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Advancing movement & sleep research

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GGIR training: Day 2

Dr. Vincent van Hees & Dr. Jairo H Migueles
v.vanhees@accelting.com, j.h.migueles@accelting.com

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DECLARATION

- Our aim is to train you to use and understand GGIR
- Flexible to tailor the course to your needs
- Feel free to interrupt the presentation if you have questions
- We will record the video session and share it with you, but ask you not to share it
- We will share slides in PDF

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What will we do today?

- Output part 2
- Exercise 2
- Lecture:
  - Sleep detection
  - Sleep Period Time
    - Automatic algorithms
    - Using sleep logs
  - Other variables
  - GGIR Output
- Question time

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Day 1 recap

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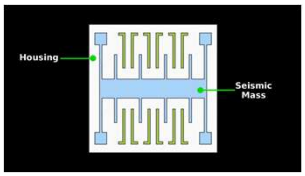
Recap of Day 1

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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Recap of Day 1

- Data Quality
- Acceleration metrics or features
- Adapt GGIR to different study protocols
- Descriptive measures and physical activity

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Configuration Parameters Vignette

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Day Segment Analysis Vignette

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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. Make sure you only analyse data from the first midnight onwards
6. We are only interested in the analysis of the first 3 days.
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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Part 2 Output

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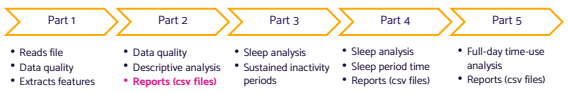
The GGIR pipeline



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Part 2

Output

- meta
  - csv
    - ID01.csv
    - ...
- results
  - QC
    - data_quality_report.csv
    - plot_to_check_data_quality.pdf
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - part2_summary.csv

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Part 2

Output

- meta
  - csv
    - ID01.csv
    - ...
- results
  - QC
    - data_quality_report.csv
    - plot_to_check_data_quality.pdf
  - **part2_daysummary.csv**
  - **part2_daysummary_longformat.csv**
  - part2_summary.csv

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Output from Part 2

Day-level features (wide)

do.report = 2

ID	filename	calendar_date	bodylocation	N valid hours	N hours	weekday	Measurement day	qwindow_ timestamps	qwindow_ names
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24	Wednesday	2	0_8_24	0_8_24
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24	Thursday	3	0_8_24	0_8_24
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24	Friday	4	0_8_24	0_8_24
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23	Saturday	5	0_8_24	0_8_24

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Output from Part 2

Day-level features (wide)

do.report = 2

part2_daysummary.csv

ID	Measurement day	qwindow_ timestamps	mean_ENMO_ mg_0-24hr	MVPA_E5S_T10D_ ENMO_0-24hr	mean_ENMO_ mg_0-8hr	MVPA_E5S_T10D_ ENMO_0-8hr	mean_ENMO_ mg_8-24hr	MVPA_E5S_T10D_ ENMO_8-24hr
11	2	0_8_24	50.297	146.833	5.368	2.167	72.762	144.667
11	3	0_8_24	16.099	51.833	4.024	3.417	22.136	48.417
11	4	0_8_24	38.232	170.417	7.903	8.5	53.396	161.917
11	5	0_8_24	15.085	41.25	7.393	4.167	18.932	37.083

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Output from Part 2

Day-level features (long)

do.report = 2 *# Only if different qwindows are defined (e.g., qwindow = c(0, 8, 24)*

part2_daysummary_longformat.csv

ID	filename	calendar_date	bodylocation	N_valid_ hours	N_hours	N_valid_hours_ in_window	N_hours_ in_window	weekday	Measurement day	qwindow_ timestamps	qwindow_ name
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24	8	8	Wednesday	2	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24	8	8	Thursday	3	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24	8	8	Friday	4	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23	8	8	Saturday	5	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24	16	16	Wednesday	2	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24	16	16	Thursday	3	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24	16	16	Friday	4	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23	15	15	Saturday	5	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24			Wednesday	2	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24			Thursday	3	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24			Friday	4	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23			Saturday	5	00:00-24:00	0-24hr

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Output from Part 2

Day-level features (long)

do.report = 2 *# Only if different qwindows are defined (e.g., qwindow = c(0, 8, 24)*

part2_daysummary_longformat.csv

ID	filename	calendar_date	bodylocation	N_valid_ hours	N_hours	N_valid_hours_ in_window	N_hours_ in_window	weekday	Measurement day	qwindow_ timestamps	qwindow_ name
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24	8	8	Wednesday	2	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24	8	8	Thursday	3	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24	8	8	Friday	4	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23	8	8	Saturday	5	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24	16	16	Wednesday	2	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24	16	16	Thursday	3	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24	16	16	Friday	4	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23	15	15	Saturday	5	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-28T00:00:00+0100	not extracted	24	24			Wednesday	2	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	not extracted	24	24			Thursday	3	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	not extracted	24	24			Friday	4	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	not extracted	23	23			Saturday	5	00:00-24:00	0-24hr

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Output from Part 2

Day-level features (long)

do.report = 2 *# default = c(2, 4, 5) - Only if different qwindows are defined (e.g., qwindow = c(0, 8, 24)*

part2_daysummary_longformat.csv

ID	qwindow_ timestamps	qwindow_ name	mean_ ENMO_mg	MVPA_ES5_ T100_ENMO	MVPA_E1M_ T100_ENMO	MVPA_ES M_ T100_ENMO	MVPA_ES5_B1M80%_ T100_ENMO	MVPA_ES5_B5M80%_ T100_ENMO	MVPA_ES5_B10M80%_ T100_ENMO
11	00:00-8:00	0-8hr	5.368	2.167	0	0	0	0	0
11	00:00-8:00	0-8hr	4.024	3.417	3	0	1.167	0	0
11	00:00-8:00	0-8hr	7.903	8.5	9	10	2.917	0	0
11	00:00-8:00	0-8hr	7.393	4.167	4	0	1.5	0	0
11	08:00-24:00	8-24hr	72.762	144.667	155	140	103.917	54.25	27.417
11	08:00-24:00	8-24hr	22.136	48.417	37	10	15.083	0	0
11	08:00-24:00	8-24hr	53.396	161.917	172	160	114.167	103.833	96.833
11	08:00-24:00	8-24hr	18.932	37.083	19	0	11.417	5.167	0
11	00:00-24:00	0-24hr	50.297	146.833	155	140	103.917	54.25	27.417
11	00:00-24:00	0-24hr	16.099	51.833	40	10	16.25	0	0
11	00:00-24:00	0-24hr	58.232	170.417	181	170	117.083	103.833	96.833
11	00:00-24:00	0-24hr	15.085	41.25	23	0	12.917	5.167	0

