Accelting
Advancing movement & sleep research

www.accelting.com

1

GGIR training: Day 2

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

Slide deck version: 06 December 2022

2

DECLARATION

- We will answer your questions in the question time, **NOT** in the chat, so that you can focus on the presentation (but questions are welcome in the chat)
- 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/

3

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

Accelting

4

Part 2 Output

www.accelting.com

5

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)

6

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

Accelting

7

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

Accelting

8

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

9

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_T100_ ENMO_0-24hr	mean_ENMO_ mg_0-8hr	MVPA_E5S_T100_ ENMO_0-8hr	mean_ENMO_ mg_8-24hr	MVPA_E5S_T100_ 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

10

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

11

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

12

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_ES5_ 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	68.232	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

13

Part 2

Output

- meta
  - csv
    - IDO1.csv
    - ...
- results
  - QC
    - data_quality_report.csv
    - plot_to_check_data_quality.pdf
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - **part2_summary.csv**

Accelting

14

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

15

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

Accelting

16

Part 2

Output

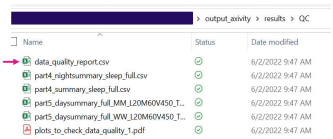
- meta
  - csv
    - IDO1.csv
    - ...
- results
  - **QC**
    - **data_quality_report.csv**
    - **plot_to_check_data_quality.pdf**
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - part2_summary.csv

Accelting

17

Output from Part 2

Data quality reports



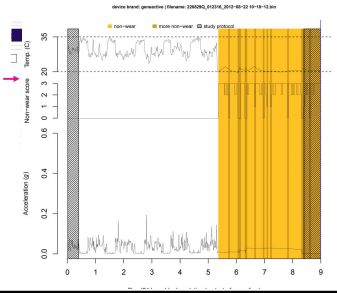
filename	cal.error.start	cal.error.end	QCmessage
meta_011_45400.cwa.RData	0.12640	0.00466	recalibration done, no problems detected
meta_013_42151.cwa.RData	0.05089	0.00286	recalibration done, no problems detected
meta_015_44944.cwa.RData	0.08323	0.00355	recalibration done, no problems detected
meta_017_42151.cwa.RData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

18

Output from Part 2

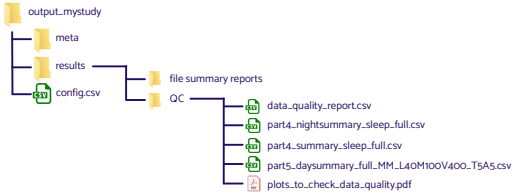
Data quality reports

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



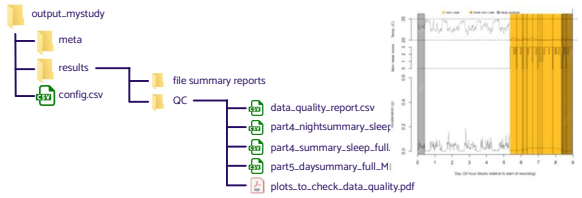
19

The GGIR pipeline (output folder)



20

The GGIR pipeline (output folder)



21

Part 2

Output

- meta
  - **csv**
    - **IDo1.csv**
    - …
- results
  - QC
    - data_quality_report.csv
    - plot_to_check_data_quality.pdf
  - part2_daysummary.csv
  - part2_daysummary_longformat.csv
  - part2_summary.csv

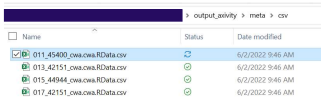
Accelting

22

Output from Part 2

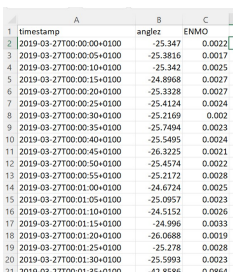
Epoch-level features

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

23

Assignment 2 (build on assignment 1 script)

1. Run GGIR parts 1 and 2 to get the following:
   - Consider the timezone: Europe/Madrid
   - Acceleration metrics: enmo and angle z
   - Study protocol: we aim to remove the first and last hour of data in the recording
   - Derive intensity levels: [0, 50), [50, 100), [100, 150), [150, 200), [200, Inf)
   - Derive MX metrics: M1/3, M120, M60, M30, M15, M5
   - Derive the intensity gradient
   - Calculate MVPA with two thresholds: 100 *mg* and 140 *mg*
2. Run the script via the source button
3. Advanced: Calculate these variables over the following Windows:
   - From 0 am to 7am
   - From 7am to 10pm
   - From 10pm to 0am next day
4. Optional: Look up the output and variables generated.

