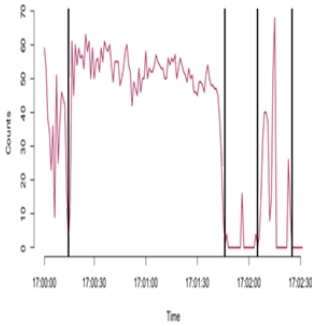
May 20th, 2:30 PM

Assessing Sedentary Behavior and Physical Activity with Wearable Sensors

Patty Freedson
University of Massachusetts Amherst

UMassAmherst

ASSESSING SEDENTARY BEHAVIOR AND PHYSICAL ACTIVITY WITH WEARABLE SENSORS



UMMC Research Retreat

May 20, 2014

Patty Freedson, Ph.D.
Co-Chair, Organizing Committee, Center for Personalized Health Monitoring
Department of Kinesiology
School of Public Health and Health Sciences
University of Massachusetts Amherst

Lone ranger pedometer

NIH Recommendations

- **Conduct experiments to explore physical activity intensity-time relationships for design of activity programs**
- **Determine optimal physical activity with regard to intensity, frequency, and duration**
- **Develop better methods of analysis and quantification of physical activity**

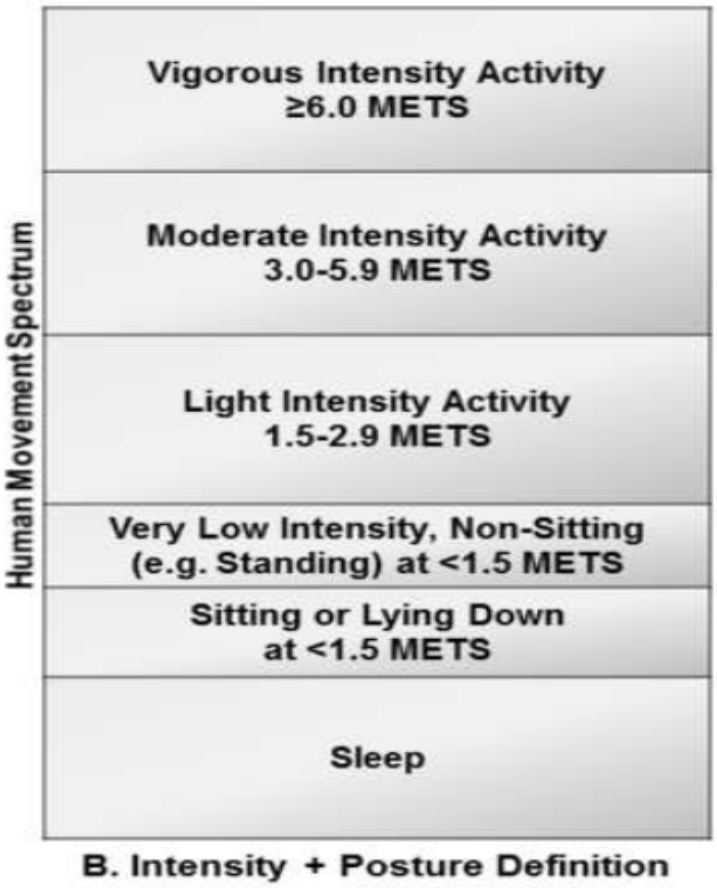
Physical Activity and Health: NIH National Consensus Conference, 1997

Physical Activity Guidelines Advisory Committee

- **Limitations in physical activity measurement**
  - **'The ability of the Physical Activity Guidelines Committee to draw strong conclusions for various outcomes was limited by the wide variety of questionnaires used to assess physical activity and numerous different approaches to data analysis and presentation.'**