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Part 2

Output

- meta
  - csv
    - ID01.csv
    - ...
- results
  - QC
    - data_quality_report.csv
    - plot_to_check_data_quality.pdf
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - **part2_summary.csv**

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Output from Part 2

Person-level features

do.report = 2

part2_summary.csv

ID	device_sn	bodylocation	filename	start_time	startday	samplefreq	device	clipping_ score	meas_dur_dys	complete_ 24hcycle
11	45400	not extracted	011_45400.cwa	2019-03-27T00:00:00+0100	Tuesday	50	axivity	0	6.99	1

All days

ID	N valid WEdays	N valid WKdays	AD_mean_ENMO _mg_0-24hr	AD_MVPA_ES5_ T100_ENMO_0-24hr	AD_mean_ENMO _mg_0-8hr	AD_MVPA_ES5_ T100_ENMO_0-8hr	AD_mean_ENMO _mg_8-24hr	AD_MVPA_ES5_ T100_ENMO_8-24hr
11	2	5	28.809	94.81	6.222	4.083	40.102	90.726

Weekdays

ID	N valid WEdays	N valid WKdays	WD_mean_ENMO _mg_0-24hr	WD_MVPA_ES5_ T100_ENMO_0-24hr	WD_mean_ENMO _mg_0-8hr	WD_MVPA_ES5_ T100_ENMO_0-8hr	WD_mean_ENMO _mg_8-24hr	WD_MVPA_ES5_ T100_ENMO_8-24hr
11	2	5	33.197	111.05	5.471	4	47.06	107.05

Weekend days

ID	N valid WEdays	N valid WKdays	WE_mean_ENMO _mg_0-24hr	WE_MVPA_ES5_ T100_ENMO_0-24hr	WE_mean_ENMO _mg_0-8hr	WE_MVPA_ES5_ T100_ENMO_0-8hr	WE_mean_ENMO _mg_8-24hr	WE_MVPA_ES5_ T100_ENMO_8-24hr
11	2	5	17.838	54.208	8.099	4.292	22.707	49.917

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Part 2

Anything else?

- Descriptives of behaviour
  - Intensity gradient (Rowlands et al.)
  - MX metrics
    - M5 & L5 metrics
  - Interdaily stability (IS)
  - Intradaily variability (IV)
- Output
  - Weighted weekdays and weekend days

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Part 2

Output

- meta
  - csv
    - ID01.csv
    - ...
- results
  - **QC**
    - **data_quality_report.csv**
    - **plot_to_check_data_quality.pdf**
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - part2_summary.csv

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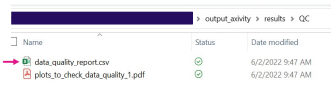
Output from Part 2

Data quality reports



filename	cal.error.start	cal.error.end	QCmessage
meta_011_45400.cwa.RData	0.12640	0.00466	recalibration done, no problems detected
meta_013_42151.cwa.RData	0.05089	0.00286	recalibration done, no problems detected
meta_015_44944.cwa.RData	0.08323	0.00355	recalibration done, no problems detected
meta_017_42151.cwa.RData	0.03493	0.00270	recalibration done, no problems detected

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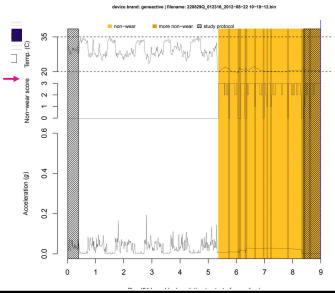
Output from Part 2

Data quality reports

do.part2.pdf = TRUE *# default = TRUE*



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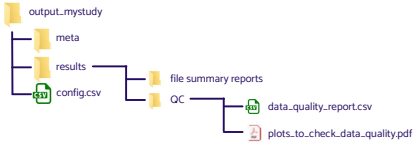
The GGIR pipeline (output folder)



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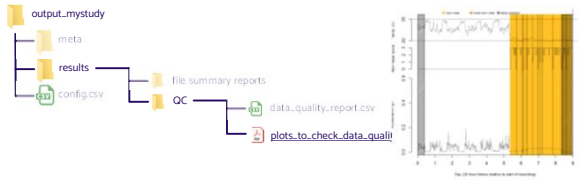
The GGIR pipeline (output folder)



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Part 2

Output

- meta
  - **csv**
    - **ID01.csv**
    - …
- results
  - QC
    - data_quality_report.csv
    - plot_to_check_data_quality.pdf
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - part2_summary.csv

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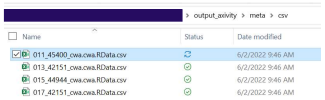
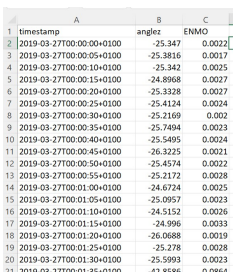
Output from Part 2

Epoch-level features

epochvalues2csv = TRUE *# default = FALSE!!*



Signal metrics only!
For time series of sleep and bout classification, see GGIR part 5 (as discussed on day 3)



	A	B	C
1	timestamp	anglez	ENMO
2	2019-03-27T00:00:00+0100	-35.347	0.0022
3	2019-03-27T00:00:05+0100	-25.3816	0.0017
4	2019-03-27T00:00:10+0100	-25.342	0.0025
5	2019-03-27T00:00:15+0100	-24.8968	0.0027
6	2019-03-27T00:00:20+0100	-25.3328	0.0027
7	2019-03-27T00:00:25+0100	-25.4124	0.0024
8	2019-03-27T00:00:30+0100	-25.2169	0.002
9	2019-03-27T00:00:35+0100	-25.7494	0.0023
10	2019-03-27T00:00:40+0100	-25.5495	0.0024
11	2019-03-27T00:00:45+0100	-26.3225	0.0021
12	2019-03-27T00:00:50+0100	-25.4574	0.0022
13	2019-03-27T00:00:55+0100	-25.2172	0.0028
14	2019-03-27T00:01:00+0100	-24.6724	0.0025
15	2019-03-27T00:01:05+0100	-25.0957	0.0023
16	2019-03-27T00:01:10+0100	-24.5152	0.0026
17	2019-03-27T00:01:15+0100	-24.996	0.0033
18	2019-03-27T00:01:20+0100	-26.0688	0.0019
19	2019-03-27T00:01:25+0100	-25.278	0.0028
20	2019-03-27T00:01:30+0100	-25.5993	0.0023

