National Cancer Institute

The Case for Objective Measurement of Physical Activity

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Diet & -Omics Workshop

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Overview

1. Questionnaire challenges

2. Population vs. individual-level data

3. Within-person activity time comparisons from 2003-2006

Characteristics of Questionnaires

- Questionnaires and diaries
  - + Relatively inexpensive
  - – Limited reliability and validity
    - General tendency to over-report
    - Low correlation with objective data
  - – Burden varies with detail desired
  - + Can provide contextual information
- Commonly used in epidemiology and surveillance as well as for counseling and interventions

Typical Question Approach (NHIS)

- The next questions are about physical activities (exercise, sports, physically active hobbies...) that you may do in your LEISURE time.

- How often do you do LIGHT OR MODERATE activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?

- About how long do you do these light or moderate activities each time?

Questionnaire Challenges

For the Respondent

Questionnaire Cognitive Challenges

- Frequency
  - Actual vs. typical vs. ideal
- Duration
  - Accumulated short, variable bouts
- Intensity
  - Lost in translation, effect of age
- Integral calculus
  - One question for varying activities

Complexity of Physical Activity

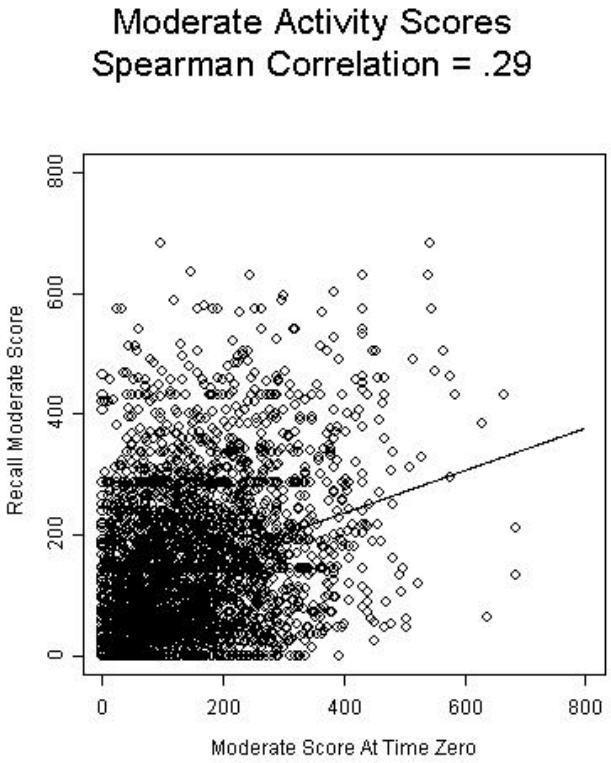
What matters for you?

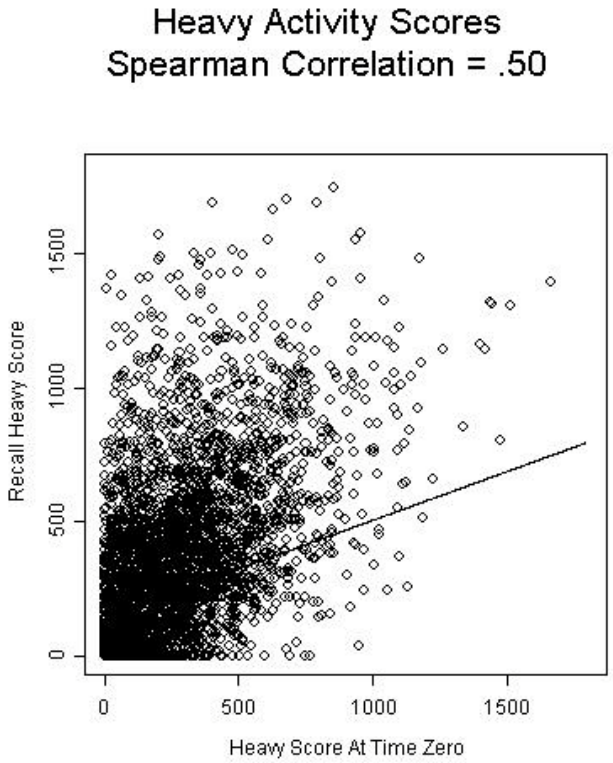
- Activity energy expenditure
- Activity time above some intensity threshold
  - What intensity and how defined (cutpoints)
  - Absolute intensity
  - Relative intensity
- Steps
  - Total
  - Activity steps (sustained bouts)
- Context of activity
  - Occupation
  - Transportation
  - Recreation, sport, leisure
  - Household tasks

