National Institute of Diabetes and Digestive and Kidney Diseases

A Symposium on Open-Source Counts

COEXISTING WITH COUNTS: WHERE DO COUNTS STAND IN THE AGE OF RAW DATA?

Samuel R. LaMunion, Alex H.K. Montoye, Kimberly A. Clevenger, Jan C. Brønd

Disclosures

- Views entirely my own
  - *The views presented in this talk do not constitute endorsement by the National Institutes of Health*
- No conflicts of interest

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Usability & Accessibility Remains A Critical Factor

Clevenger et al. 2022

› Physiol Meas. 2022 Sep 5;43(9). doi: 10.1088/1361-6579/ac89c9.

Methods for estimating physical activity and energy expenditure using raw accelerometry data or novel analytical approaches: a repository, framework, and reporting guidelines

Kimberly A Clevenger [1], Alexander H K Montoye [2], Cailyn A Van Camp [3], Scott J Strath [4], Karin A Pfeiffer [3]

Affiliations + expand

PMID: 35970174 DOI: 10.1088/1361-6579/ac89c9

Pfeiffer et al. 2022

Review › Physiol Meas. 2022 Sep 5;43(9). doi: 10.1088/1361-6579/ac89ca.

Accessibility and use of novel methods for predicting physical activity and energy expenditure using accelerometry: a scoping review

Karin A Pfeiffer [1], Kimberly A Clevenger [1], Andrew Kaplan [2], Cailyn A Van Camp [1], Scott J Strath [3], Alexander H K Montoye [4]

Affiliations + expand

PMID: 35970175 DOI: 10.1088/1361-6579/ac89ca

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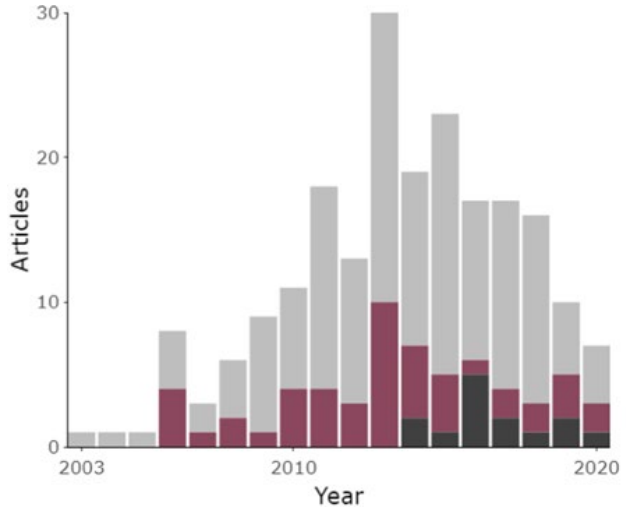
Usability Remains A Critical Factor



Accelerometer Repository

NEW!

actimetric Repository

Topic/Sub-Topic	Description and/or Example
Study Context	
☐ Setting	Where the study activities took place (e.g., track, gym, laboratory)
☐ Structure	How much control and autonomy participants had over their behavior such as unstructured (participants select the activity, intensity, and duration), semi-structured (e.g., participants are allowed to select the order of activities), or structured (researchers selected the activities, intensity, and duration)
☐ Sample	Number of participants, how they were identified for recruitment, demographics (e.g., sex, age, weight status, health status)
Development or Validation	
☐ Criterion	The type of criterion (e.g., indirect calorimetry, direct observation, room calorimeter, double-labelled water) and information regarding the reliability, sensitivity, etc.
☐ Validation or cross-validation approach	Holdout, leave-one-out, k-fold, comparison to criterion, cross-validation in an independent sample, cross-validation in a non-independent sub-sample. When possible, indicate number of folds or holdout samples and how they were selected.
☐ Activities	Number, duration, order
☐ Data processing	Data cleaning (e.g., removal of first and last minute from each activity) and whether transitions were included
Data Collection	
☐ Device	Brand and model
☐ Wear location	Right hip, left wrist, etc.
☐ Sampling rate	Number of samples recorded per second (in Hz)
☐ Any other user-defined options	For example, ActiGraph's idle sleep mode or Axivity's dynamic range
Data Processing	
☐ Data cleaning	For example, if counts over some maximum threshold were removed
☐ Filters	Any user-specified or implemented filters
☐ Calibration	If applicable, whether accelerometer data were calibrated
Model	
☐ Sampling rate, epoch of inputs, and window size/type	For example, mean acceleration in each axis over a 1-s non-overlapping window, mean acceleration in each axis over a 1-s overlapping sliding window with 50% overlap, raw acceleration in each axis at 30 Hz
☐ Features or model inputs	Describe which feature domains were extracted, how features or other variables were defined or calculated with units (for example, male is coded as '1' and female is coded as '0', vector magnitude was calculated as the square root of the sum of the squared acceleration values in each axis (in g))
☐ The model	May be a model object (as for machine learning models in R) or cut-point or regression equations
☐ Model outputs	Units and epoch (e.g., the model predicts energy expenditure as mL/kg/min for each 1-min epoch)
Reproducible Example	
☐ Instructions	Step-by-step instructions that would allow other researchers to implement the model using the example data provided
☐ Code or implementation	Example code or other method of implementation (e.g., excel with formulas or macro)
☐ Software used	The software and version used, including any required add-ons
☐ Sample input and output	With the correct headers and data format, if applicable