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Assignment 2 (build on assignment 1 script)

1. Derive MX metrics (Rowlands et al.): M120, M60, M30, M5
2. Derive intensity levels: 0, 50, 100, 200, 400, 800
3. Derive the intensity gradient
4. Derive the MVPA thresholds: 100 and 140

5. Advanced: Calculate these variables over the following Windows:
   - From 0 am to 7am
   - From 7am to 10pm
   - From 10pm to 0am next day

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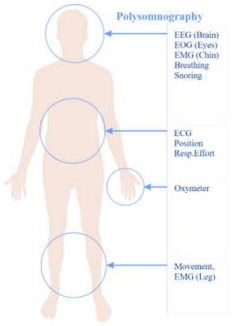
Polysomnography

Lab-based

- Reference method for sleep assessment
- Combination of monitors:
  - EEG
  - Heart rate
  - Gases exchange
  - Blood oxygen levels
  - Others
- Specialist go over the signal and classify 30-sec epochs into sleep stages



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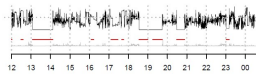
Accelerometer-based sleep assessment

Free living

- **Challenge 1:** distinguish sleep, wake, and non-wear
  - Lack of movement
  - Lack of postural change



- Term: Sustained Inactivity Bout, abbreviated as SIB

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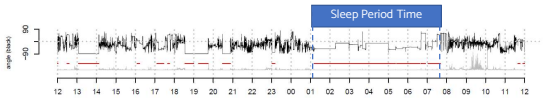
Accelerometer-based sleep assessment

Free living

- **Challenge 2:** separate daytime and nighttime (**Sleep Period Time**)
  - Automatic algorithms
  - Sleep diaries



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Sleep/rest detection

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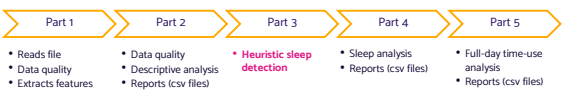
The GGIR pipeline



- Part 1: Reads file; Data quality; Extracts features
- Part 2: Data quality; Descriptive analysis; Reports (csv files)
- Part 3: **Heuristic sleep detection**
- Part 4: Sleep analysis; Reports (csv files)
- Part 5: Full-day time-use analysis; Reports (csv files)

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The GGIR()

Sleep analysis

```
GGIR(
  [...]
  # Sleep analysis
  HASIB.algo = "vanHees2015",
  [...])

GGIR(
  [...]
  # Sleep analysis
  HASIB.algo = "Sadeh1994",
  [...])

GGIR(
  [...]
  # Sleep analysis
  HASIB.algo = "ColeKripke1992",
  [...])

GGIR(
  [...]
  # Sleep analysis
  HASIB.algo = "Galland2012",
  [...])
```

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Rest/Wake detection

Algorithms

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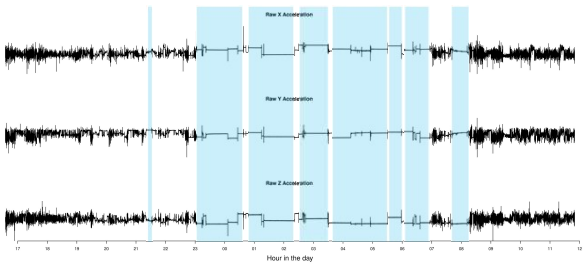
Rest/Wake detection



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Rest/Wake detection

"vanhees2015"

- Interpretable as lack of posture change and lack of movement, regardless of agreement with neurological sleep
- Angle is a more visual concept than magnitude of acceleration

Angle of z-axis (independent of attachment orientation across brands)

[van Hees et al. PLoSONE 2015, doi: 10.1371/journal.pone.0142533]

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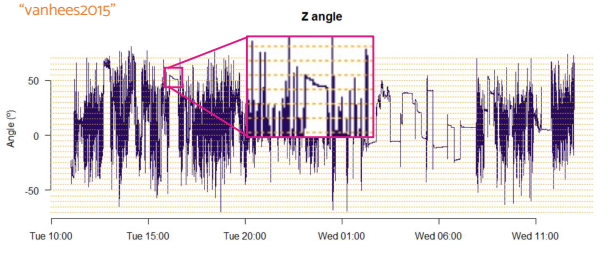
Rest/Wake detection

"vanhees2015"



van Hees et al. PLoSONE 2015, doi: 10.1371/journal.pone.0142533

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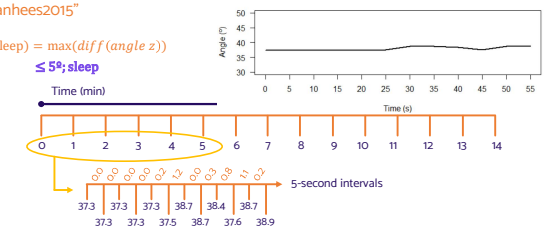
Rest/Wake detection

"vanhees2015"

$p(\text{Sleep}) = \max(diff(angle\ z))$

≤ 5°: sleep



van Hees et al. PLoSONE 2015, doi: 10.1371/journal.pone.0142533

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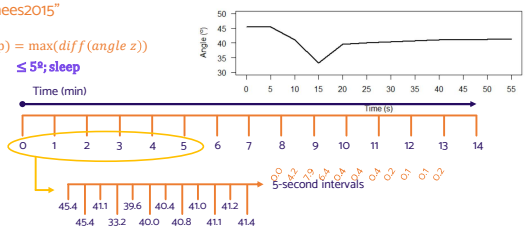
Rest/Wake detection

"vanhees2015"

$p(\text{Sleep}) = \max(diff(angle\ z))$

$\leq 5^{o}$; sleep

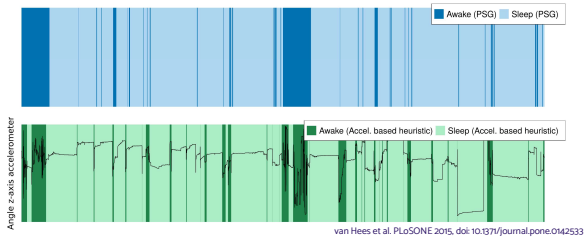


van Hees et al. PLoSONE 2015, doi: 10.1371/journal.pone.0142533

45

Rest/Wake detection

"vanhees2015"



van Hees et al. PLoSONE 2015, doi: 10.1371/journal.pone.0142533

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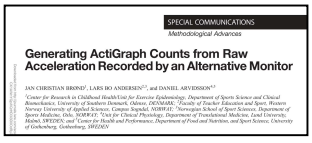
Rest/Wake detection

