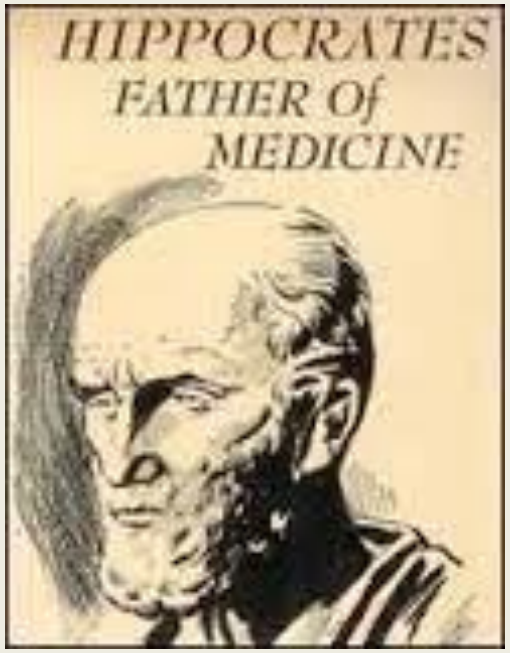


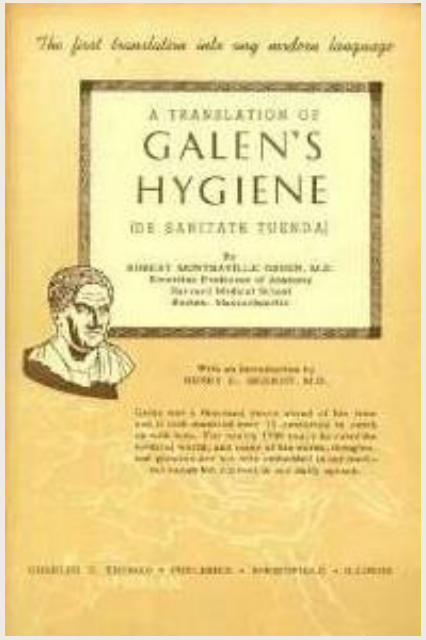
"All parts of the body which have a function, if used in moderation and exercised in labors in which each is accustomed, become thereby healthy, well developed and age more slowly, but if unused they become liable to disease, defective in growth and age quickly."

Hippocrates (460 – 357 B.C.)

"The use of exercise, I think, are twofold: one for the evacuation of the excrements, the other for the production of good condition of the firm parts of the body"

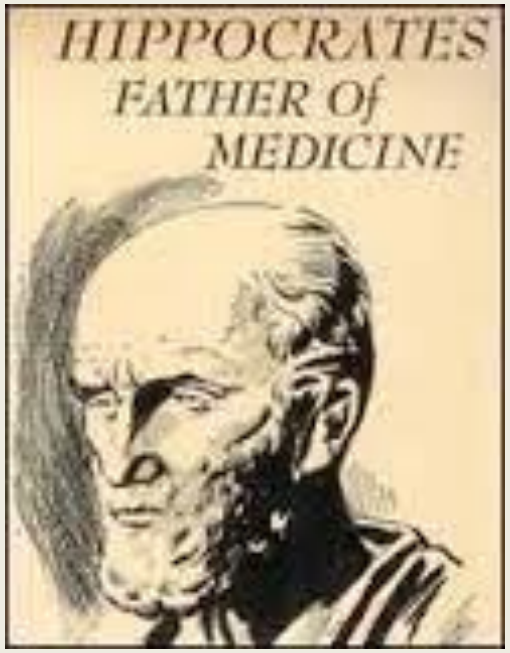
Galen 129 – 200/216 AD

On Hygiene



The What, Why and How of Physical Activity and Sedentary Behaviour Measurement

Kieran Dowd (Ph.D.)
Department of Sport and Health Sciences
Athlone Institute of Technology
Athlone



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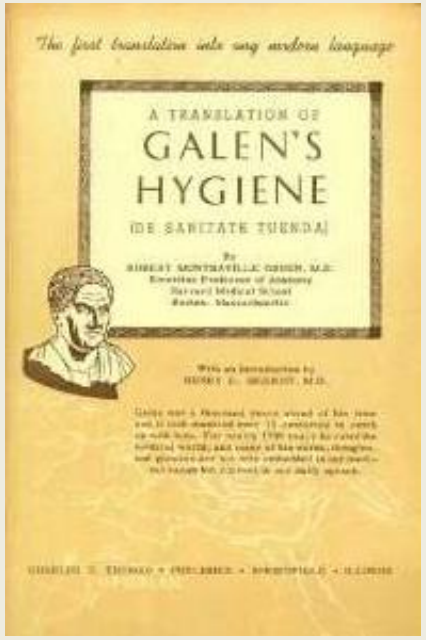
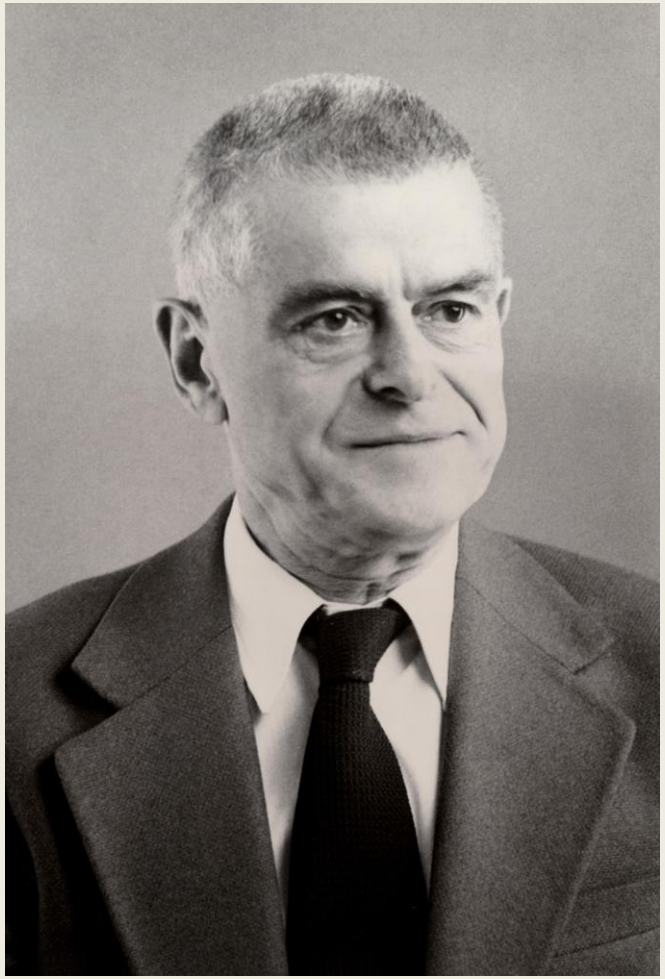


Jeremy N. Morris (1910 – 2009)

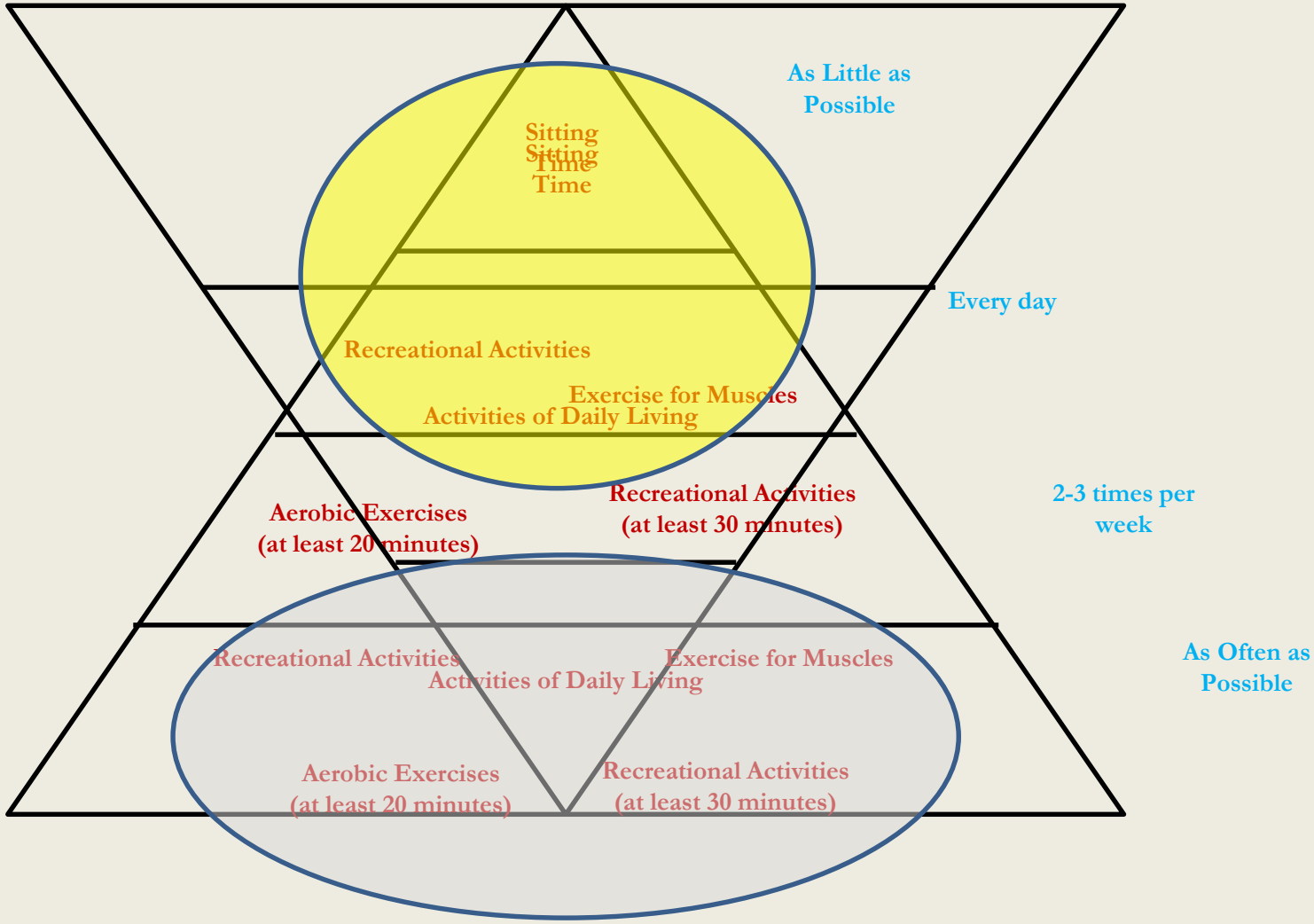
- **Study 1:** The London Transport Study (≈31,000 men)

- **Study 2:** Mortality in relation to Physical Activity of Work (≈2.5 million men)

"The possibility was considered that their may be a 'general factor' of health and disease associated with physical effort and sedentariness in work – that physical work may be 'a way of life' conducive to good health"



Physical Activity Pyramid

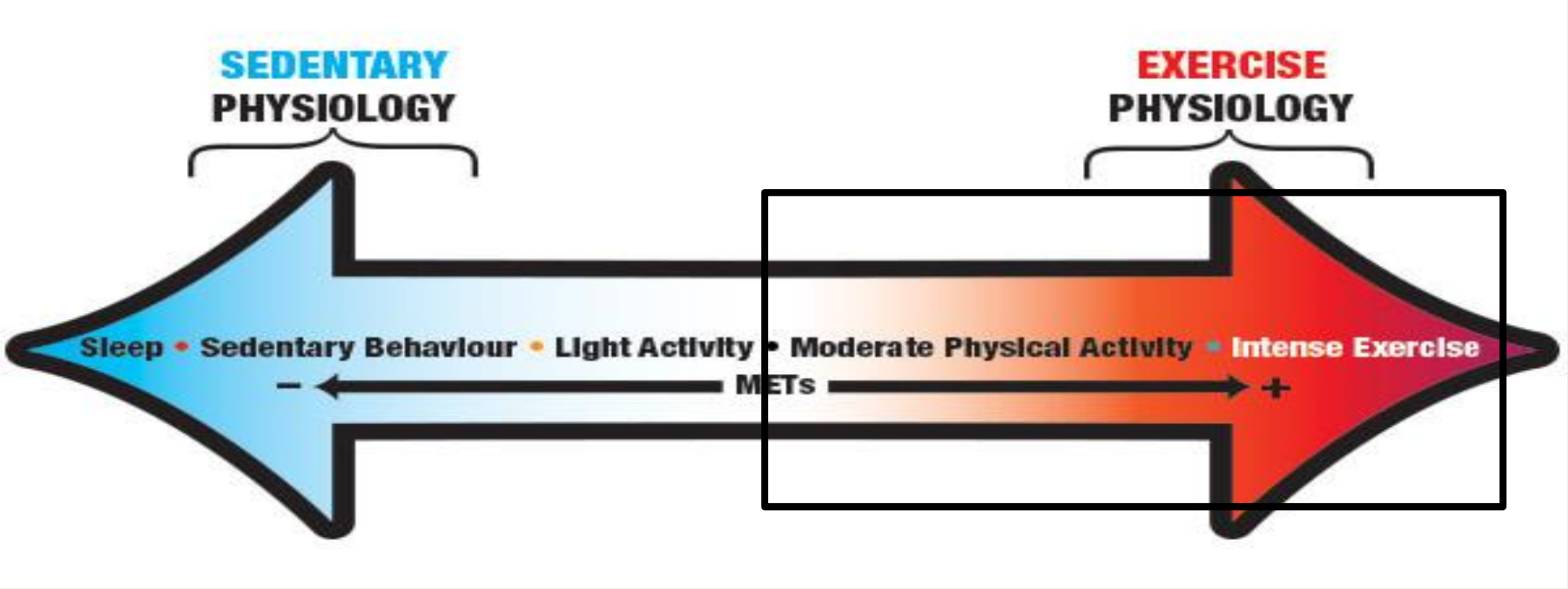


“What”

