

Internet-based Measures of Physical Activity: Combining Traditional Approaches with New Technology for Better Exposure Assessment in Large-scale Studies

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Overview

- Focus on large-scale etiologic studies
- Why internet-based measures?
- History/evolution of physical activity questionnaires (PAQs)
- Limitations of PAQs and SBQs (sedentary behavior questionnaires)
- An Internet-based Approach: Activities Completed by Time in 24 Hours (ACT24)

Why internet-based measures?

Temporal trends in access to time-saving and labor-saving technology (% US Households)

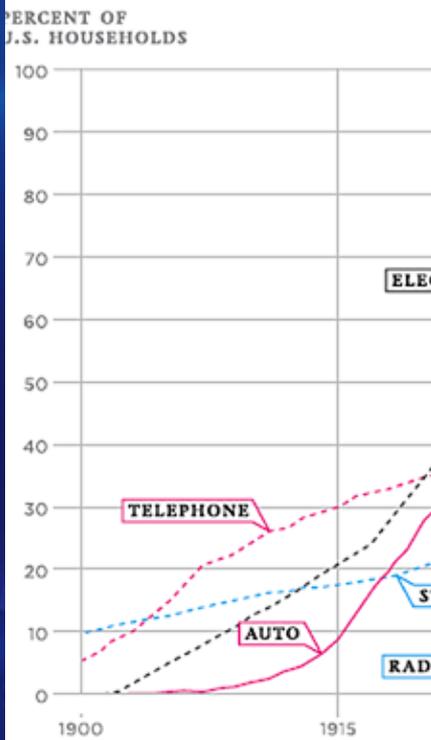
Computer Use and Broadband Access – US Adults 2011*

Computer users

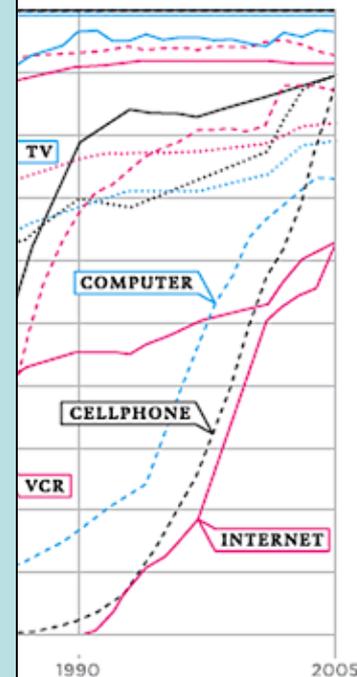
- 30-49 yrs 87%
- 50-64 yrs 74%
- 65+ yrs 42%

Broadband access

- 30-49 yrs 73%
- 50-64 yrs 57%
- 65+ yrs 29%



1900



1990

2005

Strengths/weaknesses of internet-based data collection in epidemiology

Strengths

Improved data quality

- Logic/error checking; data entry/processing
- Flexibility, responsiveness of assessment
- Automated data collection/reminders

Reduced costs (economies of scale)

Limitations

Selection factors (computer users; internet access)

Non-response bias (generalizability)

Need More Information

Do traditional methods translate to e-environment?

*History and evolution of physical
activity questionnaires (PAQs)*

Initial assessment methods for free-living physical activity behaviors

Energy, Work and Leisure

by J. V. G. A. Durnin, M.B., D.Sc.
Institute of Physiology, University of Glasgow
and R. Passmore, M.D.
Department of Physiology, University of Edinburgh