Count-based algorithms

- Sadeh1994
- ColeKripke1992
- Galland2012


```
GGIR(
  [...]
  # Acceleration metrics
  do.zcx = TRUE, do.zcy = TRUE, do.zcz = TRUE,
  do.neishabouricounts= TRUE,
  # Sleep analysis
  HASIB.algo = "Sadeh1994",
  Sadeh_axis = "Y",
  [...])
```



SPECIAL COMMUNICATIONS
Methodological Advances

Generating ActiGraph Counts from Raw Acceleration Recorded by an Alternative Monitor

For further reflection on count calculation see: https://cran.r-project.org/web/packages/GGIR/vignettes/GGIR.html#56_Sleep_analysis

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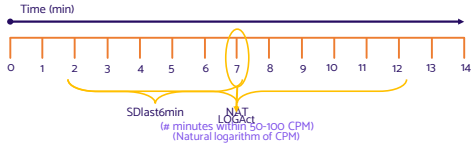
Rest/Wake detection

"Sadeh1994"

$p(\text{Sleep}) = 7.601 - 0.065 \cdot MeanCPM5\ \text{min} - 1.08 \cdot \text{NAT} - 0.056 \cdot \text{SDlast6min} - 0.703 \cdot \text{LOGAct}$

≥ 0; sleep



Sadeh et al. Sleep 1994, doi: 10.1093/sleep/17.3.201

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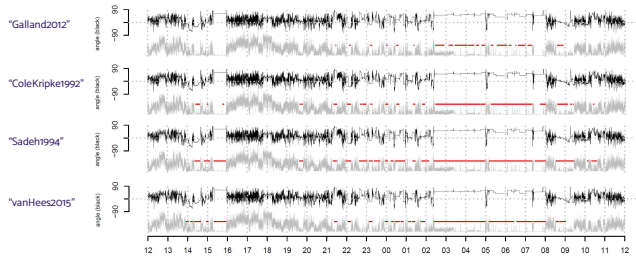
Rest/Wake detection



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Rest/Wake detection

Summary of algorithms to detect SIBs in GGIR

Algorithm	Population	Device	Attachment site
vanHees2015	**Adults** n = 28 (11 female), 21-72 yr	GENEActiv	Wrist
Sadeh1994	**Adults** n = 20 (11 female), 21-25 yr **Children** n = 16 (11 female), 10-16 yr	AMI Motionlogger actigraph	Wrist
ColeKripke1992	**Adults** n = 41 (9 female), 50 ± 15 yr	AMI Motionlogger actigraph	Wrist
Galland2012	**Infants** n = 33 (9 female), 10-22 weeks	Actical	Shin

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The GGIR()

Sleep analysis

```
GGIR(
    [...]
    # Acceleration metrics
    do.zcx = TRUE, do.zcy = TRUE, do.zcz = TRUE,
    do.brondcounts= TRUE,
    # Sleep analysis
    HASIB.algo = "Sadeh1994",
    Sadeh_axis = "Y",
    [...])
```

Accelting

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What is the best definition of a sustained inactivity bout in GGIR? *(Single choice)*

- ❑ A period of 5 minutes in which the participant is asleep
- ❑ A period of time in which we observe very low movement or posture change in the accelerometer signal and, therefore, might indicate sleep
- ❑ It is a sedentary bout with especially harmful consequences for health

54

What is the best definition of a sustained inactivity bout in GGIR? *(Single choice)*

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- ☑ A period of time in which we observe very low movement or posture change in the accelerometer signal and, therefore, might indicate sleep
- ❑ It is a sedentary bout with especially harmful consequences for health

55

What algorithms can you use in GGIR to detect rest/wake status? *(Multiple choice)*

- ❑ van Hees 2015, based on the Z-angle
- ❑ Sadeh 1994, based on zero-crossing counts
- ❑ Cole-Kripke 1992, based on zero-crossing counts
- ❑ Galland 2012, based on zero-crossing or ActiGraph counts

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What algorithms can you use in GGIR to detect rest/wake status? *(Multiple choice)*

- ☑ van Hees 2015, based on the Z-angle
- ☑ Sadeh 1994, based on zero-crossing counts
- ☑ Cole-Kripke 1992, based on zero-crossing counts
- ☑ Galland 2012, based on zero-crossing or ActiGraph counts

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Sleep Period Time

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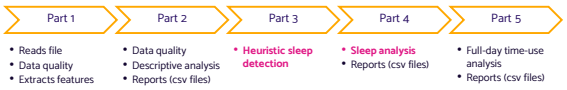
The GGIR pipeline



- Reads file
- Data quality
- Extracts features

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

- **Heuristic sleep detection**

- **Sleep analysis**
- Reports (csv files)

- Full-day time-use analysis
- Reports (csv files)

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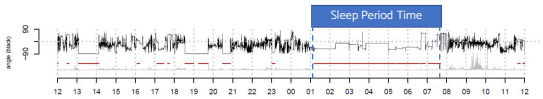
Accelerometer-based sleep assessment

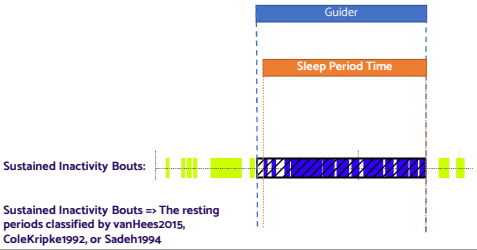
Free living

- **Challenge 2:** separate daytime and nighttime (**Sleep Period Time**)
  - Automatic algorithms
  - Sleep diaries



61

"Guiders" to guide SPT window detection



Sustained Inactivity Bouts => The resting periods classified by vanHees2015, ColeKripke1992, or Sadeh1994

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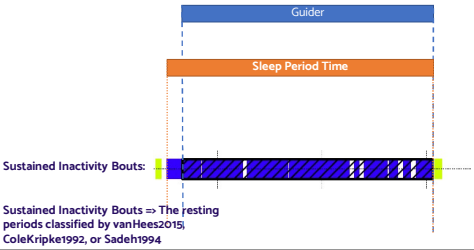
"Guiders" to guide SPT window detection



