National Cancer Institute's nonwear algorithm

Corner cases in the National Cancer Institute’s nonwear classification algorithm developed for analyzing activity data collected from NHANES 2003-2004

Hyatt Moore

2003–2004 National Health and Nutrition Examination Survey

Physical activity monitor component added to NHANES in 2003

- Goal: collect objective information on physical activity
- Dataset
  - 7,176 participants (≥6 years of age)
  - Instructed to wear accelerometer for up to seven, consecutive days, while awake.
  - Device removed for bathing and water activities
- Sensor
  - ActiGraph AM-7164, single (vertical) axis accelerometer, worn on the right hip
  - Acceleration recorded as *counts* on 1-minute *epochs*
  - Not waterproof (i.e. excludes any swimming or water aerobic activities)

2003–2004 National Health and Nutrition Examination Survey

- Data quality
  - Sensor required to be returned within calibration levels
  - Participant data required to have at least one *valid day* to be included in the analysis
  - Valid day: 24-hour period with 10 or more hours of data classified as *wear*
  - Wear: periods of time not classified as *nonwear* based on National Cancer Institute's (NCI) algorithm.
- Analysis
  - ≥ 1 valid days
    - Estimates of adherence to minimum physical activity levels
    - Adults should have 30 minutes of moderate-intensity activity (≥ 2200 CPM) per day
  - ≥ 4 valid days
    - Mean counts per minute (CPM)
    - Time spent in moderate or vigorous activity

Nonwear definition used in NHANES 2003-2004

“Nonwear was defined by an interval of at least 60 consecutive minutes of zero activity intensity counts, with allowance for 1–2 min of counts between 0 and 100.”

Troiano, Richard P., et al. "Physical activity in the United States measured by accelerometer." *Medicine and science in sports and exercise* 40.1 (2008)

Breakout exercise

You are tasked with implementing NCI's nonwear algorithm.
How do classify the following 60 minute scenarios; wear or nonwear?

A. 60 minutes with 0 counts (i.e. one hour of 0's).

B. 1 minute with 99 counts and 59 minutes with 0 counts
C. 1 minute with 100 counts and 59 minutes with 0 counts
D. 1 minute with 101 counts and 59 minutes with 0 counts

E. 3 consecutive minutes with 2 counts each and 57 minutes with 0 counts
F. 3 non-consecutive minutes with 80 counts each and 57 minutes with 0 counts

G. Every odd minute has 50 counts and every even minute has 0 counts

"Nonwear was defined by an interval of at least 60 consecutive minutes of zero activity intensity counts, with allowance for 1–2 min of counts between 0 and 100."

Extreme scenarios

"Nonwear was defined by an interval of at least 60 consecutive minutes of zero activity intensity counts, with allowance for 1–2 min of counts between 0 and 100." – Troiano et al, 2008

Scenario A: 0, 100, and 100 counts repeated every three minutes
Classification: non-wear

											Total
Minute	0	1	2	3	4	5	…	57	58	59	60
Counts	0	100	100	0	100	100	…	0	100	100	4000

Scenario B: 1 count for first three minutes; 0 counts for next 57 minutes
Classification: wear

											Total
Minute	0	1	2	3	4	5	…	57	58	59	60
Counts	1	1	1	0	0	0	…	0	0	0	3

Classification results from a 24 hour day

	Scenario A	Scenario B
Pre classification		
Duration (HH:MM)	24:00	24:00
Counts-per-minute	66.67	0.05
Counts (total)	96,000	72
NCI Classification		
Wear/non-wear classification	99.9% nonwear	100% wear
Duration wear (HH:MM)	00:02 (0.1%)	24:00 (100%)
Counts (total)	200	72
Duration excluded (HH:MM)	23:58 (99.9%)	00:00 (0%)
Counts excluded (total)	95,800	0

Same results using ActiLife, NCI SAS code, and R's accelerometry package.

