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Advancing movement & sleep research

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GGIR training: Day 1

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Slide deck version: 06 December 2022

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DECLARATION

- Our aim is to train you to use and understand GGIR for your research
- Focus on common use-cases of GGIR
- If you have questions? Feel free to post them in the chat, we will try to answer them during the course
- We will have 3 short breaks today
- We will **NOT** record the video session
- Please do **NOT** record this training and share publicly
- Slides are available as PDF => https://www.accelting.com/ggir-training/

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What will we do today?

- Introduction to GGIR and accelerometers
- Exercise 1
- Lecture:
  - Using GGIR
  - Data quality
  - Acceleration metrics
  - Accounting for study protocol
  - Description of behaviour
  - GGIR Output
- Exercise 2
- Question time

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Introduction to GGIR

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GGIR

R package for accelerometry

GGIR is an R-package to process multi-day raw accelerometer data for physical activity and sleep research.

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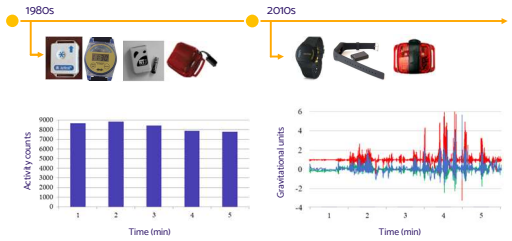
Accelerometry



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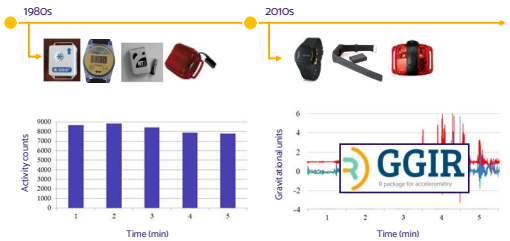
Accelerometry



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Accelerometry

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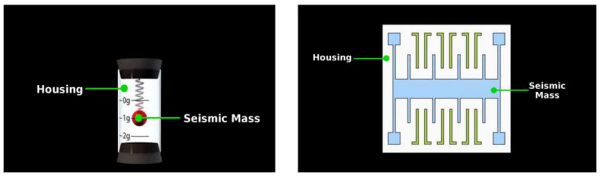
Accelerometry



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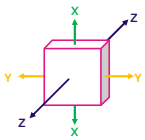
Raw data



X	Y	Z
-0.510	0.144	-0.850
-0.510	0.144	-0.845
-0.510	0.144	-0.850
-0.507	0.144	-0.845
-0.510	0.144	-0.850
-0.510	0.144	-0.845
-0.510	0.144	-0.845
-0.513	0.144	-0.842
-0.510	0.144	-0.845
-0.510	0.144	-0.845
-0.507	0.141	-0.845
-0.510	0.147	-0.845
-0.510	0.147	-0.845
-0.510	0.147	-0.842
-0.510	0.144	-0.845
-0.510	0.144	-0.842
-0.510	0.150	-0.842
-0.510	0.147	-0.845
-0.501	0.150	-0.845
-0.510	0.144	-0.845
-0.510	0.147	-0.850
-0.510	0.147	-0.845
-0.513	0.147	-0.842
-0.510	0.144	-0.842
-0.510	0.144	-0.845
-0.510	0.144	-0.845
-0.510	0.147	-0.842
-0.510	0.150	-0.845
-0.510	0.144	-0.842
-0.507	0.144	-0.845
-0.507	0.144	-0.845

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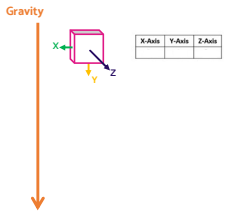
Raw data



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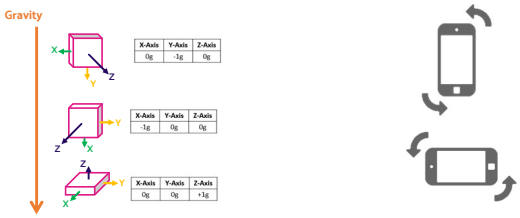
Raw data



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In-built functionality to read

- Axivity data (.cwa, .wav, and .csv)
- ActiGraph data (.gt3x and .csv)
- GENEActiv data (.bin)
- GENEA data (.bin)
- Movisens data (folder with inside .bin)

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And other csv files

- csv's with acceleration data independently of the Brand
- Flexible to variety of data formats

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Online Tutorial

https://cran.r-project.org/web/packages/GGIR/vignettes/readmyacccsv.html

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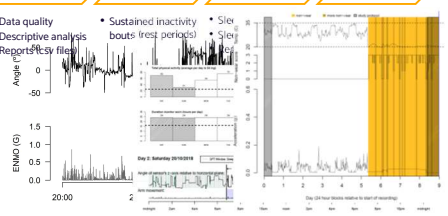
The GGIR pipeline

Part 1 | Part 2 | Part 3 | Part 4 | Part 5

- Reads file
- Extracts features
- Data quality

- Data quality
- Descriptive analysis
- Reports (.csv files)

- Sustained inactivity bouts (rest periods)



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One R command

Using all defaults:

```
library(GGIR)
GGIR(datadir="C:/mystudy/mydata",
     outputdir="D:/myresults")
```

Note:
- File paths are examples
- You can have data and output on different or on the same drive
- R uses forward slashes
- Argument datadir must differ from argument outputdir