SETTING THE STAGE

Absolute intensity of physical activity and sedentary behavior

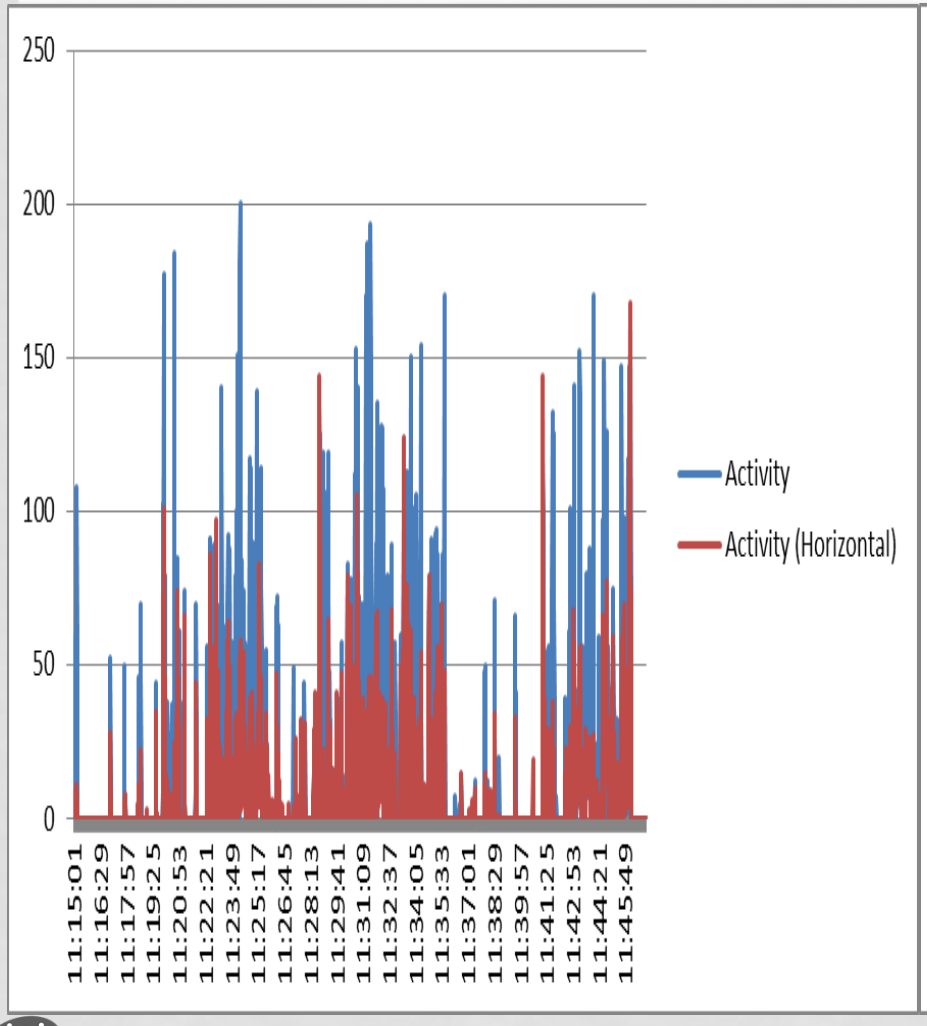


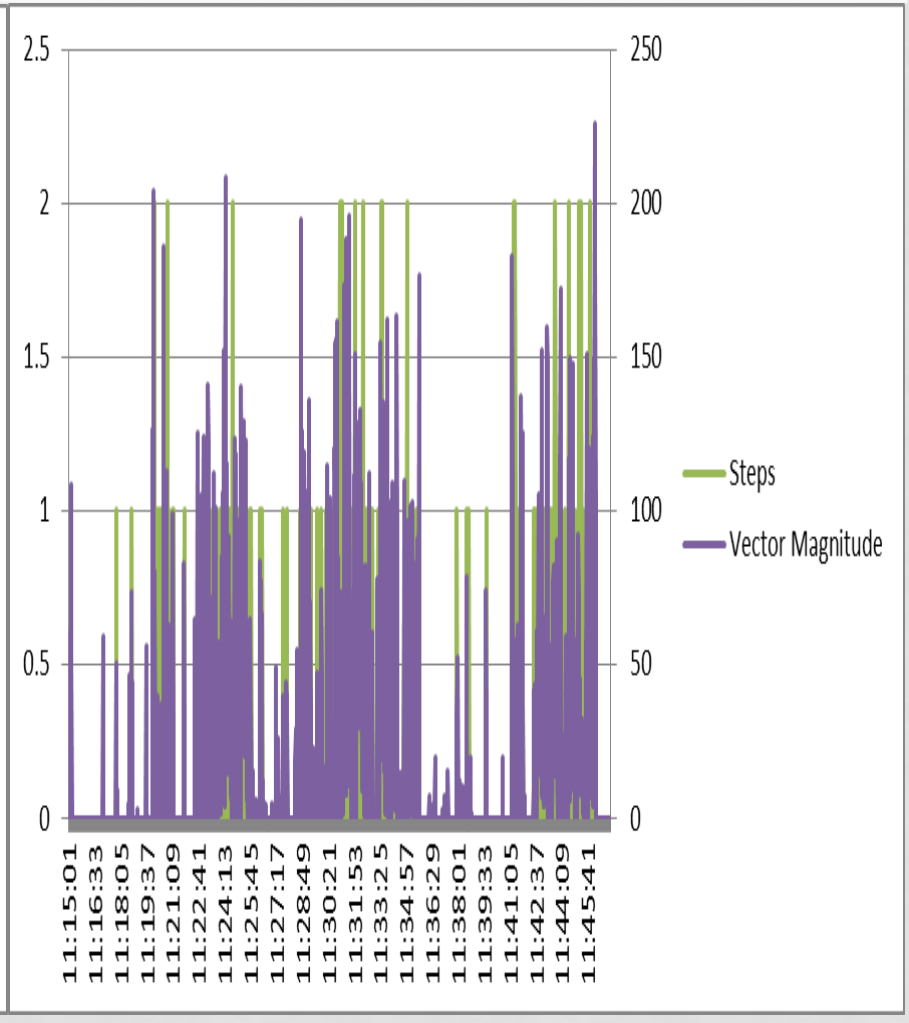
Gibbs et al, MSSE, In Press

Advantages in assessment of physical activity and sedentary behavior using wearable monitors

- Errors reduced in comparison to self-report measures
- Continuous assessment over long period of time (e.g. days, weeks, mos)
- Can be used in variety of research applications:
  - Surveillance research
  - Intervention studies
  - Determinants studies
  - Self-management of activity and sedentary behavior in intervention studies
- Assessment of exposure dose in dose-response studies
- Used to assess activity and sedentary behavior in children, adults, elderly and…..