Early 1950's → 1970s

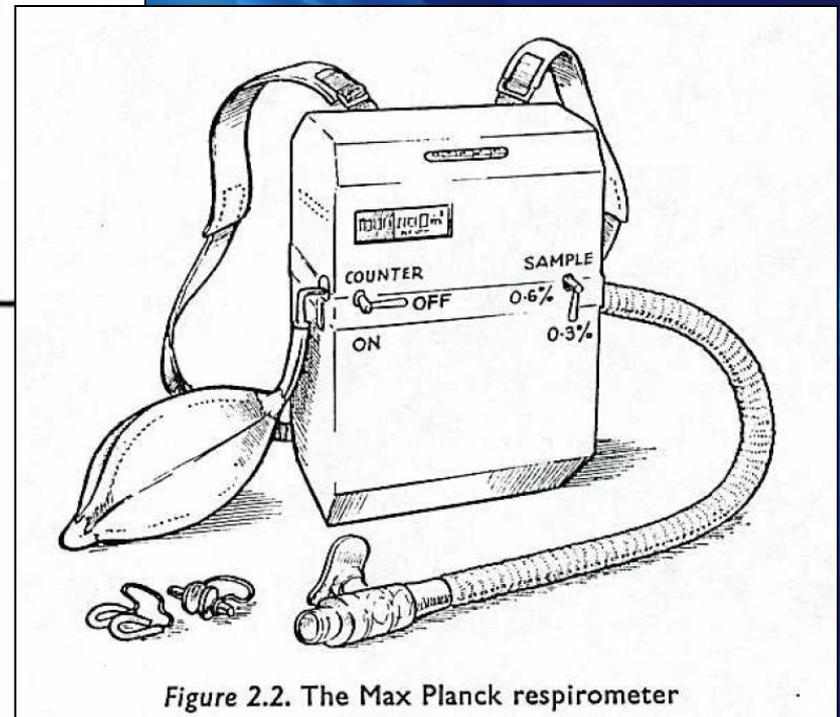
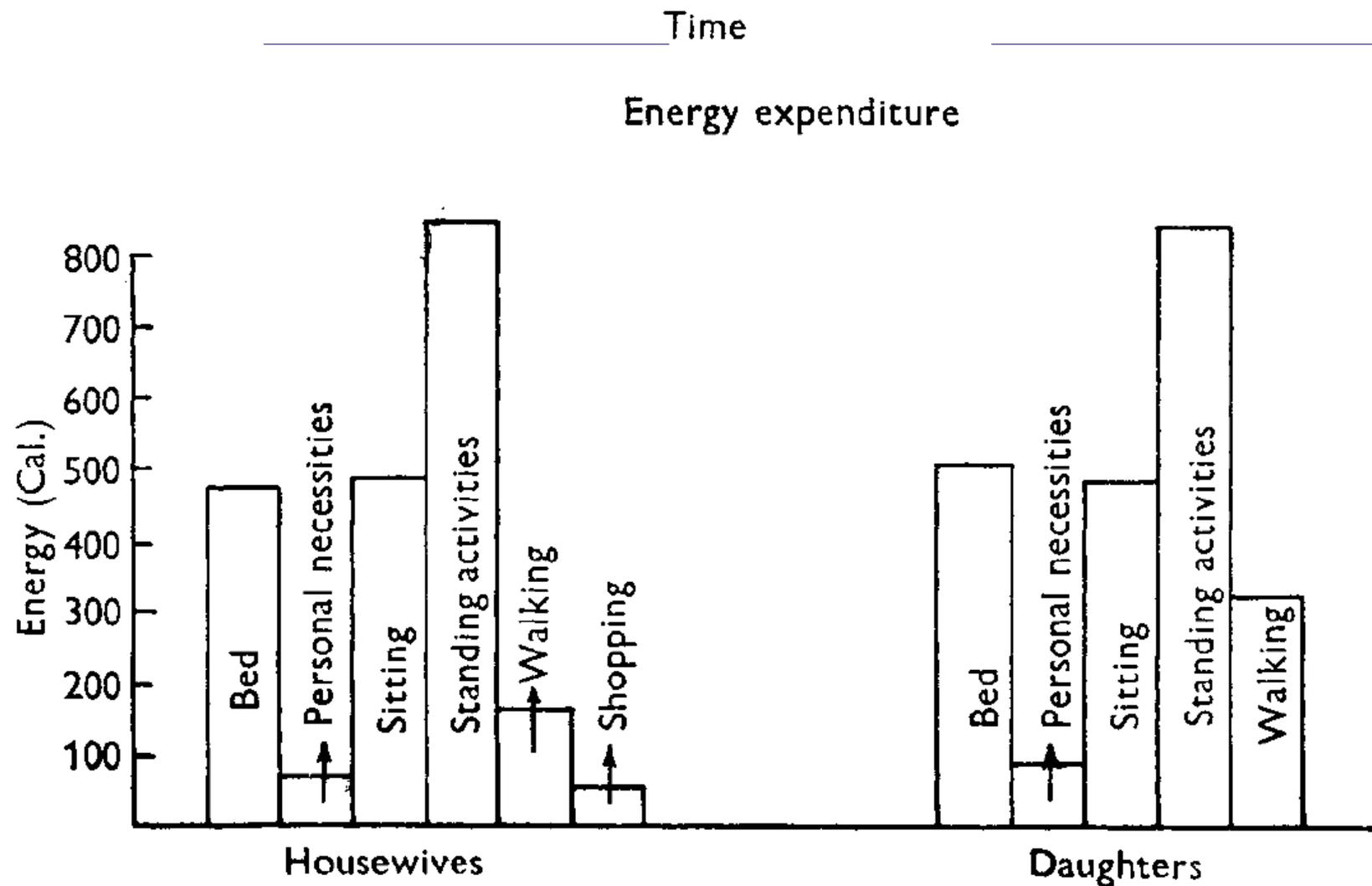


Figure 2.2. The Max Planck respirometer

The energy expenditure and food intake of middle-aged Glasgow housewives and their adult daughters

By J. V. G. A. DURIN, ELAINE C. BLAKE AND J. M. BROCKWAY



Henry Montoye's contribution

Interviewer I.D.



LEISURE TIME PHYSICAL ACTIVITIES

Listed below are a series of Leisure Time Activities. Related activities are grouped under general headings. Please read the list and check "YES" in column 3 for those activities which you have performed in the last 12 months, and "NO" in column 2 for those you have not. Do not complete any of the other columns.