Tailored to a study:

```
library(GGIR)
GGIR(
  mode=c(1,2,3,4,5),
  datadir="C:/mystudy/mydata",
  outputdir="D:/myresults",
  do.report=c(2,4,5),
  #====================
  # Part 2
  #====================
  strategy = 1,
  hrs.del.start = 0,          hrs.del.end = 0,
  maxdur = 0,                 includedaycrit = 16,
  qwindow=c(0,24),
  mvpathreshold =c(100),
  bout.metric = 6,
  excludefirstlast = FALSE,
  includenightcrit = 16,
  #====================
  # Part 3 + 4
  #====================
  def.noc.sleep = 1,
  outliers.only = TRUE,
  criterror = 4,
  do.visual = TRUE,
  #====================
  # Part 5
  #====================
  threshold.lig = c(30), threshold.mod = c(100),  threshold.vig = c(400),
  boutcriter = 0.8,      boutcriter.in = 0.9,     boutcriter.lig = 0.8,
  boutcriter.mvpa = 0.8, boutdur.in = c(1,10,30), boutdur.lig = c(1,10),
  boutdur.mvpa = c(1),
  includedaycrit.part5 = 2/3,
  #====================
  # Visual report
  #====================
  timewindow = c("WW"),
  visualreport=TRUE)
```

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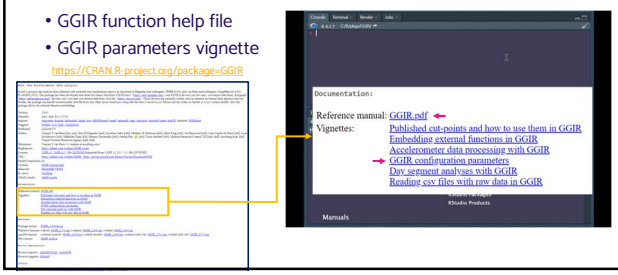
Arguments documentation

- GGIR function help file
- GGIR parameters vignette

https://CRAN.R-project.org/package=GGIR



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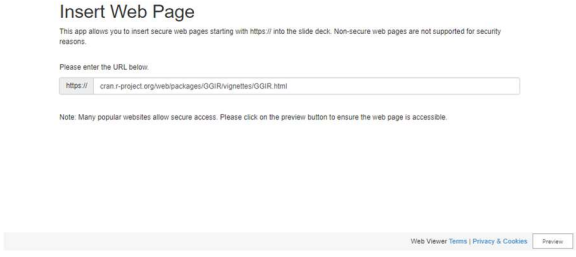
Vignette example



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Open-Source Software

- Increases reproducibility
- Increases transparency
- Supports community efforts to develop new methods

Strengths

Challenges

- Free software does not maintain itself. Therefore, maintenance depends on community.

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Run GGIR for first time

Download file: https://bit.ly/3OGtwsq

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General arguments

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel  = TRUE,
    [...]
    )
```

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel  = TRUE,
    [...]
    )
```

mode

Numeric (default = 1:5). Specify which of the five parts need to be run, e.g., mode = 1 makes that g.part1 is run; or mode = 1:5 makes that the whole GGIR pipeline is run, from g.part1 to g.part5.

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel  = TRUE,
    [...]
    )
```

studyname

Character (default = c()). If the datadir is a folder, then the study will be given the name of the data directory. If datadir is a list of filenames then the studyname as specified by this input argument will be used as name for the study.

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel  = TRUE,
    [...]
    )
```

desiredtz

Character (default = "", i.e., system timezone). Timezone in which device was configured and experiments took place. If experiments took place in a different timezone, then use this argument for the timezone in which the experiments took place and argument configtz to specify where the device was configured. See also http://en.wikipedia.org/wiki/Zone.tab

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "", # http://en.wikipedia.org/wiki/Zone.tab
```

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "Europe/London", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel = TRUE,
    [...]
    )
```

desiredtz

Character (default = "", i.e., system timezone). Timezone in which device was configured and experiments took place. If experiments took place in a different timezone, then use this argument for the timezone in which the experiments took place and argument configtz to specify where the device was configured. See also http://en.wikipedia.org/wiki/Zone.tab

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Running GGIR

General settings

idloc = 1

- 05_(6dias)CLE1B39120023 (2019-04-09).gt3x
- 06_CLE1B39120004 (2019-06-25).gt3x
- 08_MOS2D30160079 (2019-05-31).gt3x
- 09_MOS2D30160079 (2019-04-30).gt3x
- 011_NEO1F10120227 (2019-05-23).gt3x
- 013_CLE1B38120880 (2019-03-28).gt3x
- 015_CLE1B39120023 (2019-03-26).gt3x

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "Europe/London", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel = TRUE,
    [...]
    )
```

idloc

Numeric (default: idloc = 1). If idloc = 1 the code assumes that ID number is stored in the obvious header field. Note that for ActiGraph data the ID is never stored in the file header. For value set to 2, 5, 6, and 7, GGIR looks at the filename and extracts the character string preceding the first occurrence of a '_' (idloc = 2), ' ' (space, idloc = 5), '.' (dot, idloc = 6), and '-' (idloc = 7), respectively. You may have noticed that idloc 3 and 4 are skipped, they were used for one study in 2012, and not actively maintained anymore, but because it is legacy code not omitted.

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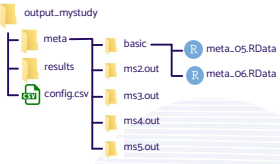
Running GGIR

General settings

- 05_(6dias)CLE1B39120023 (2019-04-09).gt3x
- 06_CLE1B39120004 (2019-06-25).gt3x
- 08_MOS2D30160079 (2019-05-31).gt3x
- 09_MOS2D30160079 (2019-04-30).gt3x
- 011_NEO1F10120227 (2019-05-23).gt3x
- 013_CLE1B38120880 (2019-03-28).gt3x
- 015_CLE1B39120023 (2019-03-26).gt3x

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "Europe/London", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel = TRUE,
    [...]
    )
```



overwrite

Boolean (default = FALSE). Do you want to overwrite analysis for which milestone data exists? If overwrite=FALSE, then milestone data from a previous analysis will be used if available and visual reports will not be created again.