Measures Should Match Needs

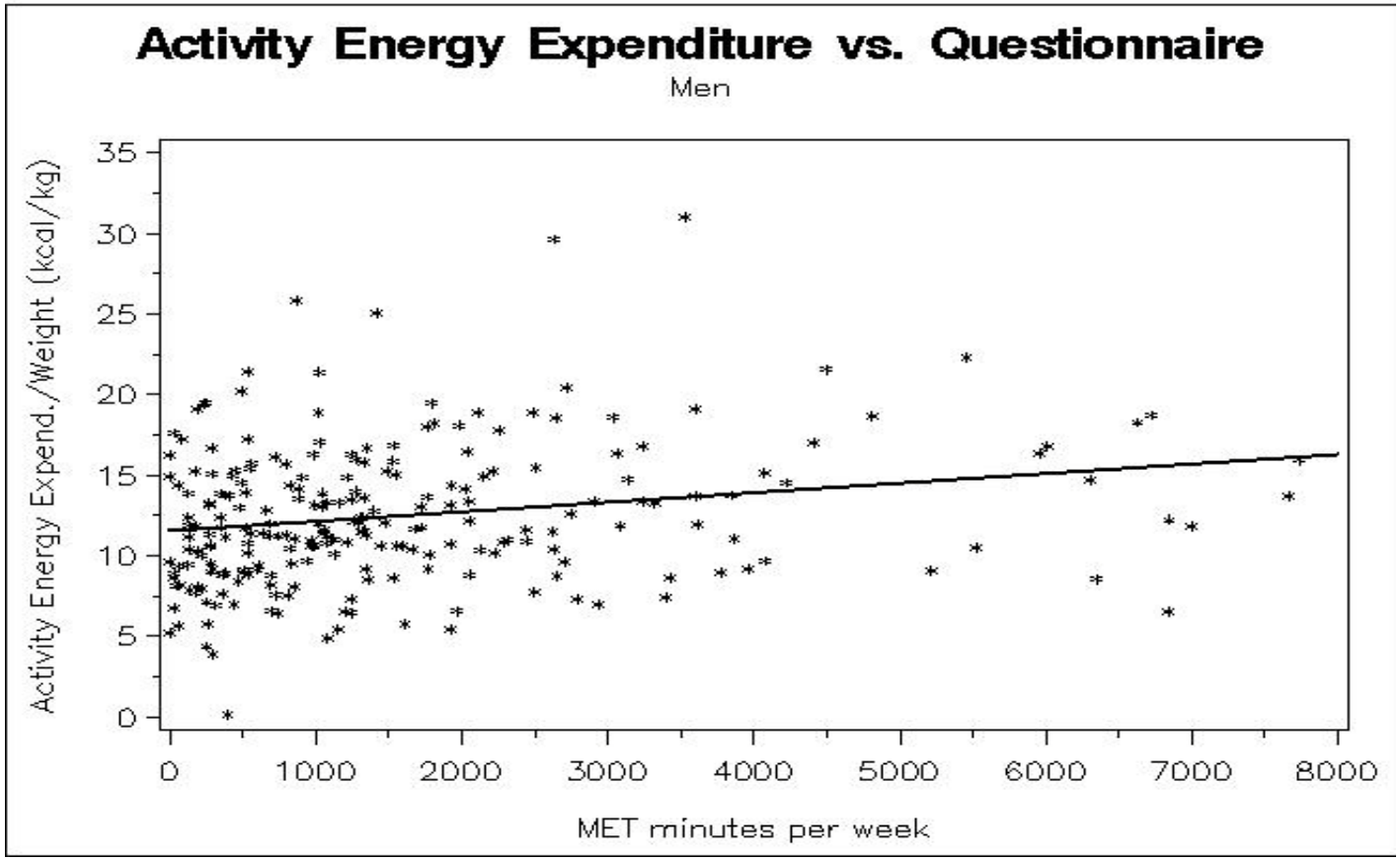
- Population level vs. individual
  - Validated questionnaires
    - Validation may not generalize across groups
    - IPAQ is not valid for interventions
- All sources of activity or only certain ones

