The Swiss Society for Public Health

Symposium "Self-Tracking

Octobre 26, 2016, Bern

Evaluation et intervention chez le sujet âgé et le patient avec trouble moteur à partir de nouvelles technologies

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Wearable technology today

- Consumer devices
  - Pedometer, Smartphone, Fitness tracker
    - High rate of decline after one year*
      - Functionality?
      - Validity?
      - Usability?
- Research oriented devices
  - Inertial sensors(accelerometer, gyroscope)
  - GPS, Barometer
  - Gait, activity(sit/stand lie, walk)
  - Walking intensity
  - Energy expenditure
  - Validation?

*Rock Health, Biosensing Wearable report, 2014

Motion sensors: body worn systems

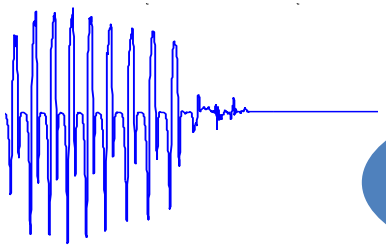
- Subject specific
- Discrete
- Ubiquitous
- Electronic protection

+Fixed place
+Present for all activity
+Ideal for feedback
- Hand movement artefact

+Large space
+Fixed place
+Most affected by locomotion
+Best placement to measure GRF
- Can be removed indoor

+Integrate many sensors
+Social behavior
+Largely available
+Connected
- not fixed location on body

Instrumented shoes: activity monitoring



Data

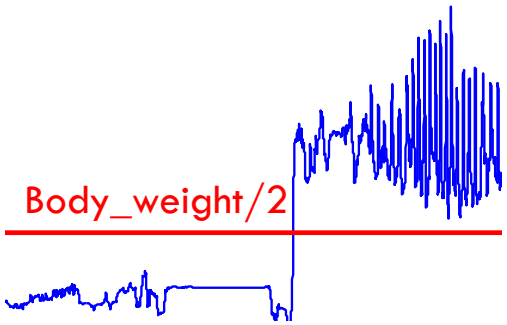
Step detection

Locomotion

Non-locomotion

Sensitivity, Precision

Gyroscope



Moufawad El Achkar et al., Gait & Posture, 2016

Smart watch:
Speed & cadence estimation

Acceleration Norm

Barometric pressure

Windowing (6s)

Mean x STD of acceleration
Barometric range
Stride frequency
Subject height

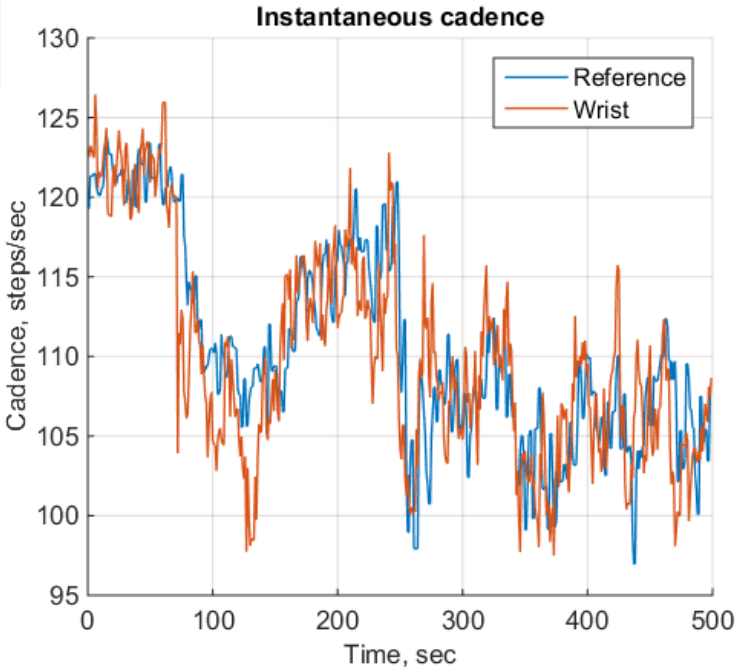
Features extraction

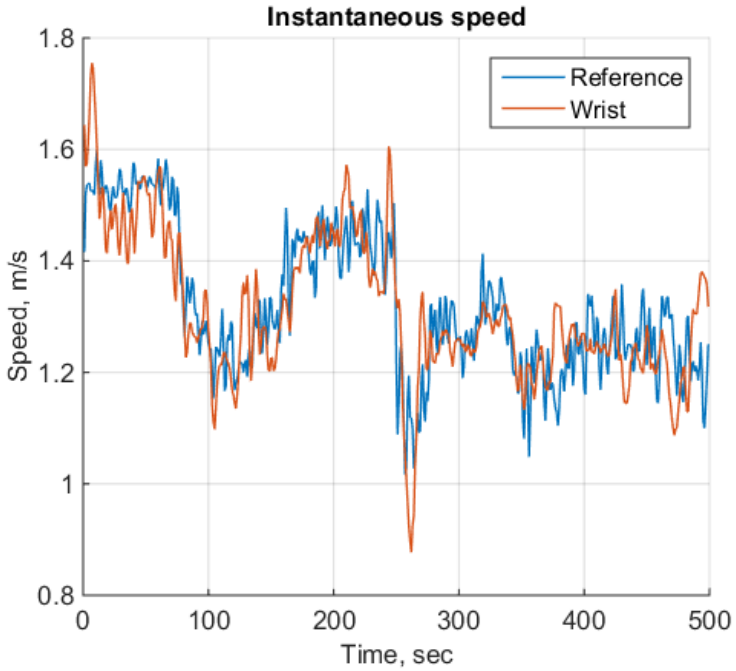
Linear Mixed Model

Mapping Model

Speed

Error: 0.8%±6.8%





How Wearables helps therapist for...

Evaluation

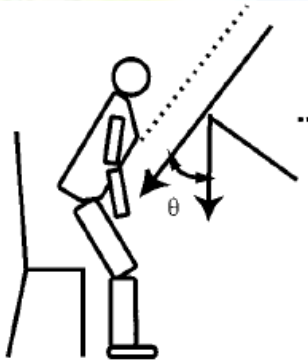
- Instrumented functional tests and gait analysis
- Activity monitoring
- Fall detection
- Smarthome

