Sedentary Behavior and Health: Unraveling the Relation with Better Measurements

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Overview

Background

• Physical Activity Guidelines (2008)
• Defining “sedentary” and “physically active” behaviors

Sedentary behavior and mortality in the NIH-AARP Diet and Health Study

Development of better exposure assessment methods for large scale studies

Summary / Conclusions

- Avoid inactivity. Some activity is better than none, more is better.
- Health-enhancing physical activity produces health benefits (added to baseline activity).
  - Aerobic activity
    - Moderate intensity (2.5 / 5.0 hr/wk)
    - Vigorous (1.25 / 2.5 hr/wk)
  - Strengthening (2+ days/wk)

- Baseline activity refers to the light-intensity activities of daily life, such as standing, walking slowly, and lifting lightweight objects.
- We don't understand enough about whether doing more baseline activity results in health benefits.
Newly Minted Definitions

Sedentary Behaviour Guidelines, UK 2011 (www.sedentarybehaviour.org)

• Sedentary behaviour refers to any waking activity characterized by an energy expenditure ≤ 1.5 metabolic equivalents and a sitting or reclining posture. In general, this means that anytime a person is sitting or lying down, they are engaging in sedentary behaviour.

![Diagram showing metabolic equivalents and sedentary, light, moderate, and vigorous physical activity levels.](image)
Defining Sedentary and Active Behaviors

- **Sedentary**: derived from Latin (sedere, “to sit”)

- **Sedentary behaviors** - Seated/reclining behaviors that require only low levels of energy expenditure (typically < 1.5 METS)

- **Active behaviors** - Upright (standing) behaviors, or any behavior that results in higher levels of energy expenditure (typically ≥ 1.5 METS).
  - Light, moderate, vigorous intensity.

Relation between physical activity intensity, sedentary time and PA Level (PAL)

![Graph showing the relationship between PA Level (PAL) and fraction of daytime (%)]

- Vigorous activity
- Inactive/sedentary
- Light to moderate activity

Westerterp Nature 410: 539, 2001
Time spent in sedentary behavior (%), by sex and age - US 2003-2004

National average = 54.9%, or 7.7 hrs/d
15.4 hrs waking → 8.5 hrs/d sedentary

Matthews et. al. AJE, 2008
Hours/day reported* in active and sedentary behaviors during waking hours

Adults (hrs/d, n=102)
- Sedentary: 9.92 (65.6%)
- Light: 1.52
- Moderate: 3.40
- Vigorous: 0.20

Adolescents (hrs/d, n=117)
- Sedentary: 9.76 (68.7%)
- Light: 2.29
- Moderate: 1.47
- Vigorous: 0.62

* Average 1-3 PDRs over 7-10 days; Matthews et al. MSSE 2013
Amount of time spent in sedentary behaviors and cause-specific mortality in US adults\textsuperscript{1,3}

Charles E Matthews, Stephanie M George, Steven C Moore, Heather R Bowles, Aaron Blair, Yikyung Park, Richard P Troiano, Albert Hollenbeck, and Arthur Schatzkin

ABSTRACT

Background: Sedentary behaviors predominate modern life, yet we do not fully understand the adverse effects of these behaviors on mortality after considering the benefits of moderate-vigorous physical activity (MVPA).

Objective: We tested the hypotheses that higher amounts of overall sitting time and television viewing are positively associated with mortality and described the independent and combined effects of these sedentary behaviors and MVPA on mortality.

Design: In the NIH-AARP Diet and Health Study, we examined 240,819 adults (aged 50–71 y) who did not report any cancer, cardiovascular disease, or respiratory disease at baseline. Mortality was ascertained over 8.5 y.