For Clinic Personnel Use Only

To be completed by participant ACTIVITY (1)		Did you perform this activity?		DO NOT WRITE IN THIS SPACE	Month of Activity												Average number of times per month		Time per occasion	
					Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec			Hrs.	Min.
SECTION A: Walking and Miscellaneous					NO	YES														
010	Walking for Pleasure																			
020	Walking to Work																			
030	Using Stairs When Elevator is Available																			
040	Cross Country Hiking																			
050	Back Packing																			
060	Mountain Climbing																			
115	Bicycling to Work and/or for Pleasure																			
125	Dancing-Ballroom, Square and/or Disco																			
135	Dancing, Aerobic, Ballet																			
140	Horseback Riding																			

SECTION B: Conditioning Exercise

Montoye AJCN 24:1113, 1971

Streamlined assessments in current etiologic/prospective studies

Example: Overall sitting in one question

National Health and Nutrition Examination Survey

680 The following question is about sitting at work, at home, getting to and from places, or with friends, including time spent sitting at a desk, traveling in a car or bus, reading, playing cards, watching television, or using a computer. Do not include time spent sleeping. How much time do you usually spend sitting on a typical day?

(Enter the number of minutes; you may need to use a calculator. If participant refused or doesn't know, see below or indicate minutes below.)

Examples of domain/behavior-specific questions

The first set of questions asks about your usual level of activity.

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.)

ACTIVITY	AVERAGE TOTAL TIME PER WEEK									
	None	5 min	15 min	30 min	1 hr	1 hr and 30 min	2-3 hrs	4-6 hrs	7-10 hrs	More than 10 hrs
a. Light household chores (for example, cooking, cleaning up, laundry, dusting, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Moderate to vigorous household chores (for example, vacuuming, sweeping, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Moderate outdoor chores (for example, weeding, raking, mowing the lawn, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Vigorous outdoor chores (for example, digging, carrying lumber, snow shoveling, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Home repairs (for example, painting, plumbing, replacing carpeting, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Caring for children (for example, pushing a stroller, playing, lifting, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Caring for another adult (for example, lifting, pushing a wheelchair, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Walking for exercise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. Walking for other daily (but not leisure time) activities, such as shopping, getting to and from work, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j. Jogging or running	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
k. Playing tennis, squash, or racquetball	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
l. Playing golf	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
m. Swimming laps	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
n. Bicycling (including riding a stationary bike)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
o. Other aerobic exercise (for example, aerobic class, exercise machines, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
p. Weight training or lifting (include free	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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Limitations of Questionnaires to Estimate Usual Physical Activity (PA) and Sedentary Behavior

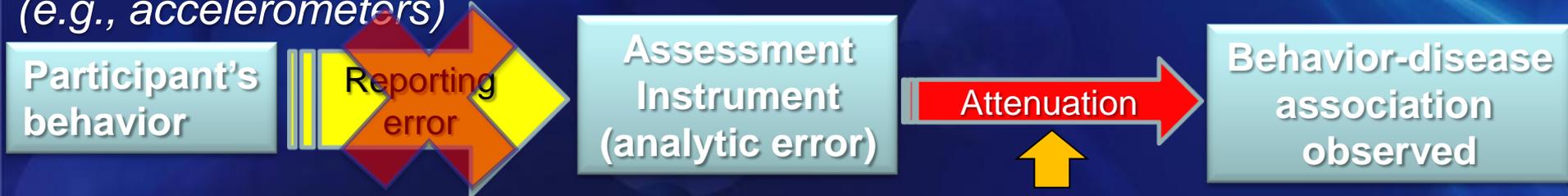
- Success in etiologic studies, but ***measurement errors are large***
- ***Cognitive demands*** associated with reporting long-term averages are extraordinary
- ***Scope of questionnaires*** often limited (e.g., only leisure-time, television, or MVPA)
- ***Systematic reporting errors*** typically assumed (i.e., social desirability)
- Assessment of ***sedentary behavior*** in its infancy

Options for improving measures of activity-related behaviors and obtaining better estimates of behavior-disease associations

Option 1: Use measurement error correction methods to minimize the impact of reporting errors
Current status: Large measurement errors and high levels of attenuation



Option 2: Eliminate reporting errors: use objective indicators of behavior (e.g., accelerometers)



Option 3: Use short-term recalls to reduce the amount of reporting error in active and sedentary behaviors



 = application of measurement error correction models

Rationale for Short-term Recalls in Large-scale Studies

Short-term PA recalls (diaries, previous-day recalls)

- Often used as a reference instrument (assumed more valid).
- Rarely used as a primary exposure due to expense (to studies) and burden (on participants).