….ANIMALS



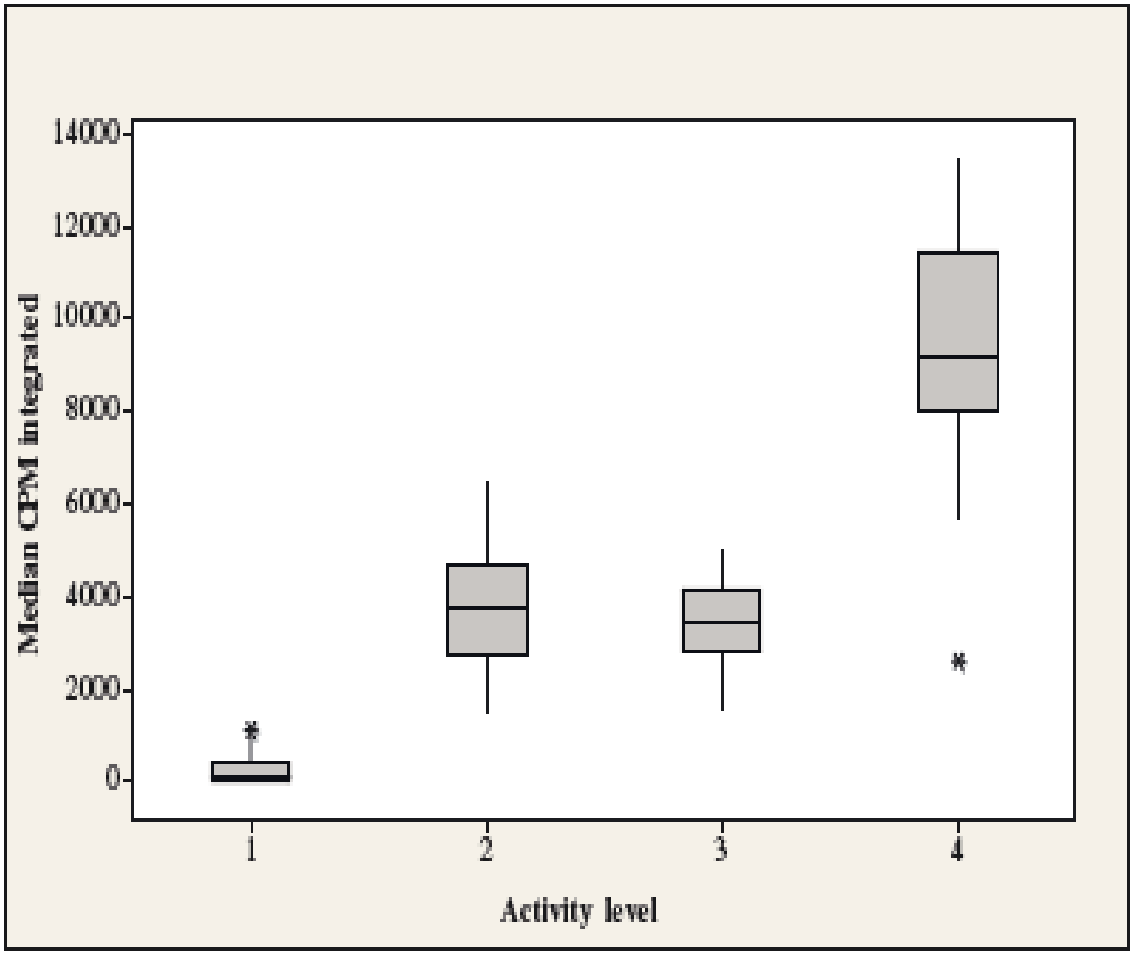


PHYSICAL ACTIVITY AND HEALTH LAB

Pictures and data, provided by Actigraph

Validation of Accelerometer in Differentiating Activity Intensity in Dogs

- N = 30 dogs
- Directly observed activity level vs accelerometer counts per minute



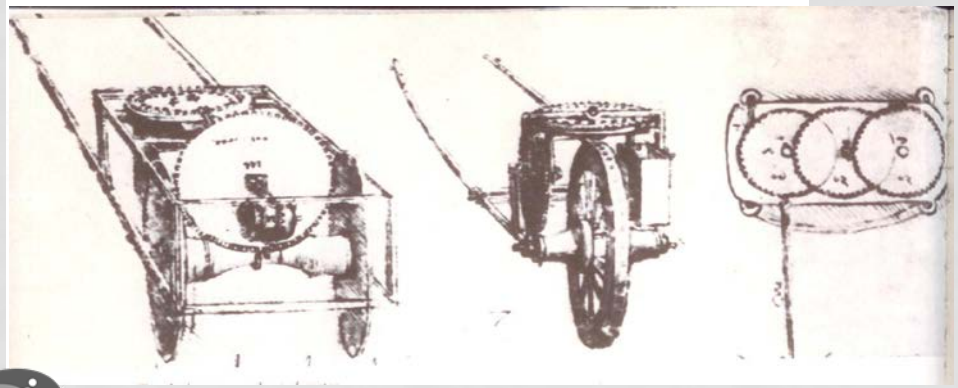
Yam et al., *J Small An Prac.*, 2011

THE ORIGINS OF WEARABLE SENSORS TO DETECT MOVEMENT BEHAVIOR

4035. INVENTIONS, Pedometer.—I send your pedometer. To the loop at the bottom of it, you must sew a tape, and at the other end of the tape, a small hook. * * * Cut a little hole in the bottom of your left watch pocket, pass the hook and tape tnrough it, and down between the breeches and drawers, and fix the hook on the edge of your knee band, an inch from the knee buckle; then hook the instrument itself by its swivel hook, on the upper edge of the watch pocket. Your tape being well adjusted in length. Your double steps will be exactly counted by the instrument.—To JAMES MADISON. ii, 379. (P., 1788.)

HISTORY OF OBJECTIVE MONITORING OF PHYSICAL ACTIVITY

- Vitruvius, Roman writer, architect and engineer from 1st C , BC
- Designed the first hodometer
- Leonardo da Vinci designed first pedometer



PHYSICAL ACTIVITY AND HEALTH LAB

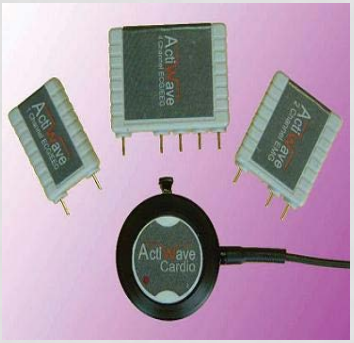

OMRON


Step Watch


025332
GENEActiv


Lifecorder PLUS


AiperMotion™
The Energy Balance Coach
Meal / Drink
Basal metabolism
Exercise
Balance (kcal)
Back


