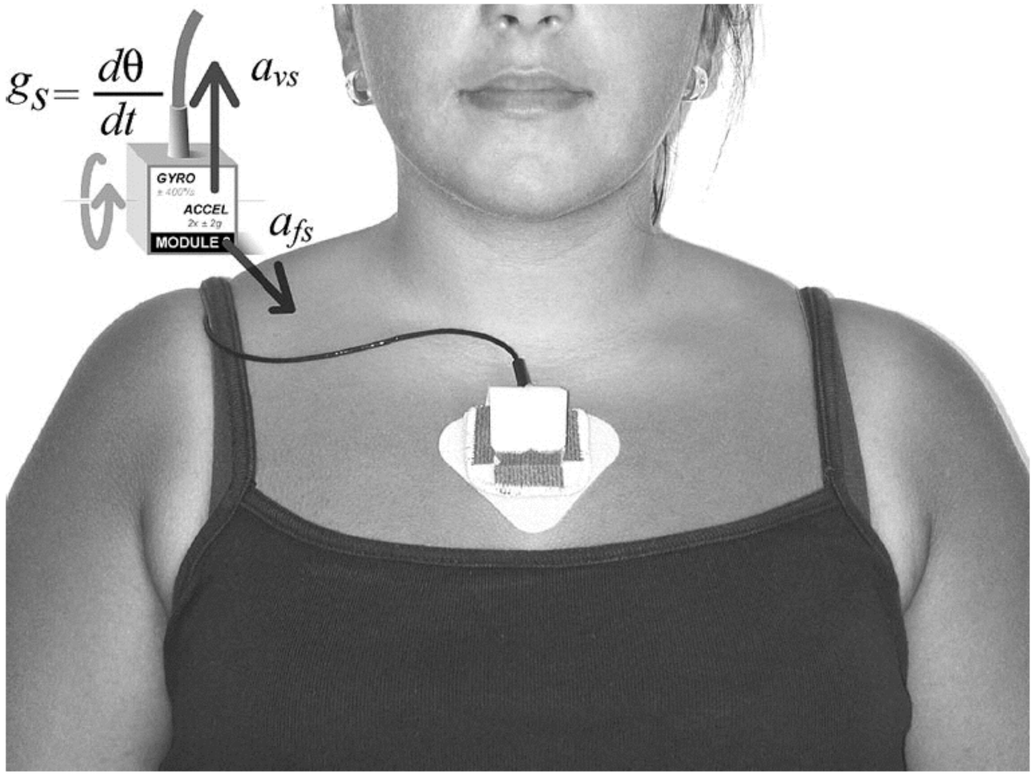

Fig. 1. Sensor attachment. Vertical and frontal acceleration (a_{vs} and a_{fs}) as well as angular velocity (g_s) are measured using a kinematic sensor attached to the subject's chest.