Internet-based implementation

- *Automated data collection/scoring*
- *Economies of scale*
- *A modest number of recalls may be sufficient (for many “current” behaviors)*

Observational Epidemiologic Studies of Nutrition and Cancer: The Next Generation (with Better Observation)

Arthur Schatzkin,¹ Amy F. Subar,² Steven Moore,¹ Yikyung Park,¹ Nancy Potischman,² Frances E. Thompson,² Michael Leitzmann,¹ Albert Hollenbeck,⁴ Kerry Grace Morrissey,⁵ and Victor Kipnis³

¹Division of
National C

Activities Completed by Time in 24 Hours (ACT24) Development Team

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naires require respondents to report "typical" diet or activity over the previous year or longer. Multiple 24-hour recalls (24HR), based on reporting only the previous day's behavior, offer potential cognitive advantages over the questionnaires, and biomarker evidence suggests the 24-hour dietary recall is more accurate than the food frequency questionnaire. The expense involved in administering multiple 24HRs in large epidemiologic studies,

Steven Moore
Heather Bowles
Amy Subar
Gordon Willis

accuracy of the Internet-based recalls vis-à-vis standard instruments and biomarkers; and (4) new statistical approaches for combining the new instruments with standard assessment tools and biomarkers The incorporation of Internet-based 24HRs into large epidemiologic studies may help advance our understanding of the nutritional determinants of cancer. (Cancer Epidemiol Biomarkers Prev 2009;18(4):1026-32)

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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

Development

- Review extant PA instruments and time use data
- Feasibility testing (NIH-AARP participants)
- Cognitive testing (card sorting, usability testing)



Exit X

Activities

- ▷ Sleeping or Napping
- ▷ Personal care
- ▷ Household chores
- ▷ Transportation, commuting, or travel
- ▷ Communicating with others
- ▷ Leisure, relaxation, social activities
- ▷ Shopping, errands, and appointments
- ▷ Caring for or playing with others
- ▷ Occupation, working for pay
- ▷ Exercise, sports, active recreation
- ▷ Lawn and garden
- ▷ Home and auto maintenance or repair
- ▷ Church or spiritual pursuits
- ▷ Miscellaneous activities

Instructions

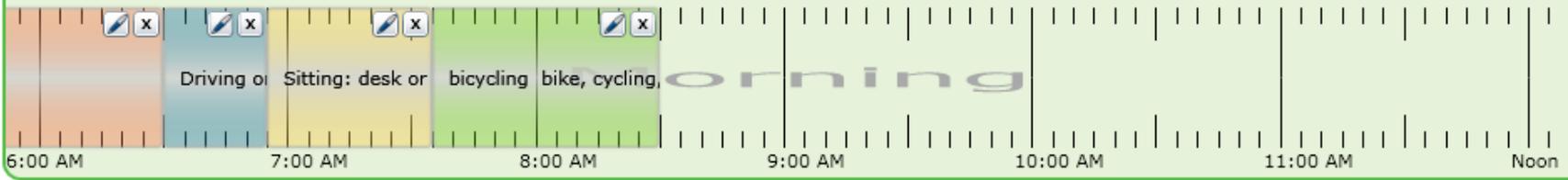
Select activities that best describe the things you did in this time-period.
 To help remember what you did, think about where you were and who you were with.

ACT24 Design Considerations

- 14 Major categories
- 111 individual activities (plus "Other")
- Exercise/sports search (~110 activities)
- Four 6 hour time-periods

Previous Time Period

Next Time Period





Exit X

Activities

- Leisure, relaxation, social activities
 - Watching TV, movies, DVDs
 - Socializing with others *i*
 - Reading (books, papers, magazines)
 - Playing computer or electronic games
 - Playing games *i*
 - Sitting quietly *i*
 - 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

Socializing with others

What time did you start?

What time did you stop?

While doing this activity, were you?

- Sitting or lying down
- Standing or physically active
- Both sitting /lying down and standing/physically active

Posture-based estimates of sedentary time

Cancel Add Activity to Timeline

Previous Time Period

Next Time Period



← Activities added to timeline

ACT24 Next Steps

Methodological Studies

MEASURE Studies

- ACT24 vs. DLW, PA Monitors (ActiGraph, activPAL)

Quantify error structure in self-report relative to reference instruments

- Active behaviors (hrs/d, PAEE), sedentary behaviors (hrs/d)

Determine optimal sampling strategy to estimate usual amount (long-term average) of active/sedentary behavior

- How many days, how many periods/seasons (per year)?

ACT24 Next Steps

MEASURE Studies

- *Lifestyle Validation Studies (Harvard School of Public Health)*
 - Nurse's Health Study (women); N=750
 - Started Fall 2010, just completed
 - Health Professionals Follow-up Study (men); N=750
 - Starting Spring 2012
- Interactive Diet & Activity Tracking in AARP (iDATA, US National Cancer Institute)
 - AARP (women, men); N=760
 - Started Winter 2012

ACT24 Next Steps (continued)

Development of Researcher Site

- Provide access to external studies
- Fall/winter 2012

If you want to take a look

<http://act24demo.westat.com>

Summary / Conclusions

Better measures of active and sedentary behavior are needed in large-scale epidemiologic studies

Internet-based measures may enable implementation of less error prone (“traditional”) methods in large-scale epidemiologic studies

Thanks!

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Steve Moore, PhD

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NCI Intramural Research Program

Evaluation of a Cell Phone–Based Physical Activity Diary

BARBARA STERNFELD¹, SHENG-FANG JIANG¹, TERESA PICCHI¹, LISA CHASAN-TABER², BARBARA AINSWORTH³, and CHARLES P. QUESENBERY JR.¹

TABLE 2. Comparison of estimates of PA and data quality variables from cell phone and paper diaries (On the Move pilot study).