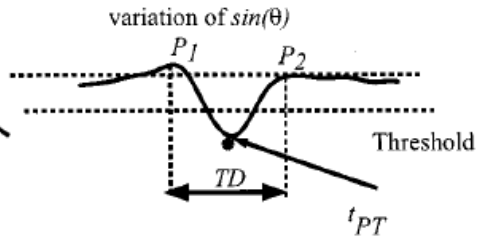
Intervention

- Exergames
- Biofeedback
- Social interaction
- Exercises Apps

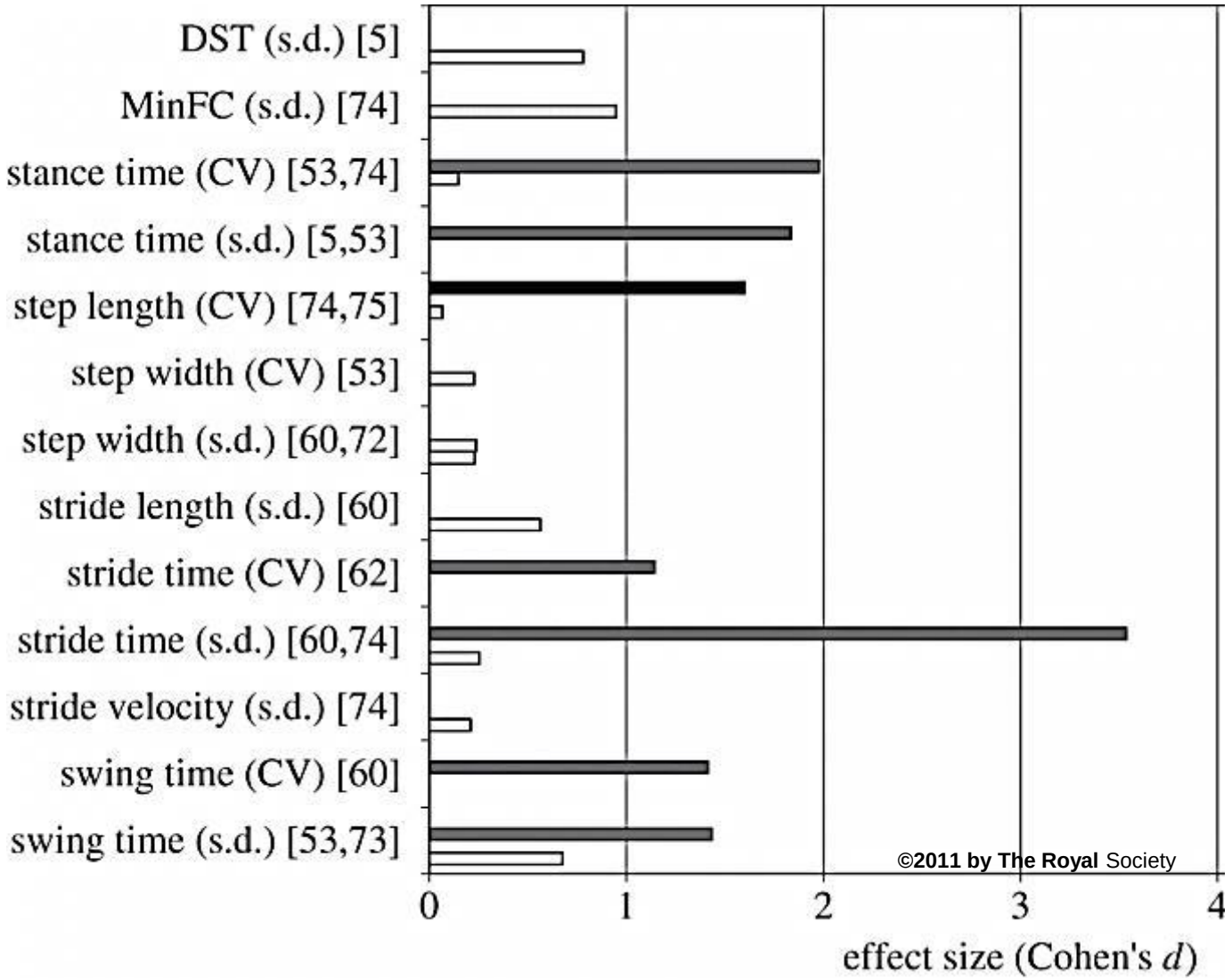
How Wearables helps for **evaluation**: Instrumented functional tests

- Gait analysis
  - 20m, 6 min walking test
  - Dual task
- Timed Up& Go
  - Turning
  - Gait initiation
- Sit-Stand
  - 5 sit-stand
  - 30s chair stand-sit
- Reaction time
  - Reaching
  - Stepping



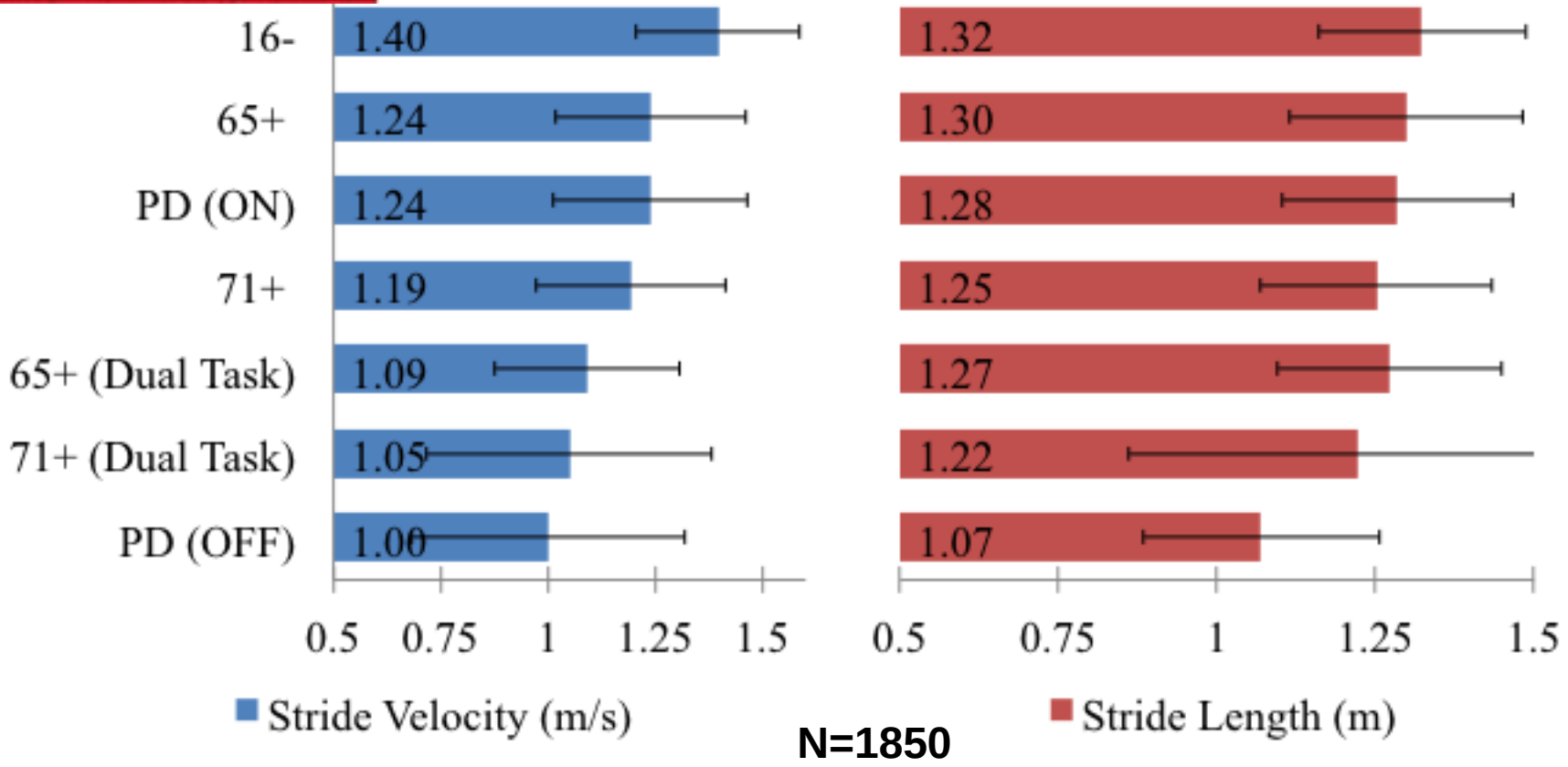


Outcome measure fallers vs. non-fallers: Effect size in different categories of fallers



D. Hamacher et al. J. R. Soc. Interface 2011;8:1682-1698

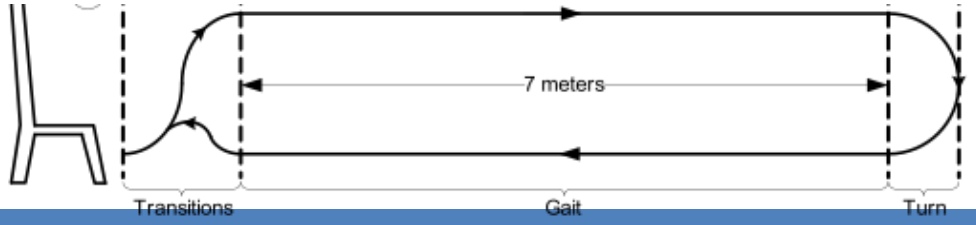
Gait metrics vs. disease, age, and dual task