Results: Sedentary behaviors were positively associated with mortality after adjustment for age, sex, education, smoking, diet, race, and MVPA. Participants who reported the most television viewing (≥7 h compared with <1 h/d) were at greater risk of all-cause (HR: 1.61; 95% CI: 1.47, 1.76), cardiovascular (HR: 1.85; 95% CI: 1.56, 2.20), and cancer (HR: 1.22; 95% CI: 1.06, 1.40) mortality after adjustment for MVPA. Overall sitting was associated with all-cause mortality. Even among adults reporting high levels of MVPA (>7 h/wk), high amounts of television viewing (≥7 h/d) remained associated with increased risk of all-cause (HR: 1.47; 95% CI: 1.20, 1.79) and cardiovascular (HR: 2.00; 95% CI: 1.33, 3.00) mortality compared with those reporting the least television viewing (<1 h/d).

Conclusions: Time spent in sedentary behaviors was positively associated with mortality, and participation in high levels of MVPA did not fully mitigate health risks associated with prolonged time watching television. Adults should be encouraged to reduce time spent in sedentary behaviors, when possible, and to participate in MVPA at recommended levels. The NIH-AARP Diet and Health Study was registered at clinicaltrials.gov as NCT00340015. *Am J Clin Nutr* doi: 10.3945/ajcn.111.019620.
1) Test the hypothesis that higher amounts of sedentary behavior (overall sitting, television viewing) are positively associated with mortality.

2) Describe the independent and combined effects of sedentary behavior and moderate-vigorous physical activity (MVPA).
The NIH-AARP Diet and Health Study

- AARP members, 50-71 years old in 1995-1996
- 6 states (CA, FL, LA, NC, NJ, PA) and 2 metropolitan areas (Detroit, MI and Atlanta, GA)
- 566,309 men and women
The NIH-AARP Diet and Health Study

Baseline Qx: Diet & Lifestyle  
N=566,309

Risk factor Qx: Lifestyle & Medical history  
n=334,908

Mortality Outcomes (National death index)  
2005
### Exposure Assessment: Sedentary behaviors

1995/96  96/97

**Baseline Qx:** Diet & Lifestyle

**Risk factor Qx:** Lifestyle & Medical history

52. **During a typical 24-hour period** over the past 12 months, how much time did you spend watching television or videos?

- None
- Less than 1 hour
- 1 to 2 hours
- 3 to 4 hours
- 5 to 6 hours
- 7 to 8 hours
- 9 or more hours

53. **During a typical 24-hour period** over the past 12 months, how many hours did you spend:

   a. **Sleeping at night?**
      - Less than 5 hours
      - 5 to 6 hours
      - 7 to 8 hours
      - 9 or more hours

   b. **Napping during the day?**
      - None
      - Less than 1 hour
      - 1 to 2 hours
      - 3 to 4 hours
      - 5 or more hours

   c. **Sitting?**
      - Less than 3 hours
      - 3 to 4 hours
      - 5 to 6 hours
      - 7 to 8 hours
      - 9 or more hours
Exposure Assessment: Mod-vig PA

1995/96   96/97

Baseline Qx: Diet, Lifestyle

Risk factor Qx: Lifestyle & Medical history

55. Read the list of examples of moderate and vigorous activities in the box below.

<table>
<thead>
<tr>
<th>EXAMPLES OF MODERATE AND VIGOROUS ACTIVITIES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tennis</td>
</tr>
<tr>
<td>Golf (walking)</td>
</tr>
<tr>
<td>Biking</td>
</tr>
<tr>
<td>Swimming</td>
</tr>
<tr>
<td>Heavy gardening</td>
</tr>
<tr>
<td>Weight lifting</td>
</tr>
<tr>
<td>Basketball/baseball</td>
</tr>
<tr>
<td>Football/soccer</td>
</tr>
<tr>
<td>Cheerleading/drift team</td>
</tr>
<tr>
<td>Handball/racquetball</td>
</tr>
<tr>
<td>Hiking/climbing mountains</td>
</tr>
<tr>
<td>Fast walking/fast dancing</td>
</tr>
<tr>
<td>Rowing</td>
</tr>
<tr>
<td>Aerobics</td>
</tr>
<tr>
<td>Jogging/running</td>
</tr>
<tr>
<td>Heavy housework</td>
</tr>
</tbody>
</table>

Think back to the ages and times listed in the table below. Mark the circles that best describe how often you participated in moderate and vigorous activities at the ages and time listed. DO NOT INCLUDE ACTIVITIES THAT YOU REPORTED IN QUESTIONS 48 - 51 ON PAGE 13.