30

Sleep & accelerometers

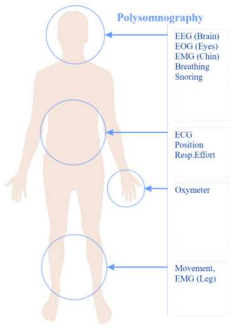
www.accelting.com

31

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

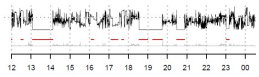


32

Accelerometer-based sleep assessment

Free living

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



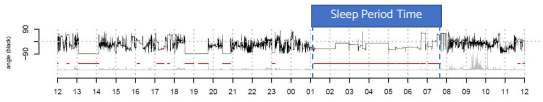
- Term: Sustained Inactivity Bout, abbreviated as SIB

33

Accelerometer-based sleep assessment

Free living

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



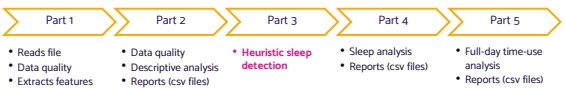
34

Sleep/rest detection

www.accelting.com

36

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)	• **Heuristic sleep detection**	• Sleep analysis • Reports (csv files)	• Full-day time-use analysis • Reports (csv files)

37

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",
  [...])
```

Accelting

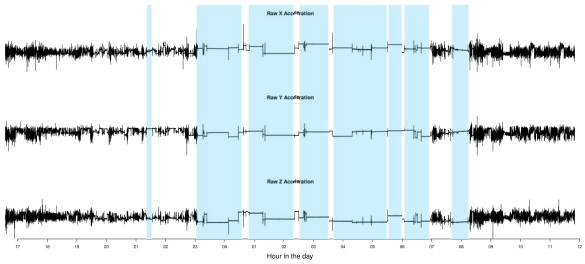
38

Rest/Wake detection

Algorithms

39

Rest/Wake detection



40

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

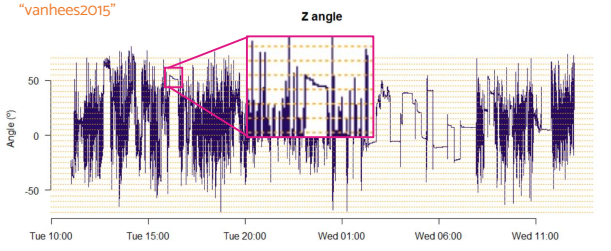
Angle of z-axis (independent of attachment orientation across brands)

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

41

Rest/Wake detection

"vanhees2015"



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

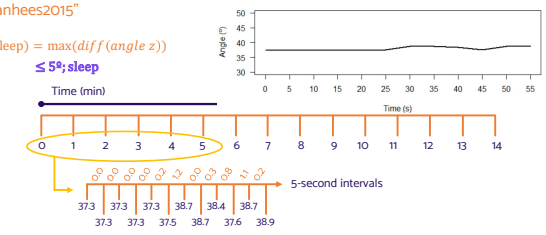
42

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

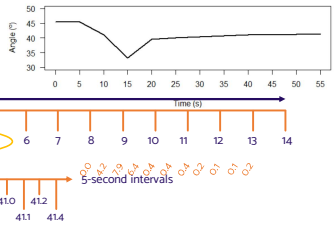
43

Rest/Wake detection

"vanhees2015"

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

$\leq 5^{o}$; sleep

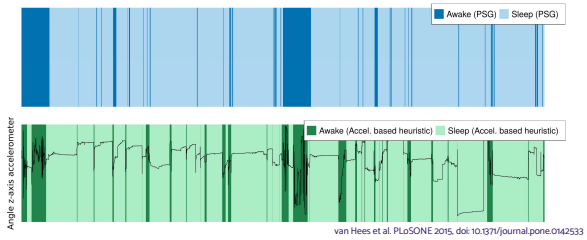


van Hees et al. PLoSONE 2015, doi: 10.1371/journal.pone.0142533

44

Rest/Wake detection

"vanhees2015"



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

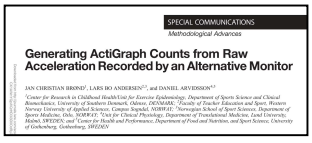
45

Rest/Wake detection

Count-based algorithms

- Sadeh1994
- ColeKripke1992
- Galland2012