Najafi et al., 2003

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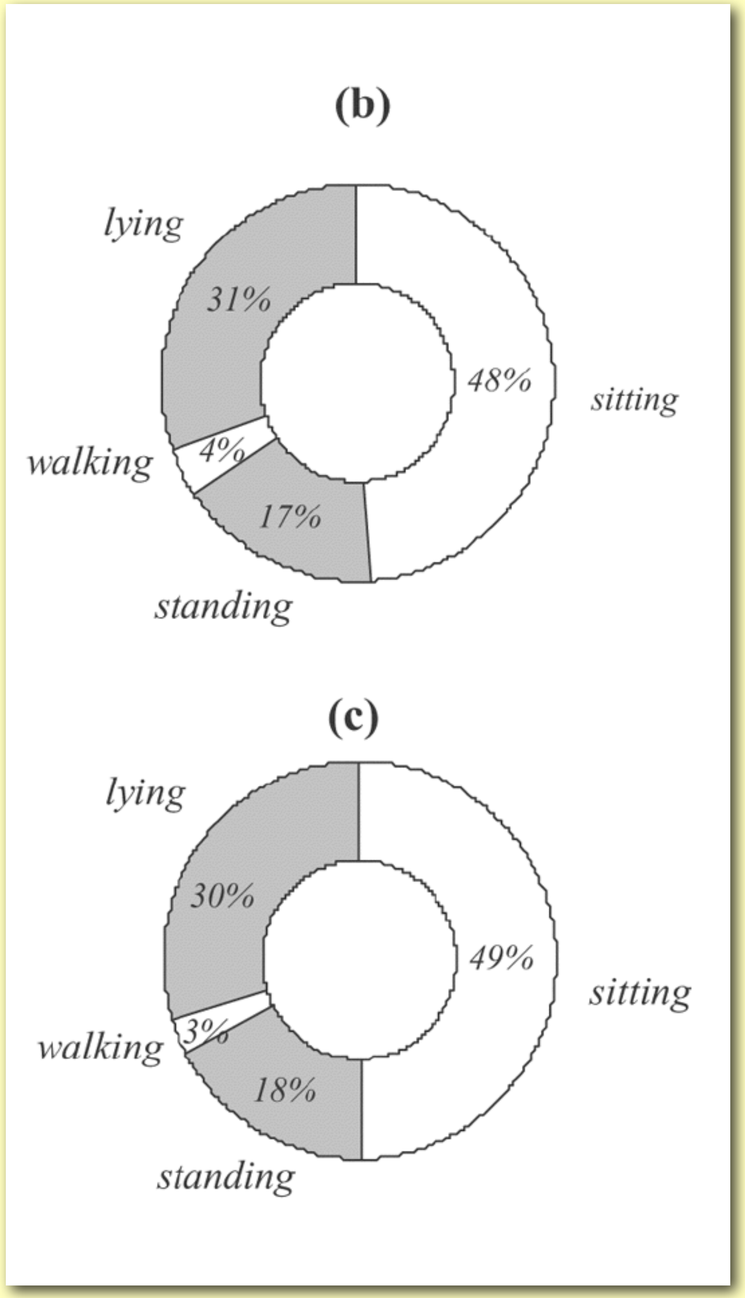
measures

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;

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- 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;

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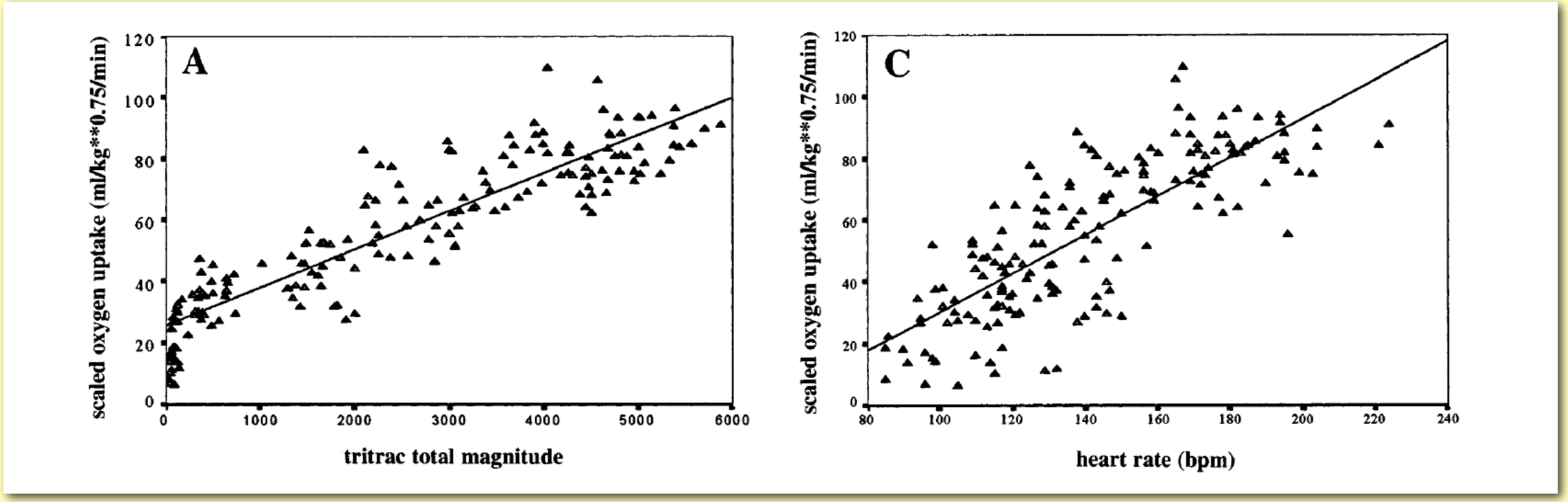

Eston et al., 1998

. 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);

Second generation accelerometers (re: children HR)