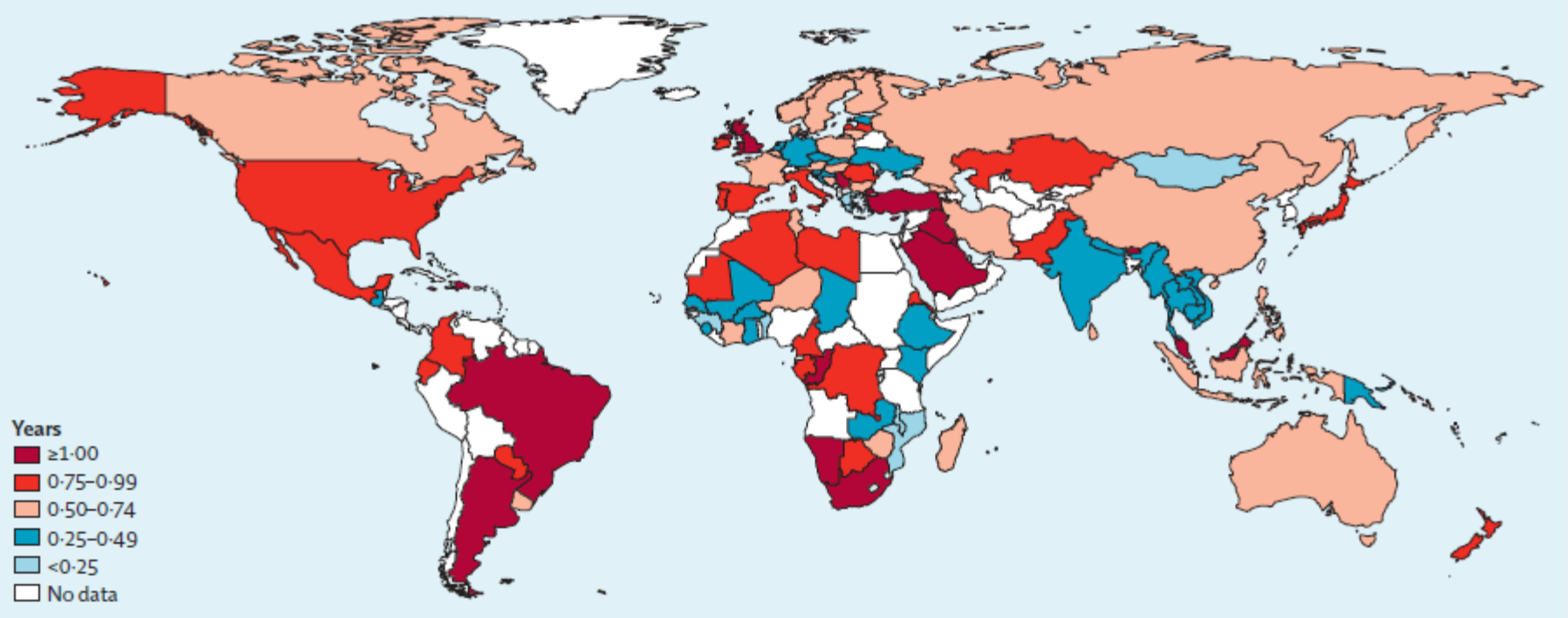
Physical Activity

"Physical activity is defined as any bodily movement produced by skeletal muscles that results in **energy expenditure**"

Caspersen et al. *Public Health Reports*. 1985; 100(2): 126–131


SEDENTARY
PHYSIOLOGY
EXERCISE
PHYSIOLOGY
Sleep • Sedentary Behaviour • Light Activity • Moderate Physical Activity • Intense Exercise
–
METs
+

Physical Activity



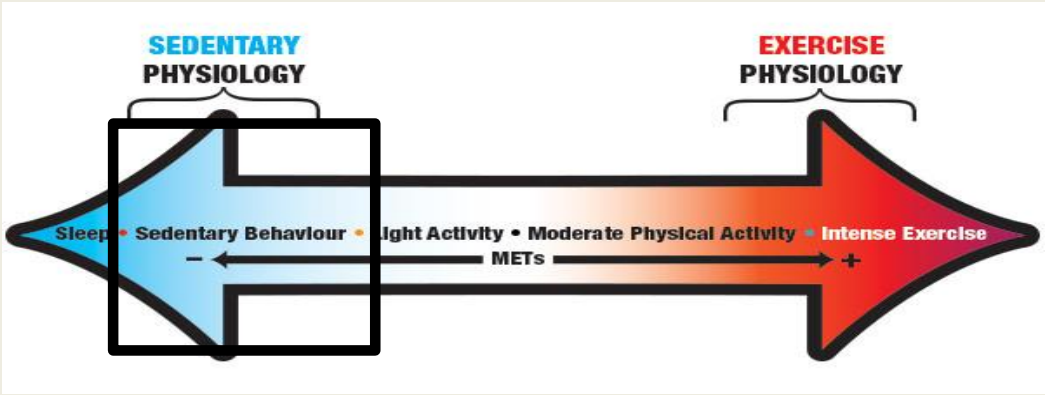
Estimated gain in life expectancy worldwide with the elimination of physical inactivity

Ireland = 0.87 (0.36-1.42)

Lee et al. *The Lancet*. 2012; 380(9838):219-29.

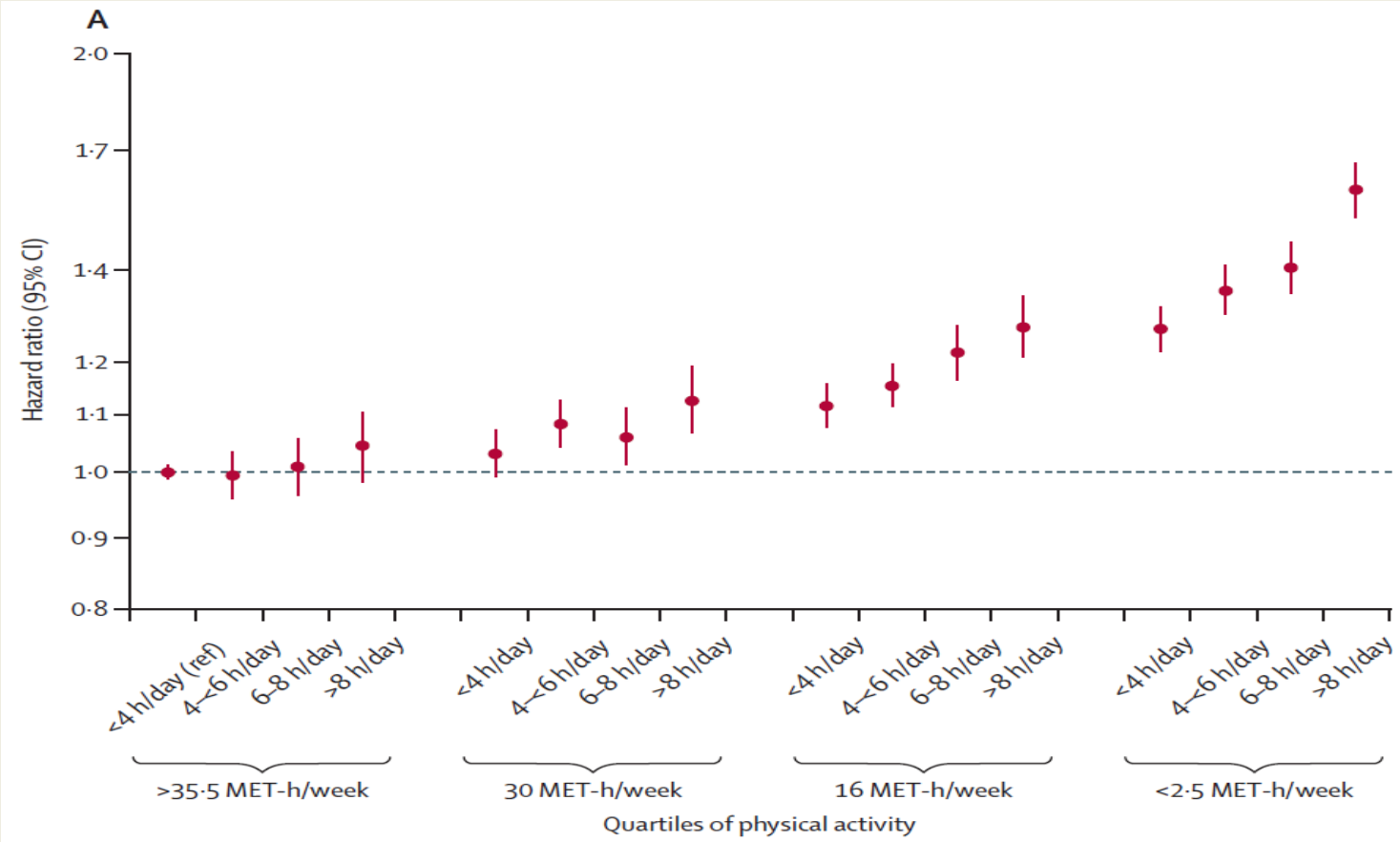
Sedentary Behaviours

Sedentary Behaviour has been defined as any waking behaviour characterised by an energy expenditure **≤ 1.5 metabolic equivalents** while in a **sitting or reclining posture**.



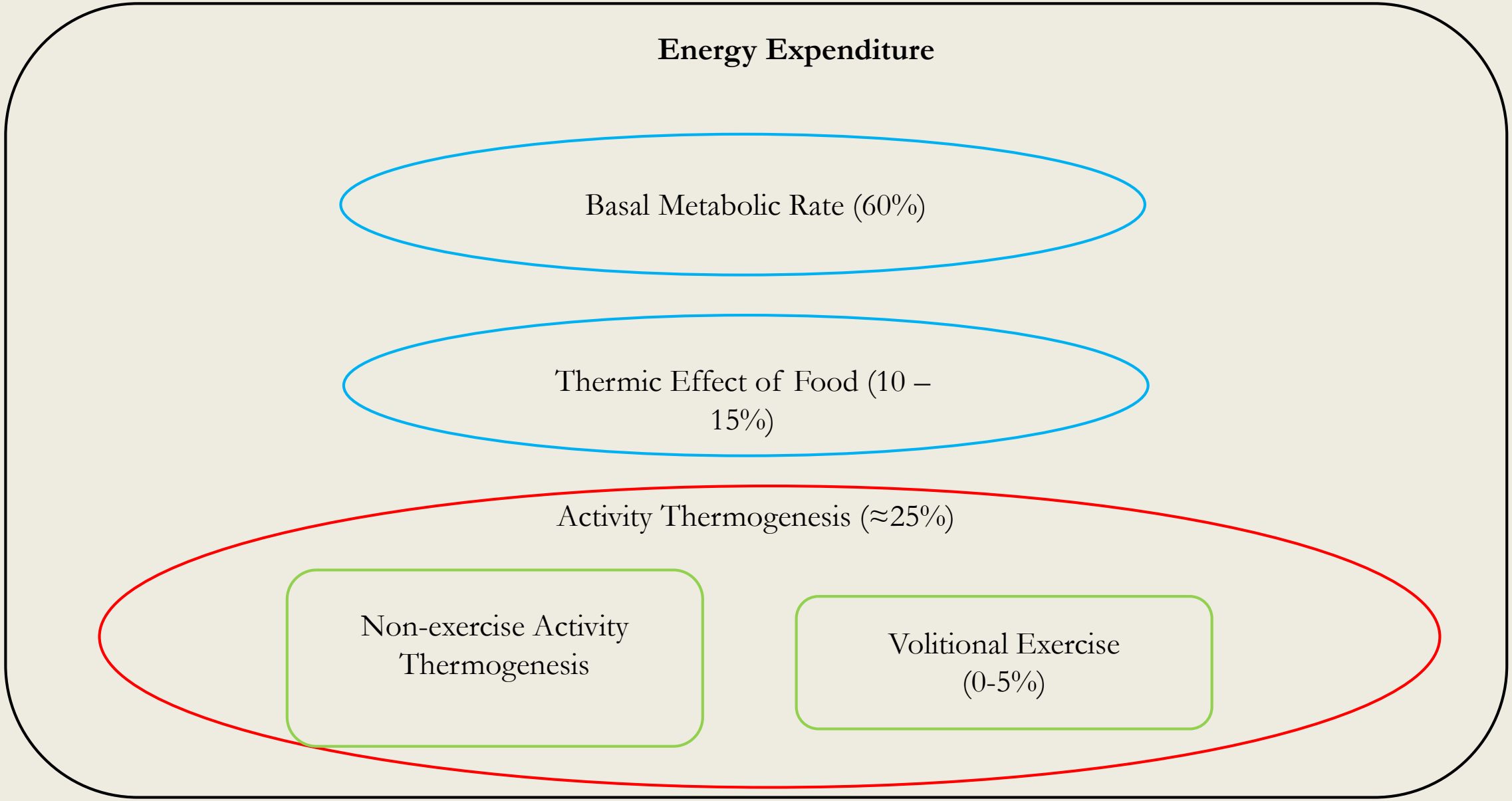
Tremblay et al. *IJBNPA, 2017;* 14:75.

Physical Activity and Sitting Time

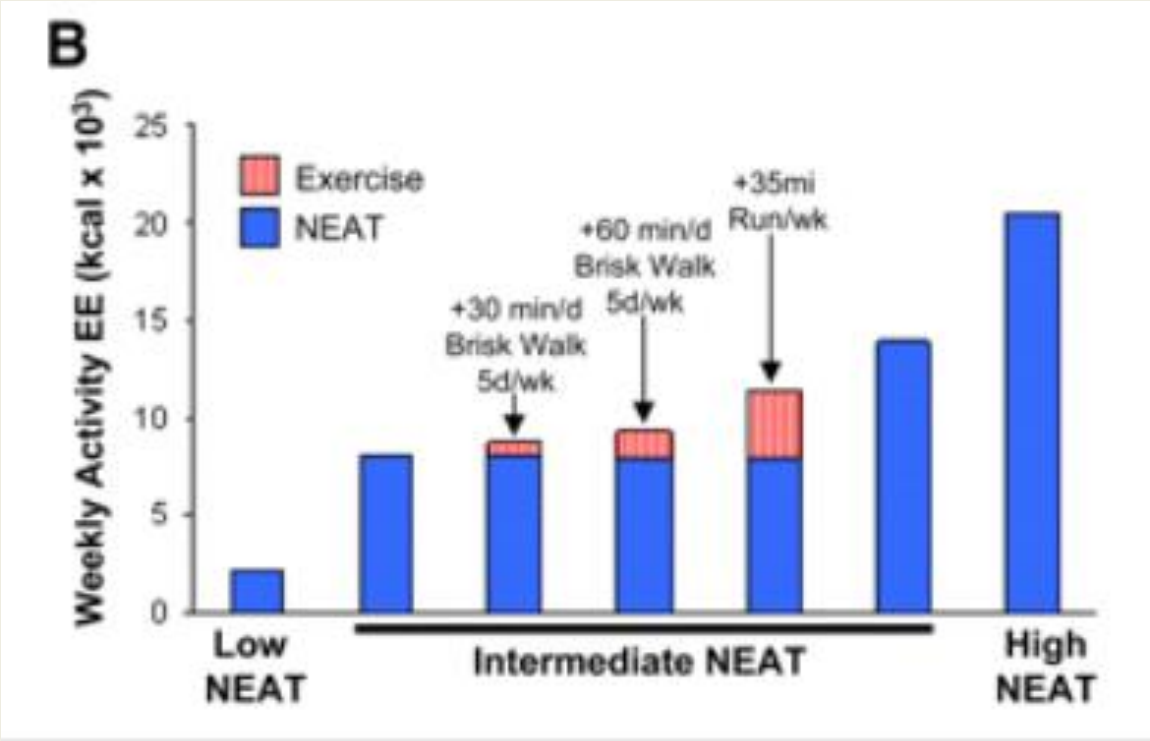


Meta-analyses of the joint associations of sitting time and physical activity with all-cause mortality (N = 1,005,791).