```
GGIR(
  [...]
  # Acceleration metrics
  do.zcx = TRUE, do.zcy = TRUE, do.zcz = TRUE,
  do.brondcounts= 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

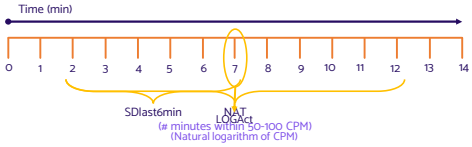
46

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

47

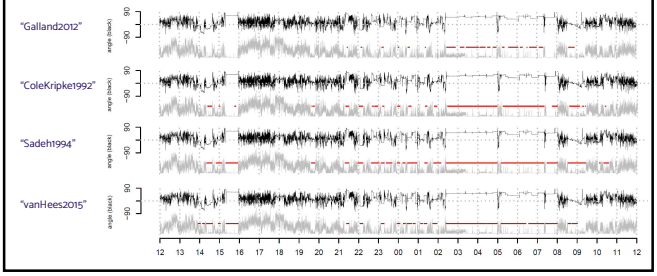
Rest/Wake detection

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	Wrist

48

Rest/Wake detection



49

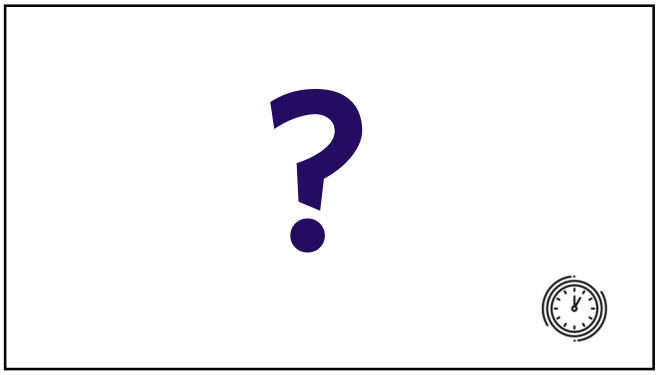
The GGIR()

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

52



53

Sleep Period Time

www.accelting.com

54

The GGIR pipeline

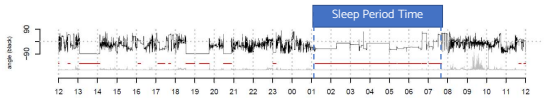
Part 1	Part 2	Part 3	Part 4	Part 5
• Reads file • Data quality • Extracts features	• Data quality • Descriptive analysis • Reports (csv files)	• **Heuristic sleep detection**	• **Sleep analysis** • Reports (csv files)	• Full-day time-use analysis • Reports (csv files)

55

Accelerometer-based sleep assessment

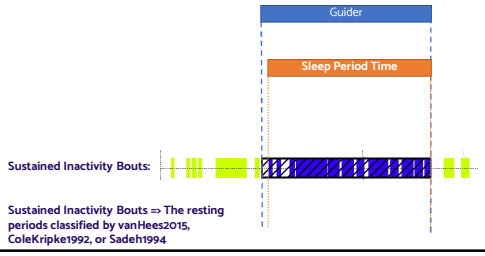
Free living

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



57

"Guiders" to guide SPT window detection



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

58

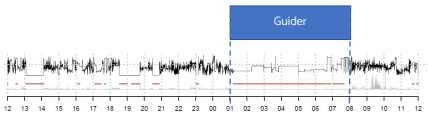
Guiders

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

59

(Fixed) Set window

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



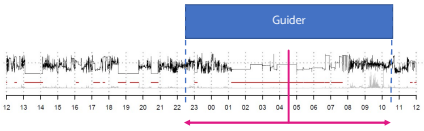
[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

61

L5 ± 12 hours

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

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**



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

62

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 → $angle_t = \left(\tan^{-1}\left(\frac{a_x}{\sqrt{a_y^2 + a_z^2}}\right)\right) \cdot 180/\pi$ → 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