ActiWave
ActiWave Cardio


ActiHeart


Today

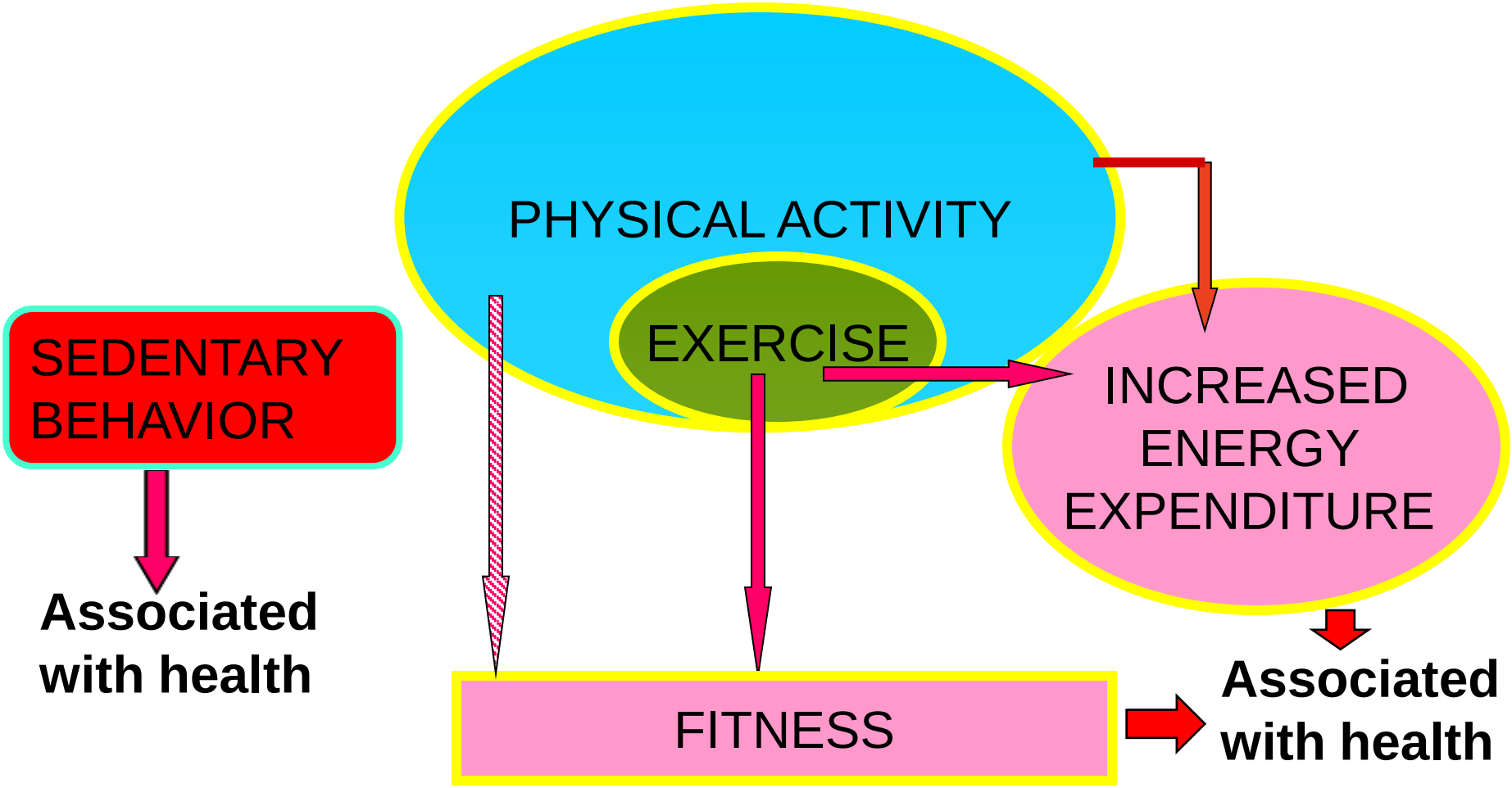

45


0056


59
98
8596


88888

Health, physical activity, fitness and sedentary behavior



activPal™ wearable sensor

- Only sensor designed specifically to quantify posture

- Designed by physical therapist/engineer to objectively assess sitting time for evaluating effects of rehabilitation for stroke patients
  - Objective tool to assess patient centered outcomes
- Currently being used by the physical activity/sedentary behavior assessment community