<table>
<thead>
<tr>
<th>How often did you participate in moderate and vigorous activities at the following ages and time?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>15-18 years old</td>
</tr>
<tr>
<td>19-29 years old</td>
</tr>
<tr>
<td>35-39 years old</td>
</tr>
<tr>
<td>in the past 10 years</td>
</tr>
</tbody>
</table>
Results

Follow-up: 8.5 (SD=1.7) yrs

Mortality outcomes (through 12/31/05)

- All-causes: 17,044 deaths
- Cardiovascular: 4,684 deaths
- Cancer: 7,652 deaths
- Other causes: 4,708
Sedentary Behavior and Cause-specific Mortality

*Adjusted: age, sex, race, education, smoking, diet quality, moderate-vigorous physical activity

Matthews et al. AJCN, 2012
Sedentary Behavior and Cause-specific Mortality

*Adjusted: age, sex, race, education, smoking, diet quality, moderate-vigorous physical activity

Matthews et al. AJCN, 2012
How Much Exercise/MVPA is Required to Eliminate Risk?

All-cause Mortality

Reference: TV < 1 h/d; MVPA > 7 h/wk

Adjusted: age, sex, race, education, smoking, diet quality

Matthews et al. AJCN, 2012
Conclusion

• Sedentary behaviors, particularly television viewing, independently associated with all-cause, cardiovascular, and cancer mortality.

• High levels of MVPA reduce, but do not completely eliminate, risks associated with prolonged television viewing.

• Sedentary behavior also associated with increased risk for developing certain cancers (colon, endometrial).
Unresolved Questions

• What is driving the association between sedentary time and mortality?
  – Does sedentary time “displace” time otherwise spent in physical activity?
  – Or, does sedentary time have unique/independent adverse health effects?

• How much, and what type(s) of activity confer protection against too much sitting?
  – Exercise alone may not be sufficient. What about common daily—non-exercise activities (i.e., “baseline activities”)?
Study Design and Analytic Cohort

Follow-up Qx:
N=318,713

Exclusions:
Proxies; Heart disease;
Stroke; Cancer; Emphysema;
Renal disease; Neurological
conditions; Missing PAQ /
Sitting items

Out of range values (PAQ ≥ 68 hrs/week [n=3,124];
Overall sitting ≥ 22.5 hrs/d [n=2,793])

Mortality (NDI)
6.8 yrs of follow-up

Men, n=7,218
Women, n=4,983

Analytic cohort:
N=155,614
### PA Items on the Follow-up Questionnaire

1. During the past 12 months, approximately how much time per week did you participate in each of the following activities? (For each activity mark only one response.)