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Running GGIR

General settings

```
GGIR(
    # general settings
    datadir = "C:/mystudy/mydata",
    outputdir = "D:/myoutput",
    mode = c(1, 2, 3, 4, 5),
    studyname = "GGIRtraining",
    desiredtz = "Europe/London", # http://en.wikipedia.org/wiki/Zone.tab
    idloc = 2,
    overwrite = FALSE,
    do.parallel = TRUE,
    [...]
    )
```

do.parallel

Boolean (default = TRUE). whether to use multi-core processing (only works if at least 4 CPU cores are available).

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Data quality

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The GGIR pipeline

Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • **Data quality** • Extracts features	• **Data quality** • Descriptive analysis • Reports (csv files)	• Sleep analysis • Sustained inactivity periods	• Sleep analysis • Sleep period time • Reports (csv files)	• Full-day time-use análisis • Reports (csv files)

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Data quality

- **Calibration of the accelerations**
- Invalid or implausible accelerations
  - Nonwear
  - Signal clipping

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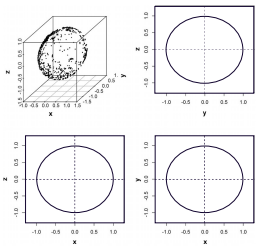
Sensor auto-calibration in GGIR

- Acceleration sensors are calibrated to *g* in factory.
- Calibration may be imperfect



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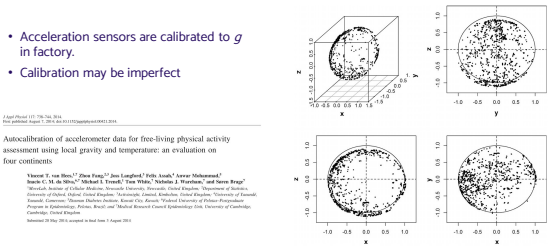
Sensor auto-calibration in GGIR

- Acceleration sensors are calibrated to *g* in factory.
- Calibration may be imperfect



J Appl Physiol 117: 738–744, 2014.
First published August 7, 2014; doi:10.1152/japplphysiol.00421.2014.

Autocalibration of accelerometer data for free-living physical activity assessment using local gravity and temperature: an evaluation on four continents

Vincent T. van Hees,[1,2] Zhou Fang,[3,4] Jess Langford,[5] Felix Assah,[6] Anwar Mohammad,[7] Inacio C. M. da Silva,[8,9] Michael J. Trenell,[5] Tom White,[1] Nicholas J. Wareham,[1] and Søren Brage[1]
[1]MRC Epidemiology Unit, Institute of Metabolic Science, University of Cambridge, Cambridge, United Kingdom; [2]Accelerometer Consulting, Haarlem, Netherlands; [3]Department of Statistics, University of Warwick, Coventry, United Kingdom; [4]Warwick Medical School, University of Warwick, Coventry, United Kingdom; [5]Institute of Cellular Medicine, Newcastle University, Newcastle, United Kingdom; [6]Department of Statistics, Faculty of Economics and Management Science, Kenyatta University, Nairobi, Kenya; [7]Diabetes Institute, Kuwait City, Kuwait; [8]Federal University of Pelotas Postgraduate Program in Epidemiology, Pelotas, Brazil; and [9]Medical Research Council Epidemiology Unit, University of Cambridge, Cambridge, United Kingdom

Submitted 28 May 2014; accepted in final form 5 August 2014

van Hees et al. 2014, doi: 10.1152/japplphysiol.00421.2014

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Data quality

- Calibration of the accelerations
- Invalid or implausible accelerations
  - **Nonwear**
  - Signal clipping

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Non-wear time detection

```
GGIR(# general settings
  [...]
  # data quality and metrics
  windowsizes = c(5, 900, 3600)
  [...])
```

1. Standard deviation per axis per time window [1]
   - IF in at least 2 sensors:
     - standard deviation per hour [3600 seconds] ≈ noise (noise threshold specific for each brand)
     - Difference between minimum and maximum value < threshold
     - in at least 2 sensor axes
   - THEN:
     - Classification ⇒ not worn
2. In 2013 [2] enhanced with:
   - Overlapping windows (default = 15 min [900 seconds])
   - Filter out 'wear' surrounded by a lot of non-wear [2]

1. van Hees et al. 2011, doi: 10.1371/journal.pone.0022922
2. van Hees et al. 2013, doi: 10.1371/journal.pone.0061691 (in supplementary material)

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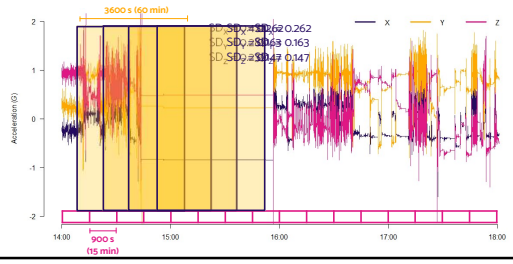
Non-wear time detection

Device noise = 13 *mg* (0.013 *g*)

```
GGIR(# general settings
  [...]
  # data quality and metrics
  windowsizes = c(5, 900, 3600)
  [...])
```



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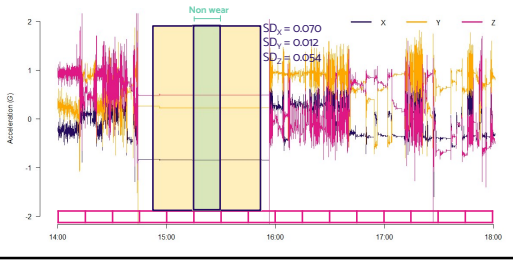
Non-wear time detection