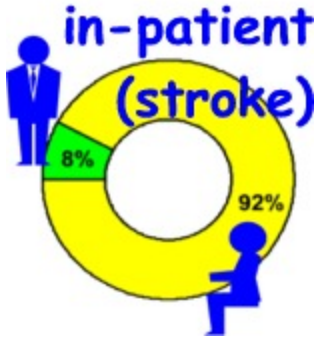
activPal™ Features

- Small (53 x 35 x 7 mm), light weight (20 g) accelerometer that attaches to the skin on the mid-thigh
- Estimates posture allocation (time spent sitting, standing) and stepping based on acceleration and position of the thigh
- Collects data continuously over several days

Descriptive activPAL data

n = 1

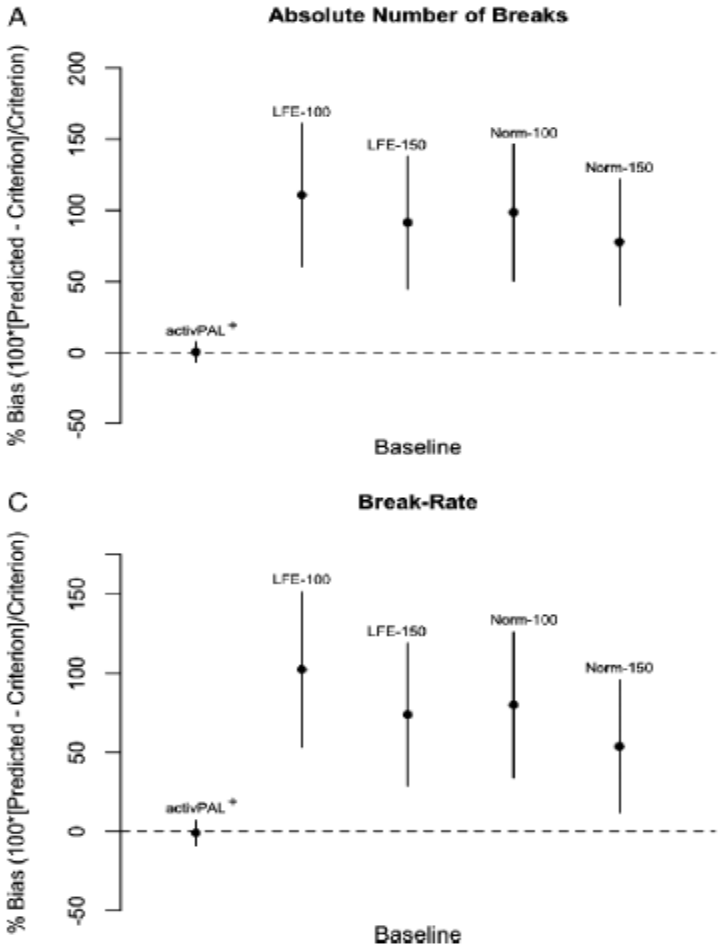
n = 29



n = 13

n =8

activPAL™ and Actigraph™ detection of breaks and break-rate



n = 13

Directly observed for 10 hrs

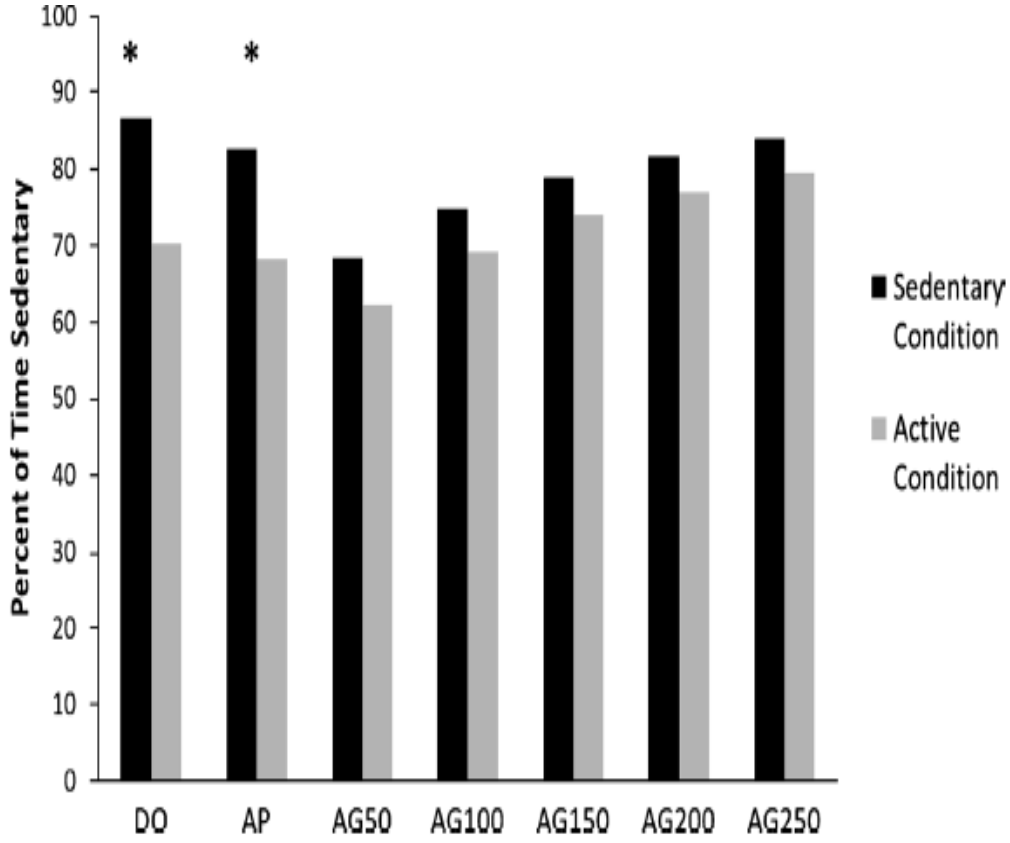
Actigraph™ sedentary time = < 100 and 150 cts/min