Sustained Inactivity Bouts => The resting periods classified by vanHees2015, ColeKripke1992, or Sadeh1994

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Guiders

Guider	Definition	Relevant arguments to use it
setwindow		
L5+/-12		
HDCZA		
HorAngle		
sleep log		

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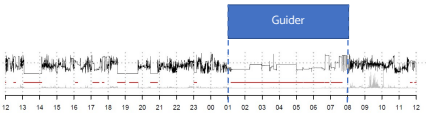
(Fixed) Set window

```
GGIR(
    [...]
    # Sleep analysis
    def.noc.sleep = c(1, 8),
    [...])
```



[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

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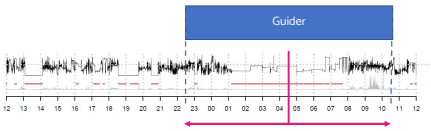
L5 ± 12 hours

1. Calculate the central point of the 5 consecutive hours with the lowest activity levels
2. Take the 12-hour interval centered at that time as the guider

```
GGIR(
  [...]
  # Sleep analysis
  def.noc.sleep = c(),
  [...])
```



[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

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The GGIR()

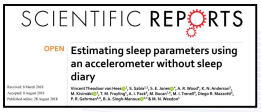
Sleep analysis

```
GGIR(
  [...]
  # Sleep analysis
  def.noc.sleep = 1,
  HASPT.algo = "HDCZA",
  [...])
```

→ Guider: HDCZA

```
GGIR(
  [...]
  # Sleep analysis
  def.noc.sleep = 1,
  HASPT.algo = "HorAngle",
  [...])
```

→ Guider: HorAngle


SCIENTIFIC REPORTS

OPEN Estimating sleep parameters using an accelerometer without sleep diary

doi: 10.1038/s41598-018-31266-z

Accelting

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HDCZA algorithm


SCIENTIFIC REPORTS

OPEN Estimating sleep parameters using an accelerometer without sleep diary

- No convincing gold standard exists for free-living conditions
- Heuristic method, 'trained' with unlabeled data from 20 random individuals.

Change in wrist angle over time invariant to sensor orientation

5 second rolling medians of raw signals x, y, z → $angle_z = \left(\tan^{-1}\left(\frac{a_z}{\sqrt{a_x^2 + a_y^2}}\right)\right)\frac{180}{\pi}$ → Consecutive 5 second averages → Absolute difference between successive values → Rolling median using 5 minute window

Detect when values < (10^{th} percentile of values in day* · 15) → Keep blocks > 30 minutes → Include time gaps < 60 minutes → Longest block in day* → Guider-window

Step 10

Threshold per individual

My assumptions about what a sleep period is

* Defined from noon to noon

[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

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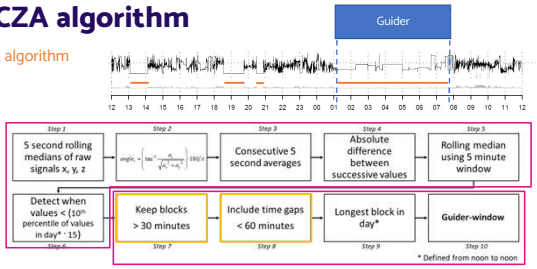
HDCZA algorithm

HDCZA algorithm



[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

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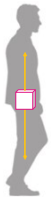
The GGIR()

Sleep analysis

```
GGIR(
  [...]
  # Sleep analysis
  def.noc.sleep = 1,
  HASPT.algo = "HorAngle",
  sensor.location = "hip",
  longitudinal_axis = 2,   # if not provided it will be estimated
  [...])
```



Accelting

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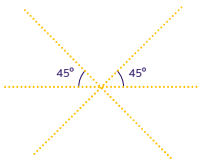
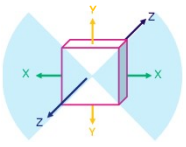
HorAngle algorithm





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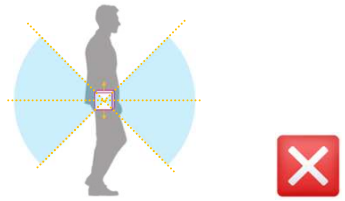
HorAngle algorithm



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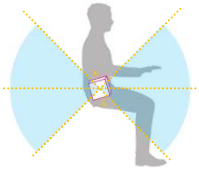
HorAngle algorithm



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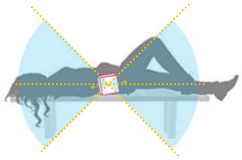
HorAngle algorithm



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HorAngle algorithm

Change in wrist angle over time invariant to sensor orientation

DETECTION OF PERIODS OF THE DAY LYING DOWN

Keep blocks > 30 minutes → Include time gaps < 60 minutes → Longest block in day* → Guider-window

Step 10

Threshold per individual

My assumptions about what a sleep period is

* Defined from noon to noon

[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

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The GGIR()

Sleep analysis

```
GGIR(
    [...]
    # Sleep analysis
    def.noc.sleep = c(23, 7),
    [...])
```
→ Guider: setwindows

```
GGIR(
    [...]
    # Sleep analysis
    def.noc.sleep = c(),
    [...])
```
→ Guider: L5+/-12

```
GGIR(
    [...]
    # Sleep analysis
    def.noc.sleep = 1,
    HASPT.algo ="HDCZA",
    [...])
```
→ Guider: in-built algorithms

Accelting

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The GGIR()

Sleep analysis guided by sleeplog

```
GGIR(
    [...]
    # Sleep analysis
    def.noc.sleep = 1,
    HASPT.algo = "HDCZA",
    loglocation = "C:/mysudy/mysleeplog.csv",
    colid = 1, colnl = 1, nnights = 7,
    sleeplosep = ",",
    sleepwindowType  = "TimeInBed",
    [...])
```

Accelting

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NOTE: If night is not available, in-built algorithms will be used (def.noc.sleep & HASPT.algo)

Basic sleeplog

nnights = 4

colid = 1

coln1 = 2

ID	Onset_n1	Wakeup_n1	Onset_n2	Wakeup_n2	Onset_n3	Wakeup_n3	Onset_n4	Wakeup_n4
01	23:00:00	07:00:00	23:45:00	08:20:00	23:15:00	08:00:00	00:30:00	
02	22:30:00	07:30:00	22:35:00	07:00:00	23:45:00	09:05:00	23:44:00	09:00:00
03	23:45:00	07:10:00	00:02:00	08:30:00	22:50:00	07:25:00	23:00:00	07:38:00
04	00:10:00	09:00:00				07:30:00	00:25:00	09:10:00