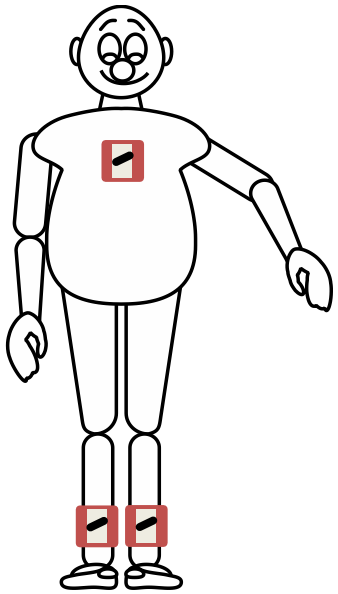
N=1850

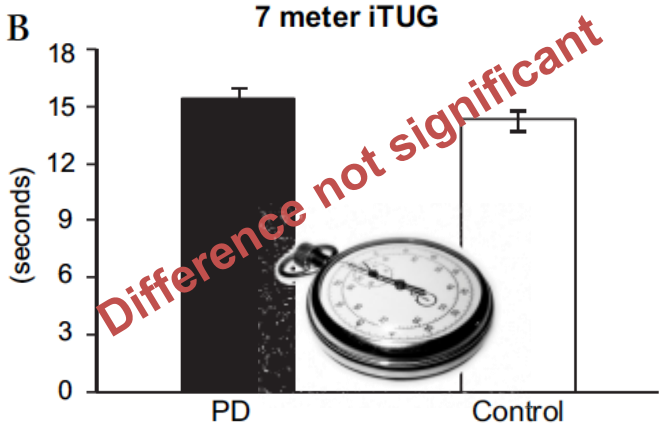
B. Mariani, EPFL Thesis, 5434, 2012

Instrumeneted TUG



	Untreated Parkinson's disease subjects Mean±SE	Control Mean±SE	p Value
Gait parameters			
Upper body			
Peak arm velocity	↓124.4±9.2	187.5±10.9	0.001
Peak trunk rotation velocity (°/s)	↓ 34.0±2.6	44.6±9.6	0.010
Lower body			
Cadence (steps/min)	↓111.7±1.7	121.2±2.1	0.001
Stride velocity (%ht/s)	71.0±2.8	77.8±2.0	0.065
Turning parameters			
Average turning velocity (°/s)	↓ 76.2±4.0	87.5±3.2	0.037

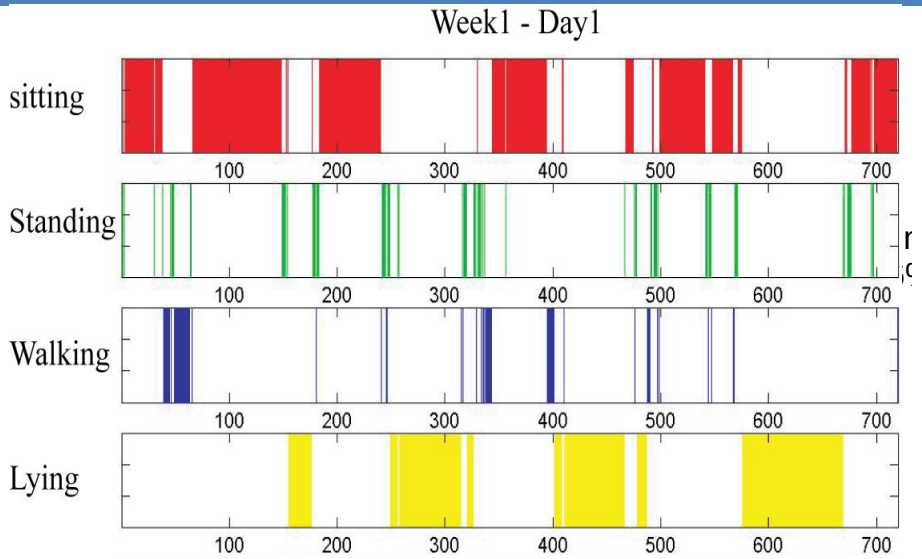


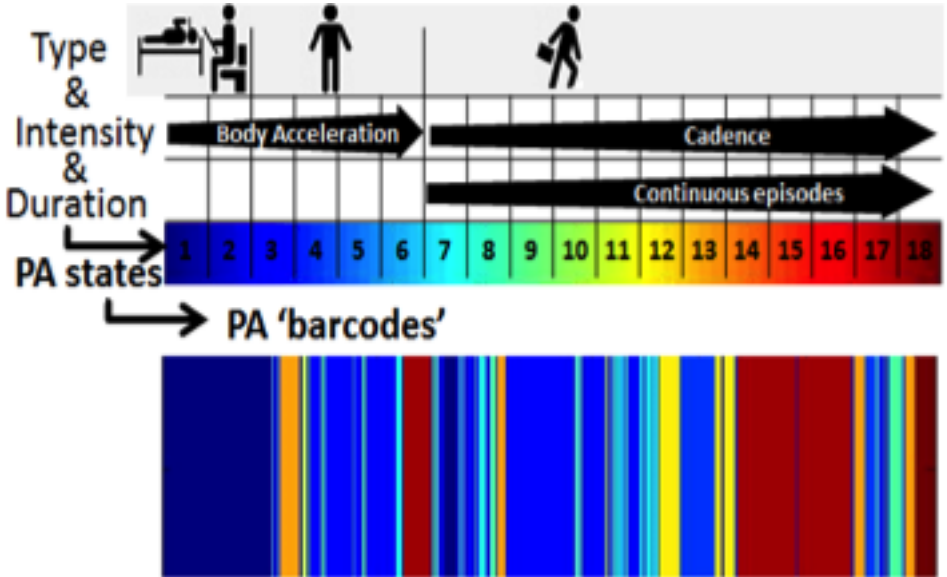


Zampieri et al., (2010), J Neurol Neurosurg Psychiatry

How Wearables helps for evaluation: daily activity

- Activity monitoring
  - Type
  - Frequency
  - Duration
  - Intensity
- Pattern
  - Complex behavior
  - Entropy of activity level