Source: Clevenger KA, Montoye AHK, Van Camp CA, Strath SJ, Pfeiffer KA. Methods for estimating physical activity and energy expenditure using raw accelerometry data or novel analytical approaches: a repository, framework, and reporting guidelines. Physiol Meas. 2022 Sep 5;43(9). doi: 10.1088/1361-6579/ac89c9.

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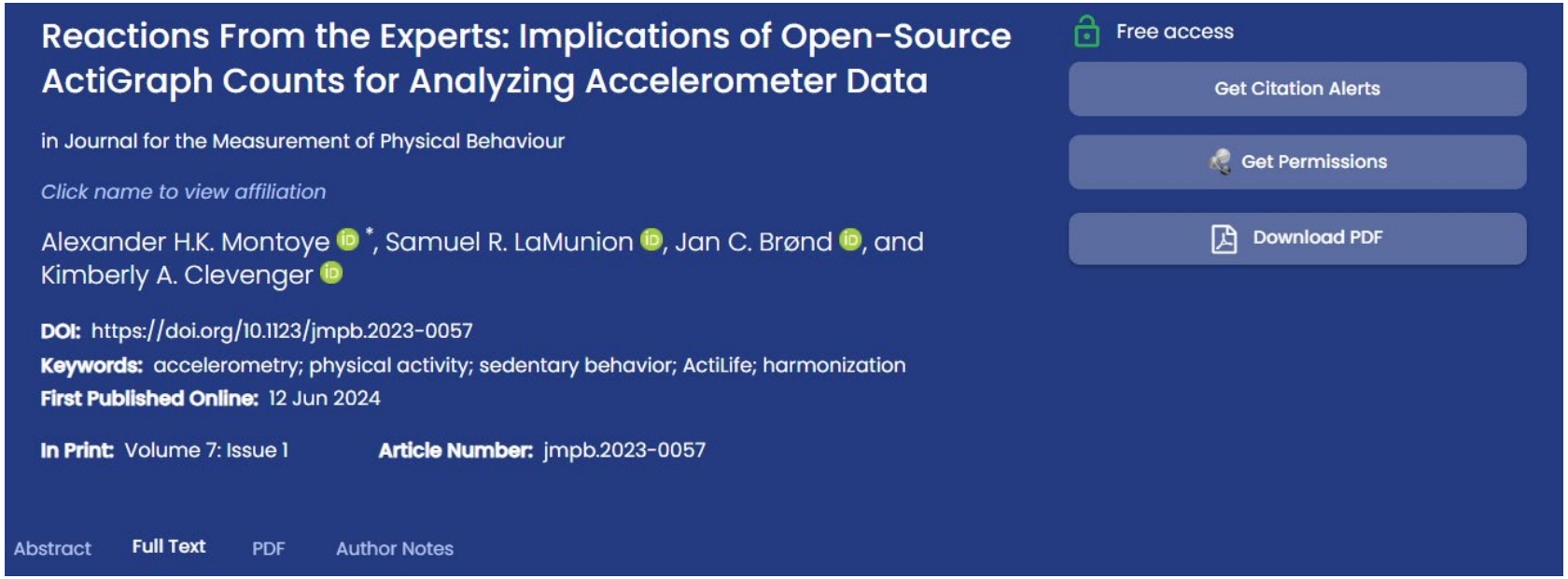
Reactions from the Experts



Reactions From the Experts: Implications of Open-Source ActiGraph Counts for Analyzing Accelerometer Data

in Journal for the Measurement of Physical Behaviour

Click name to view affiliation

Alexander H.K. Montoye *, Samuel R. LaMunion, Jan C. Brønd, and Kimberly A. Clevenger

