



NHANES and Physical Activity

For Committee to Review the DRIs for Energy

Richard Troiano, Ph.D.

Wherefore Today?

- Value of device measures and caveats
- National physical activity data (NHANES 2011-2014)

ACCELEROMETER DATA BENEFITS

Stronger Biomarker Associations

Biomarker	Self-report		Accelerometer	
	Beta (SE)	Adj. Wald F	Beta (SE)	Adj. Wald F
SBP	0.01 (0.03)	0.23	-0.43 (0.14)	8.89**
BMI	-0.04 (0.01)	14.95***	-0.77 (0.08)	86.71****
HDL (mg/dL)	0.10 (0.03)	8.54**	1.41 (0.27)	27.77****
Glycohemoglobin	-0.004 (0.001)	7.91**	-0.05 (0.01)	47.11****
Glucose	0.01 (0.07)	0.06	-1.67 (0.30)	30.77****
Insulin (μU/mL)	-0.08 (0.03)	10.15**	-1.11 (0.12)	81.53****

** p < 0.01

*** p < 0.001

**** p < 0.0001

Minutes in bouts, Beta per 10 min unit

Atienza et al., 2011 MSSE

JAMA | Original Investigation

Association of Daily Step Count and Step Intensity With Mortality Among US Adults

Pedro F. Saint-Macary, PhD; Richard P. Troiano, PhD; David R. Bassett Jr, PhD; Barry J. Goldstein, PhD; Susan A. Carlson, PhD; Eric C. Shriver, ScD; Janet E. Folsom, PhD; Charles E. Matthews, PhD

IMPORTANCE It is unclear whether the number of steps per day and the intensity of stepping are associated with overall mortality.

OBJECTIVE Describe the dose-response relationship between step count and intensity and mortality.

DESIGN, SETTING, AND PARTICIPANTS Representative sample of US adults aged at least 40 years in the National Health and Nutrition Examination Survey who wore an accelerometer for up to 7 days (from 2010–2016). Mortality was ascertained through December 2015.

EXPOSURES Accelerometer-measured number of steps per day and 3-step intensity measures (restricted-bout counts, peak 30-minute counts, and peak 1-minute counts [steps/minute]). Accelerometer data were based on measurements obtained during a 7-day period at baseline.

MAIN RESULTS AND MEASURES The primary outcome was all-cause mortality. Secondary outcomes were cardiovascular disease (CVD) and cancer mortality. Hazard ratios (HRs), mortality rates, and 95% CIs were estimated using cubic splines and quartile classifications adjusting for age, sex, race/ethnicity, education, diet, smoking status, body mass index, self-reported health, mobility limitations, and diagnoses of diabetes, stroke, heart disease, heart failure, cancer, chronic bronchitis, and asthma.

JAMA. 2020;323(12):1151–60.


Steps per Day and All-Cause Mortality in a Study of the Association of Daily Step Count and Step Intensity With Mortality Among US Adults Aged at Least 40 Years

HR = 0.49 for 8000 vs 4000 steps/d

Reviewer: “It is not clinically plausible that an increased step count is independently associated with a 50-70% reduction in mortality risk...”

Steps per day	Mortality rate per 1000 adults per year
2000	22
4000	14.5
6000	9.5
8000	7.5
10000	6
12000	5.5
14000	5
16000	5

ORIGINAL RESEARCH

 **American Heart Association**
Heart Disease and Stroke Statistics
2015 Update

Moderate-to-Vigorous Physical Activity and All-Cause Mortality: Do Bouts Matter?

Pedro P. Saint-Maurice, PhD, Richard P. Troiano, PhD, Charles L. Matthews, PhD, William E. Kraus, MD

Background: The 2008 Physical Activity Guidelines for Americans recommends that adults accumulate moderate-to-vigorous physical activity (MVPA) in bouts of ≥ 10 minutes for substantial health benefits. To what extent the same amount of MVPA accumulated in bouts versus sporadically reduces mortality risk remains unclear.