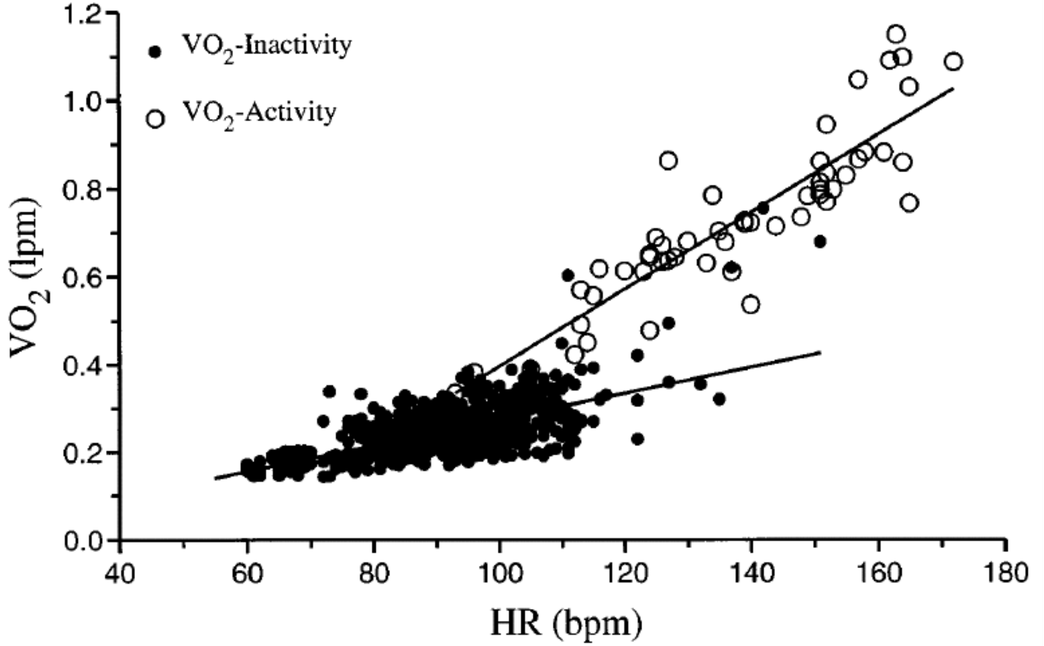

Fig. 1. Oxygen consumption ($\dot{V}O_2$) and heart rate (HR) relationship in the room calorimeter for one subject, with separate curves for active vs. inactive data for awake portion of the day (*method 3*).

Treuth et al., 1998

. solution: two different individual V'O2 vs. HR relationships, one for inactivity, one for PA;

Second generation accelerometers

- Accelerometry + HR measure:
  - . FitSense FS-1;
  - . Actiheart:
    - @chest;
    - each subject's calibration;
    - OPEN ALGORITHM;
    - user's models;
    - accelerometer-, HR monitor-, accelerometer+HR monitor-driven model;

Second generation accelerometers

measures

Figure 1. Placement of the three accelerometers. Panel A represents the accelerometers' placement and attachment onto the subject during the race. Panel B illustrates the placement of the tibial accelerometer without the attachment system, for more clarity. Panels C and D show more precisely the placement and attachment of the metatarsal and heel accelerometers, respectively.