	Cell Phone Diary (<i>n</i> = 39) ^b		Paper Diary (<i>n</i> = 38) ^b		Within-person Difference ^a (<i>n</i> = 33) ^b		Spearman Correlation
	Mean ± SD	Median (Interquartile Range)	Mean ± SD	Median (Interquartile Range)	Mean ± SD	<i>P</i> ^c	<i>ρ</i>
PA variables							
Total PA (MET·min·d ⁻¹)	2014 ± 452	1941 (1687–2265)	2074 ± 267	2038 (1904–2165)	-43.8 ± 360	0.49	0.61
MVPA ^d (min·d ⁻¹)	136 ± 100	103 (70–169)	130 ± 91	102 (76–140)	7.4 ± 66	0.53	0.79
Data quality variables							
Activities recorded (<i>n</i> ·d ⁻¹)	9.0 ± 1.7	8.6 (7.8–10.6)	10.6 ± 2.2	10.5 (9.1–12.3)	-1.3 ± 2.0	0.0005	0.52
Time accounted for (min·d ⁻¹)	1278 ± 145	1261 (1159–1397)	1301 ± 117	1328 (1246–1393)	-27.5 ± 158	0.33	0.16
Valid/expected days	0.71 ± 0.31	0.75 (0.5–1)	0.76 ± 0.37	1 (0.75–1)	-0.13 ± 0.23	0.0033	0.03

23 men, age 45–65 yr, completed cell phone and paper PA diaries 4 d·wk⁻¹ for three consecutive weeks and a user satisfaction survey. In the subsequent validation study, 623 middle-age participants (52.5% women) were asked to complete the cell phone diary and wear an accelerometer for two 7-d periods, approximately 6 months apart. They also completed two PA questionnaires. Fitness, body mass index, and percent body fat were obtained as indirect validation criteria. **Results:** Estimates of PA from the cell phone and paper diaries were similar (mean within person difference = -43.8 MET·min·d⁻¹ of total PA, SD = 360, *P* = 0.49, 7.4 min·d⁻¹ of moderate–vigorous PA, SD = 66, *P* = 0.53). Users preferred the cell phone diary over the paper diary (59.6% vs 35.4%). In the subsequent study, intraclass correlations for the cell phone diary ranged from 0.55 for light PA to 0.63 for vigorous PA. Although PA estimates from the cell phone diary were generally significantly higher than those from the accelerometer and the questionnaires, correlations for moderate and vigorous PA were moderate (*ρ* = 0.25–0.59 with the questionnaires and 0.27–0.35 with the accelerometer). The correlations between the cell phone diary and the indirect validation criteria were generally in the expected direction and of moderate magnitude. **Conclusions:** A cell phone–based PA diary is equivalent to a paper diary, acceptable to users, and a relatively reliable and valid approach to self-reported PA. **Key Words:** RELIABILITY, VALIDITY, SELF-REPORTED PHYSICAL ACTIVITY, RECALL ERROR, MOBILE TECHNOLOGY, ECOLOGICAL MOMENTARY ASSESSMENT

What kinds of studies do our measures need to serve?

Association studies (etiology of active and sedentary behaviors and disease outcomes, determinants studies)

- Long-term average, or usual level of behavior
- Specificity: targeted behaviors & contexts

Interventions (assess changes in sedentary time in response to intervention messages)

- Specificity (targeted behaviors) / responsiveness

Surveillance (estimate population average, or prevalence during specific period of time).

- Specificity (behaviors tracked by PHS)

Additional Questions for Certain Behaviors

Transportation

- Purpose of trip (e.g., commuting, errands, etc)

