Goal:

Describe the basics of our actigraphy data collection methods, usage of GGIR to quantify physical activity, and example descriptives of output. Use the description to share our usage and any insights from our data that may help inform GGIR usage for IGNITE sample, and identify weaknesses of our usage that need to be considered for improvement.

Data collection

Wear time: All participants wore a **GT9X ActiGraph Link** accelerometer (ActiGraph; Pensacola,Florida) on the non-dominant wrist for seven consecutive days during both wake and sleep. Participants were asked to wear the device at all times except during water activities (e.g., showering, washing dishes, etc.). A daily activity log was maintained to cross-check times in and out of bed, non-wear times, and perceived exertion. Participants enrolled in a training study were inactive and wore the device before randomization.

Data recording:
- Number of days: 7
- Time: 12am to 12am (midnight-to-midnight)
- Sampling rate: 60 Hz
- Options:
  - Enabled: idle sleep mode was enabled, show display, steps not shown
  - Not enabled: wireless and heart rate, IMU

Data download and reduction:
- Processed with the ActiLife v6.13.3 software
- Raw data saved in .csv -> this is the data input to GGIR
- Data also reduced to 60 second epochs in ActiLife and saved in .csv for potential analysis with ActiLife or other softwares

Inclusion criteria for data & participants: Only days when the device has valid data for 16 out of 24 hours within midnight-to-midnight recording time-frame were considered for inclusion in initial analyses. Day-level exclusions will be pursued in post-processing.

Data analysis methods with GGIR

Rationale

At the time we started, the latest relevant usage of GGIR reported with middle-age to older adults was Menai et al., 2017. The Menai study used GENEActiv devices on the non-dominant wrist, but based on Rowlands et al., 2016 support of enough similarity across GENEActiv and Actigraph on the non-dominant wrist that we felt it was OK to continue. A weakness in this decision point is that the sample in Rowlands et al., was small (N=25 with usable data) without a defined age range (likely mostly young), and they only wore the two devices for 2 consecutive days. However, we still like the strengths of using a continuous metric of acceleration that is closer to the data than cut-points like Euclidean Norm Minus One (ENMO), and we were looking for an accelerometer analysis workflow that could be automated with robust preprocessing, both of which GGIR provides.

The new paper sent by Jairo (Cabanas-Sanchez et al., 2020) is very exciting to us, as it's quite consistent with the path we have been headed down, and informs two parameters we've been working through which is how to best set bout.metric and how to handle sleep in an automated way (see open issues below).

The table below outlines method decisions from Menai, our rationale for choosing differently based on our data, and notes on relevant GGIR parameters if that applies. Reference for GGIR parameters:

- https://cran.r-project.org/web/packages/GGIR/vignettes/GGIR.html
- reference for GGIR defaults

Menai et al., 2017	Similar/appropriate for our data?	GGIR default?	GGIR parameter setting / flag	Relevant output for post-processing
Wore for 9 consecutive days on non-dominant wrist	Wore for 7 consecutive days on non-dominant wrist			
Sleep automatically detected based on van Hees et al, 2015	Yes			See post-processing in Cabanas-Sanchez et al., 2020
Wake-to-wake analysis	No, we chose to focus on data extracted midnight-to-midnight for consistency with data recording.	Default will output data for both wake-to-wake or midnight-to-midnight.	`Part 5:` `timewindow = c("MM"),`	

Valid data for a participant: operationalized as daily wear time ≥ 2/3 of waking hours, for at least 2 weekdays and 2 week-end days;	Yes	Yes, including 16/24 hours out of day (>⅔) is their default.	includedaycrit = 16	nonwear_perc_day nonwear_perc_night nonwear_perc_night andday in part 5 give percentage of non-wear during day, night, and night/day combined
Non-wear time was estimated using algorithm in van Hees et al., 2013 and was replaced by personalized mean value for each participant, calculated from their data on other days at the same time of day, supported by Sabia et al, 2014 and Catellier et al., 2005.	Yes	Yes Though, see Cabanas-Sanchez 2020 imputation using only surrounding period of excluded time-points	do.imp=TRUE	Post-processing to impute based on surrounding periods?
ENMO averaged over 5s epochs	Yes	Yes		