Correlation Scatter Plots





Questions vs. Metabolic Expenditure



Metabolic data

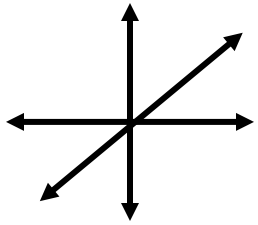
Questionnaire data

OPEN data, ages 40-69 y

The Answer to Our Problems?

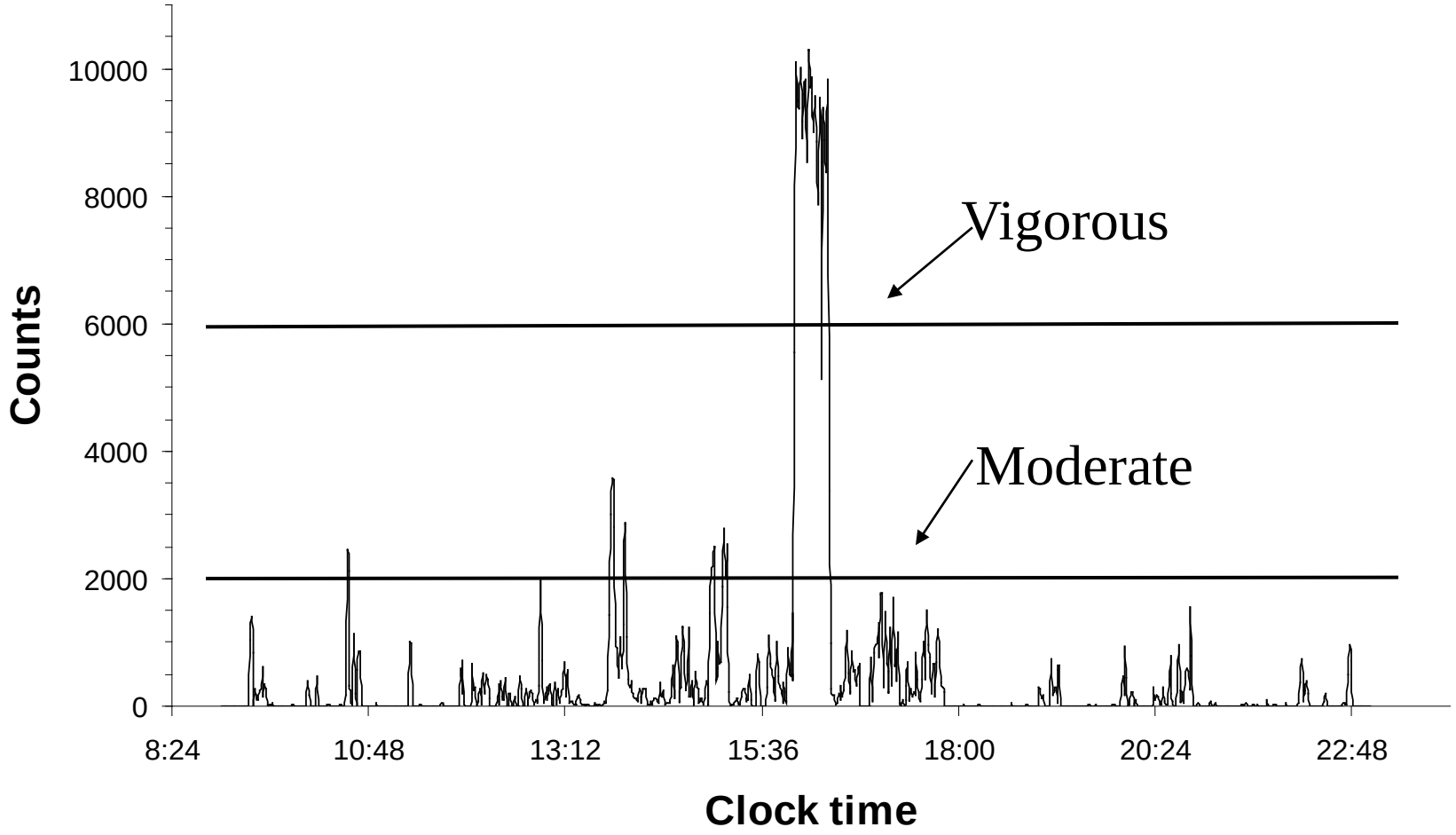
How Accelerometers Work

- 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 (Actigraph)



  - Data summed over epochs (1 min) and stored as “counts” for later download

Activity counts



Benefits of Accelerometers

- Remove cognitive aspect of data collection
- Can monitor multiple days with low burden
- Captures “real-time” intensity, duration, and can derive frequency of bouts
- Non-reactive measurement possible

Accelerometer Limitations

- Primarily measures locomotor activity
  - misses upper body movement with usual placement
  - cannot distinguish load-carrying vs. not
  - not total activity or energy expenditure
- But walking/running is a primary source of activity
- Does not provide context of activity

NHANES Physical Activity Questionnaire

- Administered in household interview
- Past 30 days reference period
  - Report times per day, week as desired
- Contexts:
  - Transportation
  - Household tasks
  - Recreational exercise, sports, active hobbies
    - Vigorous and moderate intensity separately
    - Frequency & duration for specific activities engaged for 10+ min

PA Monitors in NHANES

- Ages 6 y +
  - Wheelchair-bound/non-ambulatory excluded
- Ask for 7 d of wear while awake
  - Take off for water activities (swim, bathe)
- Mail back monitor
- Component response rate ~90%

National Adherence to Recommendation

Questionnaire data

- –BRFSS 2000: 24%, 2003 ~45%
- –NHIS 2000: 31%, 2005: 30%
- –NHANES 2003-2004 ~51% (150 min/wk)