Device noise = 13 *mg* (0.013 *g*)

```
GGIR(# general settings
  [...]
  # data quality and metrics
  windowsizes = c(5, 900, 3600)
  [...])
```



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Data quality

- Calibration of the accelerations
- Invalid or implausible accelerations
  - Nonwear
  - **Signal clipping**

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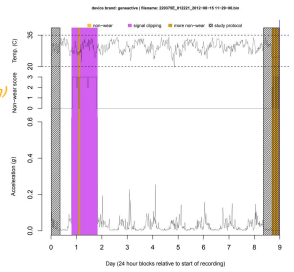
Signal clipping recognition

1. Clipping – acceleration close to dynamic range
2. If 80% of time window *(default 15 min)* close to dynamic range

```
GGIR(# general settings
  [...]
  # data quality and metrics
  windowsizes = c(5, 900, 3600)
  [...])
```



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The GGIR()

Data quality

```
GGIR(
  [...]
  windowsizes = c(5, 900, 3600),
  [...])
```

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Acceleration metrics

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The GGIR pipeline

Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • Data quality • Extracts metrics	• Data quality • Descriptive analysis • Reports (csv files)	• Sleep analysis • Sustained inactivity periods	• Sleep analysis • Sleep period time • Reports (csv files)	• Full-day time-use análisis • Reports (csv files)

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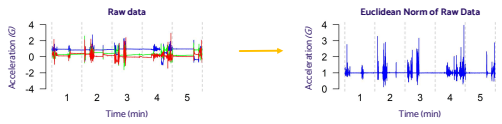
Euclidean Norm

X	Y	Z
-0.510	0.144	-0.850
-0.510	0.144	-0.845
-0.510	0.144	-0.850
-0.507	0.144	-0.845
-0.510	0.144	-0.850
-0.510	0.144	-0.845
-0.510	0.144	-0.845
-0.513	0.144	-0.842
-0.510	0.144	-0.845
-0.510	0.144	-0.845

EN
1.002
0.997
1.002
0.996
1.002
0.997
0.997
0.996
0.997
0.997

Euclidean Norm (Vector Magnitude)

$$EN = \sqrt{x^2 + y^2 + z^2}$$



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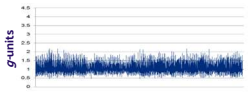
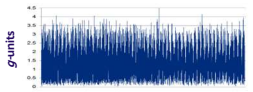
Euclidean Norm





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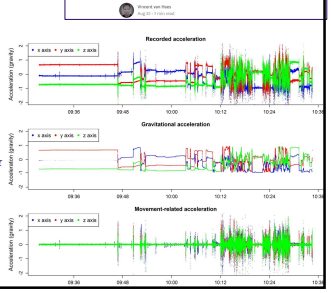
Metrics in GGIR

- Key: Separate gravitational from movement-related acceleration
- For example orientation of the z-axis (z-angle):

$$\left(\tan^{-1}\frac{acc_{z\_rollmedian}}{\sqrt{acc_{x\_rollmedian}{}^2 + acc_{y\_rollmedian}{}^2}}\right) \cdot 180/\pi$$

Blog post:

Ten Misunderstandings surrounding Information Extraction from Wearable Accelerometer data



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Default ENMO metric in GGIR

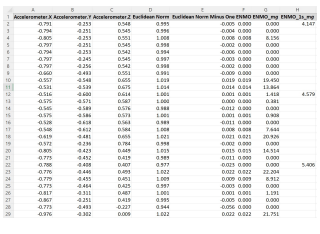
Formula:

$$\max\left\{\sqrt{acc_x{}^2 + acc_y{}^2 + acc_z{}^2} - 1{,}0\right\}$$

Broken down:

1. Euclidean norm:
   $$EN = \sqrt{x^2 + y^2 + z^2}$$
2. Substract 1*g*: $EN - 1$
3. **when** (EN – 1) < 0 **replace by** 0
4. $g \rightarrow mg$
5. Average per epoch

ENMOa: If ENMO < 0 → |ENMO|



59

Acceleration metrics in GGIR

Magnitude-based removal of gravity
- ENMO
- ENMOa
- LFENMO

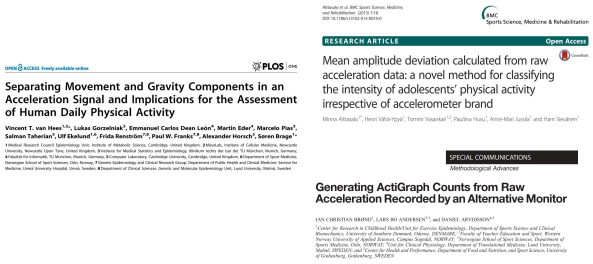
No attempt to remove gravity
- EN
- LF_X, LF_Y, LF_Z
- LFEN

Frequency-content based removal of gravity
- BFEN, BF_X, BF_Y, BF_Z
- HFEN, HF_X, HF_Y, HF_Z
- $HFEN_+$
- MAD
- (Brond counts)
- Neishabouri counts

Zero-crossing
- Zero-crossing counts
  - ZC_X, ZC_Y, ZC_Z

60

Literature about metrics in GGIR



PLOS ONE

Separating Movement and Gravity Components in an Acceleration Signal and Implications for the Assessment of Human Daily Physical Activity

Vincent T. van Hees et al.

BMC Sports Science, Medicine & Rehabilitation

RESEARCH ARTICLE — Open Access

Mean amplitude deviation calculated from raw acceleration data: a novel method for classifying the intensity of adolescents' physical activity irrespective of accelerometer brand

Minna Altavalo et al.