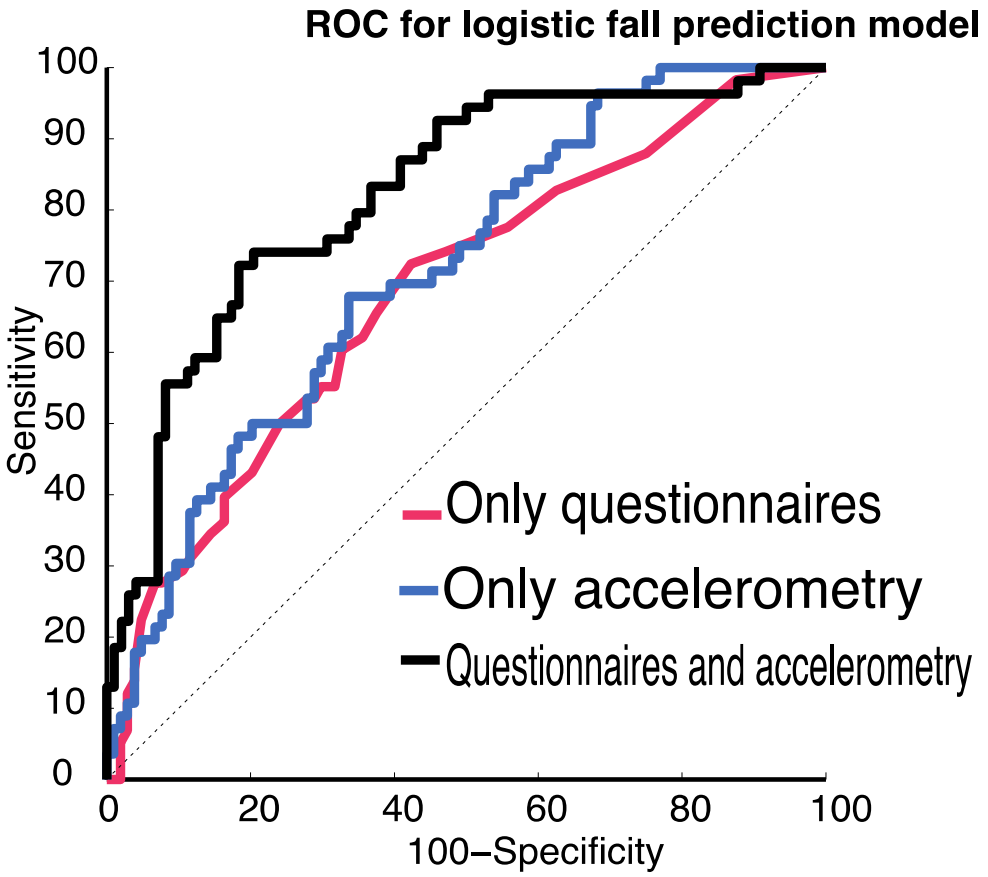




Contribution of wearable sensors:

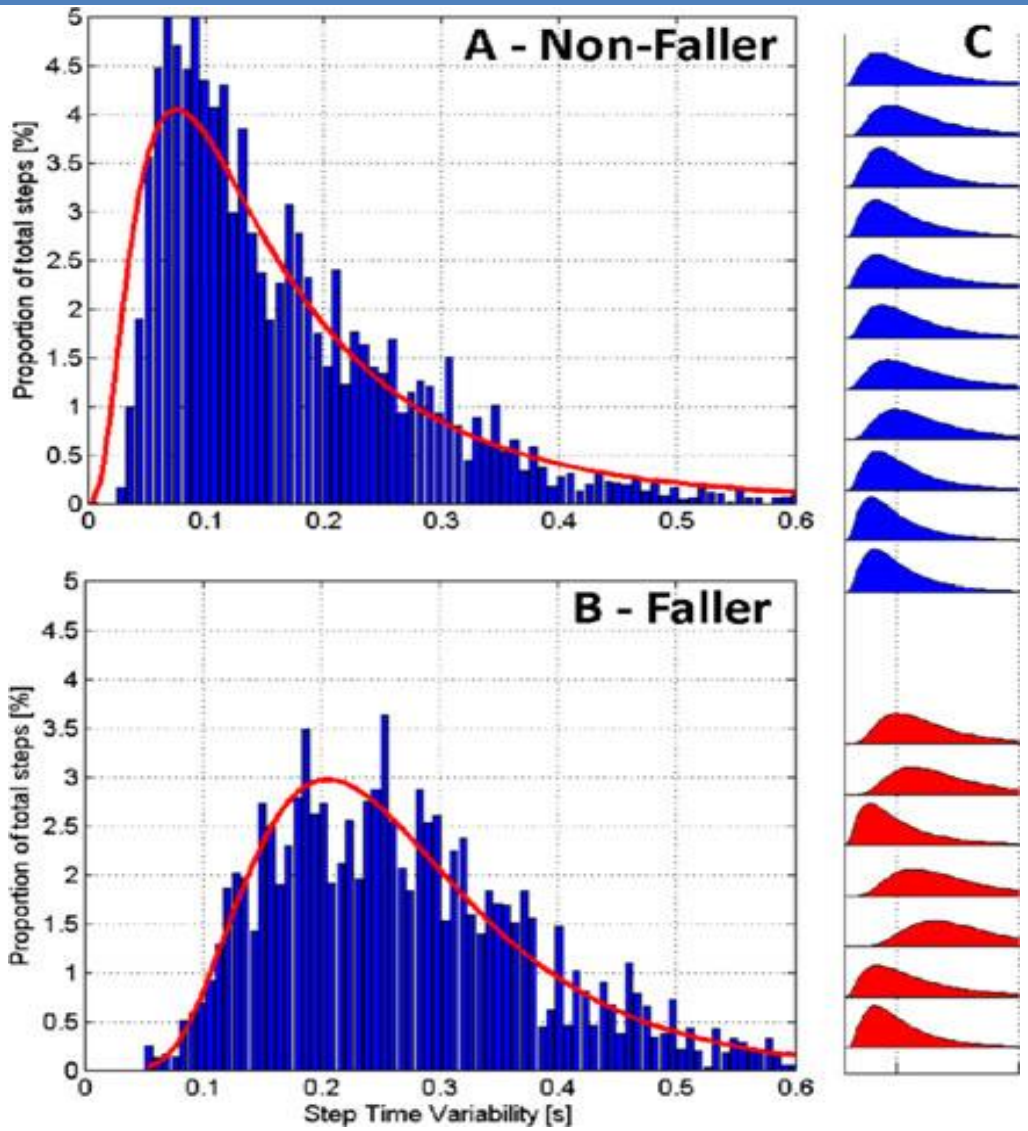
Risk of fall using daily life monitoring

- Trunk accelerometer
- 8 days
- Walking quantity and gait characteristics was associated with fall
- Highest fall prediction when accelerometer is used



Van Schooten, et.al, Journals of Gerontology: MEDICAL SCIENCES, 2015,

Eight-Week Remote Monitoring Using a Freely Worn Device: unstable Gait Patterns in Older Fallers



independent-living older people (mean age 83 years)