Giandolini et al., 2015

Second generation accelerometers

measures

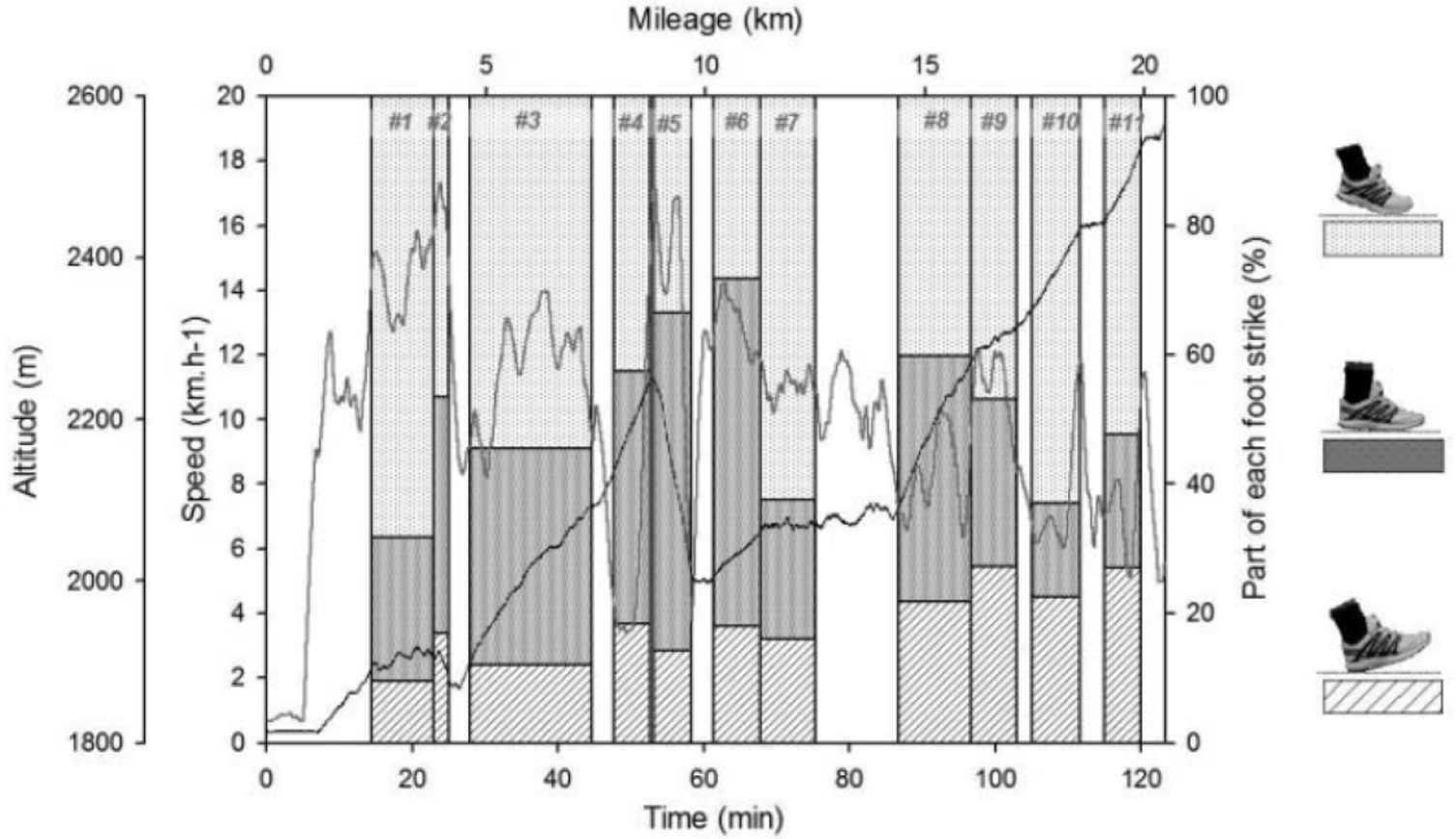

Figure 2. Altitude (black line) and speed (grey line) over the first 20 km of the race. Bar charts represent the repartition of foot strikes (RFS, MFS and FFS) within the eleven analysed sections.

Giandolini et al., 2015

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. SenseWear Armband:
- accelerometer + heat flow sensor (-> "internal heat produced") + skin galvanic response sensor (-> evaporation heat loss) + skin thermometer + instrument's shell (i.e., near-body) thermometer;
- gender, age, height, mass input;
- PROPRIETARY ALGORITHM (I.E., "HOW FROM EACH SENSOR'S OUTPUT TO ME?");

-> -18÷-7% walking, stairs climbing, cycling V'O2 ME;
-> -29% armergometer V'O2 ME;
<- investigators results driven new PROPRIETARY algorithm developed -> n.s. differences;
-> underestimate of rowing V'O2 ME;
arm cutaneous fat issue;
-> good precision of resting V'O2 ME;
-> good precision/low accuracy of cycloergometer V'O2 ME;

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-> +13÷+27% level walking V'O2 ME;
-> -22% uphill walking V'O2 ME;
-> overestimate of walking, running V'O2 ME;
-> overestimate of wheelchair users activities V'O2 ME;
-> underestimate of obese subjects resting V'O2 ME;
-> overestimate of obese subjects exercise V'O2 ME;
-> good accuracy of daily DLW ME;
-> underestimate of uphill walking, running V'O2 ME