NHANES Accelerometer data

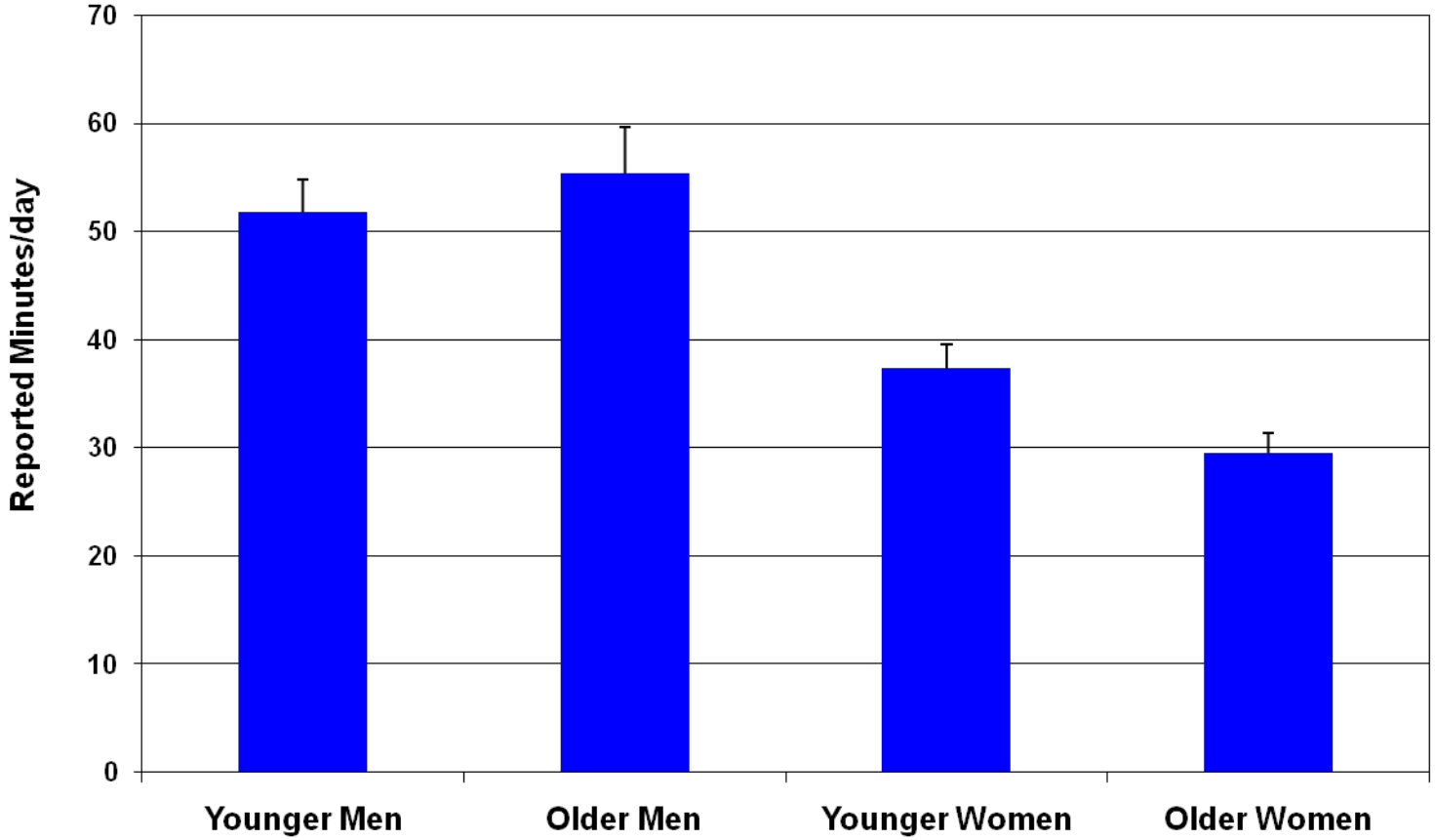
Age	Total	Males	Females
20-59	3.5%	3.8%	3.2%
60+	2.4%	2.5%	2.3%

Empirical Bayes estimate for 5 of 7 days using every valid day
Troiano et al., 2008 MSSE

Within-Person Comparisons

- 6093 adults (ages 20 y +) with questionnaire data and accelerometer wear for 4-7 days
- Questionnaire (Q)
  - Summed all minutes reported as moderate or greater intensity
- Accelerometer (A)
  - Summed moderate intensity or greater minutes in “bouts”
- Categorized by zero, non-zero minutes from Q and A
  - Calculated minutes of moderate or greater intensity PA within each category
  - Estimated correlation and attenuation for categories that were non-zero on both measures
  - Divided non-zero groups into quintiles for classification agreement

Many Minutes Are Reported with Zero Measured Bouts



Percent with no measured bouts	**39.2%**	**66.2%**	**52.8%**	**74.1%**

Correlation and Attenuation

- Calculated when measured and reported were both non-zero
  - Correlations are quite low, suggesting poor agreement between measures
  - Attenuation factors are similar to correlations in magnitude, suggesting that RR based on self-report may be significantly attenuated

	Men		Women	
	20-59 y	60+ y	20-59 y	60+ y
Correlation	0.17	0.13	0.31	0.23
Attenuation	0.14	0.14	0.27	0.25