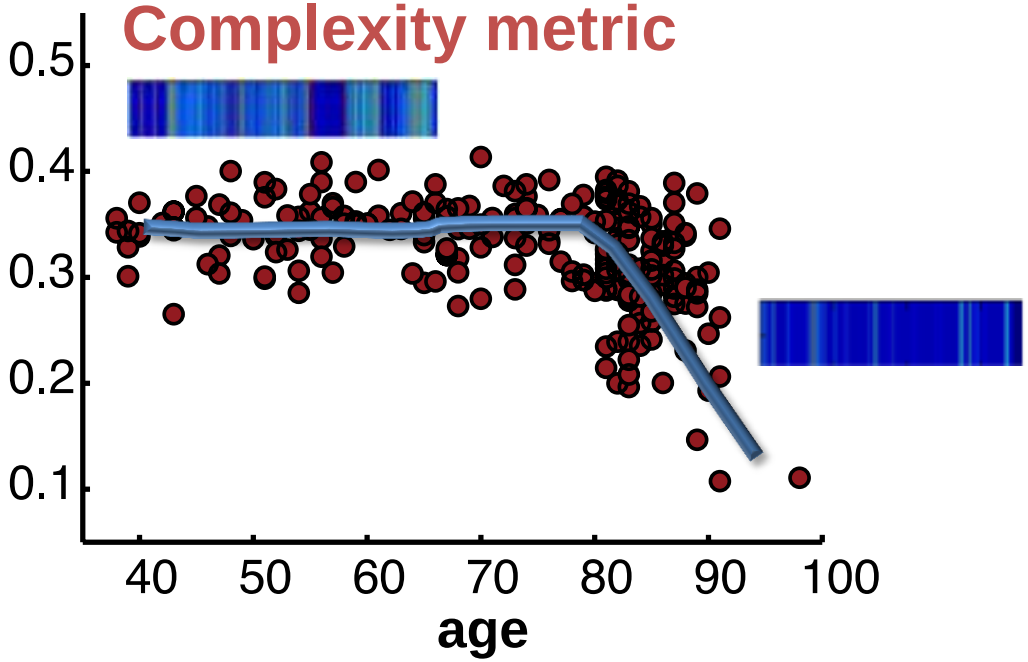
More shorter walking bouts in fallers

Different Mode of Step variability

Brodie et al. IEEE TBME, 2015

Smartphone:
activity decline with aging

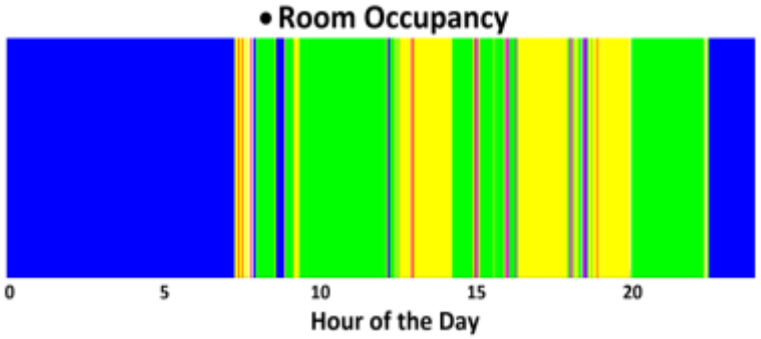
- Subjects: N=254, Age: 41-98 y.o
- Smartphone recording: 7 days, 9hours/day
- Activity **states & Barcodes:**
  - **type**: lying/sedentary, active, gait
  - **intensity**: activity counts, cadence
  - **duration**: walking (gait) bouts
  - **18 states barcodes**

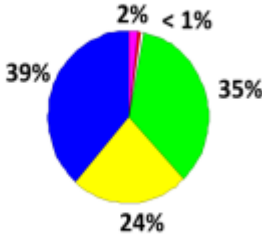


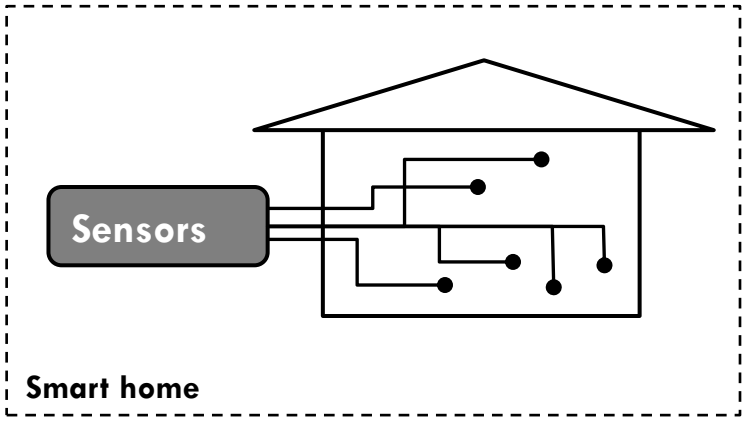
Plateau then drop just before 80 years (~ 75)

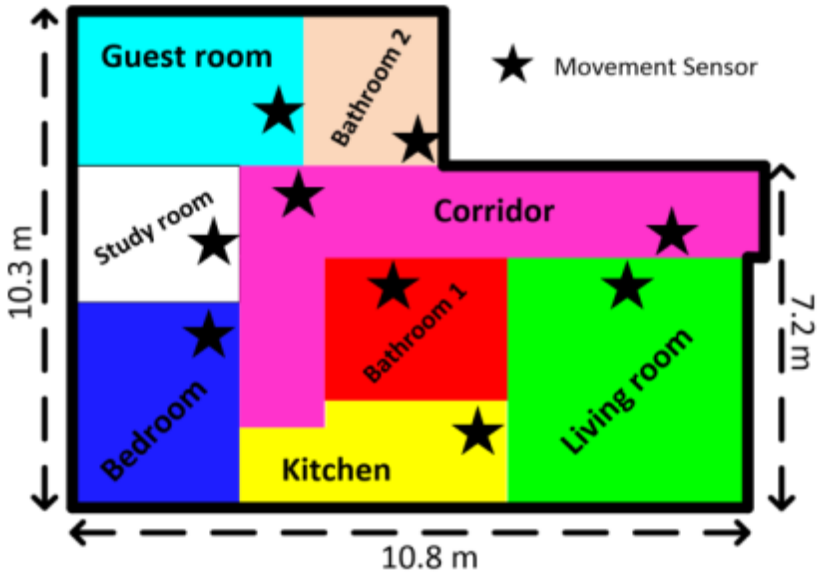
Smart home

- Ambient sensors
  - IR detector
  - Gas, temperature
  - RFID
  - Push-button switches
  - Electrical usage









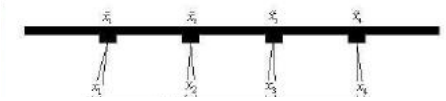
Smart home: Velocity distribution

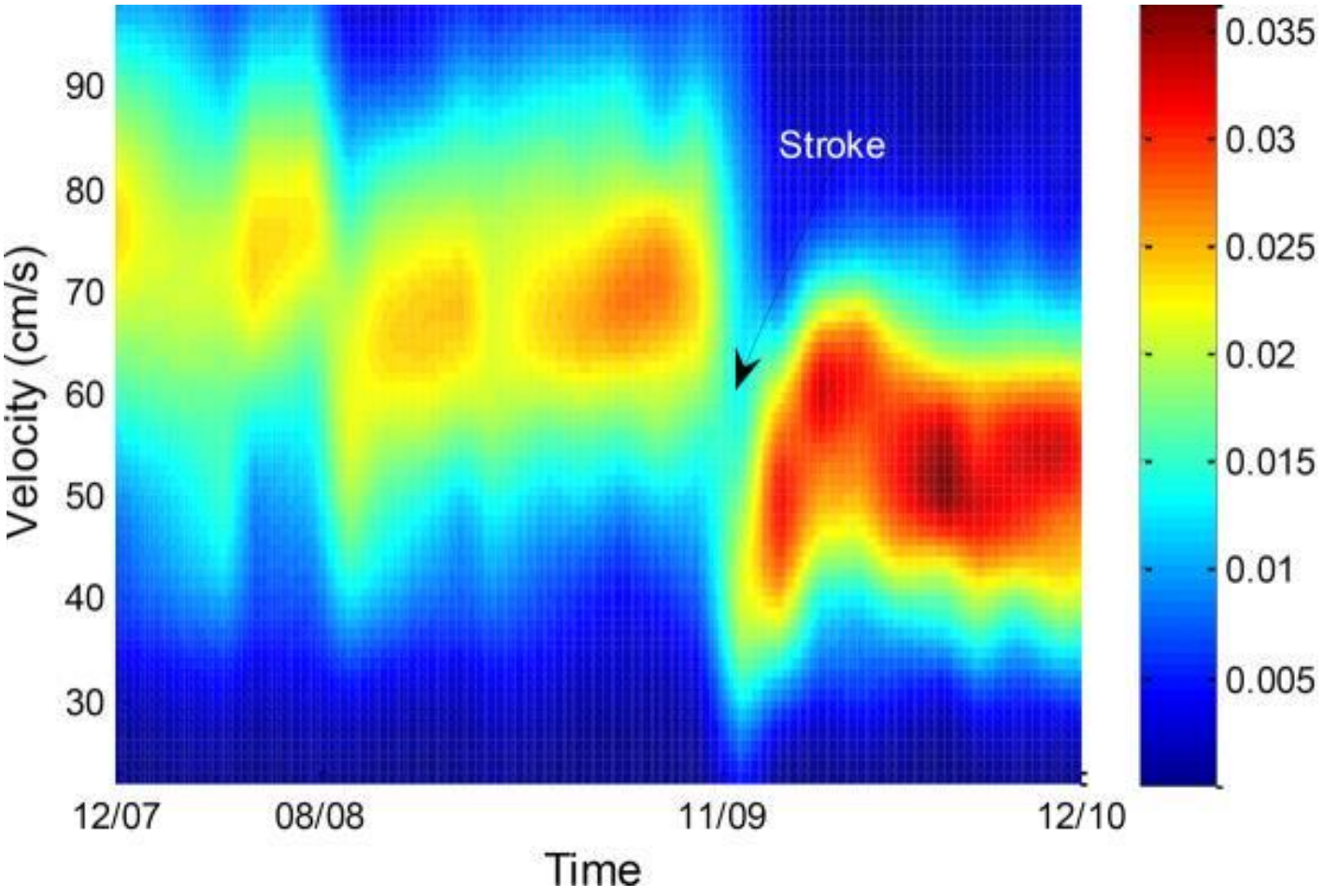
Example: Model-Based meas
Monitoring, modeling and as