As documented in: https://cran.r-project.org/web/packages/GGIR/vignettes/GGIR.html

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Advanced sleeplog

nnights = ...

colid = 1

coln1 = 2

ID	D1_date	D1_wakeup	D1_inbed	D1_nap_start	D1_nap_end	D1_nonwear1_off	D1_nonwear1_on	D2_date
01	2022-06-24	07:00:00	23:15:00	15:00:00	15:45:00	13:35:00	14:10:00	2022-06-25
02	2022-06-26	07:30:00	23:45:00			09:05:00	10:30:00	2022-06-27
03	2022-07-24	07:10:00	22:50:00	13:02:00	13:30:00	18:00:00	19:10:00	2022-07-25
04	2022-06-14	09:00:00	00:50:00			20:30:00	21:00:00	2022-06-15

As documented in: https://cran.r-project.org/web/packages/GGIR/vignettes/GGIR.html

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Advanced sleeplog

- Date columns → "date"
- Wakeup columns → "wakeup"
- Sleep onset columns → "onset", "inbed", "tobed", "lightsout"
- Napping columns → "nap"
- Nonwear columns → "nonwear"

ID	D1_date	D1_wakeup	D1_inbed	D1_nap_start	D1_nap_end	D1_nonwear1_off	D1_nonwear1_on	D2_date
01	2022-06-24	07:00:00	23:15:00	15:00:00	15:45:00	13:35:00	14:10:00	2022-06-25

As documented in: https://cran.r-project.org/web/packages/GGIR/vignettes/GGIR.html

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Guider & SIB => SPT

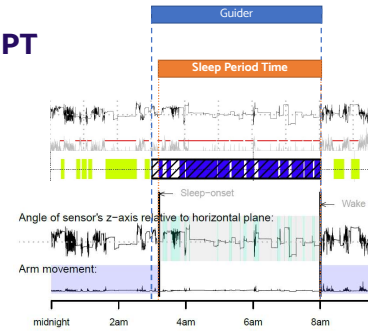
Default behaviour

Guider

Sleep Onset	Wake
3:00:00	8:00:00

SPT

Sleep Onset	Wake
3:12:05	8:00:00



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Guider & SIB => SPT

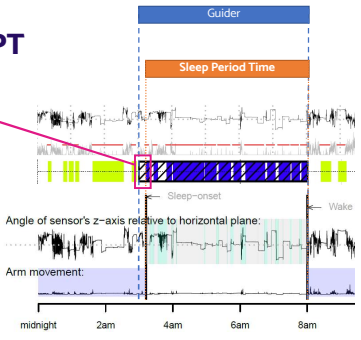
Sleeplog: time in bed or lights out

```
GGIR(
  [...]
  # Sleep analysis
  sleepwindowType = "TimeInBed",
  [...])
```

Only relevant for sleeplog as guider

Sleep latency
Sleep efficiency

Sleep Onset	Wake
3:12:05	8:00:00



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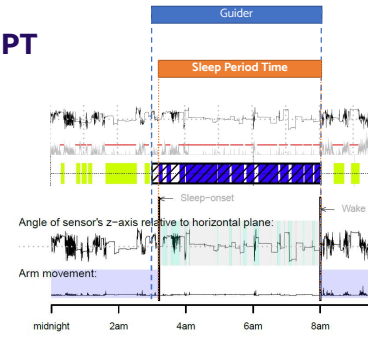
Guider & SIB => SPT

Sleeplog: time sleep onset

```
GGIR(
  [...]
  # Sleep analysis
  sleepwindowType = "SPT",
  [...])
```

Only relevant for sleeplog as guider

Sleep Onset	Wake
3:12:05	8:00:00



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Guiders

Summary of guiders

Guider	Definition	Relevant arguments to use it
setwindow	Fixed windows for all nights/participants	
L5+/-12	Midpoint of L5 and surrounding 12h window	
HDCZA	HDCZA algorithm (van Hees 2018)	
HorAngle	HorAngle algorithm intended to detect lying posture	
sleep log	Reported sleep diaries (basic or advanced)	

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Guiders

Summary of guiders

Guider	Definition	Relevant arguments to use it
setwindow	Fixed windows for all nights/participants	def.noc.sleep = c(23, 7)
L5+/-12	Midpoint of L5 and surrounding 12h window	def.noc.sleep = c()
HDCZA	HDCZA algorithm (van Hees 2018)	def.noc.sleep = 1 HASPT.algo = "HDCZA"
HorAngle	HorAngle algorithm intended to detect lying posture	def.noc.sleep = 1 HASPT.algo = "HorAngle" longitudinal_axis = 2 sensor.location = "hip"
sleep log	Reported sleep diaries (basic or advanced)	loglocation = "C:/mystudy/sleeplog.csv" colid = 1, colnt = 2, nnights = 7, sleeplogsep = ",", sleepwindowType = "TimeInBed"

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"Unusual" sleepers

- More than one sleep period time per day?
- Daysleeper?
  - If guider-defined wake-up > 12pm → re-do sleep analysis from 6pm-to-6pm
  - Classified as daysleeper in reports
  - Intended to adapt the algorithm to night workers

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Other input arguments

```
GGIR(
    [...]
    # Data cleaning
    do.report = 4,
    includenightcrit = 16,
    [...])
```

16 hours available from noon-to-noon or from 6pm-to-6pm

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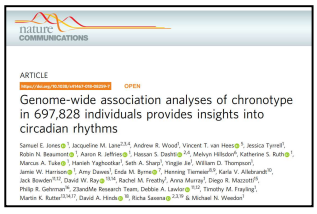
Other forms over evaluation…


nature COMMUNICATIONS

ARTICLE

Genetic studies of accelerometer-based sleep measures yield new insights into human sleep behaviour

https://www.nature.com/articles/s41467-019-09576-1


nature COMMUNICATIONS

ARTICLE

Genome-wide association analyses of chronotype in 697,828 individuals provides insights into circadian rhythms

https://www.nature.com/articles/s41467-018-08259-7

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What is the sleep period time? *(Single choice)*

- ❑ The main (longest) episode of rest in the day that starts and ends with sleep
- ❑ The total time in bed
- ❑ The sum of the minutes classified as sleep every day
- ❑ The total sleep time

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What is the sleep period time? *(Single choice)*