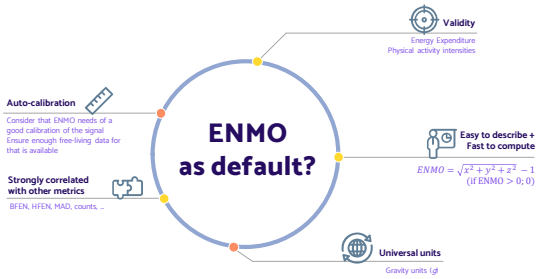
SPECIAL COMMUNICATIONS
Methodological Advances

Generating ActiGraph Counts from Raw Acceleration Recorded by an Alternative Monitor

IAN CHRISTIAN BRØND et al.

61

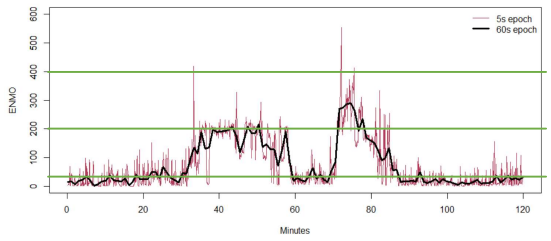
ENMO as default?



62

Epoch length

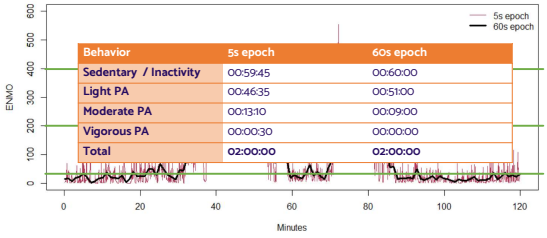
```
GGIR(# general settings
  [...]
  # data quality and metrics
  windowsizes = c(5, 900, 3600),
  [...])
```



64

Epoch length

```
GGIR(# general settings
  [...]
  # data quality and metrics
  windowsizes = c(5, 900, 3600),
  [...])
```



Behavior	5s epoch	60s epoch
Sedentary / Inactivity	00:59:45	00:60:00
Light PA	00:46:35	00:51:00
Moderate PA	00:13:10	00:09:00
Vigorous PA	00:00:30	00:00:00
Total	**02:00:00**	**02:00:00**

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Why do we aggregate per epoch?

- Reduces dependency on sampling frequency, which varies between studies
- Evidence on the value of raw accelerometer data primarily based on epoch aggregates

66

The GGIR()

Acceleration metrics

```
GGIR(
    [...]
    windowsizes = c(5, 900, 3600),
    part5_agg2_60sec = TRUE,
    do.enmo = TRUE,
    do.enmoa = FALSE,
    do.anglex = FALSE,
    do.angley = FALSE,
    do.anglez = TRUE,
    # [see all "do..." metrics]
    [...])
```

Accelting

67

?

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Study protocol

www.accelting.com

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The GGIR pipeline

Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • Data quality • Extracts features	• Data quality • **Descriptive analysis** • Reports (csv files)	• Sleep analysis • Sustained inactivity periods	• Sleep analysis • Sleep period time • Reports (csv files)	• Full-day time-use analysis • Reports (csv files)

70

Need to select/mask data

- Non-wear detection may not be perfect
  - Accelerometer may be in the mail
  - Accelerometer may be left in a bag
  - Recording is expected to run longer than wear instruction
- Some days may be expected to include non-representative data
  - Participant is invited to come to the clinic

71

Available options in GGIR to select/mask data

- Exclude X hours from start
- Exclude X hours from end
- Exclude all data before first and after last midnight
- Exclude all data before first midnight
- Include X days with the highest activity levels
- Include only first X 24 hour blocks in data
- Include only first X calendar days

Set maximum number of days or calendar days

```
GGIR(
    [...]
    # Study protocol
    maxdur = 0,
    max_calendar_days = 0,
    [...])
```

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The GGIR()

Study protocol

Purpose: analyze all the data available (default)

```
GGIR(
  [...]
  # Study protocol
  strategy = 1,
  hrs.del.start = 0, hrs.del.end = 0,
  [...])
```

strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 1 means select data based on hrs.del.start and hrs.del.end.

Accelting

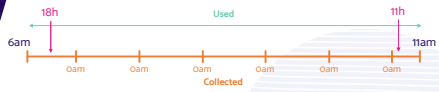
73

The GGIR()

Study protocol

Purpose: Skip first and last day

```
GGIR(
  [...]
  # Study protocol
  strategy = 1,
  hrs.del.start = 0, hrs.del.end = 0,
  [...])
```



strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 1 means select data based on hrs.del.start and hrs.del.end.

Accelting

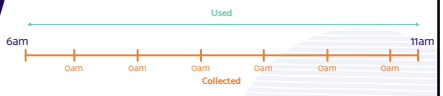
74

The GGIR()

Study protocol

Purpose: Skip first and last day

```
GGIR(
  [...]
  # Study protocol
  strategy = 1,
  hrs.del.start = 18, hrs.del.end = 11,
  [...])
```



strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 1 means select data based on hrs.del.start and hrs.del.end.

Accelting

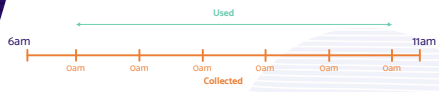
75

The GGIR()

Study protocol

Purpose: Skip first and last day

```
GGIR(
  [...]
  # Study protocol
  strategy = 2,
  hrs.del.start = 18, hrs.del.end = 11,
  [...])
```



strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 2 makes that only the data between the first midnight and the last midnight is used.