- Unobtrusive assessment
- Modeling sensors and hu

rement of gait velocity
essment of gait

f everyday speed of walking
nan gait

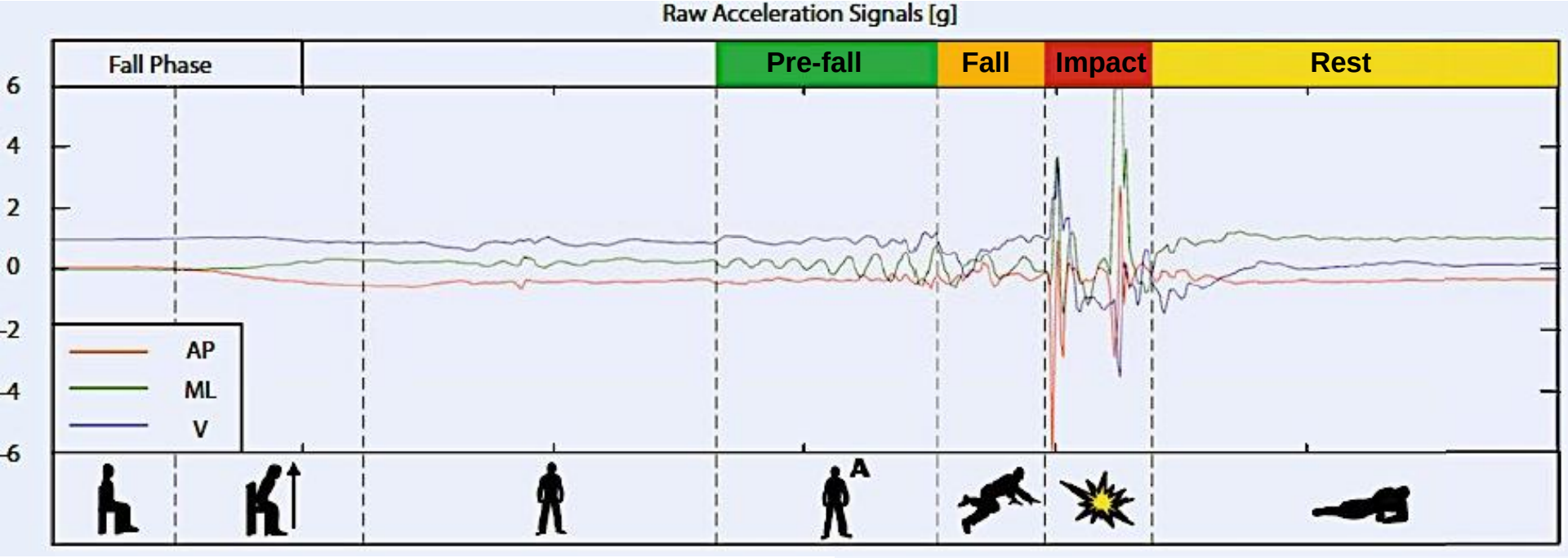




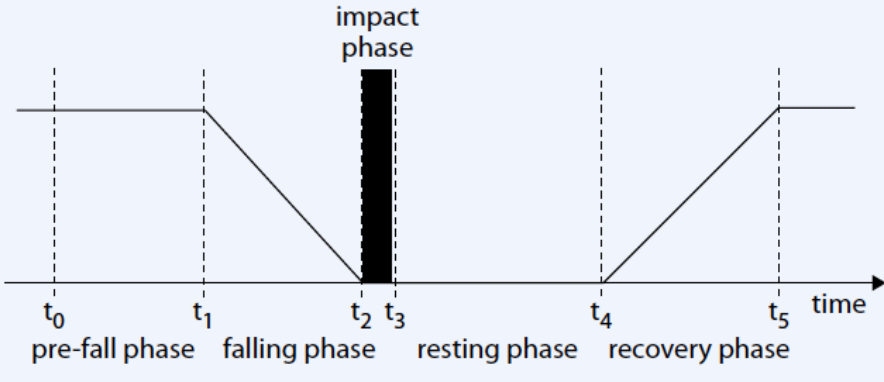
Austin D, et al.*(EMBS), 2011 Annual International Conference of the IEEE*. 2011:

How Sensors can help therapist in Monitoring fall

- Fall detection and characterization



- World's largest database of real fall (>200 real fall)

