ActiPASS - a software to process raw accelerometer data from thigh worn accelerometers

+ Validation of time in lying down and sleep

Peter J. Johansson
peter.johansson@medsci.uu.se

Pasan Hettiarachchi
Pasan.hettiarachchi@medsci.uu.se

Occupational and Environmental Medicine
Uppsala University Hospital

ActiPASS

5th Nordic Seminar on technical Measurement of Physical Activity and Sedentary Behaviour
Trondheim 1-2 June 2022
Acti-4
Sedentary behaviour

Time spent sitting or lying with low energy expenditure, while **awake**

First step towards sleep detection

Detection of Lying down
Differentiate lying down from sitting

Differentiating Sitting and Lying Using a Thigh-Worn Accelerometer
KATE LYDEN, DINESH JOHN, PHILIPPA DALL, and MALCOLM H. GRANAT

Two steps:
Optimization and implementing Lyden algorithms in Acti-4
n= 50, 1 week

Validation
n= 47, 1 week
Lying down detection from thigh worn accelerometer compared to reference

<table>
<thead>
<tr>
<th></th>
<th>Optimization n=50</th>
<th>Validation N=47</th>
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<tbody>
<tr>
<td>Sensitivity</td>
<td>0.94</td>
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<tr>
<td>Specificity</td>
<td>0.96</td>
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Validation
Difference in lying down time/day between thigh accelerometer and reference

Automatic “Bedtime” – By Filtering Lying
Part 1 Optimization
n=23
Polysomnography in laboratory

Part 2 Validation
n = 71
Men
Population study
Age 35-65
Polysomnography at home

Results

Polysomnography

Algorithm

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Submitted but not published results
2022-06-03 Please contact authors for more info
Validation – Uppsala

Difference in total sleep time between algorithm and polysomnography

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<tr>
<th>Device Type</th>
<th>Study (Year)</th>
<th>N</th>
<th>Bias Limits</th>
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<tr>
<td>Sleep diary</td>
<td>Zickler 2014; n=90</td>
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<td>Hip or trunk worn accelerometers</td>
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</table>

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Total Sleep time ≈ 5.5h

Sleep Intervall
01:00-07:00 = 6h
Validation - Uppsala

Sleep Parameters - Algorithm vs PSG

Submitted but not published results
2022-06-03 Please contact authors for more info

ActiPASS

ActiPASS is developed by Pasan Hettiarachchi and Peter J. Johansson at Occupational and Environmental Medicine, Department of Medical Sciences, Uppsala University. [Magnus Svarthgren]

ActiPASS is based on: Acti4 thigh accelerometer activity detection algorithm developed by Jørgen Skotte at the National Research Centre for the Working Environment (NFA), Copenhagen, Denmark. [Andreas Holtermann]

The development of ActiPASS has partly been funded by ProPASS Consortium
ActiPASS

- Open published algorithms
- Works with multiple brands of accelerometers
- Automated workflow – Auto corrects wear problems such as:
  - orientation issues
  - Automatic device calibration
  - automatic individual calibration
- Easy to use streamlined workflow

ActiPASS Workflow
ActiPASS Workflow – Little more detailed

Raw tri-axial Acc. Data & optional diary → Device Calibration – Automatic → Automatic Flip/Rotation correction → For Each Day

Non wear detection → Lying Detection Algorithm → Acti4 Core Alg → Automatic individual calibration (Ref. positions)

Aggregate data (whole measurement) → Bedtime Detection → Sleep Algorithm → Visualization for quality checks

Descriptive Statistics (activity times, intensity classes, bouts, domain specific results)

Time series data saved to disk

Autocalibration Module

van Hees et al.
J appl Physiol 117: 738-744, 2014

Uses existing free living data
No specific protocol is needed
Flips/Rotations Detection Module

- Correct
- Wrong Flipped
- Wrong Flipped and rotated

Accelerometer auto alignment correction

- Standing reference position (based on diary)
- Automatic reference position estimation from walking
ActiPASS outputs (variables)

- Time series (1s epoch) of physical and sedentary behaviour
- Times of physical and sedentary behaviours and time of Sleep-Interval according to 24H ProPASS construct
  
  - $24H = \text{Awake} + \text{Sleep-Interval} + \text{Excluded} + \text{NonWear}$
  
  - $\text{Awake} = \text{Lie} + \text{Sit} + \text{Stand} + \text{Move} + \text{Walk} + \text{Run} + \text{Stair} + \text{Cycle} + \text{Other}$

ActiPASS output variables contd..

- Step counts at epoch level (cadence) and total step counts
- Times of energy intensity classes based on above (Sleep, SED, LPA, MPA, MVPA, VPA etc – intensity variables are not yet finalized)
- Activity transitions information (ex. Number of “SitLie” to “Stand”)
- Separate statistics for domains/intervals such as “Work” and “Leisure”
- Bouts of physical and sedentary behaviours and intensity classes
  
  - Adjustable bout breaks
  
  - Adjustable bout thresholds
Quality checks & Automatic outlier detection

- An automatic quality-check flag based on predefined outlier criteria and other potential problems
  - No Walking
  - Too much ‘Other’
  - Too much Stair
  - Not enough wear

A user interface for further quality checks
ActiPASS Visualizations for quality checks, feedback and clinical studies

Visualizations – quality check, feedback and clinical studies

Weekdays (4 days)

Weekends (1 days)

Event: Work (duration: 46.25 hrs)

Event: Leisure (duration: 59.08 hrs)

Event: Bed (duration: 20.09 hrs)
A pedagogical tool in communication about physical behaviour with a patient

ActiPASS Documentation

https://github.com/Ergo-Tools/ActiPASS/wiki/
Interested in using ActiPASS on your thigh accelerometer data

Please contact
Peter.johansson@medsci.uu.se
Pasan.hettiarachchi@medsci.uu.se