Accelting

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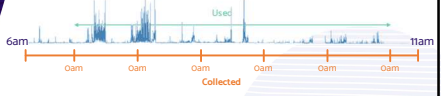
The GGIR()

Study protocol

Purpose: Handle study protocol when recording lasts longer than instructed wear period

```
GGIR(
  [...]
  # Study protocol
  strategy = 3,
  ndayswindow = 3,
  [...])
```



strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 3 only selects the most active X days in the file where X is specified by argument ndayswindow

Accelting

77

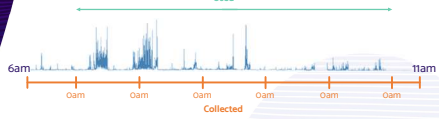
The GGIR()

Study protocol

Purpose: Handle study protocol when recording lasts longer than instructed wear period

```
GGIR(
  [...]
  # Study protocol
  strategy = 3,
  ndayswindow = 3,
  [...])
```

Assumption!
the days of data collection record higher activity than the other days



strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 3 only selects the most active X days in the file where X is specified by argument ndayswindow

Accelting

78

The GGIR()

Study protocol

Purpose: Skip only the first day

```
GGIR(
  [...]
  # Study protocol
  strategy = 4,
  [...])
```

strategy
Numeric (default = 1). How to deal with knowledge about study protocol.
strategy = 4 to only use the data after the first midnight.

Accelting

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The GGIR()

Study protocol

Purpose: divide days at 7am so that we can get one more day into data analysis

```
GGIR(
  [...]
  # Study protocol
  dayborder = 0,
  [...])
```

Accelting

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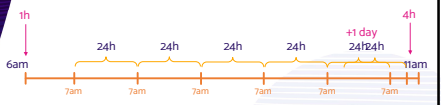
The GGIR()

Study protocol

Purpose: divide days at 7am so that we can get one more day into data analysis

```
GGIR(
  [...]
  # Study protocol
  dayborder = 7,
  [...])
```

Caution!
- Bouts overlapping with dayborder will not be detected
- Definition of days gets compromised



Accelting

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Data cleaning

- How many hours should the device be worn to consider...
  - ✓a valid day? → includedaycrit
  - ✓a valid waking-hours window? → includedaycrit.part5
  - ✓a valid night? → includenightcrit

```
GGIR(
  [...]
  # Data cleaning
  includedaycrit = 16,
  includedaycrit.part5 = 0.667,
  includenightcrit = 16,
  [...])
```

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The GGIR()

Study protocol

```
GGIR(
  [...]
  # Study protocol
  dayborder = 0,
  strategy = 1,
  hrs.del.start = 0, hrs.del.end = 0,
  ndayswindow = 7,
  includedaycrit = 16,
  [...])
```

Accelting

83

?

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Imputation

www.accelting.com

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The GGIR pipeline

Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • Data quality • Extracts features	• Data quality • **Descriptive analysis** • Reports (csv files)	• Sleep analysis • Sustained inactivity periods	• Sleep analysis • Sleep period time • Reports (csv files)	• Full-day time-use analysis • Reports (csv files)

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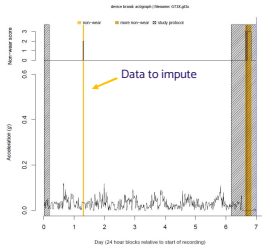
Imputation of invalid data points



87

Imputation of invalid data points

Scenario 1: Monitor was not worn on Thursday from 9:00 to 9:30 AM

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Avg
9:00:00 - 9:00:05	3	4	3	2.2	2	0	1	2.2
9:00:05 - 9:00:10	3	5	2	2	1	0	1	2
9:00:10 - 9:00:15	2	4	2	1.8	1	0	2	1.8
9:00:15 - 9:00:20	3	4	3	2.3	2	1	1	2.3
--	--	--	--	--	--	--	--	--
9:29:55 - 9:30:00	5	2	4	2.8	2	1		2.8

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Imputation of invalid data points

Scenario 2: Monitor was not worn any day from 9:00 to 9:30 AM

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Avg
9:00:00 - 9:00:05	0	0	0	0	0	0	0	0
9:00:05 - 9:00:10	0	0	0	0	0	0	0	0
9:00:10 - 9:00:15	0	0	0	0	0	0	0	0
9:00:15 - 9:00:20	0	0	0	0	0	0	0	0
--	--	--	--	--	--	--	--	--
9:29:55 - 9:30:00	0	0	0	0	0	0	0	0

Do you want to turn off the data imputation?

```
GGIR(...)
  # data quality and metrics
  do.imp = FALSE,
  ...)
```

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?

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Physical activity & acceleration distribution

91

The GGIR pipeline

Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • Data quality • Extracts features	• Data quality • **Descriptive analysis** • Reports (csv files)	• Sleep analysis • Sustained inactivity periods	• Sleep analysis • Sleep period time • Reports (csv files)	• Full-day time-use analysis • Reports (csv files)

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Acceleration distribution

- Quantiles
- Intensity levels
- Intensity gradient

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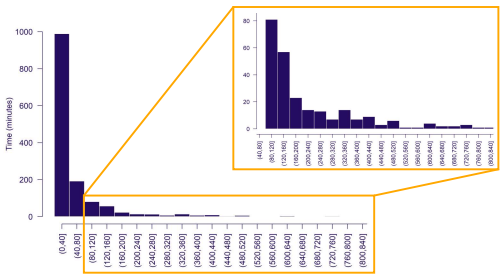
Acceleration distribution



94

Acceleration distribution

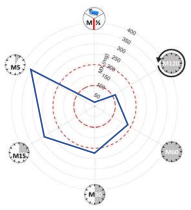
- **Quantiles** → Percentiles of acceleration over the day (e.g., percentile 0.5 refers to 12 hours [i.e., 0.5 over 24 hours])
- Intensity levels
- Intensity gradient