Methods and Results: We analyzed data from the National Health and Nutrition Examination Survey 2003–2006 and death records available through 2011 (follow-up period of ≤ 6.6 years; 700 deaths) to examine the associations between objectively measured physical activity accumulated with and without a bout criteria and all-cause mortality in a representative sample of US adults ≥ 40 years and older ($n=8400$). Physical activity data were processed to generate minutes per day of total and bouts MVPA. Bouts MVPA was defined as MVPA accumulated in bouts of a minimum duration of either 5 or 10 minutes allowing for 1- to 2-minute interruptions. Hazard ratios for all-cause mortality associated with total and bouts MVPA were similar and ranged from 0.24 for the third quartile of total to 0.64 for the second quartile of 10-minute bouts. The examination of jointly classified quartiles of total MVPA and tertiles of proportion of bouts activity revealed that greater amounts of bouts MVPA did not result in additional risk reductions for mortality.

Conclusions: These results provide evidence that mortality risk reductions associated with MVPA are independent of how activity is accumulated and can impact the development of physical activity guidelines and inform clinical assessment. (*J Am Heart Assoc.* 2015;4:e007678. DOI: 10.1161/JAHA.115.007678.)

Key Words: accelerometer • activity bouts • activity • epidemiology • exercise • National Health and Nutrition Examination Survey

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Correlation of Total Daily Counts with DLW


Accelerometer Variables	DLW Measures			
	TDEE	PAEE	TDEE	PAEE
	Women		Men	
	Triaxial			
TAC per day				
Crude	0.59	0.57	0.58	0.56
Adjusted for weight	0.57	0.52	0.54	0.52
Multivariable-adjusted ^a	0.44	0.44	0.42	0.41
Deattenuated ρ and 95% CI	0.62	0.61	0.50	0.49
	(0.47, 0.73)	(0.47, 0.71)	(0.40, 0.58)	(0.40, 0.57)

^a Adjusted for weight, age, wear time and fat free mass

From Table 3 in Chomistek et al., 2017

HOW ACCELEROMETERS WORK

Accelerometer Methods

- Measures body movement in terms of acceleration
 - related to intensity of physical activity
 - measured in 1 to 3 orthogonal planes
 - anterior-posterior
 - medial-lateral
 - vertical
- Relevant to waist-wear
- 
- Data stored or uploaded for download/analysis
 - Proprietary filtering and processing for "counts" or other metrics
 - Need intensity thresholds from calibration studies OR
 - Algorithms to classify raw data

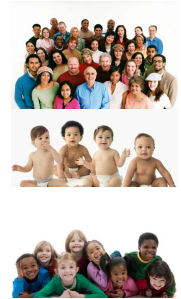
Motion Sensor Characteristics

- Activity monitor
 - Inexpensive (pedometer) to moderate cost (accelerometer, inclinometer)
 - Removes cognitive aspect
 - Includes all activity contexts
- No specific contextual information
- Primarily measures locomotor activity (at waist/leg) AND
- Misses upper body and other movements
- OR
- Measures movement of the limb on which it is attached (different issues!)
- Does not account for resistance (e.g. walking with added weight or uphill)

NHANES 2011-2014 ACCELEROMETER

NHANES Sample

- Nationally representative
- Civilian, non-institutionalized household population in the United States
- All ages
- Oversample minorities
- Target: 5,000 individuals examined annually



NHANES 2011-14 Protocol

- Sample
 - Age 6+ (3+ from 2012)
- Location
 - Worn on nondominant wrist
- Wearing Protocol
 - 7+ days of continuous wear (24/7)
- Actigraph GT3X+
- 80 Hz triaxial data
 - + lux data



RESULTING DATA

NHANES Component Compliance and Data

- Over 4 years:
 - >16,000 participants agreed to wear
 - ~88% of eligible examinees ages 3 years and older
 - >95% of devices were returned by participants
- Analytic n=14,705 after data quality exclusions
 - Females: 3,054 youth; 4,525 adults (20 y +)
 - Males: 2,976 youth; 4,150 adults

Wrist Accelerometer Reference Data

US Population-referenced Percentiles for Wrist-Worn Accelerometer-derived Activity

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¹Department of Population and Public Health Sciences, Keck School of Medicine, University of Southern California, Los Angeles, CA; ²Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD; ³Department of Mathematics and Statistics, University of Massachusetts, Amherst, Amherst, MA; and ⁴US Public Health Service (retired), Silver Spring, MD