Sports/exercise

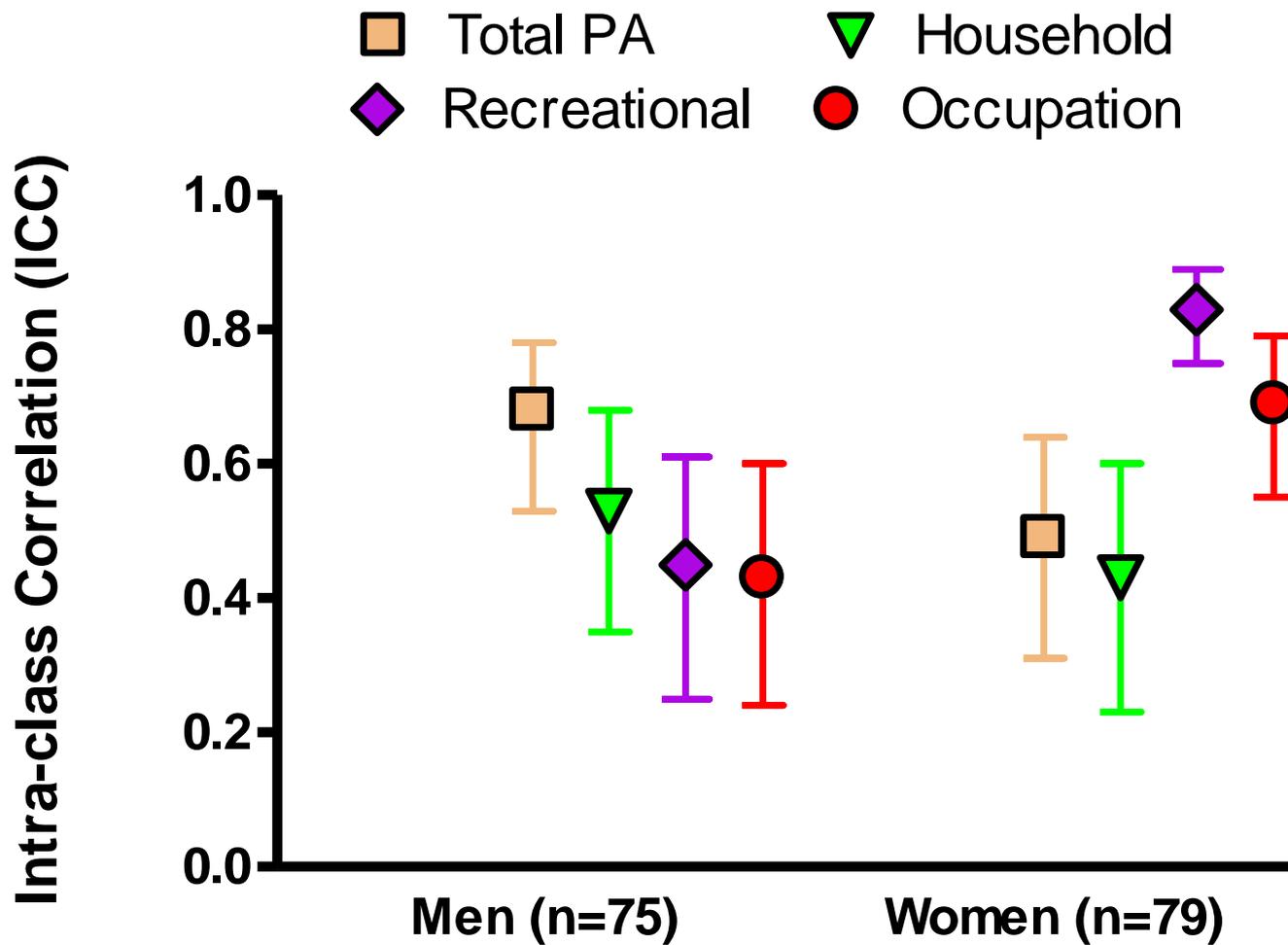
- Details about selected activities (e.g., walking, running, swimming distance)
- Rating of perceived exertion (relative intensity)
- Contextual information (where?, with whom?)

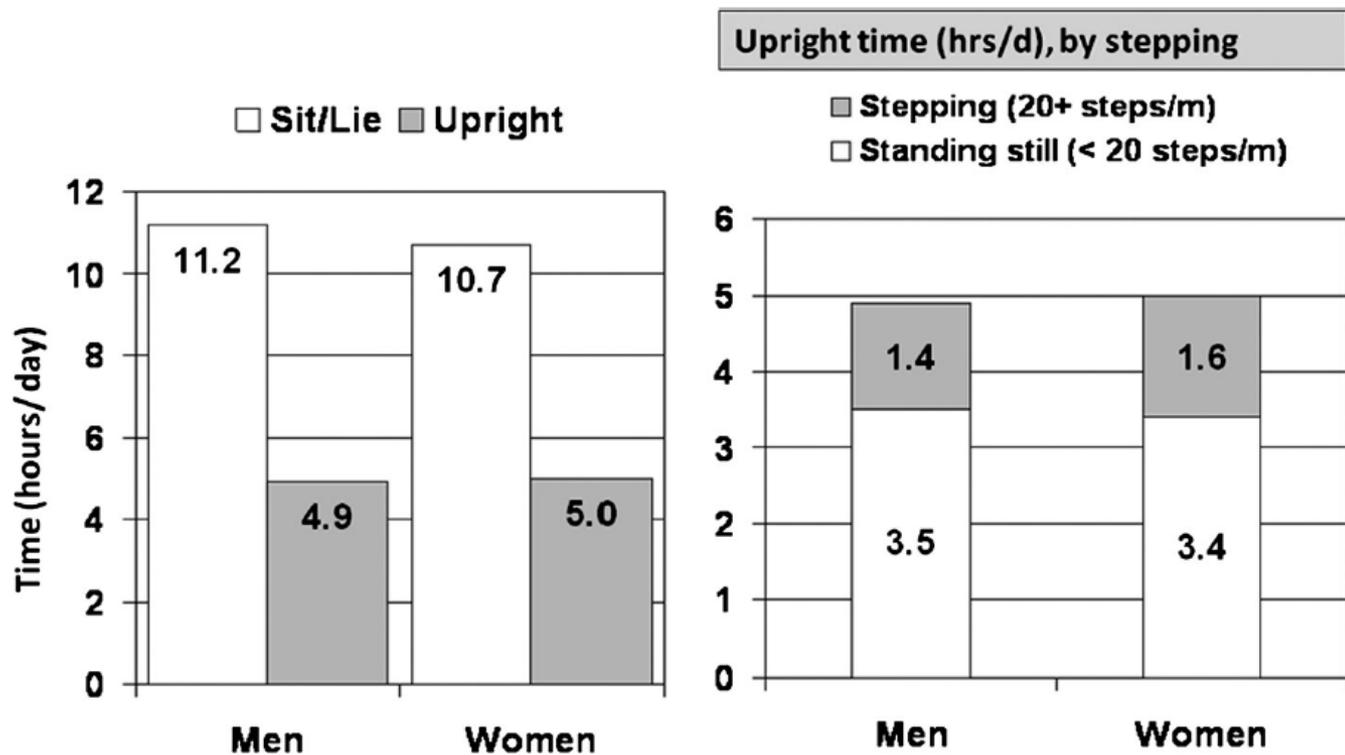
Approaches to Self-Reported Physical Activity