Lyden et al., MSSE, 2012

Detection of sedentary time and changes in sedentary time using the activPal™ and Actigraph™ wearable sensors

- **Methods**
  - 20 inactive, overweight office workers
  - Direct observation for 6 hrs (2 conditions)
    - Baseline
    - Reduced of sedentary time
  - Participants wore the activPal™ and Actigraph™ wearable sensors
- **Aims**
  - To determine accuracy of wearable sensors in estimating sedentary time
  - To determine sensitivity of devices in estimating reduction in sedentary time

Detection of sedentary time and changes in sedentary time using the activPal™ and Actigraph™ wearable sensors



activPal (AP)
worn on thigh

Actigraph™ (AG)
worn on hip
count cutpoints
100 cts/min
150 cts/min
200 cts/min
250 cts/min

Kozey-Keadle et al., MSSE 2011

Use of activPal™ in patients with intermittent claudication

- **Derived output from activPal™ in individuals with intermittent claudication**
- **Event-based claudication index**

  number of walking events per upright event

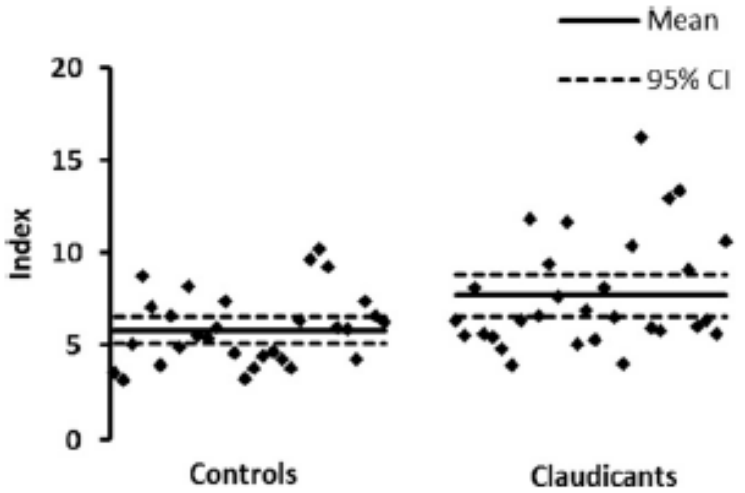
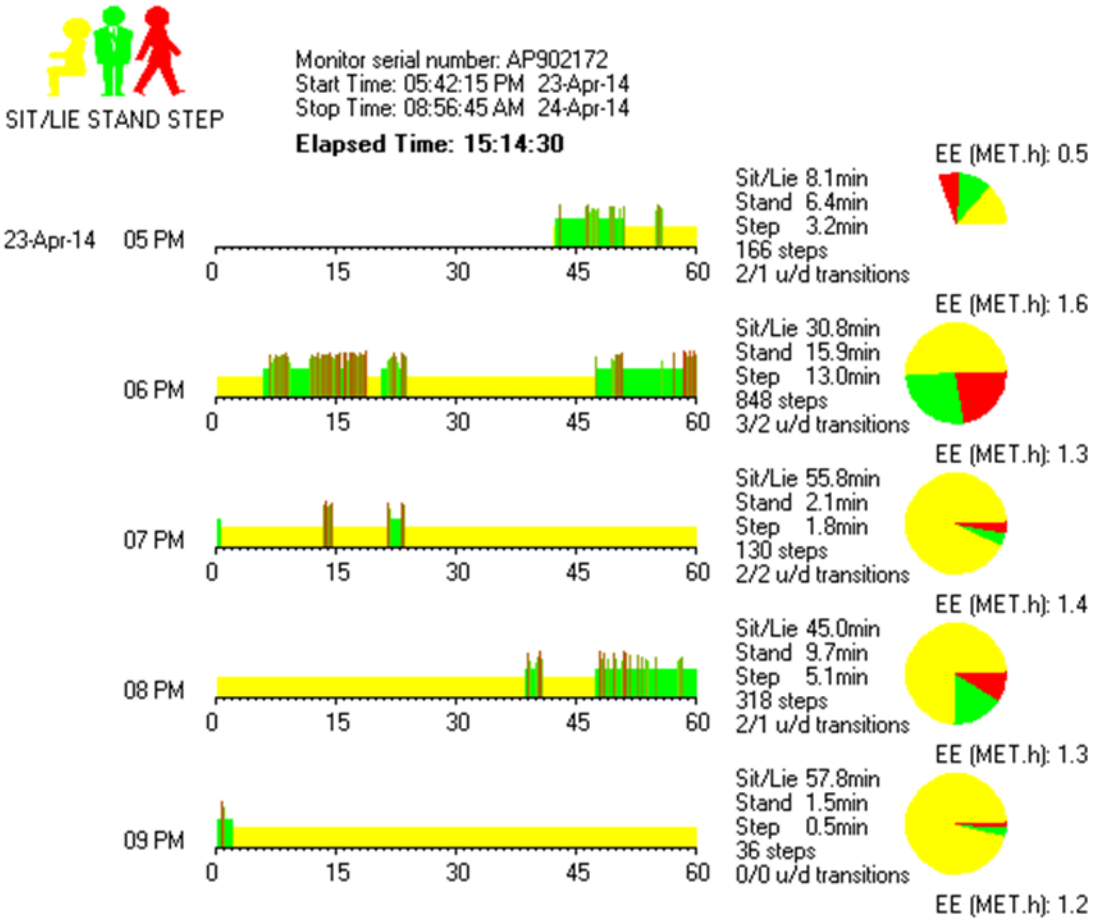


Figure 3. Total number of walking events per upright event (EBCI) over 7-day period in individuals with IC and controls.

Clarke et al., Europ J Vasc Endovasc Surg, 2013