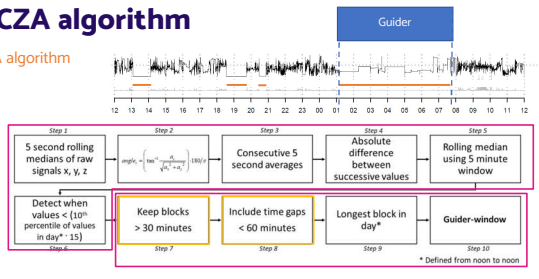
* Defined from noon to noon

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

64

HDCZA algorithm

HDCZA algorithm



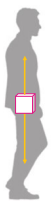
[van Hees et al. Scientific Reports 2018, doi:10.1038/s41598-018-31266-z]

67

The GGIR()

Sleep analysis

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



Accelting

68

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

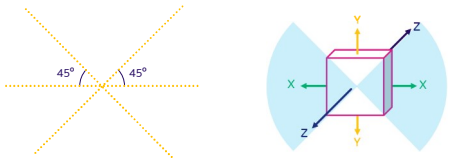
My assumptions about what a sleep period is

* Defined from noon to noon

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

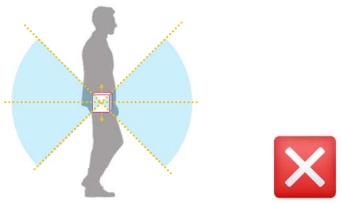
69

HorAngle algorithm



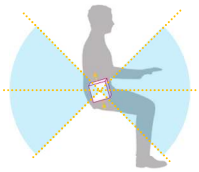
70

HorAngle algorithm



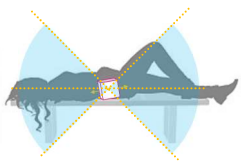
71

HorAngle algorithm



72

HorAngle algorithm



73

The GGIR()

Sleep analysis guided by sleeplog

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

Accelting

74

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

sleeplogidnum = TRUE

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

75

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

78

Advanced sleeplog

nnights = ...

colid = 1

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

sleeplogidnum = TRUE

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

77

Guider & SIB => SPT

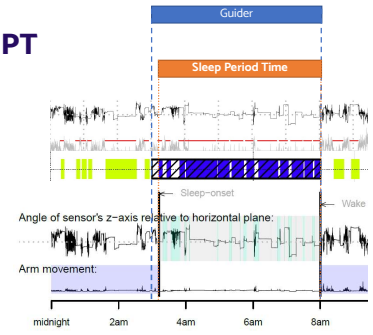
Default behaviour

Guider

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

SPT

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



79

Guider & SIB => SPT

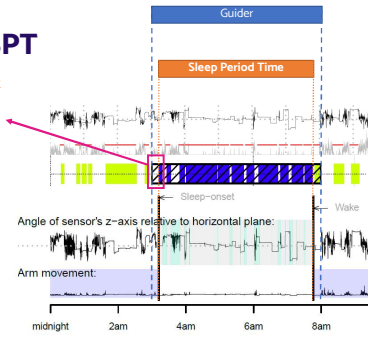
Sleeplog: time in bed or lights out

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

Only relevant for sleeplog as guider

Sleep latency

Sleep Onset	Wake
3:12:05	7:45:35



80

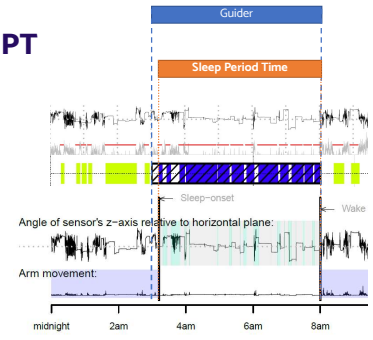
Guider & SIB => SPT

Sleeplog: time sleep onset

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

Only relevant for sleeplog as guider

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



81

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)	

83

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 = "Y" sensor.location = "hip"
sleep log	Reported sleep diaries (basic or advanced)	loglocation = "C:/mystudy/sleeplog.csv" colid = 1, coln1 = 2, nnights = 7, sleeplogidnum = TRUE, sleeplogsep = ",", sleepwindowType = "TimeInBed"