DOI: https://doi.org/10.1123/jmpb.2023-0057
Keywords: accelerometry; physical activity; sedentary behavior; ActiLife; harmonization
First Published Online: 12 Jun 2024

In Print: Volume 7: Issue 1 **Article Number:** jmpb.2023-0057

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Reactions from the Experts

Highlights

- Transparency
- Usability
- Accessibility
- Comparability
- Interpretability

Drawbacks

- Timing
- Applicability
- Relevance
- Counts flaws still remain a factor

Expert Opinion

“Having multiple ways of translating accelerometer data into the desired physical behaviour outputs is important, as being able to use both new and old methods allows researchers the opportunity to test the new approaches against the older approaches to determine accuracy and reliability, feasibility for use, etc.”

Open-Source: Minimizing Burden while Maximizing Flexibility

- Open-source methods can work collaboratively in a data processing pipeline by calling other packages/functions

- Can be reported, shared, and reproduced by others more readily
  - *GGIR* offers an option to generate counts to complement the other raw data options available
  - Example: *SummarizedActigraphy* package in *R* by Dr. John Muschelli
    - Not comprehensive but many open-source metrics integrated

⟸ ***SummarizedActigraphy* on Github**

Flexibility for Comparison

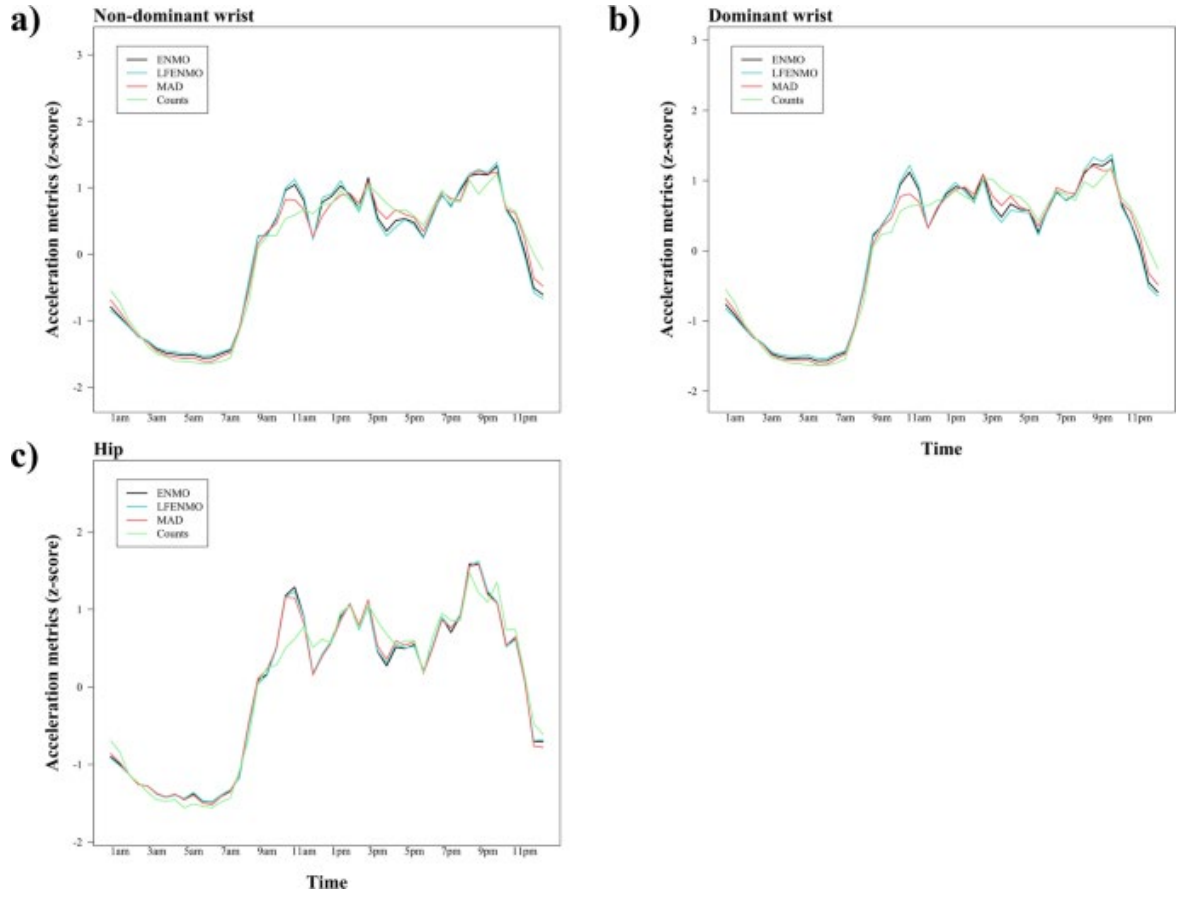
Migueles et al. 2019

Article | Open access | Published: 03 December 2019

Comparability of accelerometer signal aggregation metrics across placements and dominant wrist cut points for the assessment of physical activity in adults