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>AVERAGE TOTAL TIME PER WEEK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>a. Light household chores (for example, cooking, cleaning up, laundry, dusting, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>b. Moderate to vigorous household chores (for example, vacuuming, sweeping, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>c. Moderate outdoor chores (for example, weeding, raking, mowing the lawn, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>d. Vigorous outdoor chores (for example, digging, carrying lumber, snow shoveling, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>e. Home repairs (for example, painting, plumbing, replacing carpeting, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>f. Caring for children (for example, pushing a stroller, playing, lifting, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>g. Caring for another adult (for example, lifting, pushing a wheelchair, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>h. Walking for exercise</td>
<td>○</td>
</tr>
<tr>
<td>i. Walking for other daily (but not leisure time) activities, such as shopping, getting to and from work, etc.</td>
<td>○</td>
</tr>
<tr>
<td>j. Jogging or running</td>
<td>○</td>
</tr>
<tr>
<td>k. Playing tennis, squash, or racquetball</td>
<td>○</td>
</tr>
<tr>
<td>l. Playing golf</td>
<td>○</td>
</tr>
<tr>
<td>m. Swimming laps</td>
<td>○</td>
</tr>
<tr>
<td>n. Bicycling (including riding a stationary bike)</td>
<td>○</td>
</tr>
<tr>
<td>o. Other aerobic exercise (for example, aerobic class, exercise machines, etc.)</td>
<td>○</td>
</tr>
<tr>
<td>p. Weight training or lifting (include free weights and machines)</td>
<td>○</td>
</tr>
</tbody>
</table>
2. In a typical 24-hour period during the past 12 months, how many hours per day did you spend: (MARK ONLY ONE RESPONSE PER ACTIVITY.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>AVERAGE NUMBER OF HOURS PER DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Sitting watching television, video, or DVD?</td>
<td>□</td>
</tr>
<tr>
<td>Sitting or driving in a car, bus, or train?</td>
<td>□</td>
</tr>
<tr>
<td>Other sitting (reading, knitting, using a computer)?</td>
<td>□</td>
</tr>
<tr>
<td>Sleeping at night or napping during the day?</td>
<td>□</td>
</tr>
</tbody>
</table>

**Overall sitting**

**Sleep time**
Association* between all-cause mortality and exercise and non-exercise activity estimated by restricted cubic splines, by sex, the NIH-AARP Diet and Health Study

*Values are Hazard Ratios and 95% Confidence Intervals adjusted for Age (years), Education (< 12 yrs, high school graduate, some college, college graduate, unknown), Smoking history (never, stopped 10+, stopped 5-9, stopped 1-4 years, stopped < 1 year, current smoker, unknown), Sleep duration (< 4, 4-5.9, 6-7.9, 8-9.9, 10+ hours/day, unknown), Overall sitting time (hrs/d), Overall health (excellent, very good, good, fair, poor, unknown), and Body Mass Index (< 25, 25-29.9, 30+ kg/m², unknown), and the other type of physical activity
Overall Sitting (hrs/d) and Mortality, by Sex

**Men**

<table>
<thead>
<tr>
<th>Overall Sitting</th>
<th>Adjusted* Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>1.00</td>
</tr>
<tr>
<td>5-6.9</td>
<td>1.04</td>
</tr>
<tr>
<td>7-8.9</td>
<td>1.10</td>
</tr>
<tr>
<td>9-11.9</td>
<td>1.20</td>
</tr>
<tr>
<td>12+</td>
<td>1.24</td>
</tr>
</tbody>
</table>

$P_{\text{trend}} < 0.01$

**Women**

<table>
<thead>
<tr>
<th>Overall Sitting</th>
<th>Adjusted* Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>1.00</td>
</tr>
<tr>
<td>5-6.9</td>
<td>1.10</td>
</tr>
<tr>
<td>7-8.9</td>
<td>1.10</td>
</tr>
<tr>
<td>9-11.9</td>
<td>1.27</td>
</tr>
<tr>
<td>12+</td>
<td>1.43</td>
</tr>
</tbody>
</table>

$P_{\text{trend}} < 0.01$

*Values are Hazard Ratios and 95% Confidence Intervals adjusted for Age (years), Education (< 12 yrs, high school graduate, some college, college graduate, unknown), Smoking history (never, stopped 10+, stopped 5-9, stopped 1-4 years, stopped < 1 year, current smoker, unknown), Sleep duration (< 4, 4-5.9, 6-7.9, 8-9.9, 10+ hours/day, unknown), Overall health (excellent, very good, good, fair, poor, unknown), and Body Mass Index (< 25, 25-29.9, 30+ kg/m$^2$, unknown), and the other type of physical activity.
Conclusion

• The adverse effect of sedentary time on mortality may be due to displacement of non-exercise activities.
• Higher levels of overall activity, particularly non-exercise activities, can substantially minimize risks associated with large amounts of sedentary time.
• Aside from formal exercise, household and lawn/garden activities, and daily walking provide benefit.
Future Directions

• Continue to extend evidence-base
  – Incident cancers, cancer survivors
  – Incident disease end-points

• Dose-response/public health issues
  – How little activity do I have to do?
  – How much sitting can I get away with?
  – What type, intensity, duration of activity needed?
  – What about sleep?