Ekelund et al. *The Lancet*. 2016; 388(10051): 1302-1310


Energy Expenditure
Basal Metabolic Rate (60%)
Thermic Effect of Food (10 – 15%)
Activity Thermogenesis (≈25%)
Non-exercise Activity Thermogenesis
Volitional Exercise (0-5%)

Non-exercise activity thermogenesis (NEAT) is described as the energy expended throughout activities of daily living, and is composed of sitting/lying time (SLT), standing time (StT) and all light intensity physical activity (LIPA)



Hamilton et al. *Diabetes*. 2007;56(11):2655-67

Non-Exercise Activity Thermogenesis

The Crouching Tiger Hidden Dragon of Societal Weight Gain

James A. Levine, Mark W. Vander Weg, James O. Hill, Robert C. Klesges

Abstract—Non-exercise activity thermogenesis (NEAT) is the energy expenditure of all physical activities other than volitional sporting-like exercise. NEAT includes all the activities that render us vibrant, unique, and independent beings such as working, playing, and dancing. Because people of the same weight have markedly variable activity levels, it is not surprising that NEAT varies substantially between people by up to 2000 kcal per day. Evidence suggests that low NEAT may occur in obesity but in a very specific fashion. Obese individuals appear to exhibit an innate tendency to be seated for 2.5 hours per day more than sedentary lean counterparts. If obese individuals were to adopt the lean "NEAT-o-type," they could potentially expend an additional 350 kcal per day. Obesity was rare a century ago and the human genotype has not changed over that time. Thus, the obesity epidemic may reflect the emergence of a chair-enticing environment to which those with an innate tendency to sit, did so, and became obese. To reverse obesity, we need to develop individual strategies to promote standing and ambulating time by 2.5 hours per day and also re-engineer our work, school, and home environments to render active living the option of choice. (***Arterioscler Thromb Vasc Biol.*** **2006;26:729-736.)**

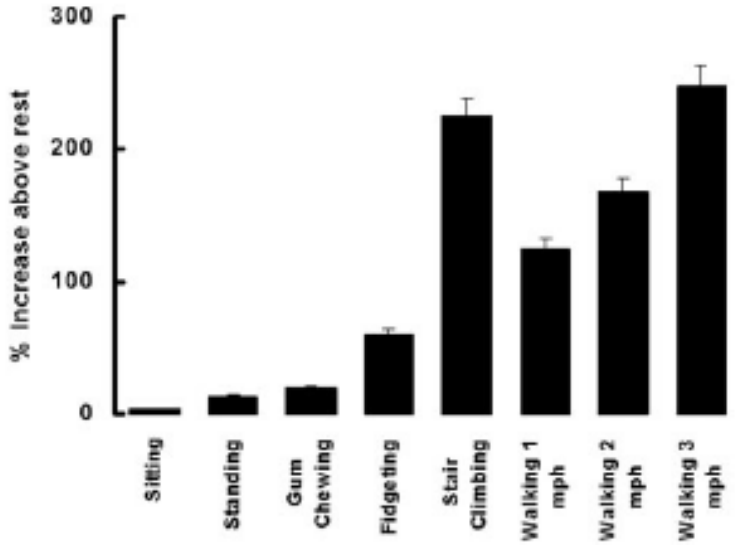


Figure 4. Energy expenditure above resting for a variety of activities.

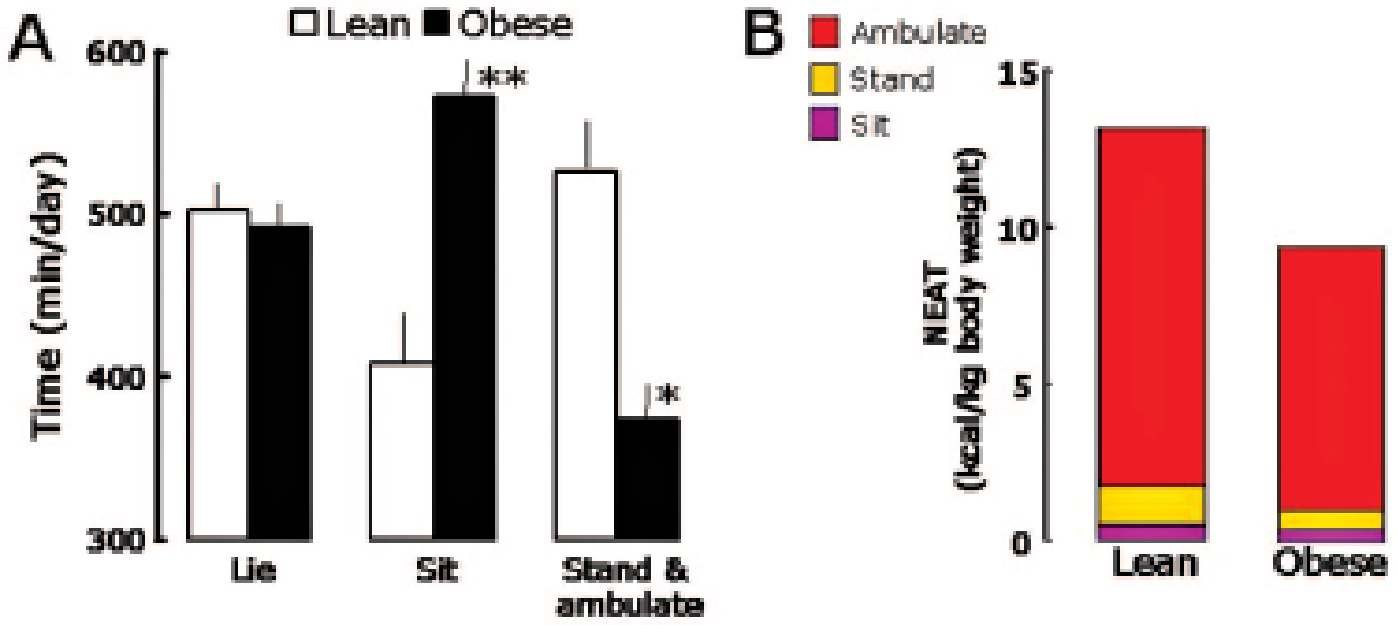
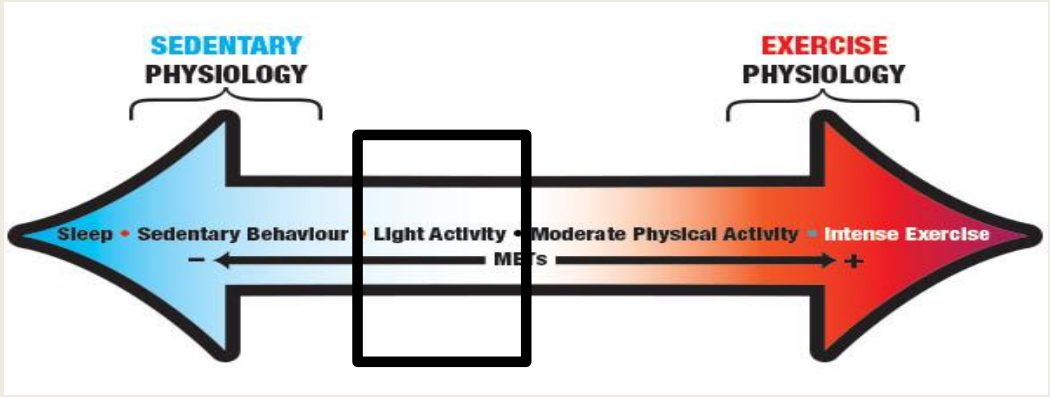


Figure 5. Time allocation (A) and energetic (B) components of NEAT in sedentary lean and obese individuals.

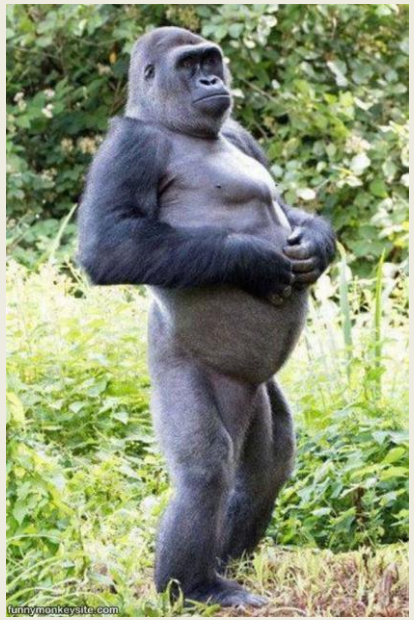
Light Intensity Physical Activity

"Light Intensity Physical Activity is favourably associated with health outcomes including obesity, markers of lipid and glucose metabolism and mortality"



Fuzeki et al. *Sports Medicine.* 2017; 47(9):1769-1793

What about Standing Time?



Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Brief Original Report

Standing time and all-cause mortality in a large cohort of Australian adults

Hidde P. van der Ploeg [a,b,*], Tien Chey [b], Ding Ding [b], Josephine Y. Chau [b], Emmanuel Stamatakis [c,d,e], Adrian E. Bauman [b]

Standing and Mortality in a Prospective Cohort of Canadian Adults

PETER T. KATZMARZYK

Pennington Biomedical Research Center, Baton Rouge, LA

ABSTRACT

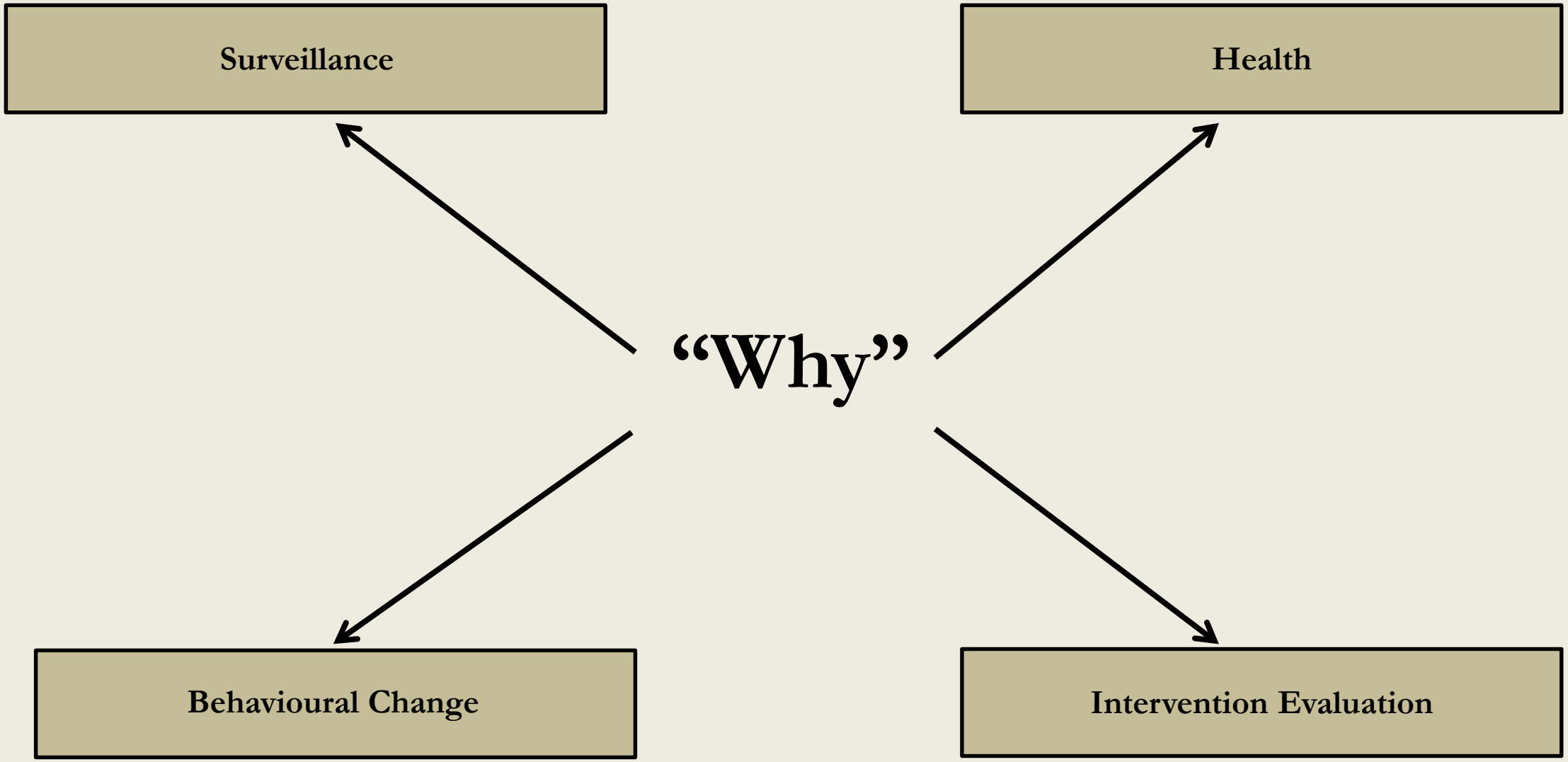
KATZMARZYK, P. T. Standing and Mortality in a Prospective Cohort of Canadian Adults. *Med. Sci. Sports Exerc.*, Vol. 46, No. 5, pp. 940–946, 2014. **Purpose**: Several studies have documented significant associations between sedentary behaviors such as sitting or

The sedentary office: an expert statement on the growing case for change towards better health and productivity

John P Buckley,[1] Alan Hedge,[2] Thomas Yates,[3,4] Robert J Copeland,[5] Michael Loosemore,[6] Mark Hamer,[6] Gavin Bradley,[7] David W Dunstan[8]