84

"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

85

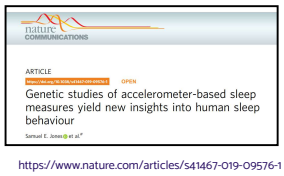
Other input arguments

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

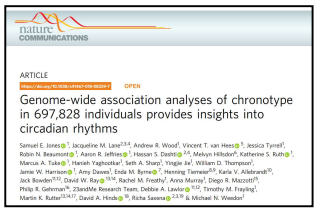
16 hours available from noon-to-noon or from 6pm-to-6pm

86

Other forms over evaluation…



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



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

87

90

Part 3 & 4 Output

www.accelting.com

94

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)	• Heuristic sleep detection	• Sleep analysis • **Reports (csv files)**	• Full-day time-use analysis • Reports (csv files)

95

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

96

Part 3 & 4

Output

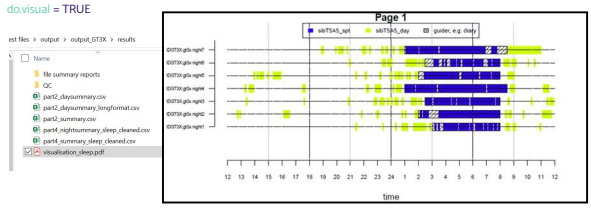
- results
  - QC
    - part4_nightsummary_sleep_full.csv
    - part4_summary_sleep_full.pdf
  - part4_nightsummary_sleep_cleaned.csv
  - part4_summary_sleep_cleaned.csv
  - **visualisation_sleep.pdf**

Accelting

97

Sleep visualizations

do.visual = TRUE



98

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

100

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

101

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	2.269	17
1	2	26.11	31.936	5.826	4.888	0.939	2.558	9
1	3	26.5	32	5.5	4.997	0.503	2.967	12
1	4	25	32.475	7.475	7.115	0.36	2.568	13
1	5	26.413	32	5.588	5.071	0.517	3.056	11
1	6	27.131	32	4.869	3.526	1.343	2.661	9
1	7	25.074	31.761	6.688	6	0.688	4.294	9

103

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	2.269	17
1	2	26.11	31.936	5.826	4.888	0.939	2.558	9
1	3	26.5	32	5.5	4.997	0.503	2.967	12
1	4	25	32.475	7.475	7.115	0.36	2.568	13
1	5	26.413	32	5.588	5.071	0.517	3.056	11
1	6	27.131	32	4.869	3.526	1.343	2.661	9
1	7	25.074	31.761	6.688	6	0.688	4.294	9

104

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	2.269	17
1	3	26.5	32	5.5	4.997	0.503	2.967	12
1	4	25	32.475	7.475	7.115	0.36	2.568	13
1	5	26.413	32	5.588	5.071	0.517	3.056	11
1	6	27.131	32	4.869	3.526	1.343	2.661	9

105

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	2.269	17
1	3	26.5	32	5.5	4.997	0.503	2.967	12
1	4	25	32.475	7.475	7.115	0.36	2.568	13
1	5	26.413	32	5.588	5.071	0.517	3.056	11
1	6	27.131	32	4.869	3.526	1.343	2.661	9

106

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

107

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_TSA5_mn	SptDuration_AD_TSA5_sd	SleepDurationInSpt_AD_TSA5_mn	SleepDurationInSpt_AD_TSA5_sd	WASO_AD_TSA5_mn	WASO_AD_TSA5_sd
11	5.372	1.142	4.685	1.375	0.687	0.383

Weekdays

ID	SptDuration_WD_TSA5_mn	SptDuration_WD_TSA5_sd	SleepDurationInSpt_WD_TSA5_mn	SleepDurationInSpt_WD_TSA5_sd	WASO_WD_TSA5_mn	WASO_WD_TSA5_sd
11	5.64	1.277	5.045	1.404	0.594	0.34

Weekend days

ID	SptDuration_WE_TSA5_mn	SptDuration_WE_TSA5_sd	SleepDurationInSpt_WE_TSA5_mn	SleepDurationInSpt_WE_TSA5_sd	WASO_WE_TSA5_mn	WASO_WE_TSA5_sd
11	4.838	0.877	3.966	1.409	0.872	0.532

108

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

109

?

110

Day Evaluation

111

Thank you!

112