MX metrics M120 = (24 − 2) / 24 ~ 0.917


Sports Medicine - Open

CURRENT OPINION Open Access

Enhancing the value of accelerometer-assessed physical activity: meaningful visual comparisons of data-driven translational accelerometer metrics



95

Acceleration distribution

- **Quantiles** → Percentiles of acceleration over the day (e.g., percentile 0.5 indicates the acceleration threshold over the participants have spent half of the day [i.e., 12 hours])
- Intensity levels
- Intensity gradient

```
GGIR(
  [...]
  # Physical activity and acceleration distribution
  qlevels = c(0.5, 0.7, 0.9, 0.95),
  [...])
```

```
GGIR(
  [...]
  # Physical activity and acceleration distribution
  qlevels = c((24 − 2) / 24,   # M120
              (24 − 1) / 24),  # M60
  [...])
```

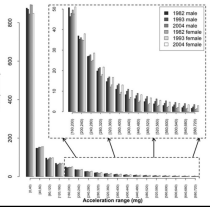
96

Acceleration distribution

- Quantiles
- **Intensity levels** → Time spent in intensity levels, e.g., c(0, 50, 100, 200, 8000)
- Intensity gradient


Original article

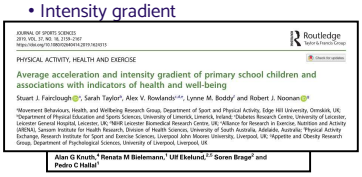
Physical activity levels in three Brazilian birth cohorts as assessed with raw triaxial wrist accelerometry



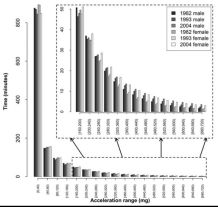
97

Acceleration distribution

- Quantiles
- **Intensity levels** → Time spent in intensity levels, e.g., c(0, 50, 100, 200, 8000)
- Intensity gradient


PHYSICAL ACTIVITY, HEALTH AND EXERCISE

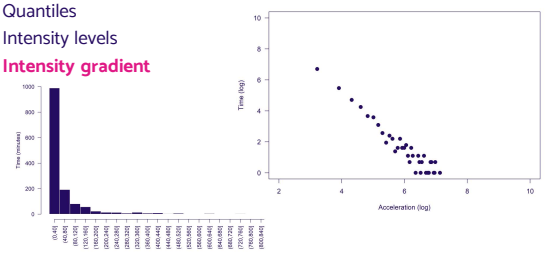
Average acceleration and intensity gradient of primary school children and associations with indicators of health and well-being



98

Acceleration distribution

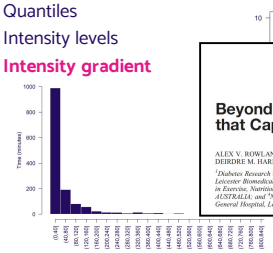
- Quantiles
- Intensity levels
- **Intensity gradient**

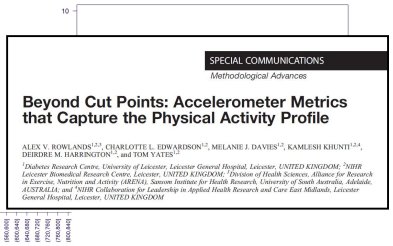


99

Acceleration distribution

- Quantiles
- Intensity levels
- **Intensity gradient**




SPECIAL COMMUNICATIONS

Methodological Advances

Beyond Cut Points: Accelerometer Metrics that Capture the Physical Activity Profile

ALEX V. ROWLANDS[1,2,3], CHARLOTTE L. EDWARDSON[1,2], MELANIE J. DAVIES[1,2], KAMLESH KHUNTI[1,2,4], DEIRDRE M. HARRINGTON[1,2], and TOM YATES[1,2]

[1]*Diabetes Research Centre, University of Leicester, Leicester General Hospital, Leicester, UNITED KINGDOM;* [2]*NIHR Leicester Biomedical Research Centre, Leicester, UNITED KINGDOM;* [3]*Division of Health Sciences, Alliance for Research in Exercise, Nutrition and Activity (ARENA), Sansom Institute for Health Research, University of South Australia, Adelaide, AUSTRALIA; and* [4]*NIHR Collaboration for Leadership in Applied Health Research and Care East Midlands, Leicester General Hospital, Leicester, UNITED KINGDOM*

100

Acceleration distribution

- Quantiles
- Intensity levels
- **Intensity gradient**

```
GGIR(
  [...]
  # Physical activity and acceleration distribution
  qlevels = c(0.5, 0.7, 0.9, 0.95),
  ilevels = c(0, 50, 100, 200, 8000),
  iglevels = 1,
  [...])
```

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The GGIR pipeline

Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • Data quality • Extracts features	• Data quality • **Descriptive analysis** • Reports (csv files)	• Sleep analysis • Sustained inactivity periods	• Sleep analysis • Sleep period time • Reports (csv files)	• **Full-day time-use analysis** • Reports (csv files)

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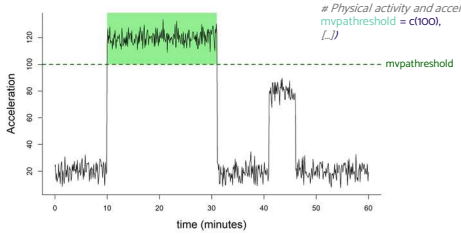
Physical activity in part 2

1. Time above threshold

```
GGIR(
  [...]
  # Physical activity and acceleration distribution
  mvpathreshold = c(100),
  [...])
```



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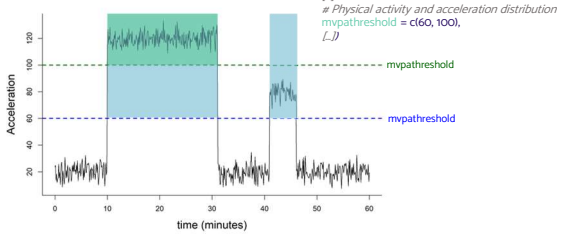
Physical activity in part 2