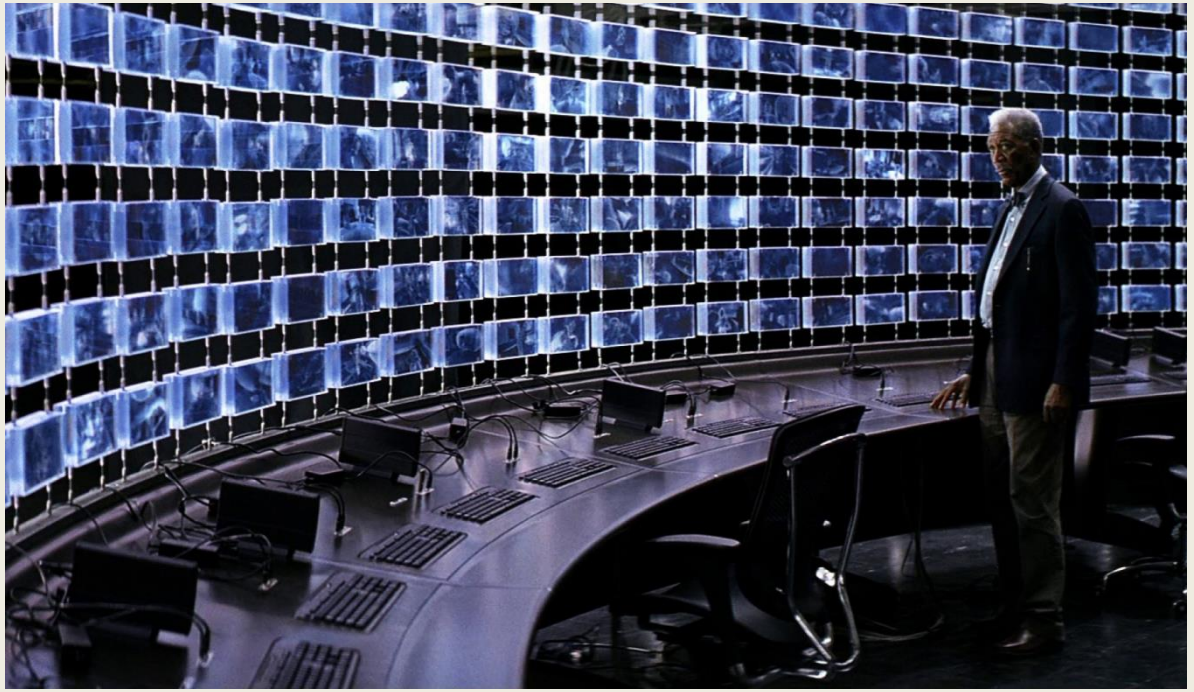
- Initially progress towards accumulating at least 2 h/day of standing and light activity (light walking) during working hours, eventually progressing to a total accumulation of 4 h/day (prorated to part-time hours) (B and C)*
- Seated-based work should be regularly broken up with standing-based work and vice versa, and thus, sit–stand adjustable desk stations are highly recommended (B)

Buckley JP, et al. *Br J Sports Med.* 2015;49:1357–1362.


Surveillance
Health
"Why"
Behavioural Change
Intervention Evaluation

Surveillance

- Monitoring health behaviours across society
- Monitoring health behaviours across the lifespan
- Monitoring changes in health behaviours throughout aging (longitudinal)
- National and International comparison (EU & Worldwide (HBSC))



Health

- Refining our understanding of disorders related to physical activity behaviours

- Define the does response relation between physical activity (volume, duration, intensity and patterns) and associated health benefits

Behavioural Change (Determinants)

- Existing interventions for Physical Activity and Sedentary Behaviour have had limited sustained success

- Improved understanding of determinants informs interventions with greater potential for success

- To improve our understanding of determinant of physical activity and sedentary behaviour, improved measures are required

Intervention Effectiveness

- Ability to detect whether an intervention is effective
  - Many interventions deemed ineffective based on findings from PA measures that have questionable validity, reliability and sensitivity
  - A need to identify effective interventions

“How”

Measurement Types

Self-report

Behavioural Observation

Motion Sensors

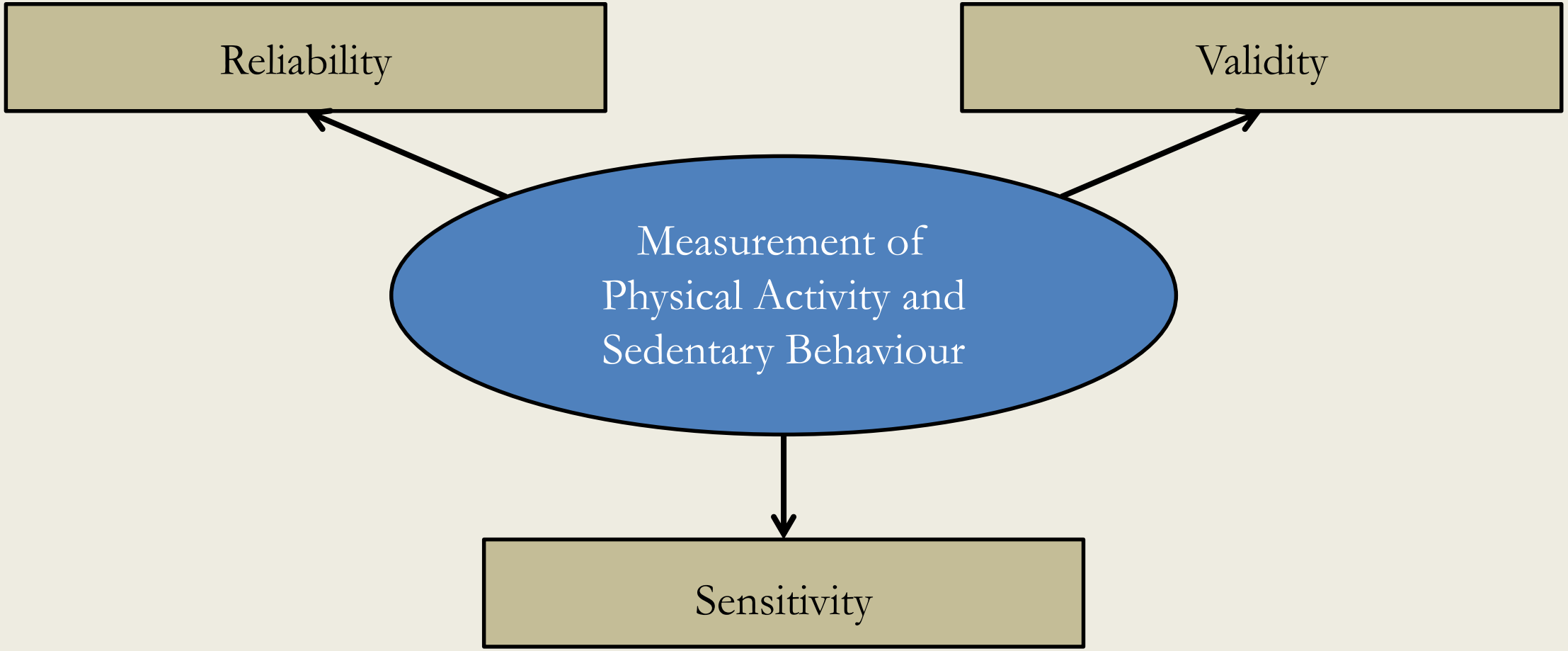
Physiological Variables

Calorimetry

Some Critical Questions

- What do I intend to measure?
  - Sedentary Time
  - Time spent in Physical Activity Intensities
  - Setting of Activity Behaviours
- What type of study am I conducting?
  - Observational
  - Longitudinal
  - Intervention
- Who do I intend to measure?
  - Children/Adolescents
  - Adults/Older Adults
  - Clinical Populations (RA, Back Pain etc.)
- What are the aims of the study
  - Surveillance
  - Dose-Response Relationships
  - Effectiveness of Interventions

Important Issues to Consider



DEDIPAC: My Role

Physical Activity Review of Reviews

- Two Systematic Literature Review of Reviews
- Original articles sourced from each review
- Total number of original papers included:
  - Adult: 749
  - Youth: 343

Sedentary Behaviour Reviews

- Two Systematic Literature Reviews
- Original articles sourced from each review
- Total number of original papers included:
  - Adult: 192
  - Youth: 104

Physical Activity Review of Reviews

Dowd *et al. International Journal of Behavioral Nutrition and Physical Activity*
(2018) 15:15
DOI 10.1186/s12966-017-0636-2

International Journal of Behavioral
Nutrition and Physical Activity

REVIEW Open Access

A systematic literature review of reviews on techniques for physical activity measurement in adults: a DEDIPAC study

Kieran P. Dowd[1], Robert Szeklicki[2], Marco Alessandro Minetto[3], Marie H. Murphy[4], Angela Polito[5], Ezio Ghigo[3], Hidde van der Ploeg[6,7], Ulf Ekelund[8,9], Janusz Maciaszek[2], Rafal Stemplewski[2], Maciej Tomczak[2] and Alan E. Donnelly[10*]

Criterion Validity of Physical Activity Measures

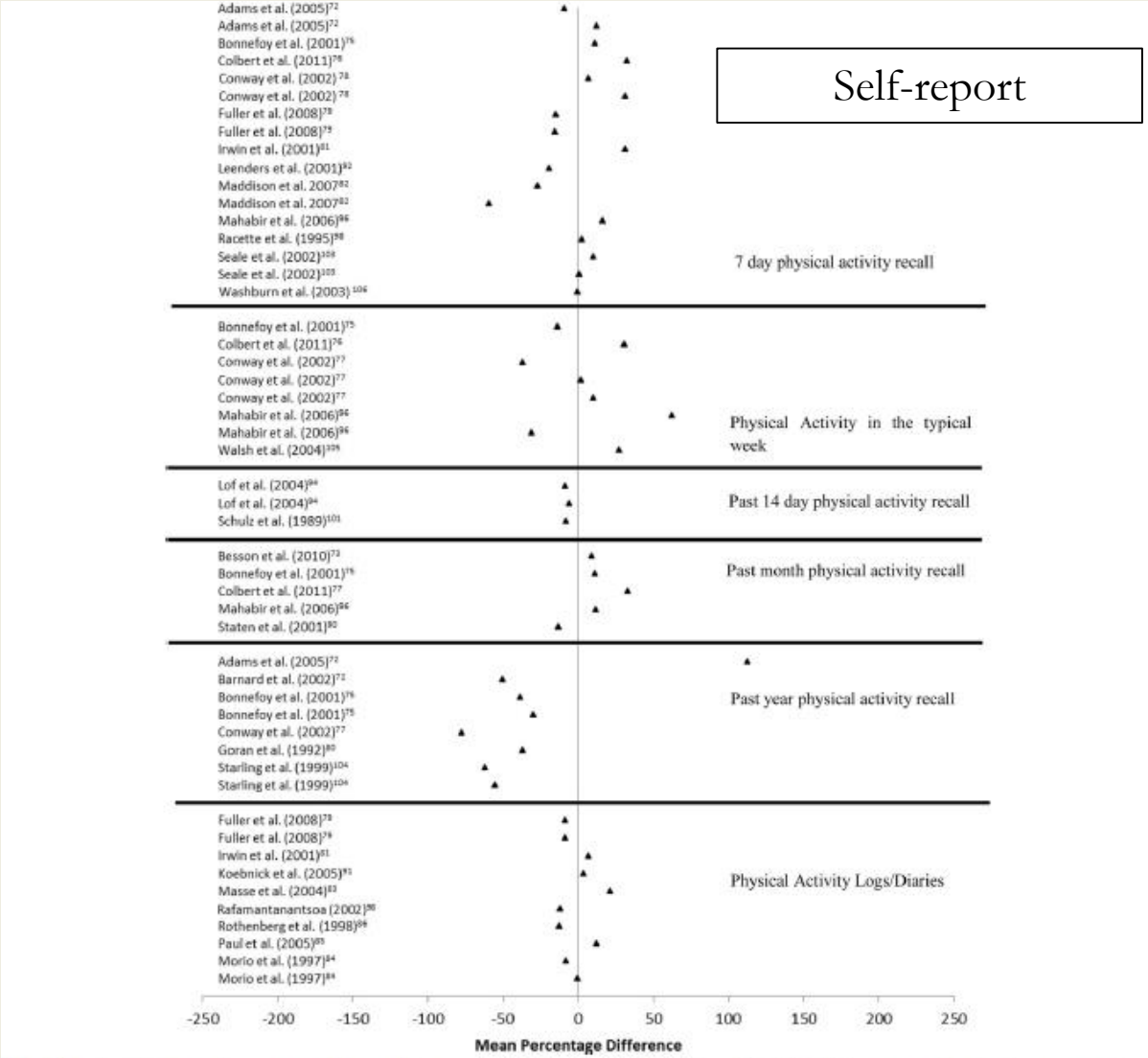
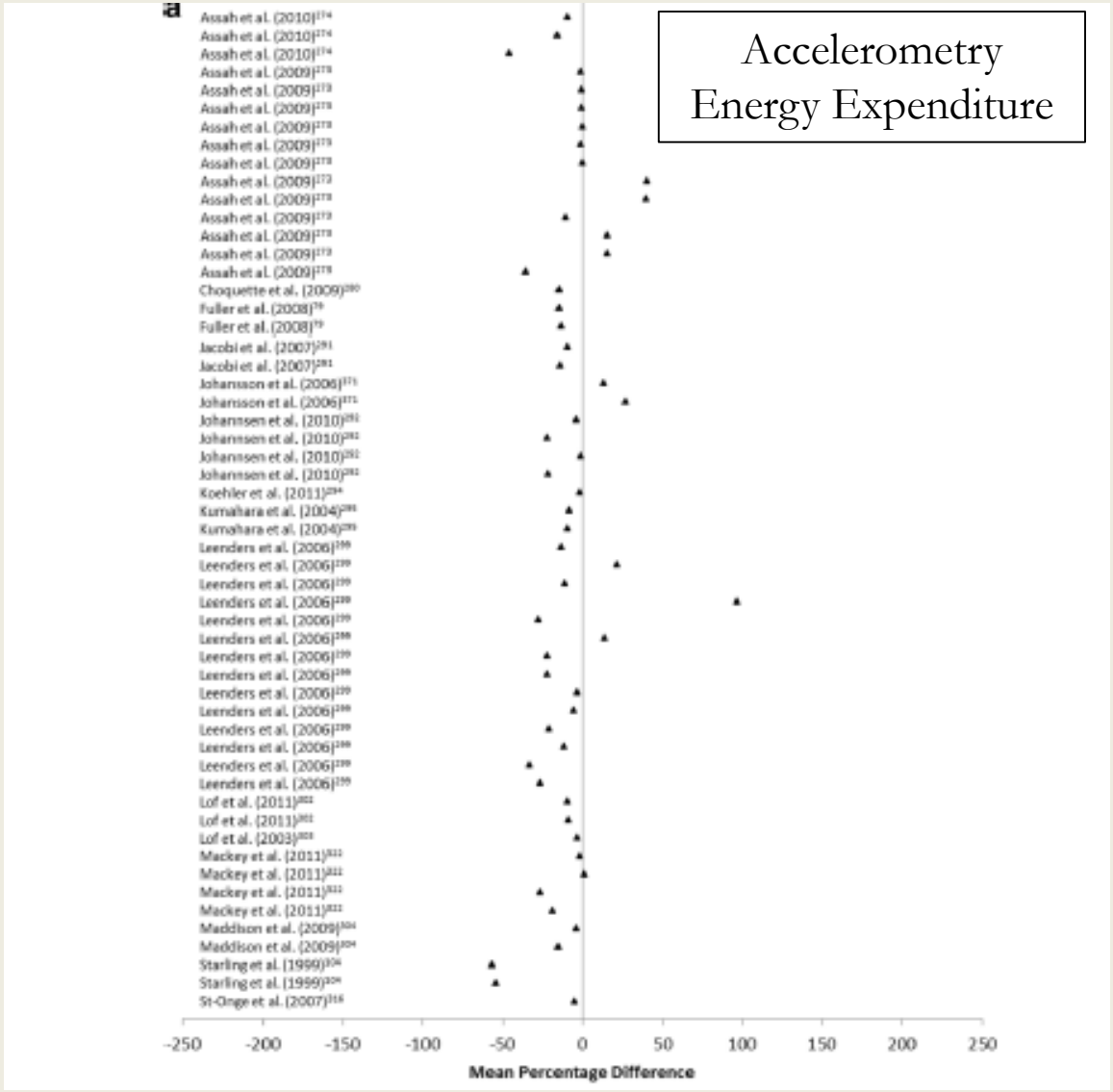
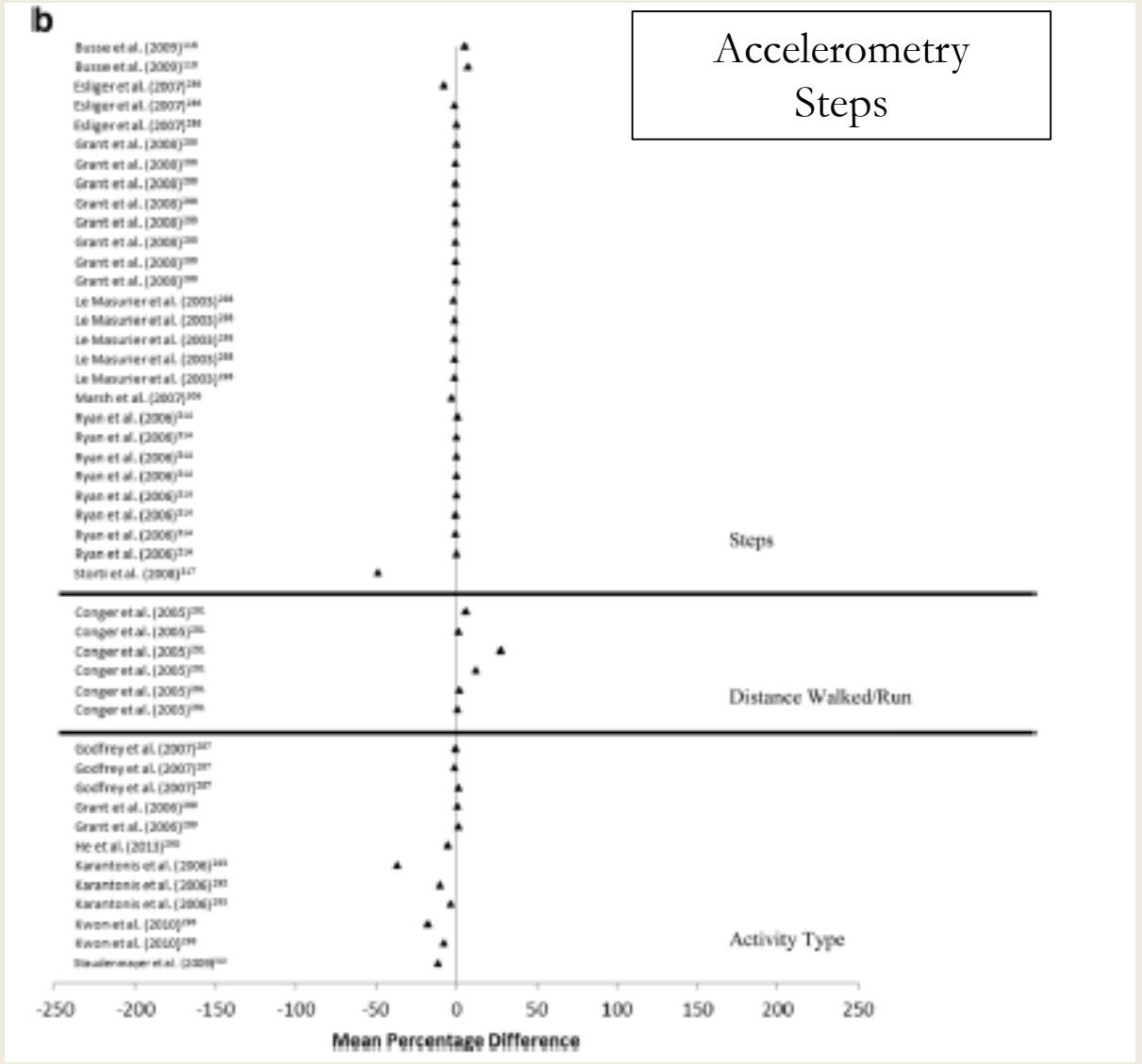