Jairo H. Migueles, Cristina Cadenas-Sanchez, Alex V. Rowlands, Pontus Henriksson, Eric J. Shiroma, Francisco M. Acosta, Maria Rodriguez-Ayllon, Irene Esteban-Cornejo, Abel Plaza-Florido, Jose J. Gil-Cosano, Ulf Ekelund, Vincent T. van Hees & Francisco B. Ortega

Scientific Reports **9**, Article number: 18235 (2019) | Cite this article



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SummarizedActigraphy - Example Tutorial

Observational Study › JMIR Mhealth Uhealth. 2022 Jul 22;10(7):e38077. doi: 10.2196/38077.

Comparison of Accelerometry-Based Measures of Physical Activity: Retrospective Observational Data Analysis Study

Marta Karas [# 1], John Muschelli [# 1], Andrew Leroux [2], Jacek K Urbanek [3], Amal A Wanigatunga [4], Jiawei Bai [1], Ciprian M Crainiceanu [1], Jennifer A Schrack [3 4]

Affiliations + expand

PMID: 35867392 PMCID: PMC9356340 DOI: 10.2196/38077

Computing the measures

We calculate minute-level summary measures: AC, MIMS, ENMO, MAD, AI. The output shows values of the measures per each minute.

```
out_i = SummarizedActigraphy::calculate_measures(
  df = dat_input_i,
  dynamic_range = c(-8, 8),  # dynamic range
  fix_zeros = FALSE,         # fixes zeros from idle sleep mode -- not needed in our case
  calculate_mims = TRUE,     # uses algorithm from MIMSunit package
  calculate_ac = TRUE,       # uses algorithm from activityCounts package
  flag_data = FALSE,         # runs raw data quality control flags algorithm -- not used in our case
  verbose = FALSE)

================================================================================

out_i <- out_i %>% select(HEADER_TIME_STAMP = time, AC, MIMS = MIMS_UNIT, ENMO = ENMO_t, MAD, AI)
out_i

# A tibble: 51 × 6
   HEADER_TIME_STAMP            AC  MIMS     ENMO     MAD    AI
   <dttm>                    <dbl> <dbl>    <dbl>   <dbl> <dbl>
 1 2021-01-01 00:00:00.000  3623.  19.3  0.0882   0.140    7.62
 2 2021-01-01 00:01:00.000  2460.  14.8  0.0544   0.0971   5.84
 3 2021-01-01 00:02:00.000   648.   6.52 0.00607  0.0192   2.44
 4 2021-01-01 00:03:00.000    36.2  1.86 0.000769 0.00862  1.03
 5 2021-01-01 00:04:00.000  8084.  34.8  0.323    0.316   15.1
 6 2021-01-01 00:05:00.000 13845.  60.1  0.442    0.358   25.3
 7 2021-01-01 00:06:00.000 10549.  44.1  0.475    0.248   18.7
 8 2021-01-01 00:07:00.000 11219.  45.8  0.508    0.244   19.6
 9 2021-01-01 00:08:00.000 11624.  51.6  0.393    0.338   22.1
10 2021-01-01 00:09:00.000 11049.  45.8  0.404    0.288   20.0
# … with 41 more rows
```