Frequency of scenarios in NHANES

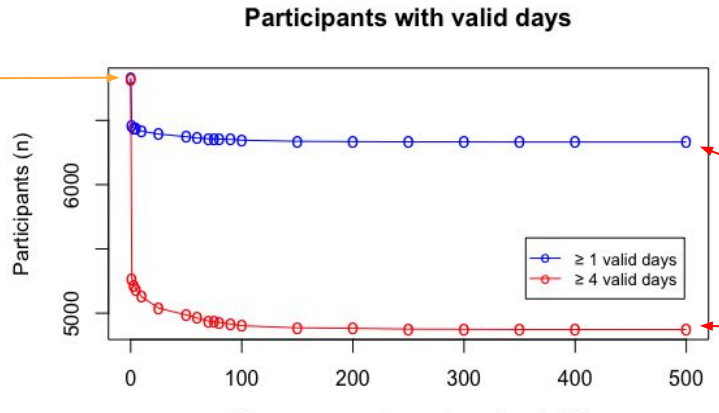
Occurrence of scenario A type hours in NHANES 2003-2004.

T (counts per hour)	≥ 10	≥ 50	≥ 75	≥ 100	≥ 150	≥ 200	≥ 500
Participants (n)	5150 (75.44%)	3581 (52.45%)	2805 (41.09%)	1930 (28.27%)	1104 (16.17%)	630 (9.23%)	13 (0.19%)

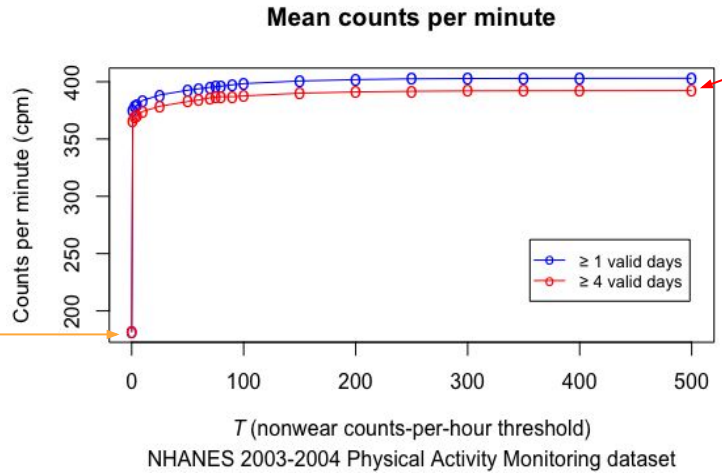
Occurrence of scenario B type hours in NHANES 2003-2004.

T (counts per hour)	1	1 ≤ T ≤ 3	1 ≤ T ≤ 5	1 ≤ T ≤ 10	1 ≤ T ≤ 25	1 ≤ T ≤ 50	1 ≤ T ≤ 60
Participants (n)	4 (0.06%)	5 (0.07%)	8 (0.12%)	13 (0.19%)	35 (0.51%)	99 (1.45%)	122 (1.79%)

No classification
(all data included)



NHANES default
exclude all nonwear



All data included

Summary

- Corner cases do exist within NHANES wear time classification algorithm.
- This was not an issue with previous analysis done with NHANES because
  - Many participants
  - Valid day criteria
  - Cutpoints for nonsedentary behavior above maximum CPM allowed during nonwear (e.g. 1000).
- It is important to understand precise definition of non-wear implementation
- There may be issues using NHANES algorithm when
  - Smaller dataset: few participants and/or only a small number of days collected
  - Cutpoints for non-sedentary behavior categories are lower than 66.7 CPM (e.g. Evenson).

Links

- Open source software webinar series (#15)
  - https://github.com/wadpac/oss-dev-webinar-series-pb-field/issues/15
- NHANES 2003-2004 overview and data
  - https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/default.aspx?BeginYear=2003
- Potential corner case cautions of NCI algorithm
  - https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0210006