Fig. 2 Forest plot of percentage mean difference between self-reported energy expenditure (TEE, PAEE, PAL) compared to criterion measure of energy expenditure (doubly labelled water)

Criterion Validity of Physical Activity Measures





Criterion Validity of Physical Activity Measures

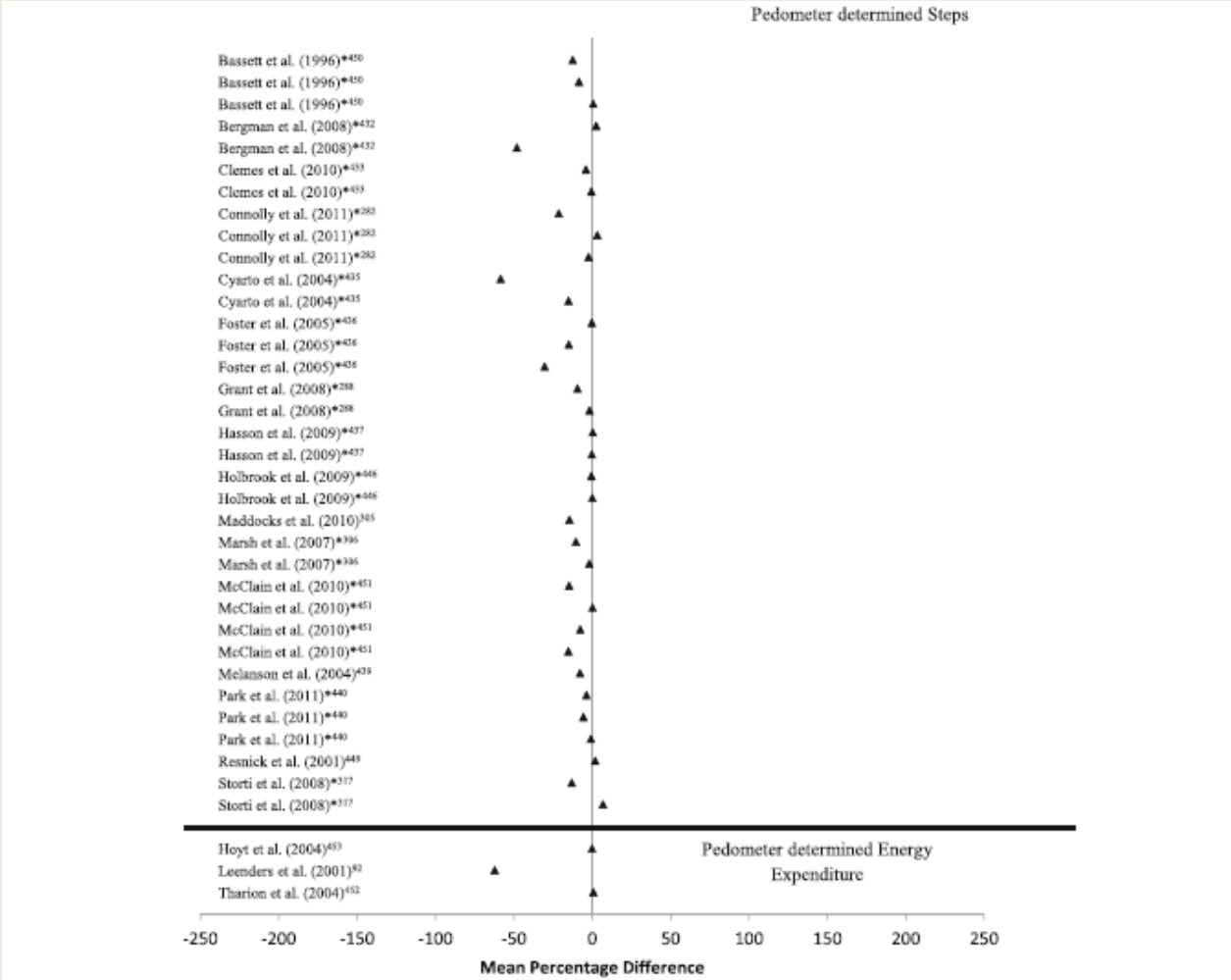


Fig. 4 Forest plot of mean percentage difference between pedometer determined step count/energy expenditure compared to criterion measure (direct observation/doubly labelled water respectively). * denotes multiple devices compared in the same study

Criterion Validity of Physical Activity Measures

Heart Rate Monitoring

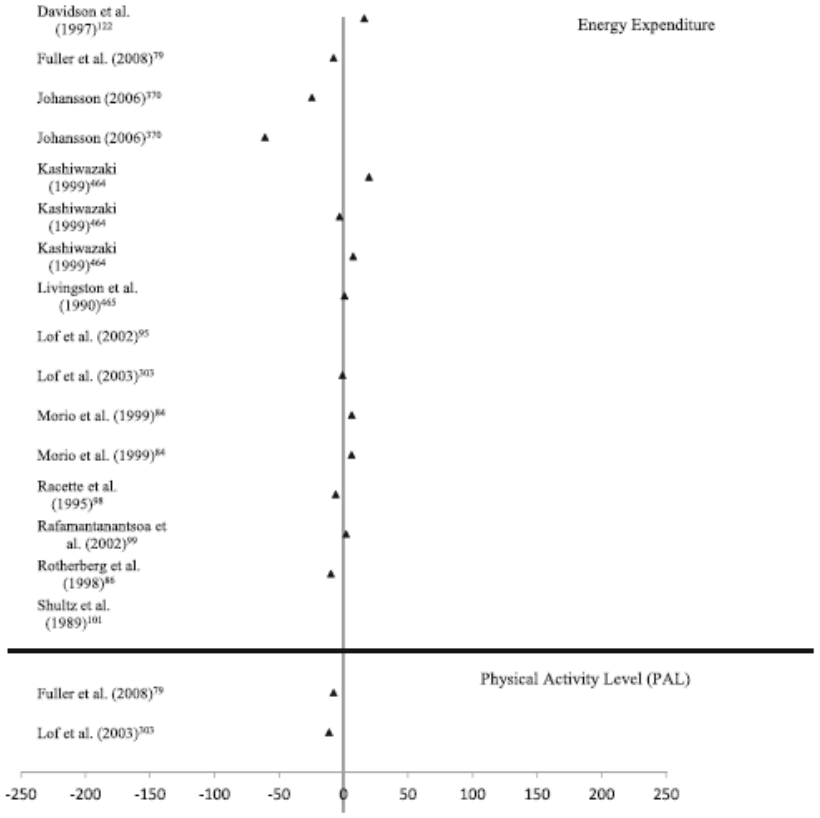


Fig. 5 Forest plot of percentage mean difference between heart rate monitor determined energy expenditure/physical activity level compared to criterion measure (doubly labelled water)

Combined Sensors

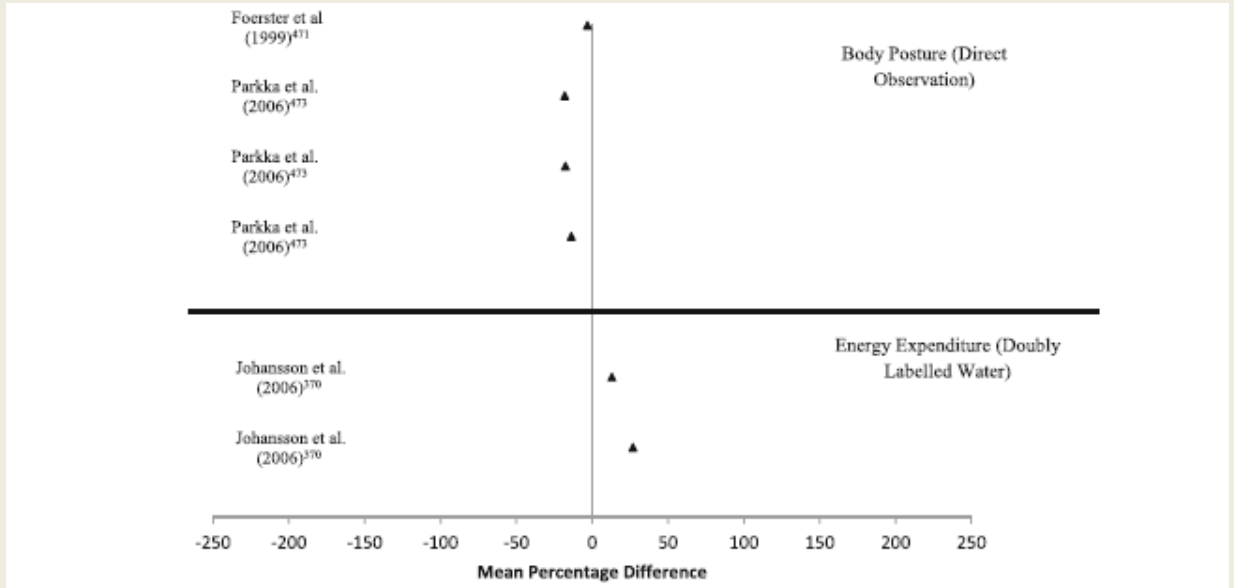


Fig. 6 Forest plot of percentage mean difference between energy expenditure/body posture determined by combined sensors compared to criterion measure (doubly labelled water/direct observation)

Reliability of Physical Activity Measures

- A greater amount of variability observed for self-reported physical activity compared to objective measures.
- Reduced levels of test-retest reliability as the duration of recall increased
- Although a measure may be reliable for one output, it may not be reliable for all outcomes
- Responsiveness to change of physical activity measures dramatically under-researched, regardless of measurement type.