• Biological & social mechanisms

• Better exposure assessment methods
Limitations of Questionnaires to Estimate Usual Physical Activity (PA) and Sedentary Behavior

• Success in etiologic studies, but measurement errors are large (r ~ 0.3 to 0.5)

• Cognitive demands associated with reporting long-term averages are extraordinary

• Scope of questionnaires often limited (e.g., only leisure-time, television, or MVPA)

• Systematic reporting errors typically assumed (i.e., social desirability)

• Assessment of sedentary behavior in its infancy
Methodological Studies: Exposure Assessment
Questionnaires Have Many Limitations

- Cognitive demands are large
- Measurement errors are large
  - Validity modest, R ~ 0.3 to 0.5
- Impact of errors may be large:
  - Risk estimates biased (attenuation)
  - Loss of statistical power
  - Difficulty estimating dose-response
- Scope of questionnaires often limited
Approaches for Improving Measures in Large Etiologic Studies

1. Questionnaires + calibration & measurement error correction

\[ Q_{ij} = \mu_{Qj} + \beta_{Q0} + \beta_{Q1} T_i + r_i + \varepsilon_{ij} \]

\[ \lambda_1 = \frac{\text{cov}(T, Q)}{\text{var}(Q)} = \frac{\beta_{Q1}}{\beta_{Q1}^2 + \sigma_r^2 / \sigma_T^2 + \sigma_e^2 / \sigma_T^2} \]

2. Objective measures of target behaviors (accelerometers)

3. Previous-day recalls of target behaviors
   Activities Completed over Time in 24 hours (ACT24)

Matthews et al., ESSR, 2012
Previous-Day Recall: Proof-of-Principle

Study Design

- 213 Adolescents (12-17 y) & Adults (18-75 y)
- 7-day study period
- 3 unannounced Previous-day Recalls (PDR)
- 2 activity monitors:

Statistical Methods

Previous-day Recall

\[ ij = \beta_0 + \beta_1 T_{ij} + r_i + \epsilon_{ij} \]

- Sedentary/sitting (hrs/d)
- Active/upright (hrs/d)

Gold standard “Truth”

Slope
Person-specific bias
Random error

Matthews et al. MSSE, 2013
activPAL

06 AM
Sit/Lie 60.0min
Stand 0.0min
Step 0.0min
0 steps
0/0 u/d transitions
EE (MET.h): 1.2

07 AM
Sit/Lie 60.0min
Stand 0.0min
Step 0.0min
0 steps
0/0 u/d transitions
EE (MET.h): 1.8

08 AM
Sit/Lie 13.8min
Stand 21.9min
Step 24.3min
1194 steps
7/6 u/d transitions
EE (MET.h): 1.8

09 AM
Sit/Lie 42.6min
Stand 3.5min
Step 13.9min
1410 steps
4/3 u/d transitions
EE (MET.h): 1.3

10 AM
Sit/Lie 53.2min
Stand 4.5min
Step 2.3min
194 steps
2/1 u/d transitions
EE (MET.h): 1.3

11 AM
Sit/Lie 56.9min
Stand 2.5min
Step 0.6min
48 steps
1/0 u/d transitions
EE (MET.h): 1.3

12 PM
Sit/Lie 60.0min
Stand 0.0min
Step 0.0min
0 steps
0/0 u/d transitions
EE (MET.h): 1.3

01 PM
Sit/Lie 44.6min
Stand 12.4min
Step 3.0min
190 steps
EE (MET.h): 1.4
activPAL vs. Direct Observation

- 27 participants
- 47 observation periods (focal sampling, PDA)
- Avg 3.8 hrs/period (1.8 to 6.6 hrs)
Previous-day Recall (PDR) Methods