Threshold for moderate-to-vigorous physical activity (MVPA): mean 5s ENMO ≥ 100mg, with 1 minute duration, with 80% of activity within 1minute epoch over ENMO threshold	Yes	Yes	`Part 2:`
			
			`mvpathreshold =c(100)`
			
			`Part 5:`
			
			`boutcriter.mvpa = 0.8`
				MVPA_E5S_B1M80_T100_ENMO_0-24hr

Bouts specified in two ranges, where “short” was defined as 1-9:59 minutes, and “long” defined as >10minutes	Yes	No
		
		bout.metric=4 is suggested (and used by Cabanas-Sanchez)
			`Part 5:`
			
			`boutdur.mvpa = c(1,10)`	

Time spent in MVPA bouts lasting 1 minute or more was calculated as the sum of short and long bouts.	Yes, of interest		post-processing?	bout.metric=2 may be needed for summation of short/long bouts OR run bout length in separate loops?

The daily accelerometer-assessed time in MVPA over a week was calculated as the mean of measures over 7 days. For participants with less than 7 valid days of data, the following formula was used to standardize measurement to one week for all participants: [(5 × mean daily weekday MVPA time + 2 × mean daily week-end MVPA time)]/7.	Yes, we recorded over 7 days though so may just eliminate invalid days and include mix of weekend and weekday.			AD_ (average day prefix) post-processing could be calculated from the WE_ prefix and WD_ prefix and N valid hrs fields

Anatomy of our GGIR call

```
mode= c(1,2,3,4,5) # added 5 for bout summary

datadir= "/path-to-directory-with-raw-csv-files"

outdir= "/path-to-directory-where-you-want-output"

f0 = 1

f1 = 0 # changed to 0 from 2

g.shell.GGIR(#-------------------------------

# General parameters

#-------------------------------

mode=mode,

datadir=datadir,

outputdir=outdir,

# studyname=studyname,

f0=f0,

f1=f1,

overwrite = FALSE, #may want to be FALSE, changed it so it would work for
errored subject

do.imp=TRUE,
```

```
# idloc=1,

# print.filename=FALSE,

# storefolderstructure = TRUE,

#-------------------------------

# Part 1 parameters:

#-------------------------------

windowsizes = c(5,900,3600),

do.cal=TRUE,

do.enmo = TRUE,

do.anglez=TRUE,

chunksize=1,

printsummary=FALSE,

#-------------------------------

# Part 2 parameters:

#-------------------------------

strategy = 1,

ndayswindow=7,

# hrs.del.start = 1,

# hrs.del.end = 1,

# maxdur = 9,

includedaycrit = 16,

# L5M5window = c(0,24),

# M5L5res = 10,

# winhr = c(5,10),

# qlevels = c(c(1380/1440),c(1410/1440)),

# qwindow=c(0,24),

# ilevels = c(seq(0,400,by=50),8000),#Levels for acceleration value frequency
distribution in mg,more of a continuum

mvpathreshold =c(100), # considered threshold of 69 from Evaluation of wrist
and hip sedentary behaviour and moderate-to-vigorous physical activity raw
acceleration cut-points in older adults (Sanders et al., 2019), but this is the
```

```
hip value, 100 from Accelerometer assessed moderate-to-vigorous physical
activity and successful ageing: results from the Whitehall II study (Menai et
al., 2017)

#-------------------------------

# Part 3 parameters:

#-------------------------------

timethreshold= c(5),

anglethreshold=5,

ignorenonwear = TRUE,

#-------------------------------

# Part 4 parameters:

#-------------------------------

excludefirstlast = TRUE,

includenightcrit = 16,

def.noc.sleep = 1,

#loglocation=

outliers.only = FALSE,

criterror = 1,

relyonsleeplog = FALSE,

sleeplogidnum = FALSE, # changed from TRUE, number is a character

#idloc #added field, may need to specify where the participant ID is.

#colid=1,

#coln1=4,

do.visual = FALSE,

# nnights = 6,

#-------------------------------

# Part 5 parameters:

#-------------------------------

# Key functions: Merging physical activity with sleep analyses

threshold.lig = c(40),
```

```
threshold.mod = c(100),
threshold.vig = c(400),
excludefirstlast = TRUE
boutcriter = 0.8,
boutcriter.in = 0.9,
boutcriter.lig = 0.8,
boutcriter.mvpa = 0.8,
boutdur.in = c(1),
boutdur.lig = c(1),
boutdur.mvpa = c(1),
timewindow = c("MM"),
#-----------------------------------
# Report generation
#-------------------------------
## End(Not run)
do.report=c(2,4,5),
visualreport=FALSE)
```