Review of Measures of Sedentary Behaviour

Criterion Validity of Measures of Sedentary Behaviour

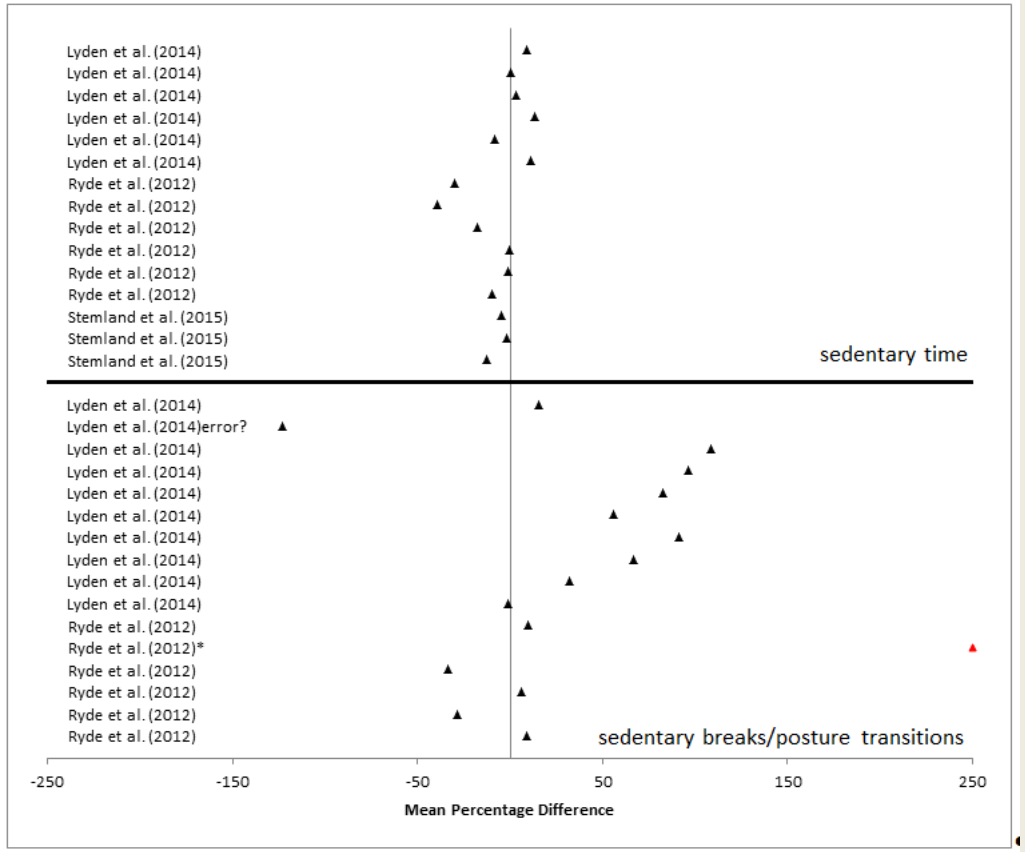


Figure 2. Forest plot of mean percentage difference between accelerometer/activity monitor determined sedentary behaviour compared to criterion measure of sedentary behaviour (direct observation). *MPD >250%

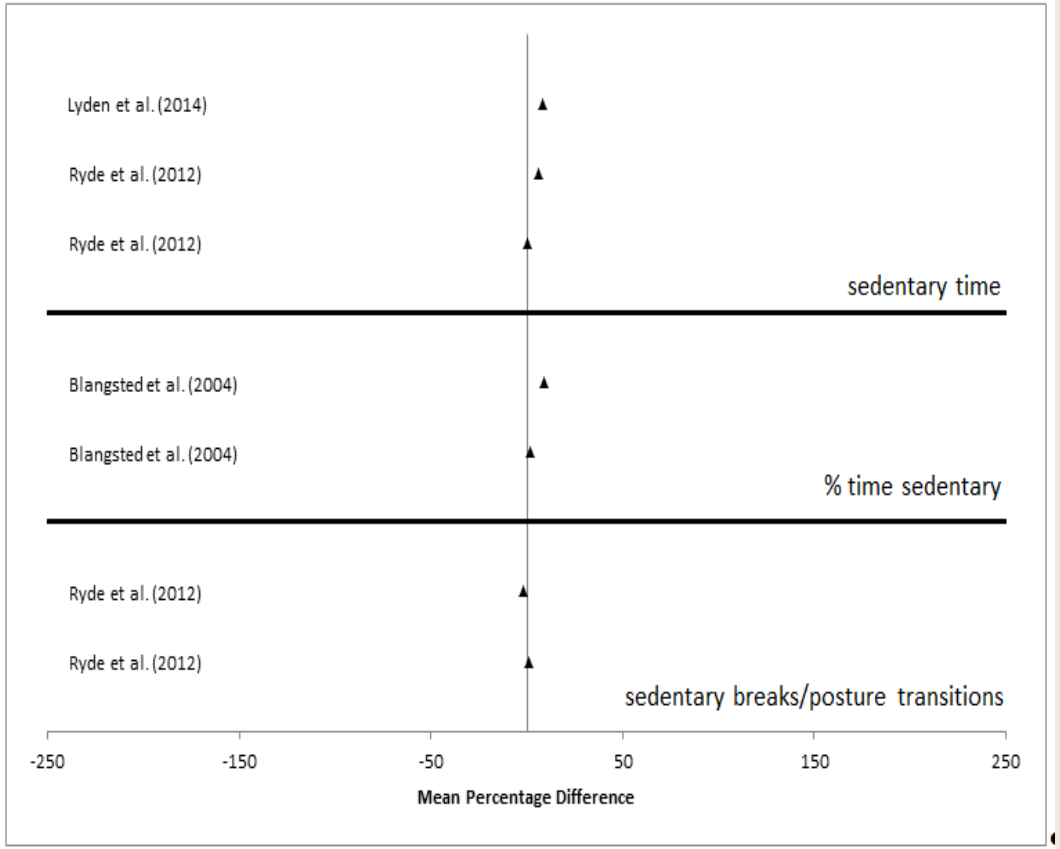


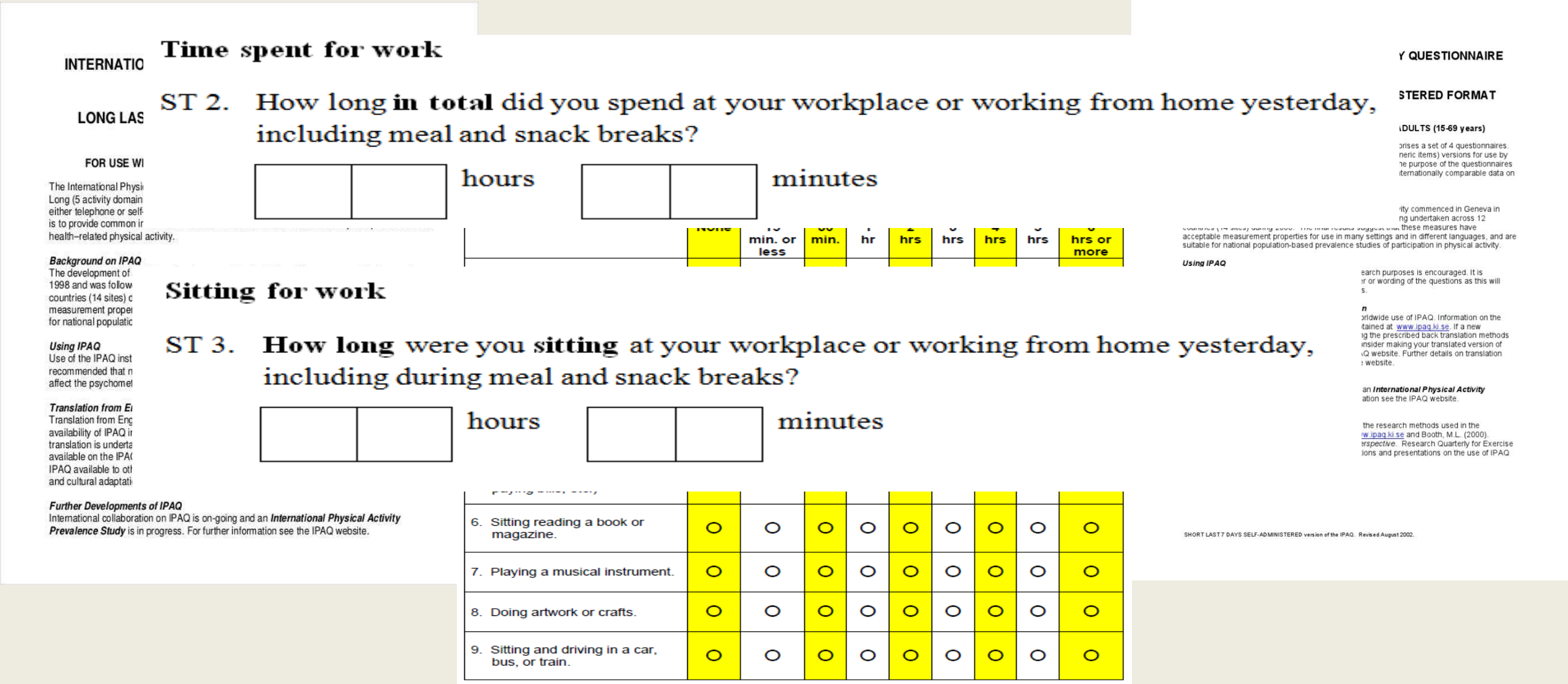
Figure 4. Forest plot of mean percentage difference between combined/other sensor determined sedentary behaviour compared to criterion measure of sedentary behaviour (direct observation).

Review of Measures of Sedentary Behaviour

- Little variation in estimated sedentary time between measures and direct observation
- Greater variation in the estimated posture transitions and sedentary breaks
- The test-retest reliability of self-reported instruments was moderate and decreased with increasing length of time between testing
- Relative absence in available information on sensitivity to change over time

Understanding Objective versus Subjective Measures

Self-Reported Measures of Sedentary Behaviour



INTERNATIO

LONG LAS

FOR USE WI

The International Physi
Long (5 activity domain
either telephone or self-
is to provide common in
health–related physical activity.

Background on IPAQ
The development of
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countries (14 sites) c
measurement prope
for national populatic

Using IPAQ
Use of the IPAQ inst
recommended that n
affect the psychomet

Translation from E
Translation from Eng
availability of IPAQ ir
translation is underta
available on the IPA(
IPAQ available to oth
and cultural adaptati

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

Time spent for work

ST 2. How long **in total** did you spend at your workplace or working from home yesterday, including meal and snack breaks?

hours minutes

Sitting for work

ST 3. **How long** were you **sitting** at your workplace or working from home yesterday, including during meal and snack breaks?

hours minutes

	None	15 min. or less	30 min.	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs or more
6. Sitting reading a book or magazine.	O	O	O	O	O	O	O	O	O
7. Playing a musical instrument.	O	O	O	O	O	O	O	O	O
8. Doing artwork or crafts.	O	O	O	O	O	O	O	O	O
9. Sitting and driving in a car, bus, or train.	O	O	O	O	O	O	O	O	O

Y QUESTIONNAIRE

STERED FORMAT

DULTS (15-69 years)

prises a set of 4 questionnaires.
neric items) versions for use by
he purpose of the questionnaires
ternationally comparable data on

ity commenced in Geneva in
ng undertaken across 12
these measures have
acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

earch purposes is encouraged. It is
r or wording of the questions as this will
s.

n
orldwide use of IPAQ. Information on the
tained at www.ipaq.ki.se. If a new
g the prescribed back translation methods
nsider making your translated version of
Q website. Further details on translation
website.

an ***International Physical Activity***
ation see the IPAQ website.

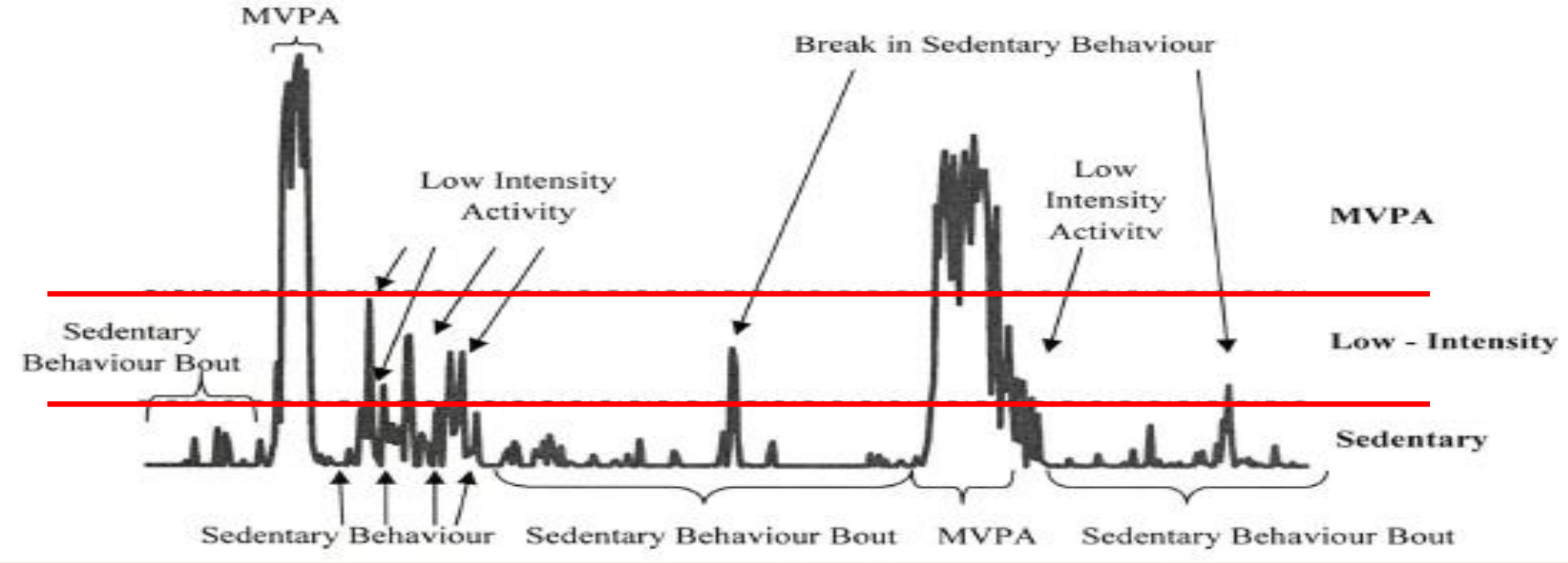
the research methods used in the
w.ipaq.ki.se and Booth, M.L. (2000).
erspective. Research Quarterly for Exercise
ions and presentations on the use of IPAQ