- ☑ The main (longest) episode of rest in the day that starts and ends with sleep
- ❑ The total time in bed
- ❑ The sum of the minutes classified as sleep every day
- ❑ The total sleep time

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How to instruct GGIR to use the HorAngle algorithm? *(Single choice)*

- ❑ SPT.algo = "HorAngle"
- ❑ HASPT.algo = 2
- ❑ SPT.algo = 2
- ❑ HASPT.algo = "HorAngle"

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How to instruct GGIR to use the HorAngle algorithm? *(Single choice)*

- ❑ SPT.algo = "HorAngle"
- ❑ HASPT.algo = 2
- ❑ SPT.algo = 2
- ☑ HASPT.algo = "HorAngle"

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Part 3 & 4 Output

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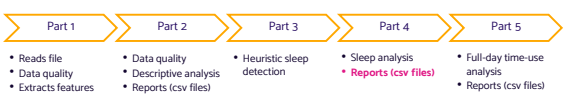
The GGIR pipeline



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Part 3 & 4

Output

- results
  - QC
    - part4_nightsummary_sleep_full.csv
    - part4_summary_sleep_full.pdf
  - part4_nightsummary_sleep_cleaned.csv
  - part4_summary_sleep_cleaned.csv
  - visualisation_sleep.pdf

Accelting

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Part 3 & 4

Output

- results
  - QC
    - part4_nightsummary_sleep_full.csv
    - part4_summary_sleep_full.pdf
  - part4_nightsummary_sleep_cleaned.csv
  - part4_summary_sleep_cleaned.csv
  - **visualisation_sleep.pdf**

Accelting

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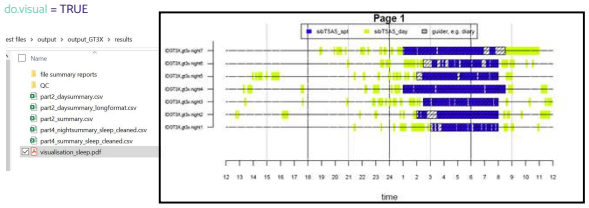
Sleep visualizations

do.visual = TRUE



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Part 3 & 4

Output

- results
  - QC
    - **part4_nightsummary_sleep_full.csv**
    - **part4_summary_sleep_full.pdf**
  - **part4_nightsummary_sleep_cleaned.csv**
  - **part4_summary_sleep_cleaned.csv**
  - visualisation_sleep.pdf

Accelting

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Output from Part 4

Night-level features (full report)

ID	Onset_n1	Wakeup_n1	Onset_n2	Wakeup_n2	Onset_n3	..
01	23:00:00	07:00:00			23:15:00	..

part4_nightsummary_sleep_full.csv

ID	night	cleaningcode	sleeplog_used	acc_available	guider
1	1	0	1	1	sleeplog
1	2	1	0	1	HDCZA
1	3	0	1	1	sleeplog
1	4	0	1	1	sleeplog
1	5	0	1	1	sleeplog
1	6	0	1	1	sleeplog
1	7	2	1	0	sleeplog

Cleaning code	Meaning
0	No problem
1	Sleep log not available (HDCZA used)
2	Not enough valid data
3	No accelerometer data available
4	No nights to be analyzed
5	Guider-defined SPT
6	SPT could not be defined either by sleeplog or algorithms

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Output from Part 4

Night-level features (full report)

do.report = 4

part4_nightsummary_sleep_full.csv

ID	night	sleeponset	wakeup	SptDuration	SleepDurationInSpt	WASO	sleepefficiency	sleeplatency
1	1	27.201	32	4.799	3.696	1.103	0.864	0.215
1	2	26.11	31.936	5.826	4.888	0.939	0.868	0.282
1	3	26.5	32	5.5	4.997	0.503	0.834	0.004
1	4	25	32.475	7.475	7.115	0.36	0.799	0.512
1	5	26.413	32	5.588	5.071	0.517	0.798	0.428
1	6	27.131	32	4.869	3.526	1.343	0.929	0.003
1	7	25.074	31.761	6.688	6	0.688	0.856	0.261

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Output from Part 4

Night-level features (clean report)

do.report = 4

```
GGIR(
  [...]
  # Data cleaning
  includenightcrit = 16,
  excludefirst.part4 = FALSE,
  excludelast.part4 = FALSE,
  [...])
```

part4_nightsummary_sleep_cleaned.csv

ID	night	sleeponset	wakeup	SptDuration	SleepDurationInSpt	WASO	sleepefficiency	sleeplatency
1	1	27.201	32	4.799	3.696	1.103	0.864	0.215
1	2	26.11	31.936	5.826	4.888	0.939	0.868	0.282
1	3	26.5	32	5.5	4.997	0.503	0.834	0.004
1	4	25	32.475	7.475	7.115	0.36	0.799	0.512
1	5	26.413	32	5.588	5.071	0.517	0.798	0.428
1	6	27.131	32	4.869	3.526	1.343	0.929	0.003
1	7	25.074	31.761	6.688	6	0.688	0.856	0.261

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Output from Part 4

Night-level features (clean report)

do.report = 4

```
GGIR(
  [...]
  # Data cleaning
  includenightcrit = 16,
  excludefirst.part4 = TRUE,
  excludelast.part4 = FALSE,
  [...])
```

part4_nightsummary_sleep_cleaned.csv

ID	night	sleeponset	wakeup	SptDuration	SleepDurationInSpt	WASO	sleepefficiency	sleeplatency
1	1	27.201	32	4.799	3.696	1.103	0.864	0.215
1	3	26.5	32	5.5	4.997	0.503	0.834	0.004
1	4	25	32.475	7.475	7.115	0.36	0.799	0.512
1	5	26.413	32	5.588	5.071	0.517	0.798	0.428
1	6	27.131	32	4.869	3.526	1.343	0.929	0.003

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Output from Part 4

Night-level features (clean report)

do.report = 4

```
GGIR(
  [...]
  # Data cleaning
  includenightcrit = 16,
  excludefirst.part4 = TRUE,
  excludelast.part4 = FALSE,
  [...])
```

part4_nightsummary_sleep_cleaned.csv

ID	night	sleeponset	wakeup	SptDuration	SleepDurationInSpt	WASO	sleepefficiency	sleeplatency
1	1	27.201	32	4.799	3.696	1.103	0.864	0.215
1	3	26.5	32	5.5	4.997	0.503	0.834	0.004
1	4	25	32.475	7.475	7.115	0.36	0.799	0.512
1	5	26.413	32	5.588	5.071	0.517	0.798	0.428
1	6	27.131	32	4.869	3.526	1.343	0.929	0.003