Descriptive data for insight about strengths and weaknesses of our analysis choices

Sample demographics:

Basics across projects of AMBI, PACR, BIKE, NORM

- N=134, Avg age 67 ± 5.7 yrs, 42% female
- ~N=120 available if we add baseline data from BETTER and EXTEND

[goal: table including additional education and metabolic variables before exclusions, as reference to compare to demographics of those with issues in the data]

Distribution and descriptive questions:

To inform our exclusion criteria for days, how variable is non-wear time?
[distribution of valid days]
Compare descriptives to results in Cabanas-Sanchez et al., 2020.

Reliability

[consider split-half of same session vs. test-retest with participant's first recording during training]

Open issues in consideration

- **Accounting for sleep with and/or without logs**
    - We had a lot of issues with sleep logs when trying to use it on a large set of participants. Each participant was like a unique use case and would almost need the GGIR run separately for them. We also would need an automated robust way to translate the actigraph sleeplog format to GGIR format.
    - There are options to have the sleep log simply guide the automated detection, but really the automated detection within GGIR did pretty well for us. If sleep is the main outcome, I would think they would probably want to do something more precise, but that also takes a lot more manual work of sleeplog alignment.
    - Post-processing in Cabanas-Sanchez et al., 2020 looks like a good compromise; initial detection of abnormal sleep could flag a moderation with the log.
- **Best call when comparing PA of different bout lengths in the same individual and/or analysis. Understanding options, from GGIR manual:**
    - Option closedbout = TRUE if you want breaks in bouts to be counted towards time spent in bouts (argument only active for bout.metric 1 and 2).
        - If bout.metric value=1, the code uses the MVPA bout definition as has been available since 2014 (see papers by Sabia AJE 2014 and da Silva IJE 2014). Here, the algorithm looks for 10 minute windows in which more than XX percent of the epochs are above mvpathreshold, and then *counts the entire window as mvpa*.
            - The motivation for the defition 1 was: A person who spends 10 minutes in MVPA with a 2 minute break in the middle is equally active as a person who spends 8 minutes in MVPA without taking

a break. Therefore, both should be counted equal and counted as 10 minute MVPA bout.

    - If bout.metric value=2, the code looks for a group or groups of epochs with a value above mvpa threshold that span a time window of at least mvpadur minutes in which more than boutcriter percent of the epochs are above the threshold.
        - The motivation for the definition 2 is: not counting breaks towards MVPA simplifies interpretation and still counts the two persons in the example as each others equal.
    - If value=3, using sliding window across the data to test bout criteria per window and do not allow for breaks of 1 minute or longer.
    - If value=4, same as 3 but also requires the first and last epoch to require the threshold criteria
        - This is the suggested setting from the manual and what was used in recent paper with a similar sample (Cabanas-Sanchez et al., 2020)
  - Figure (work in progress) to work out understanding implications of different bout settings
- **Have there been any new relevant papers published using GGIR or ENMO based on non-dominant wrist recordings with older adults?**
  - We can look at this now to inform our base call before we look at our data.
  - Evaluate ENMO in comparison with Mean Amplitude Deviation (e.g., Bakarania et al., 2016)
  - Cabanas-Sanchez et al., 2020 is now great reference to compare our initial code and output to
- **Based on descriptive data, are there major weaknesses in our call that should be reconsidered?**
  - Wait until we flesh out GGIR call and verify we're all happy with it before describing data.
- **With all this considered, what is the most theoretically relevant and/or practically useful way to examine bout length?**
  - MV likes approach of Menai et al 2017 shown in Tables 2 and 3 because the bout lengths examined track with different iterations of public health guidelines and typical natural lengths of bouts of different intensities. What are its major weaknesses, could it be improved or what are other examples in the literature to compare to?
  - Compare to Cabanas-Sanchez et al., 2020
  - [additional best papers for comparison?]

References

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