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

Objective Measures of Activity Behaviours

ActiGraph Accelerometer

Measurement of Sedentary Behaviours using ActiGraph



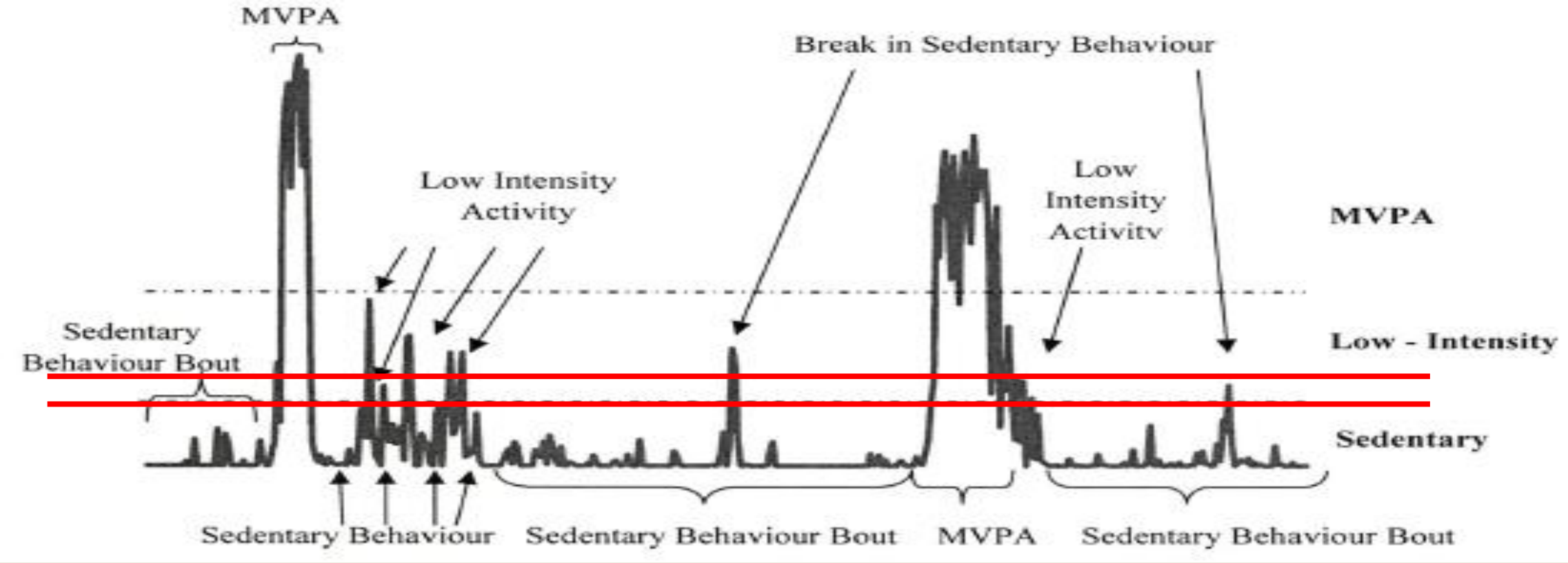
Carson and Janssen (2011)

Some ActiGraph 7164 Thresholds: Youth

- <100 counts.min^{-1} (Trueth et al. 2004)
- <1100 counts.min^{-1} (Reilly et al. 2003)
- <1204 counts.min^{-1} (Sirard et al. 2005)
- <1452 counts.min^{-1} (Sirard et al. 2005)
- <1592 counts.min^{-1} (Sirard et al. 2005)

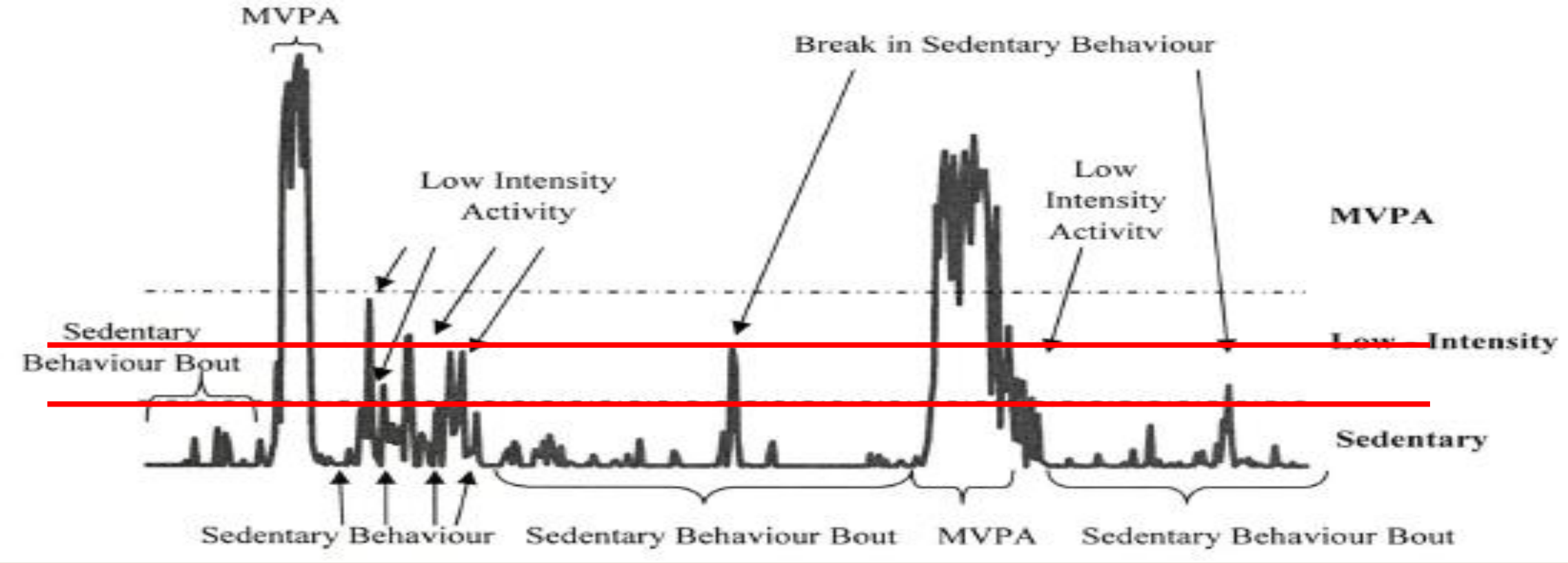
Lubans et al. *Obesity Reviews.* 2011;12(10):781-99.

Measurement of Sedentary Behaviours using Accelerometers



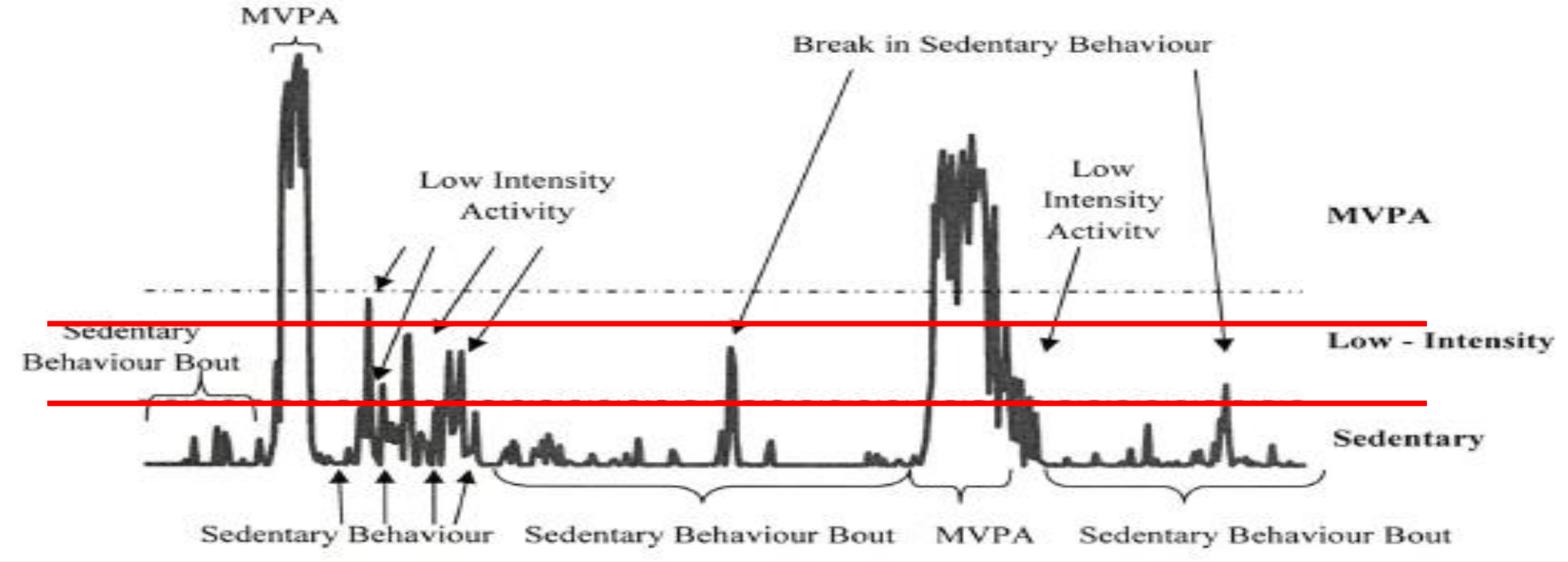
Carson and Janssen (2011)

Measurement of Sedentary Behaviours using Accelerometers



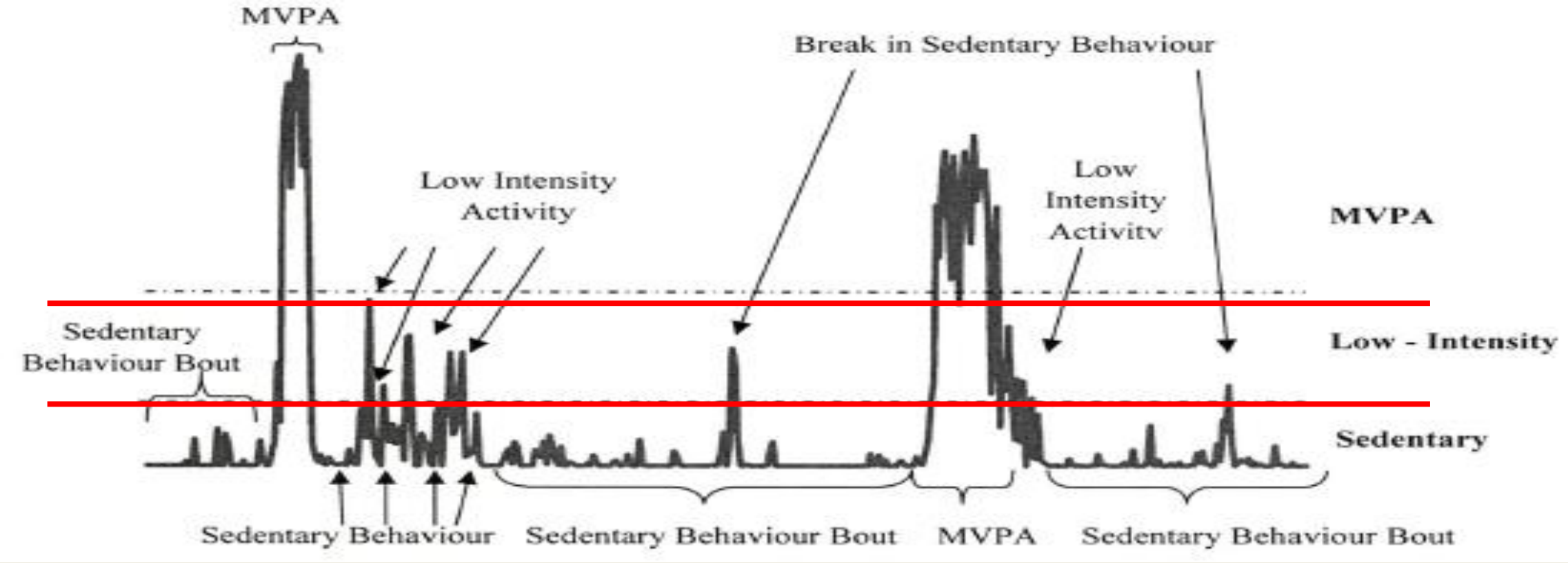
Carson and Janssen (2011)

Measurement of Sedentary Behaviours using Accelerometers



Carson and Janssen (2011)

Measurement of Sedentary Behaviours using Accelerometers



Carson and Janssen (2011)