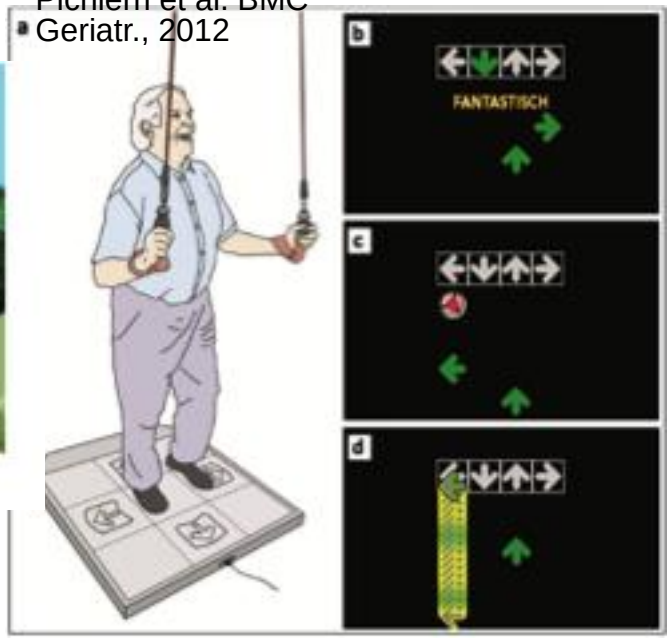


Becker et al., Zeitschrift für Gerontologie und Geriatrie 8 · 2012

How ICT helps for **intervention**

- Exergames studies

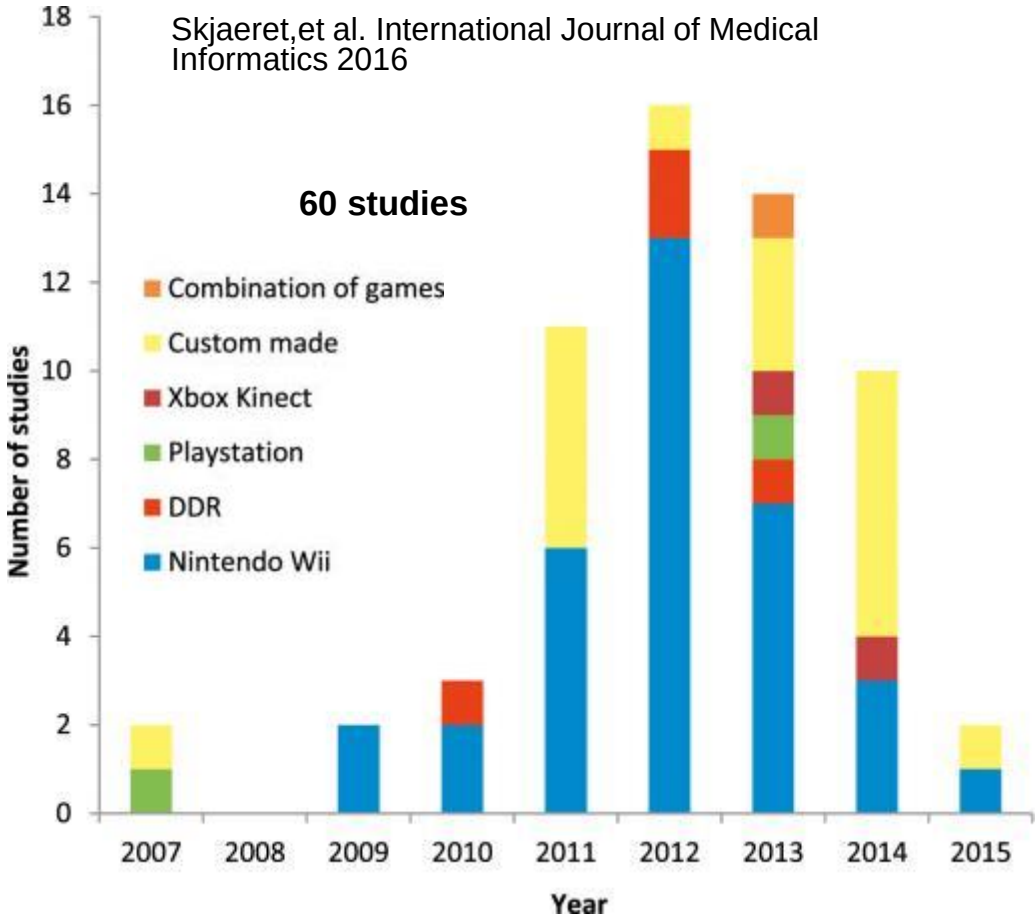
Pichierri et al. BMC Geriatr., 2012



How ICT helps for intervention

- Similar or better effects of exergaming compared to traditional forms of exercise

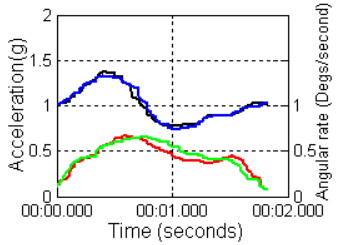
- Outcome measures indicate
  - Improvement of balance and gait
  - Less fear of falling
  - Less fall
- Recommendations
  - Personalization
  - Address multiple Physical functions
  - Adherence and Safety measures
  - Studies for long-term effects

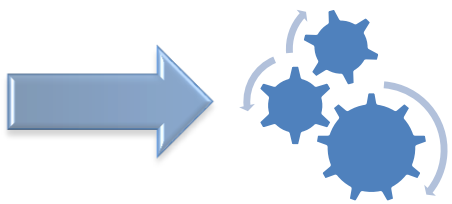


Make ICT-based effective exercise therapy:

Serious Computer Game to Assist Tai Chi Training for the Elderly

- Create a virtual instructor using acquired images from the real instructor
- Challenge the player to mimic gestures presented by the virtual instructor
- Compute the similarity of a measured gesture with a known prerecorded gesture template
- In progress: Sahlgrenska University Hospital in Gothenburg, Sweden

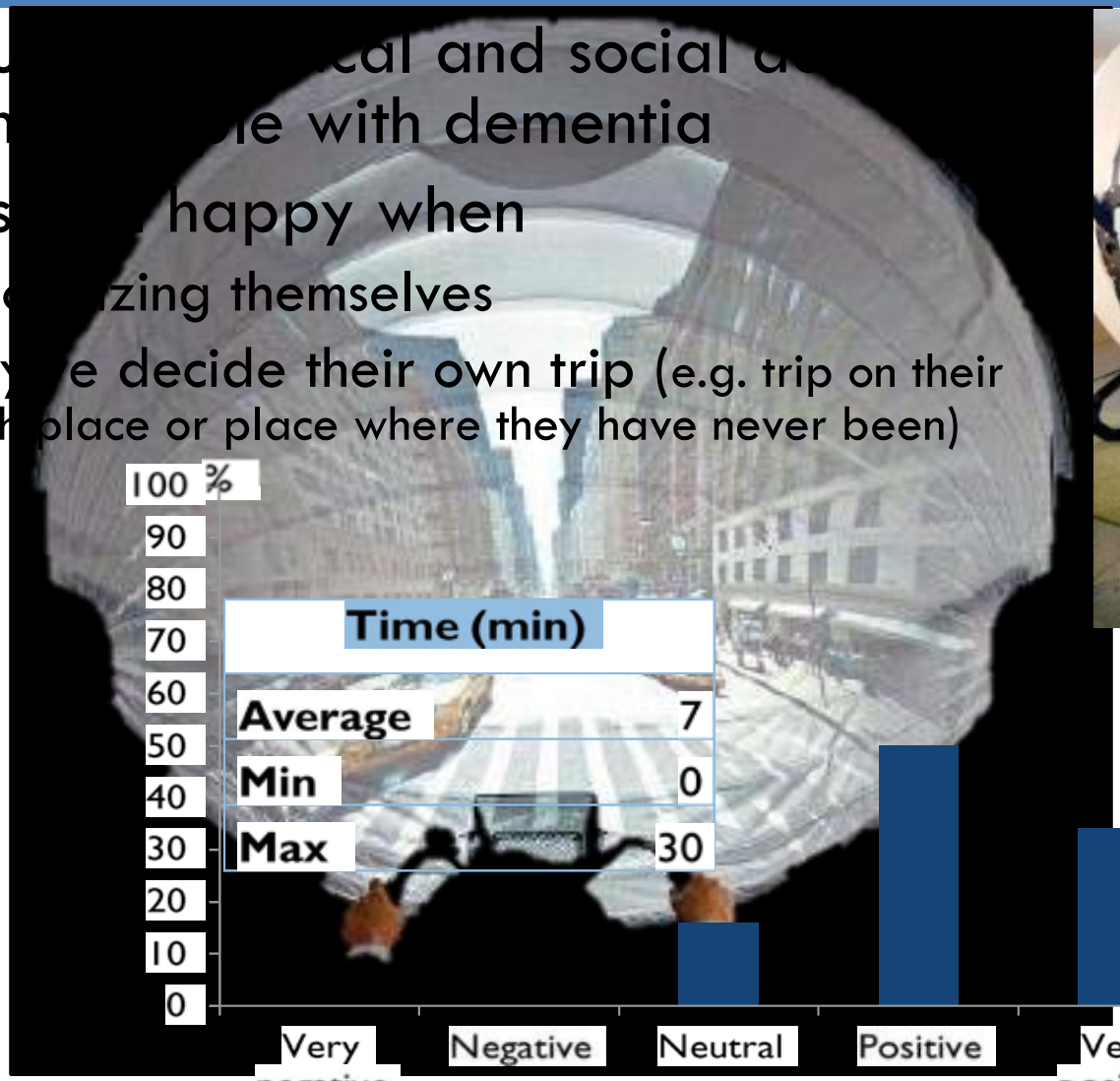




N. Wickström, IEEE 1st International Conference on Serious Games and Applications for Health 2011

Merging social and physical activity by involving users: jDome Bike Around

- Encou…cal and social a… amon…e with dementia
- Users … happy when
  - rec…izing themselves
  - they … decide their own trip (e.g. trip on their birth…place or place where they have never been)