Category	Level of Detail	Timeframe	Uses
Diaries	High (all activities)	Real time	Validation
Logs	High (specific activities)	Real time, past day	Intervention adherence
Recalls	Medium (selected activities)	Past 1 to 7 days	Changes, current activity
Questionnaires	Medium (selected activities)	Past year, usual	Usual activity
Global surveys	Low (broad categorization)	Current, unspecified	Ranking usual activity

Test-retest (9 wk) reliability (ICC) for the Past Year Total Physical Activity Questionnaire

Friedenreich et al. AJE 163: 959, 2005

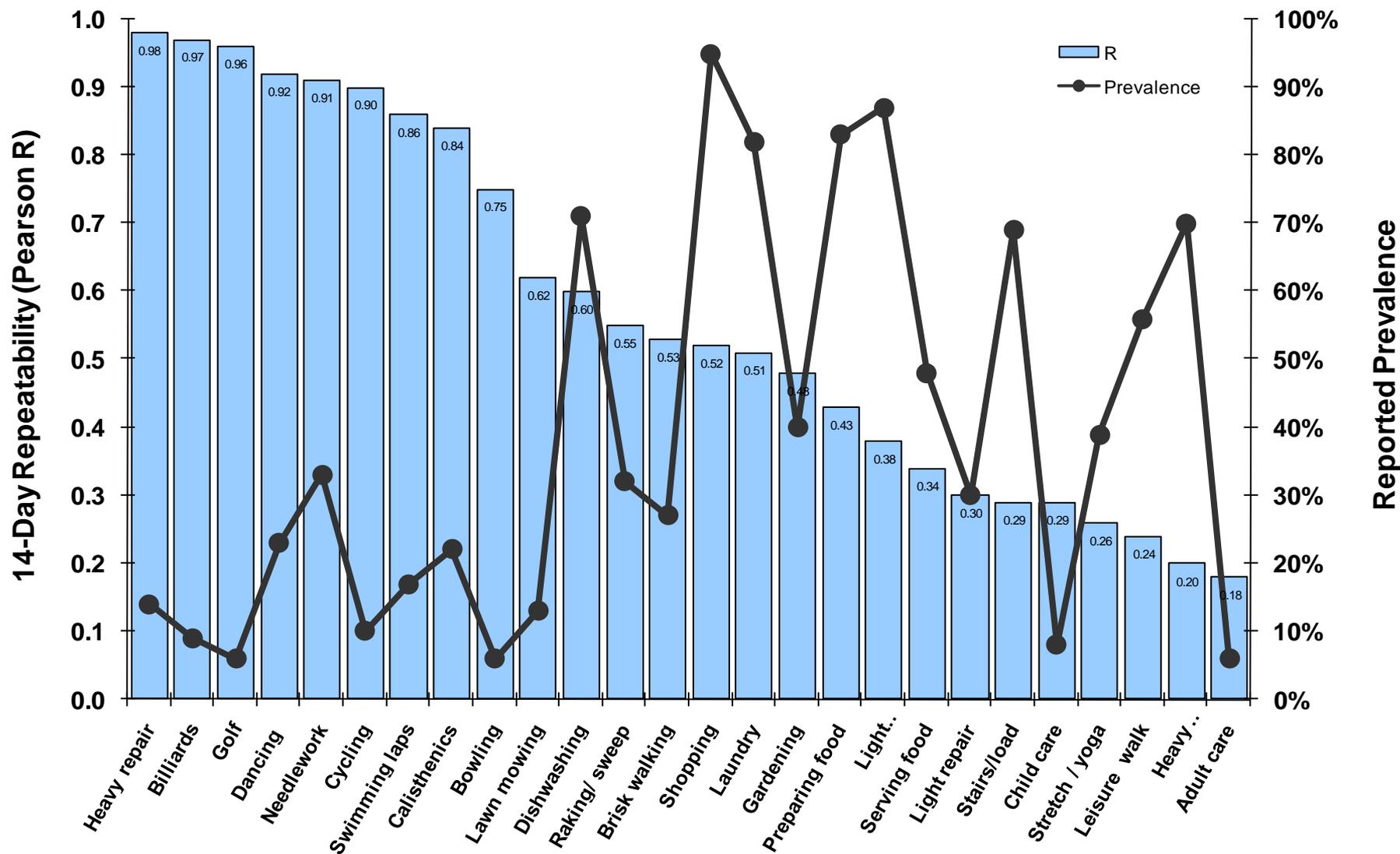




Up/down transitions:
47.2 (SD=13.3) per day

FIGURE 1—Distribution of time in upright/active and sedentary behaviors in healthy controls and cancer survivors (N = 95).