ActiGraph Sedentary Thresholds – activPAL Sitting Time

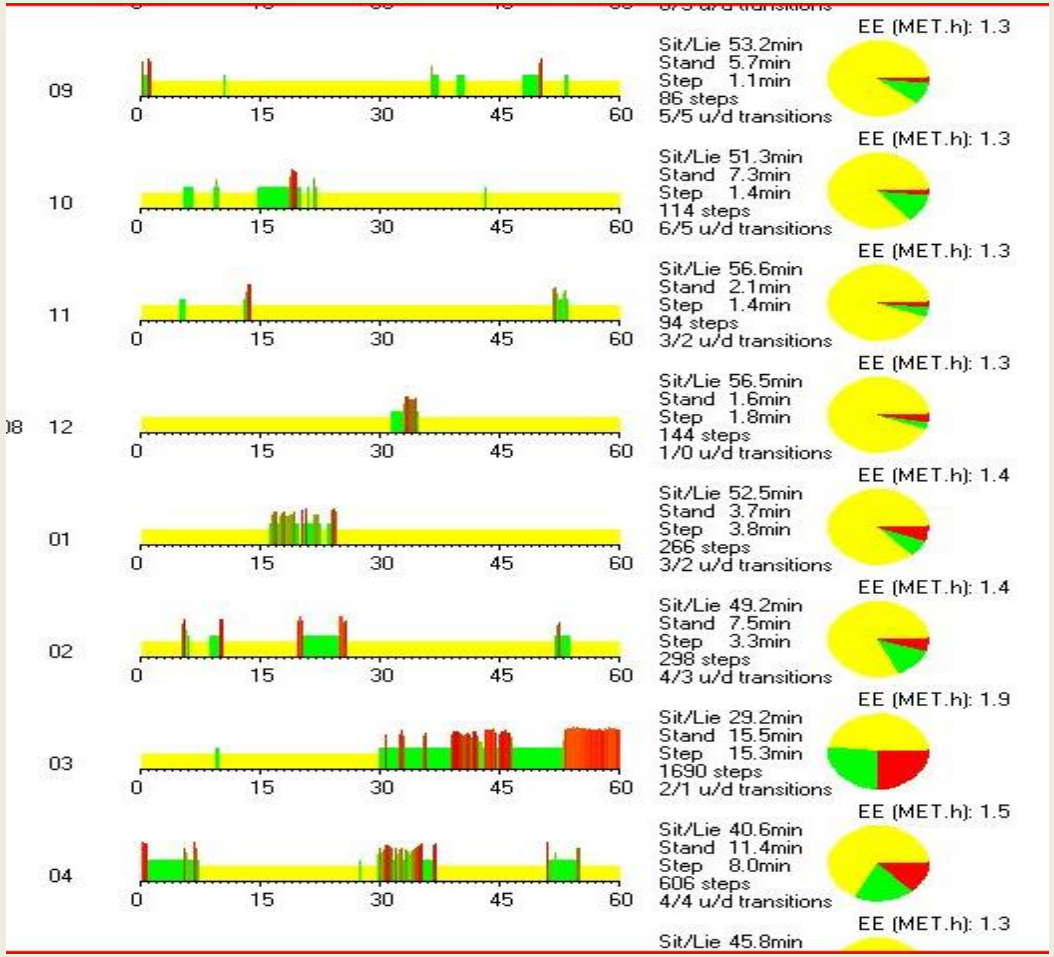
Table 1 Mean (range) time (minutes) spent sedentary according to activPAL and ActiGraph cut-points

	Class time (min) (300 min/day)	Break time (min) (90 min/day)	School Day (min) (390 min/day)
activPAL			
Sitting	189.9 (137.4, 256.6)	28.9 (7.3, 67.2)	218.9 (150.2, 321.9)
Sitting plus standing	257.3 (230.1, 283.4)	58.2 (35.6, 83.5)	315.5 (284.2, 364.0)
ActiGraph (cut-point)			
50	163.8 (109.9, 238.8)	28.2 (12.3, 63.6)	192.0 (129.5, 302.4)
100[1]	181.3 (134.6, 249.8)	32.4 (14.8, 65.9)	213.6 (157.5, 315.6)
150	193.7 (150.0, 256.3)	35.7 (17.4, 67.9)	229.4 (176.3, 324.1)
200[2]	202.7 (161.3, 261.0)	38.3 (19.8, 68.6)	241.0 (190.9, 329.6)
250	210.3 (172.4, 265.3)	40.7 (21.4, 70)	251.0 (203.8, 335.3)
300	216.2 (181.4, 268.1)	42.7 (22.2, 71.3)	258.9 (213.6, 339.4)
350	221.7 (189.6, 271.3)	44.7 (23.9, 71.9)	266.4 (223.6, 343.1)
400	226.2 (196.5, 272.6)	46.3 (25.0, 73.3)	272.4 (231.1, 345.1)
450	230.5 (201.3, 275.0)	47.8 (26.0, 75.3)	278.3 (238.9, 348.3)
500[3]	234.1 (205.4, 276.5)	49.1 (26.4, 77.5)	283.2 (245.1, 350.0)
550	237.6 (209.5, 277.6)	50.5 (27.9, 78.4)	288.1 (250.1, 351.6)
600	240.6 (213.3, 278.3)	51.7 (29.1, 79.3)	292.2 (253.5, 352.8)
650	243.4 (217.3, 280.1)	52.8 (29.9, 79.8)	296.3 (261.1, 354.9)
700	245.8 (220.1, 281.4)	53.3 (30.5, 80.0)	299.1 (265.5, 356.6)
750	248.3 (224.4, 282.1)	55.1 (32.5, 80.8)	303.3 (269.4, 358.1)
800[4]	250.5 (227.9, 282.8)	56.1 (33.8, 81.4)	306.6 (272.6, 359.0)
850	252.6 (229.9, 283.5)	57.1 (34.9, 81.5)	309.7 (277.3, 360.0)

[1] Treuth et al. (7); Evenson et al. (6); [2] Riddoch et al. (8); [3] Ekelund et al. (3); Sardinha et al. (4); [4] Puyau et al. (9)

Ridgers et al. *IJBNPA* 2012;9(1):1-15.

activPAL: Sitting Time, Standing Time and Stepping Time



activPAL – Direct Observation

Table 4 The percentage agreement, sensitivity and predictive value for the *activ*PAL monitor for sitting, upright, standing and walking with one of the observers

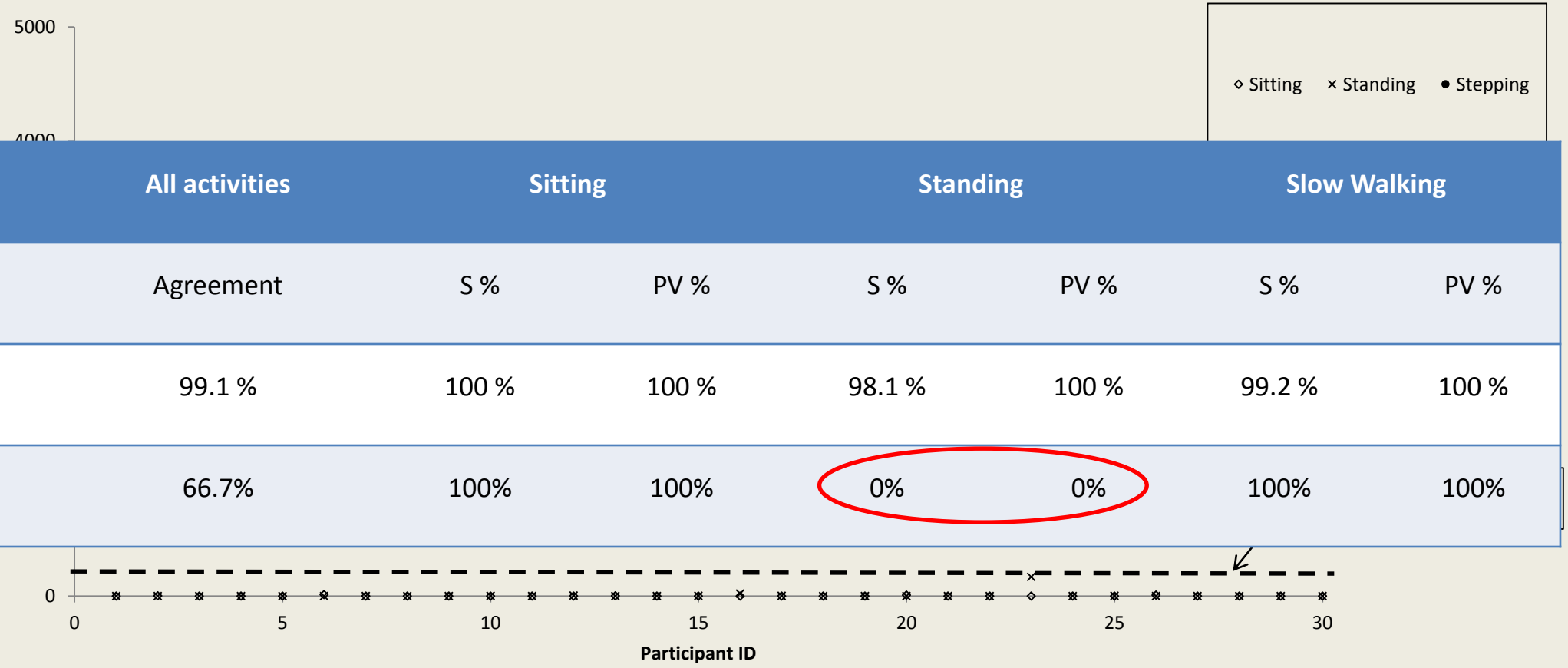
Activities section	Agreement (%)	Sitting		Upright		Standing		Walking	
		S (%)	PV (%)	S (%)	PV (%)	S (%)	PV (%)	S (%)	PV (%)
Controlled	98.5	99.7	99.8	99.8	99.7	97.1	97.1	97.3	97.1
ADL	93.6	99.4	99.5	99.0	98.6	84.9	88.0	67.4	63.7
Combined	95.9	99.5	99.6	99.6	99.3	89.9	91.3	90.0	88.1

PV, predictive value; S, sensitivity.

- Controlled = Range of laboratory-based activities
- ADL = Activities of Daily Living (laboratory-based)

Grant et al. *British Journal of Sports Medicine.* 2006;40(12):992-7.

activPAL and Actigraph
Sitting, Standing and Stepping



	All activities	Sitting		Standing		Slow Walking	
	Agreement	S %	PV %	S %	PV %	S %	PV %
activPAL	99.1 %	100 %	100 %	98.1 %	100 %	99.2 %	100 %
ActiGraph	66.7%	100%	100%	0%	0%	100%	100%

Dowd KP at el. *PLoS One.* 2012;7(10):e47633.

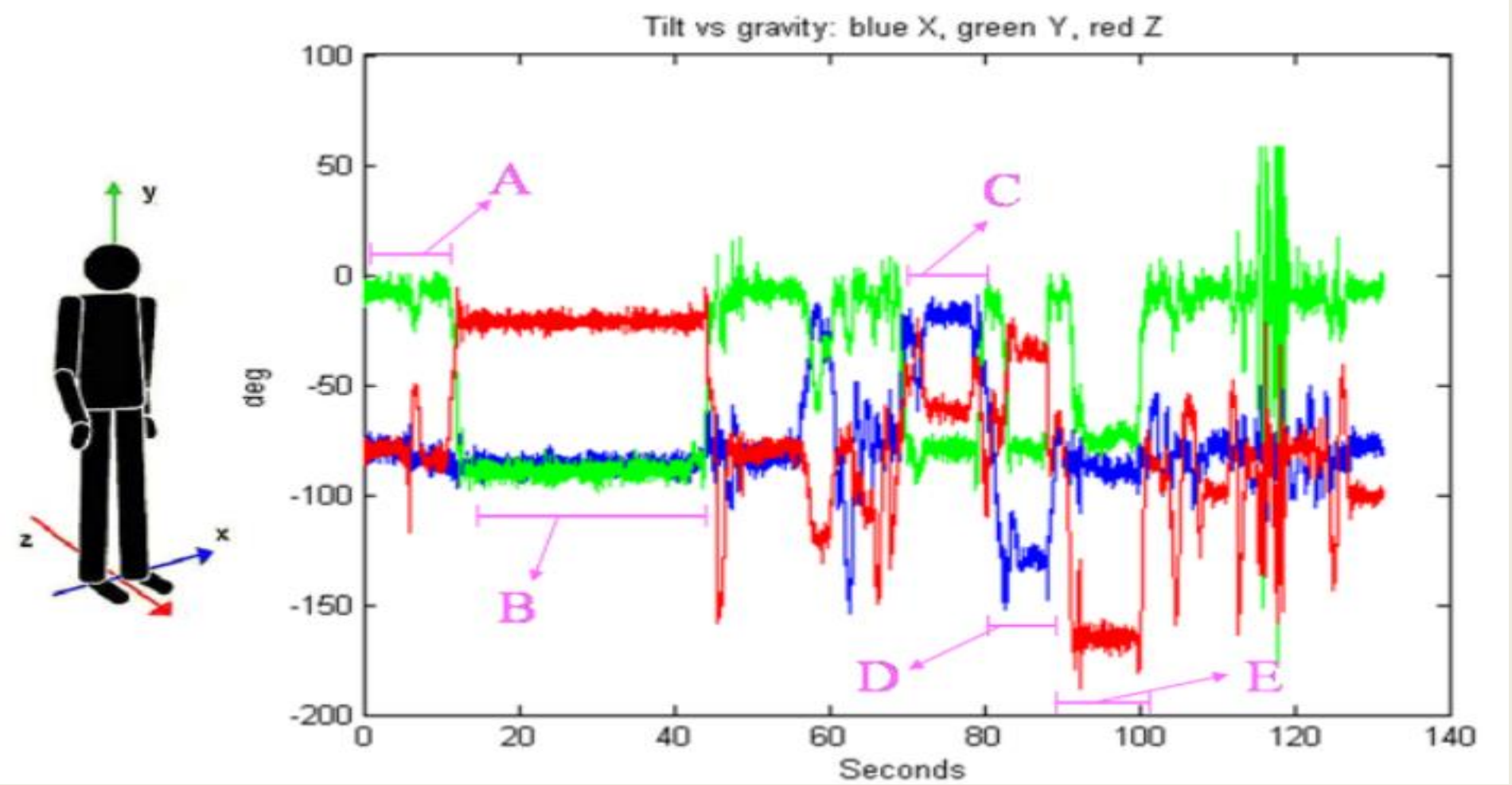
GENEActiv: Sedentary Sphere

- Wrist worn device (GENEActiv)
- Activity Classification Algorithm used to identify sedentary time
- High levels of agreement between GENEActiv and activPAL determined sedentary time (Agreement = 77.7 (95% CI 75.3 – 80.1))

GENEActiv Device

Rowlands AV et al. *Medicine and science in sports and exercise.* 2015.

Posture Recognition



A=Standing Up
B=Lying Horizontally face up
C=Lying Horizontally on left side
D=Lying Horizontally on right side
E=Lying Horizontally face down

Gargiulo et al. *Intelligent and biosensors,* 2010

Implications

- **Self-report** methods to date have poor validity for measurement of physical activity and sedentary behaviours.
- **Objective** based methods have increased validity, but there are still technical issues (use of accelerometer cut-points etc.).
- Comparing activity information from different **objective** devices with different wear positions is problematic.
- The most valid methods utilise an **accelerometer** to determine body posture; but data from these devices needs careful interpretation.

Implications

WHAT ARE WE DOING WHEN ACTIVE

COST

ANALYSIS EXPERTISE

WHO ARE WE ACTIVITY WITH

TIME

WHERE ARE WE ACTIVITY

Conclusion

- Be clear on the behaviours of interest, and what behaviour we want to measure
- Be clear on why we are measuring this, an what we want our data to achieve
- Ensure that the measure we select can achieve this, and that its measurement properties will allow us to draw appropriate conclusions

Thank you for your time

Questions?