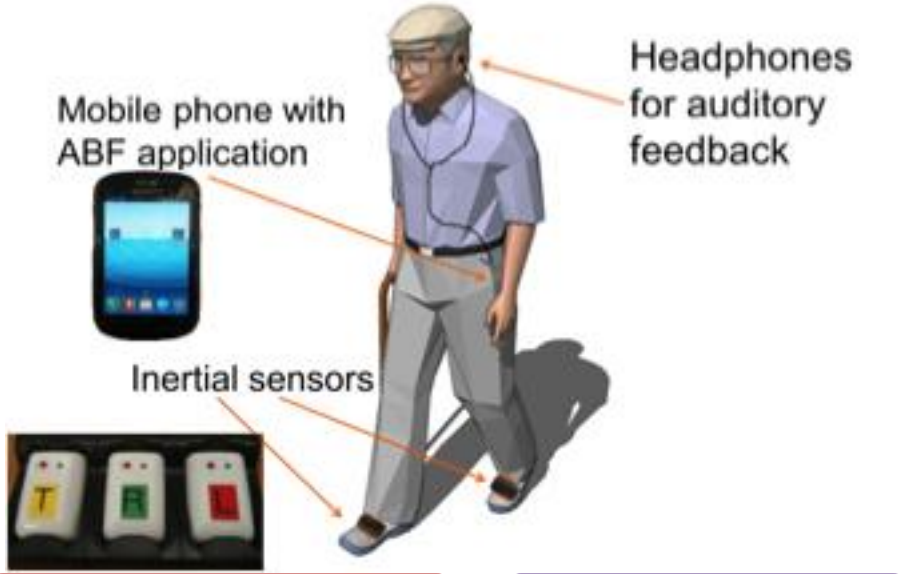


"Get outdoor", lead anywhere they prefer with the help of Google Street View do exercise safely and a have a good time

ICT-based intervention can do better that standard intervention?

Closed-loop system for personalized and at home rehabilitation of people with PD

- 18 sessions (3 X 6 weeks) of personalized rehabilitation exercises for people with Parkinson's disease at home.
- 30 minutes of continuous gait training
- 20 active control, 20 Cupid training through smartphone



Freezing of gait detection and prevention

Biofeedback for gait training

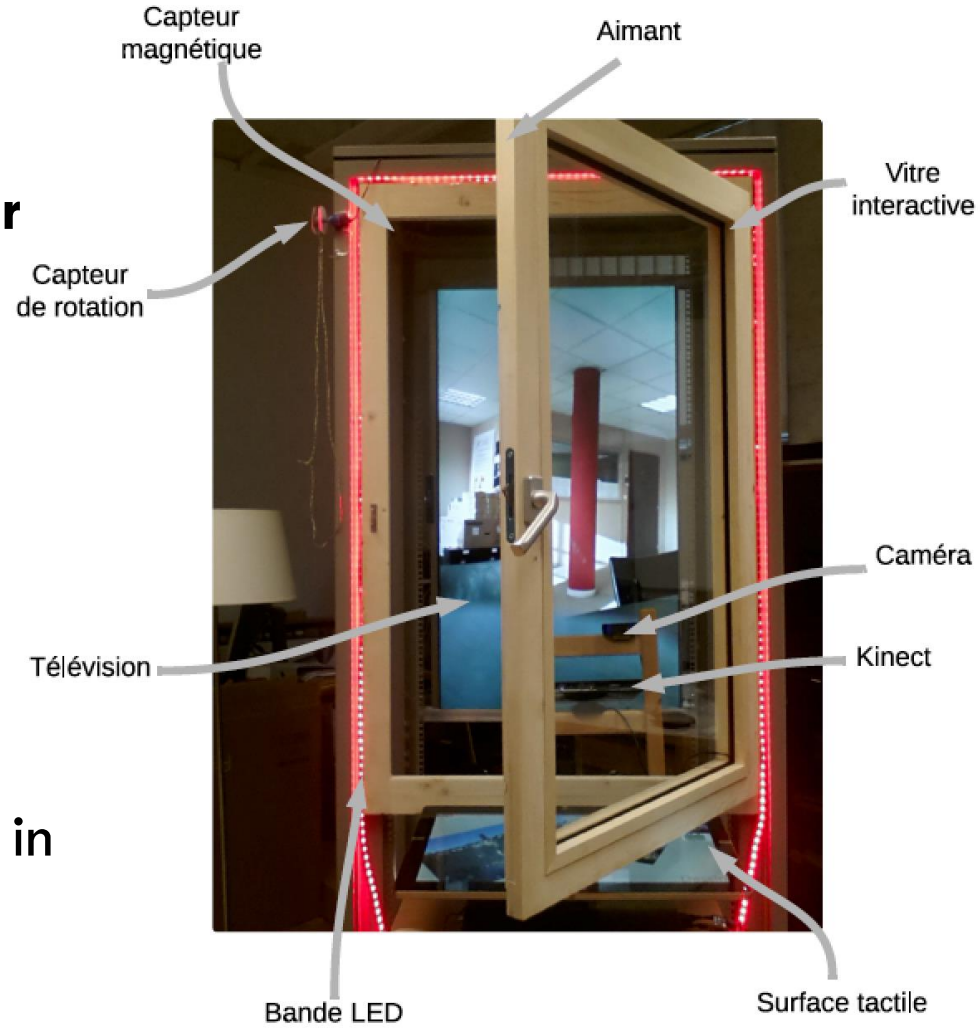
- **Both groups significantly improved on the primary outcomes (single and dual task gait speed) at post-test and follow-up.**
- **The CuPiD group improved significantly more on balance (MiniBESTest) at post-test.**
- **The CuPiD group maintained quality of life (SF-36 physical health) at follow-up whereas the control group deteriorated.**
- **The CuPiD system was well-tolerated and participants found the tool user-friendly.**

Ginis et al. Parkinsonism and Related Disorders, 2016

The Tel Aviv Sourasky Medical Center

Social interaction: Interactive Window

- Based on **Tangible and Natural Interaction**
- Use the **window metaphor** to facilitate remote communication
  - Seamlessly connect remote people
  - Stimulate **social interaction**
- 3 tangible interactive windows are connected today (2 in Switzerland, 1 in France)



https://www.youtube.com/watch?v=yZMsvFVweuk

"The Multisensory Interactive Window: Immersive Experiences for the Elderly", L. Angelini, M. Caon, N. Couture, O. Abou Khaled, E. Mugellini. UbiComp/ISWC'15 Adjunct. http://dx.doi.org/10.1145/2800835.2806209

Prevent IT

- Early risk detection and prevention of functional decline in young older adults
- LiFE concept (Clemson et al.):
  - Daily life: Every hour offers many chances to train
  - Exercises: "make life more challenging"
  - Habit: it part of your lifestyle



Change in behavior

LiFE: Lifestyle Functional Exercise , see: *BMJ* 2012;345:e4547

eLiFE: ICT based intervention

Assessment

Activity planning and counseling

Embedding activities in lifestyle

Conclusions

- Body worn sensors provides unseen detail of subject functional performance
  - Gait instability, variability, foot clearance
- Sensor-based intervention outcomes:
  - Balance and gait improvement
- ICT should/can merge social and physical activity
  - social interaction
  - Physical contact with therapist
- Further needs:
  - personalization
  - Usability
  - Adherence and safety
  - Data protection
- Still in infancy for intervention: needs long-term effect evaluation