Reliability and prevalence of reporting in the Yale PA Survey, by activity type



Study Types and Objectives

Consider three study types,...

1. *Surveillance* (public health objectives)
2. *Interventions* (behavior change)



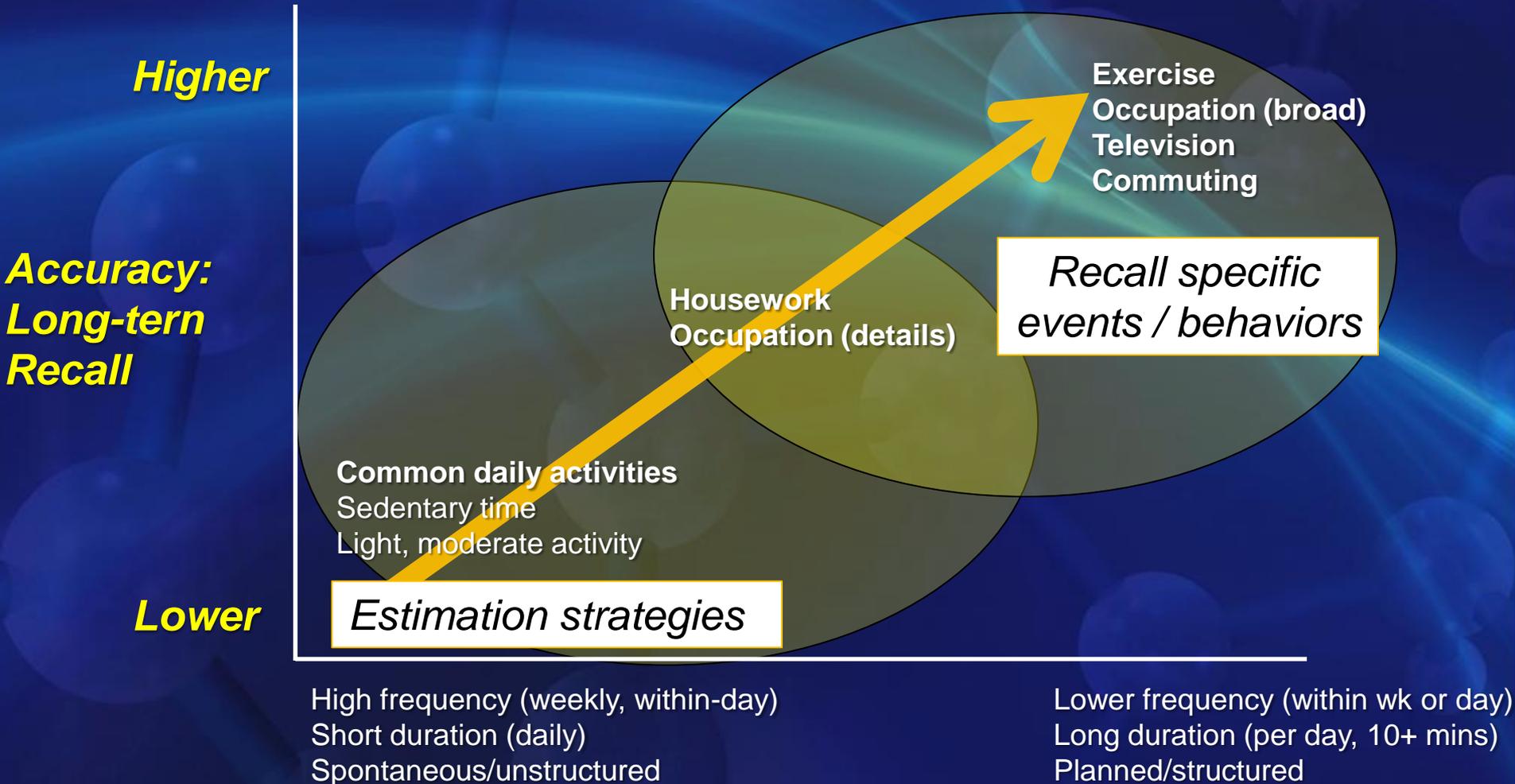
***Population estimates
(means, prevalence [%])***

3. Association studies (etiologic relations)



***Individual estimates
(classification)***

Characteristics of behavior, cognition, and accuracy of long-term recall



Characteristics of free-living active/sedentary behaviors