⟸ ***SummarizedActigraphy*** **tutorial on Github**

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Inspired by *SummarizedActiGraphy* Example Tutorial

```r
rm(list = ls())
pacman::p_load(
  magrittr, ggplot2, dplyr, janitor, vroom,
  ggpubr, patchwork, table1, AGread, MIMSunit, GGIR, agcounts,
  lubridate, SummarizedActigraphy, activityCounts
)

# remotes::install_github('paulhibbing/AGread')
# remotes::install_github('muschellij2/SummarizedActigraphy')
# remotes::install_github('walkabillylab/activityCounts')

##### Load and Extract Raw Data #####

DISABLED <- AGread::read_gt3x("ISM_001_SL_DISABLED_PROXIMAL (2023-08-09).gt3x",
                              parser = "dev",
                              verbose = TRUE,
                              include = c("METADATA",
                                          "EVENT",
                                          "TAG",
                                          "ACTIVITY",
                                          "ACTIVITY2",
                                          "SENSOR_DATA"),
                              flag_idle_sleep = TRUE,
                              cleanup = TRUE,
                              data_checks = FALSE) # uses 'AGread' to read in the raw .gt3x file and metadata for a file with ISM disabled


Disabled_Raw <- DISABLED$RAW %>% # extracts the triaxial raw from the parsed .gt3x file packets
  janitor::clean_names()

colnames(Disabled_Raw) <- c("HEADER_TIME_STAMP", "X", "Y", "Z") # makes the column headers

out <- SummarizedActigraphy::calculate_measures(Disabled_Raw,
                                                unit = "1 min",
                                                fix_zeros = FALSE,
                                                calculate_mims = TRUE,
                                                calculate_ac = TRUE) # uses SummarizedActigraphy to generate a variety of metrics
```

Open-Source Counts…but from which open source?

 ActiGraphCounts: MATLAB; Brond et al. 2017 reverse-engineered

 activityCounts: R; conversion of reverse engineered - Brond et al. 2017

 agcounts: Python; release from ActiGraph – Neishabouri et al. 2022

 actilifecounts: R; used in GGIR

 agcounts: R; tutorial in JMPB Special Issue

Helsel et al. 2024 – agcounts in JMPB Open-Source Counts Special Issue

So where does this leave us with counts?

- Usability remains paramount
  - Lots of accessible, interpretable counts-based methods
  - Counts remain relevant to many
  - Many developers offering GUIs to enhance end-user experience
    - *GGIR, agcounts, activAnalyzer, etc.*
- Numerous compatibility and comparison opportunities with existing data
- Open-Source methods offers flexibility
- However, raw-data methods may be preferable, especially for 24-hr wrist data

Parting Thoughts

- Be transparent where possible
  - Transparency seems to be universally highly valued
- Provide access when possible
  - People will use what they feel most comfortable with and have access to
  - Many developers offering ShinyApps as a point-and-click interface for wider adoption and use
- Promote collaborative efforts*
- Pursue resource development and maintenance
- Continue to push for consensus/harmonization
  - Standards development
  - Intrinsic properties, SI units
  - Equivalence definition

Med Sci Sports Exerc. 2015 Oct; 47(10): 2129–2139.
Published online 2015 Sep 1. doi: 10.1249/MSS.0000000000000661
PMCID: PMC4731236
NIHMSID: NIHMS751348
PMID: 25785929

Utilization and Harmonization of Adult Accelerometry Data: Review and Expert Consensus

KATRIEN WIJNDAELE,[1] KATE WESTGATE,[1] SAMANTHA K. STEPHENS,[2] STEVEN N. BLAIR,[3] FIONA C. BULL,[4] SEBASTIEN F. M. CHASTIN,[5] DAVID W. DUNSTAN,[6] ULF EKELUND,[1,7] DALE W. ESLIGER,[8,9] PATTY S. FREEDSON,[10] MALCOLM H. GRANAT,[11] CHARLES E. MATTHEWS,[12] NEVILLE OWEN,[6] ALEX V. ROWLANDS,[9] LAUREN B. SHERAR,[8,13] MARK S. TREMBLAY,[14] RICHARD P. TROIANO,[15] SØREN BRAGE,[1] and GENEVIEVE N. HEALY[2]

Br J Sports Med. 2022 Apr;56(7):376-384. doi: 10.1136/bjsports-2020-103604. Epub 2021 Apr 12.

GRANADA consensus on analytical approaches to assess associations with accelerometer-determined physical behaviours (physical activity, sedentary behaviour and sleep) in epidemiological studies

Jairo H Migueles [1,2], Eivind Aadland [3], Lars Bo Andersen [3], Jan Christian Brønd [4], Sebastien F Chastin [5,6], Bjørge H Hansen [7,8], Kenn Konstabel [9,10,11], Olav Martin Kvalheim [12], Duncan E McGregor [5,13], Alex V Rowlands [14,15,16], Séverine Sabia [17,18], Vincent T van Hees [19,20], Rosemary Walmsley [21,22], Francisco B Ortega [1,23]; External review group

Collaborators, Affiliations + expand

PMID: 33846158 PMCID: PMC8938657 DOI: 10.1136/bjsports-2020-103604