1. Time above threshold

```
GGIR(
  [...]
  # Physical activity and acceleration distribution
  mvpathreshold = c(60, 100),
  [...])
```



104

Physical activity in part 2

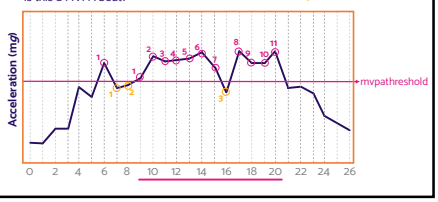
2. Bouts detection:

- mvpathreshold = 100
- boutdur = 10
- boutcriter = 0.8

Time above mvpathreshold without gaps lasting longer than 1 minute = 11 min
Below mvpathreshold = 1 min

Rate $x = \frac{11}{12} = 0.92$

Is this a MVPA bout?



105

Why does GGIR facilitates bout detection?

- Guidelines mainly based:
  - 1-min epoch
  - Data from hip-worn sensors

  ... but bouts might be useful for:
  - 5-s epochs
  - Data from wrist-worn sensors to smooth out spontaneous movements
- Guidelines based on:
  - Specific health outcomes

  ... but bouts might be relevant for:
  - health outcomes not covered by current research
- Bouts might be useful to investigate fragmentation of behavior
- We aim to be neutral in the discussion and try to facilitate all approaches

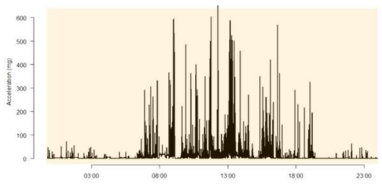
106

Windows definition

The argument **qwindow**

Numeric or character (default = c(0, 24)).

```
GGIR(
  [...]
  qwindow = c(0, 24),
  [...])
```



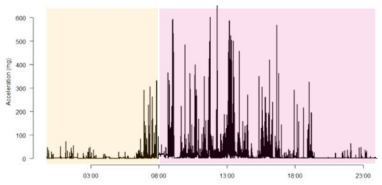
107

Windows definition

The argument **qwindow**

Numeric or character (default = c(0, 24)).

```
GGIR(
  [...]
  qwindow = c(0, 8, 24),
  [...])
```



108

Windows definition

The argument **qwindow**

Numeric or **character** (default = c(0, 24)).

If you want to use a day specific segmentation, then you can set qwindow to be the **full path to activity diary file (csv file)**.

```
GGIR(
    [...]
    qwindow = "C:/mystudy/activitylog.csv",
    [...])
```

ID	Date	PE_1	PE_2	Date	PE_1	PE_2
ID01	20-01-2022	09:00:00	10:00:00	21-01-2022		
ID02	22-01-2022	11:30:00	12:30:00	23-01-2022	09:00:00	10:00:00
ID03	02-02-2022			03-02-2022	10:00:00	11:00:00
ID04	15-01-2022	09:00:00	10:00:00	16-01-2022		
ID05	04-02-2022			05-02-2022	11:30:00	12:30:00

Will only get the 24h indicators

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The GGIR()

Physical activity & distribution

```
GGIR(
    [...]
    # Physical activity and acceleration distribution
    qlevels = c(0.5, 0.7, 0.9, 0.95),
    ilevels = c(0, 50, 100, 200, 8000),
    iglevels = 1,
    mvpathreshold = 100,
    mvpadur = c(1, 5, 10),
    boutcriter = 0.8,
    qwindow = c(0,24),
    [...])
```

Accelting

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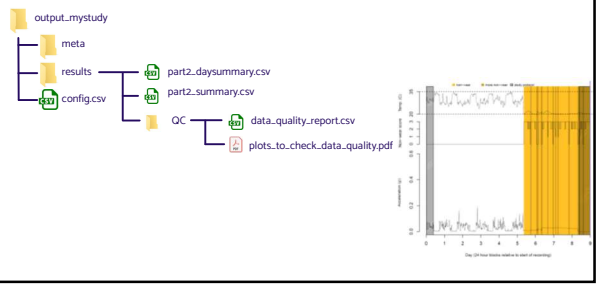
GGIR output part 2



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Assignment 1

1. Open RStudio and an empty script
2. Create a GGIR function call
3. Define datadir and outputdir
   - Tip 1: datadir should specify the path to out demo file
   - Tip 2: outputdir should be an existing folder (different to datadir)
4. Define mode to run GGIR parts 1 and 2
5. Turn off the report generation for GGIR parts 4 and 5
6. Turn off the generation of the visual report
7. Run the script via the source button
8. Advanced: Look up the output and meaning of variables
9. Optional: Try to run GGIR parts 1 and 2 on your own data

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Day Evaluation

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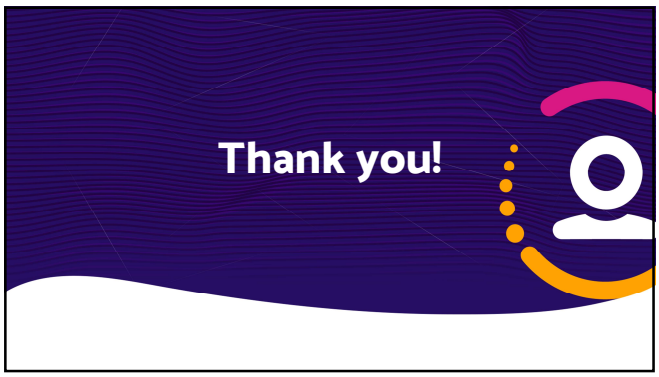

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