Interview elicits open-ended reports of specific behaviors from previous day (midnight-midnight) by phone

Key elements of the recall

Segmentation of the day (morning, afternoon, evening)
Individual behaviors reported (largely) in chronological order
Assessment of body posture (active or sedentary)
Contextual information about each behavior
  - Location (home, community, work/school)
  - Purpose of behavior (e.g., leisure, work, school, transport)

Time cues available to interviewers (over/under time)
Review information at end of each segment
Sedentary/sitting (hrs/d)  

- Men: $r=0.81$  
- Women: $r=0.81$  
- Boys: $r=0.80$  
- Girls: $r=0.60$

Upright/active (hrs/d)  

- Men: $r=0.77$  
- Women: $r=0.80$  
- Boys: $r=0.75$  
- Girls: $r=0.52$

Previous-day Recall

**ActiGraph**

- Men: $r=0.75$  
- Women: $r=0.77$  
- Boys: $r=0.68$  
- Girls: $r=0.70$

- Men: $r=0.74$  
- Women: $r=0.79$  
- Boys: $r=0.57$  
- Girls: $r=0.67$
Difference between PDR and ActiGraph (hrs/d), by Activity Intensity (mean, 95% CI)

<table>
<thead>
<tr>
<th>Activity Intensity</th>
<th>PDR</th>
<th>ActiGraph</th>
<th>Difference (PDR - ActiGraph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>760</td>
<td>1952</td>
<td>-2.0</td>
</tr>
<tr>
<td>Mod-vig</td>
<td></td>
<td></td>
<td>-1.5</td>
</tr>
<tr>
<td>Mod-vig 760</td>
<td></td>
<td></td>
<td>-1.0</td>
</tr>
<tr>
<td>Mod-vig 1952</td>
<td></td>
<td></td>
<td>-0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0</td>
</tr>
</tbody>
</table>

Women: ▢
Men: ■
Girls: ○
Boys: □
Conclusions

- Correlations between the PDR and activPAL were high
- Systematic reporting errors on the PDR were lower than random errors
- PDR performance was comparable to the ActiGraph
- PDRs may have value in studies of physical activity and health
Activities Completed by Time in 24 Hours (ACT24) System

Objective

• To assess how adults spend their time in sleep, active, and sedentary behaviors over 24-hrs via an automated email/web-based system
Activities Completed over Time in 24 Hours (ACT24)

Please select your next activity.

To find an activity:
1) Review the categories on the Activities list (left).
2) To see all activities within a category click on the category.
3) Click on the activity that best describes what you did, or choose "Other" and type in what you did.

After each follow-up question, remember to click the green check box to save your answer.

Note: You can report up to three overlapping activities at the same time, or multitasking.

How do I report overlapping activities or multitasking?

After adding all activities for this time period, click on the Next Time Period button (below right).
Adding Activities to ACT24

Activities
- Leisure, relaxation, social activities
  - Watching TV, movies, DVDs
- Socializing with others
- Reading (books, papers, magazines)
- Playing computer or electronic games
  - Playing games
  - Sitting quietly
- Eating out
- Dancing
- Arts and crafts, hobbies
- Fishing or hunting
- Other
- Shopping, errands, and appointments
- Caring for or playing with others
- Occupation, working for pay

Watching TV, movies, DVDs

It is common to do other things while you are watching TV. You can report up to three things you did at the same time.