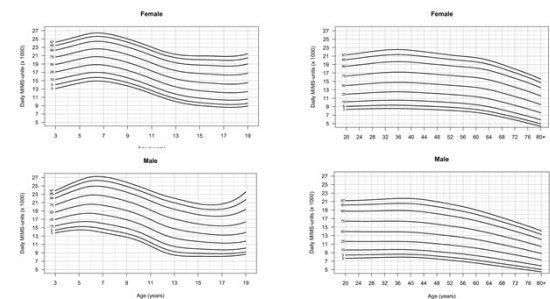
ABSTRACT

BELCHER, B. R., D. L. WOLFF-HUGHES, E. E. DOOLEY, J. STAUDENMAYER, D. BERRIGAN, M. S. EBERHARDT, and R. P. TROIANO. US Population-referenced Percentiles for Wrist-Worn Accelerometer-derived Activity. *Med. Sci. Sports Exerc.*, Vol. 53, No. 11, pp. 2435–2444, 2021. **Purpose:** This study aimed to present age- and sex-specific percentiles for daily wrist-worn movement metrics in US youth and adults. This metric represents a summary of all recorded movement, regardless of the purpose, context, or intensity. **Methods:** Wrist-worn accelerometer data from the combined 2011–2014 National Health and Nutrition Examination Survey cycles and the 2012 National Health and Nutrition Examination Survey National Youth Fitness Survey were used for this analysis. Monitor Independent Movement Summary units (MIMS-units) from raw triaxial accelerometer data were used. We removed the partial first and last assessment days and days with >5% nonwear time. Participants with ≥1 valid day were included. Mean MIMS-units were calculated across all valid days. Percentile tables and smoothed curves of daily MIMS-units were calculated for each age and sex using the Generalized Additive Models for Location, Shape and Scale. **Results:** The analytical sample included 13,705 participants age ≥2 yr. The MIMS-unit activity among youth was similar for both sexes, whereas adult females generally had higher MIMS-unit activity than did males. Median daily MIMS-units peaked at age 6 yr for both sexes (males, 20,813; females, 20,796). Lowest activity was observed for males and females 80+ yr of age. **Conclusion:** Population-referenced MIMS-unit percentiles for US youth and adults are a useful means of characterizing total activity volume. By using MIMS-units, we provide a standardized reference that can be applied across various wrist-worn accelerometer devices. Further work is needed to link these metrics to activity intensity categories and health outcomes. **Key Words:** NHANES, NHTFS, MONITOR-INDEPENDENT MOVEMENT SUMMARY UNITS, MIMS-UNITS, PHYSICAL ACTIVITY, SURVEILLANCE, YOUTH, ADULTS

Curve Generation

- Daily sum of Monitor Independent Motion Summary units
 - Device-agnostic motion summary, like non-proprietary Actigraph counts
 - Details: John et al., J Meas Phys Behav, 2019
- Algorithms for wake-wear, non-wear, sleep-wear used for data quality day exclusions (nw ≥ 5% [72 min], sleep ≥ 17h)
- Average of 1+ valid days/person (mean 4.2–6.3 valid days by sex/age group)
- Generalized Additive Models for Location Scale and Shape (GAMLSS) code run in *gamlss* r package using Box-Cox t distribution

Daily MIMS-units Percentiles by Age



Important Points

Total daily activity metric

- Represents PA from all sources, contexts, and intensities
- Does not quantify PA by intensity → MIMS ≠ Actigraph counts
 - No consensus on cutpoints across ages

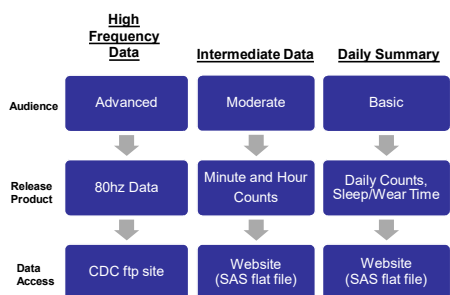
Percentile values

- Can be used to predict outcomes
- Provide reference data for other studies
- May apply to other device data if converted to MIMS

Wear/sleep algorithms likely to improve; misclassification at present

DATA AVAILABILITY

Data Release



REPORTED DATA

Global Physical Activity Questionnaire

In NHANES 2011-2014

- Ages 12 y and older
- Asks about “typical week”
 - Days per week and time per day asked for:
 - Activity at work (moderate and vigorous asked separately)
 - Travel to and from places (all walk/bike assumed to be moderate)
 - Recreational activity (moderate, vigorous separately)
 - MET values assigned to responses (4 for moderate, 8 for vigorous)
- Summary metric of MET minutes/week

Thank you

Questions and Discussion

Physical Activity Conceptual Framework