SIT/LIE STAND STEP
Monitor serial number: AP902172
Start Time: 05:42:15 PM 23-Apr-14
Stop Time: 08:56:45 AM 24-Apr-14
Elapsed Time: 15:14:30
23-Apr-14 05 PM
0 15 30 45 60
Sit/Lie 8.1min
Stand 6.4min
Step 3.2min
166 steps
2/1 u/d transitions
EE (MET.h): 0.5
06 PM
0 15 30 45 60
Sit/Lie 30.8min
Stand 15.9min
Step 13.0min
848 steps
3/2 u/d transitions
EE (MET.h): 1.6
07 PM
0 15 30 45 60
Sit/Lie 55.8min
Stand 2.1min
Step 1.8min
130 steps
2/2 u/d transitions
EE (MET.h): 1.3
08 PM
0 15 30 45 60
Sit/Lie 45.0min
Stand 9.7min
Step 5.1min
318 steps
2/1 u/d transitions
EE (MET.h): 1.4
09 PM
0 15 30 45 60
Sit/Lie 57.8min
Stand 1.5min
Step 0.5min
36 steps
0/0 u/d transitions
EE (MET.h): 1.3
EE (MET.h): 1.2

Why use the activPal™ in patients with hip and/or knee osteoarthritis?

- Objective measure of sedentary behavior
  - Hard to detect changes in physical activity which is comprised of a small portion of daily behavior which may not change much with an intervention
- Accurately estimates sedentary behavior
- Can quantify such metrics as breaks from sedentary behavior and walking events per upright event
  - May be linked to pain and function
- Currently limited research on sedentary behavior in patients with osteoarthritis

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Thank-you