What time did you start?
11:30 AM

What time did you stop?
12:05 PM (35 min)

While doing this activity, were you?
- Sitting or lying down
- Standing or physically active
- Both sitting/lying down and standing/physically active

Add Activity to Timeline

Previous Time Period
Next Time Period
Methodological Studies: Ongoing/Future Work

- Activities Completed over Time in 24 Hours
  - Evaluate validity/error structure (iDATA, Harvard Studies)
  - Share with extramural community (https://act24.westat.com/researcher)

- Apply measurement error correction in NIH-AARP
  - iDATA (calibration study) → AARP Cohort (risk estimates)
Physical Activity Guidelines for Americans (2008): Adults

- **Avoid inactivity.** Some activity is better than none, more is better.
- **Health-enhancing physical activity** produces health benefits (added to baseline activity).
  - *Aerobic activity*
    - Moderate intensity (2.5-5.0 hr/wk)
    - Vigorous (1.25-2.5 hr/wk)
  - *Strengthening* (2+ days/wk)
- **Baseline activity** refers to the light-intensity activities of daily life, such as standing, walking slowly, and lifting lightweight objects.
- We don't understand enough about whether doing more baseline activity results in health benefits.
Acknowledgements

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James McClain

AARP
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Kate Lyden (Colorado)

Vanderbilt University
Jay Fowke
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Summary of My Research Program

• Prospective Etiologic Studies

• Methodological Studies: Exposure Assessment

• Studies of Biological Mechanism
ActiGraph Methods

- ActiGraph GT3X
- Secured to right hip by elastic belt
- Recorded vertical acceleration in one-second epochs
- Low-frequency extension selected

- **Sedentary time** (hrs/d < 100 cpm)
- **Active time** (hrs/d 100+ cpm)
  - Light activity (100-759 cpm)
  - Mod-vig activity (760+ cpm; 1952+ cpm)
Slope term ($\beta_1$) and correlation ($R$) for Previous-day Recall (vs. activPAL)

**Sedentary**

- Men ($n=40$): $\beta_1 = 1.13$, $R = 1.05$
- Women ($n=48$): $\beta_1 = 0.96$, $R = 0.96$
- Boys ($n=43$): $\beta_1 = 0.81$, $R = 0.81$
- Girls ($n=48$): $\beta_1 = 0.80$, $R = 0.80$

**Active**

- Men ($n=40$): $\beta_1 = 0.97$, $R = 0.88$
- Women ($n=48$): $\beta_1 = 1.09$, $R = 0.64$
- Boys ($n=43$): $\beta_1 = 0.77$, $R = 0.75$
- Girls ($n=48$): $\beta_1 = 0.80$, $R = 0.52$
Variance estimates for Person-specific bias ($\sigma^2_r$) and random error ($\sigma^2_\varepsilon$) terms for the Previous-day Recall (vs. activPAL)

Sedentary

- Men (n=40)
- Women (n=48)
- Boys (n=43)
- Girls (n=48)

Active

- Men (n=40)
- Women (n=48)
- Boys (n=43)
- Girls (n=48)
Slope term ($\beta_1$) and correlation ($R$) for ActiGraph (vs. activPAL)
Variance estimates for Person-specific bias ($\sigma^2_r$) and random error ($\sigma^2_\varepsilon$) terms for the ActiGraph (vs. activPAL)

<table>
<thead>
<tr>
<th></th>
<th>Sedentary</th>
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<th>Active</th>
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<tbody>
<tr>
<td></td>
<td>Men (n=40)</td>
<td>Women (n=44)</td>
<td>Boys (n=51)</td>
</tr>
<tr>
<td>Person-specific bias ($\sigma^2_r$)</td>
<td>1.41</td>
<td>1.27</td>
<td>0.76</td>
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<td>Random error ($\sigma^2_\varepsilon$)</td>
<td>0.83</td>
<td>0.76</td>
<td>0.78</td>
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<td></td>
<td>Men (n=40)</td>
<td>Women (n=44)</td>
<td>Boys (n=51)</td>
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<tr>
<td>Person-specific bias ($\sigma^2_r$)</td>
<td>1.29</td>
<td>1.35</td>
<td>0.64</td>
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<tr>
<td>Random error ($\sigma^2_\varepsilon$)</td>
<td>0.61</td>
<td>0.65</td>
<td>0.64</td>
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