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Part 3 & 4

Output

- meta
  - sleep.qc
    - graphperday_id_01.pdf
    - ...
- results
  - QC
    - part4_nightsummary_sleep_full.csv
    - **part4_summary_sleep_full.pdf**
  - part4_nightsummary_sleep_cleaned.csv
  - **part4_summary_sleep_cleaned.csv**
  - visualisation_sleep.pdf

Accelting

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Output from Part 4

Person-level features

do.report = 4

part4_summary_sleep_cleaned.csv

ID	sleeplog_used	n_nights_acc	n_nights_sleeplog	n_WE_nights_complete	n_WD_nights_complete	n_WEnights_daysleeper	n_WDnights_daysleeper
11	1	6	6	2	4	0	0

All days

ID	SptDuration_AD_TSAS_mn	SptDuration_AD_TSAS_sd	SleepDurationInSpt_AD_TSAS_mn	SleepDurationInSpt_AD_TSAS_sd	WASO_AD_TSAS_mn	WASO_AD_TSAS_sd
11	5.372	1.142	4.685	1.375	0.687	0.383

Weekdays

ID	SptDuration_WD_TSAS_mn	SptDuration_WD_TSAS_sd	SleepDurationInSpt_WD_TSAS_mn	SleepDurationInSpt_WD_TSAS_sd	WASO_WD_TSAS_mn	WASO_WD_TSAS_sd
11	5.64	1.277	5.045	1.404	0.594	0.34

Weekend days

ID	SptDuration_WE_TSAS_mn	SptDuration_WE_TSAS_sd	SleepDurationInSpt_WE_TSAS_mn	SleepDurationInSpt_WE_TSAS_sd	WASO_WE_TSAS_mn	WASO_WE_TSAS_sd
11	4.838	0.877	3.966	1.409	0.872	0.532

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Output from Part 4

Complete list of variables

Sleeponset, sleeponset_ts
Wakeup, wakeup_ts
SptDuration
Sleepparam
guider_inbedStart, guider_inbedStart_ts
guider_inbedEnd, guider_inbedEnd_ts
guider_inbedDuration
fraction_night_invalid
SleepDurationInSpt
WASO
duration_sib_wakinghours
number_sib_sleepperiod
number_of_awakenings
number_sib_wakinghours
duration_sib_wakinghours_atleast15min
sleeplatency
sleepefficiency
page
daysleeper
weekday
calendar_date
filename
cleaningcode
sleeplog_used
acc_available
guider
SleepRegularityIndex
SriFractionValid
longitudinal_axis
nonwear_perc_spt

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What is the column cleaningcode? *(Single choice)*

- ❑ An indicator of the nights that should be removed from datasets
- ❑ An indicator of the time that the device was not worn during nights
- ❑ An indicator of the quality of the sleep period time detection
- ❑ An estimate of the fraction of time in which the device recorded valid data throughout the measurement

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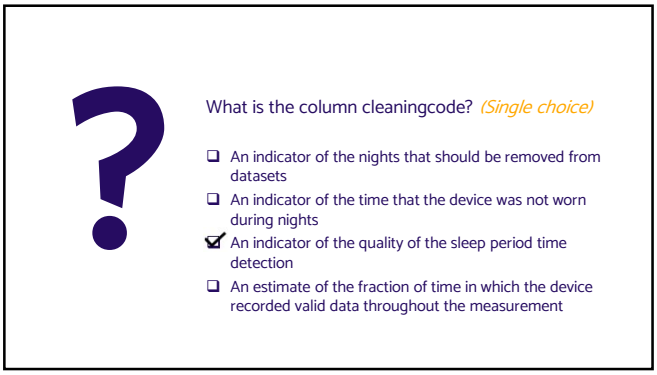
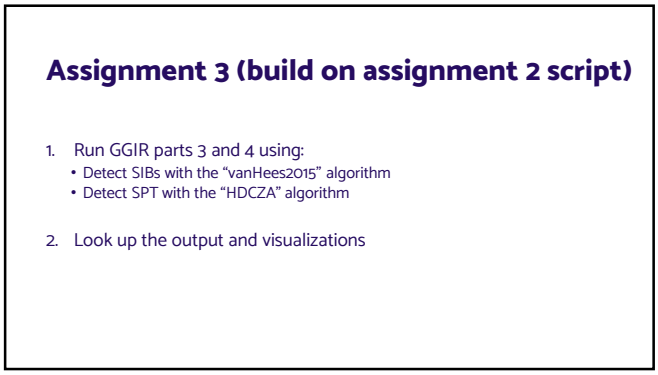
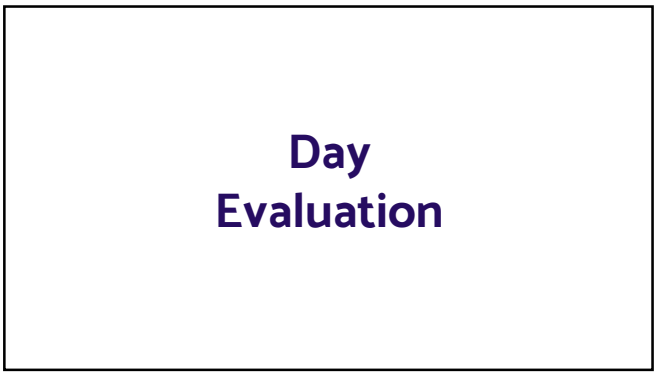


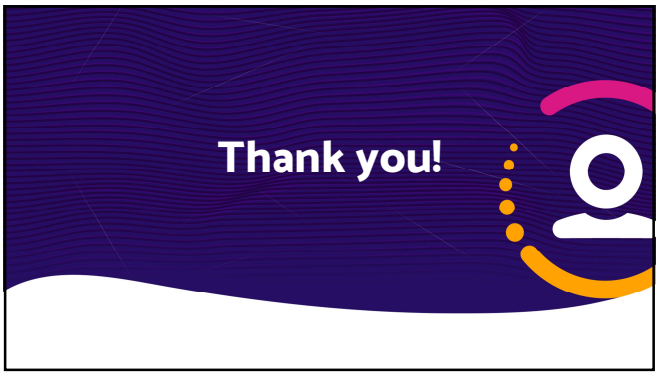
119



120



121



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