Category Agreement: Men Ages 20-59 y

Accel. Categ	*Category Based on Self-Report*						
	0	1	2	3	4	5	Total
0	***4.89***	9.43	7.70	5.11	6.64	5.42	39.20
1	1.60	***1.95***	2.51	2.32	1.98	1.75	12.12
2	1.43	2.03	***1.96***	2.59	1.58	2.51	12.09
3	0.94	2.03	2.31	***2.10***	2.65	2.21	12.23
4	0.58	1.44	2.07	2.97	***2.58***	2.47	12.11
5	0.76	0.89	1.57	2.49	2.92	***3.62***	12.25
Total	10.22	17.77	18.12	17.58	18.35	17.98	100.0

Values are weighted percent within each cell

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17.1 % agree

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48.6 % agree
+/- 1 category

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Note distribution across accelerometer categories for low active individuals

Values are weighted percent within each cell

Racial-Ethnic Differences

- Overestimate of activity time was smallest for Mexican-Americans
  - Mean differences of 19-36 minutes/day
- Differences were greatest for Non-Hispanic Whites
  - Mean differences of 53-68 minutes/day
- Categorical agreement was poor for all groups
  - M-A 19.8% agree, 48.3% +/- 1 category
  - NH-W 17.2% agree, 48.5% +/-1 category
  - NH-B 17.0% agree, 45.6% +/- 1 category

Conclusions

- If believe objective data (accelerometer) provide a “truer” measure of moderate or greater intensity physical activity, then:
- Self-reports provide poor estimates of minutes of physical activity
- Substantial misclassification can occur when categories are based on self-report
- Observed relationships between self-reported activity and outcomes may be related to something more than “physical activity”

“When we measure, we know better.”

NCHS NHANES slogan

Questions?

Minutes (SEM) of Physical Activity by Zero/Non-zero Category from Q & A

Agreement condition	Men				Women			
	20-59 y		60+ y		20-59 y		60+ y	
	A	Q	A	Q	A	Q	A	Q
A=0, Q>0	**A=0**	**59.2** (3.39)	**A=0**	**67.3** (5.15)	**A=0**	**44.1** (2.60)	**A=0**	**44.1** (2.91)
A>0, Q=0	**11.8** (1.03)	**Q=0**	**7.4** (1.77)	**Q=0**	**10.3** (1.82)	**Q=0**	**8.5** (2.62)	**Q=0**
A>0, Q>0	**14.6** (0.64)	**75.2** (4.30)	**14.90** (1.28)	**86.5** (6.00)	**13.2** (0.59)	**67.6** (4.23)	**14.4** (1.05)	**72.0** (6.35)

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Category Agreement: Women, 20-59 y

Accel. Categ	*Category Based on Self-Report*						
	0	1	2	3	4	5	Total
0	*7.77*	11.51	9.07	9.83	6.80	6.43	51.42
1	0.91	***2.54***	1.23	1.95	1.14	1.65	9.42
2	0.77	1.20	***2.72***	1.51	2.11	1.44	9.76
3	0.42	1.22	1.88	***1.52***	2.78	2.11	9.94
4	0.67	0.89	0.78	2.35	***2.38***	2.60	9.67
5	0.32	0.31	1.07	1.63	2.74	***3.73***	9.80
Total	10.87	17.67	16.74	18.81	17.96	17.95	100.0

Values are weighted percent within each cell

Agreement: Men Ages 60+ y

Accel. Categ	*Category Based on Self-Report*						
	0	1	2	3	4	5	Total
0	***12.77***	12.07	12.40	8.12	10.34	9.69	65.38
1	0.77	***0.35***	1.05	1.71	2.09	0.77	6.74
2	0.53	0.59	***1.62***	1.43	1.29	1.44	6.90
3	0.53	1.29	0.89	***1.05***	1.28	1.89	6.92
4	0.57	0.98	1.69	0.86	***1.46***	1.53	7.11
5	0.35	0.23	0.55	1.64	2.43	***1.75***	6.95
Total	15.51	15.52	18.20	14.81	18.88	17.07	100.0

Values are weighted percent within each cell

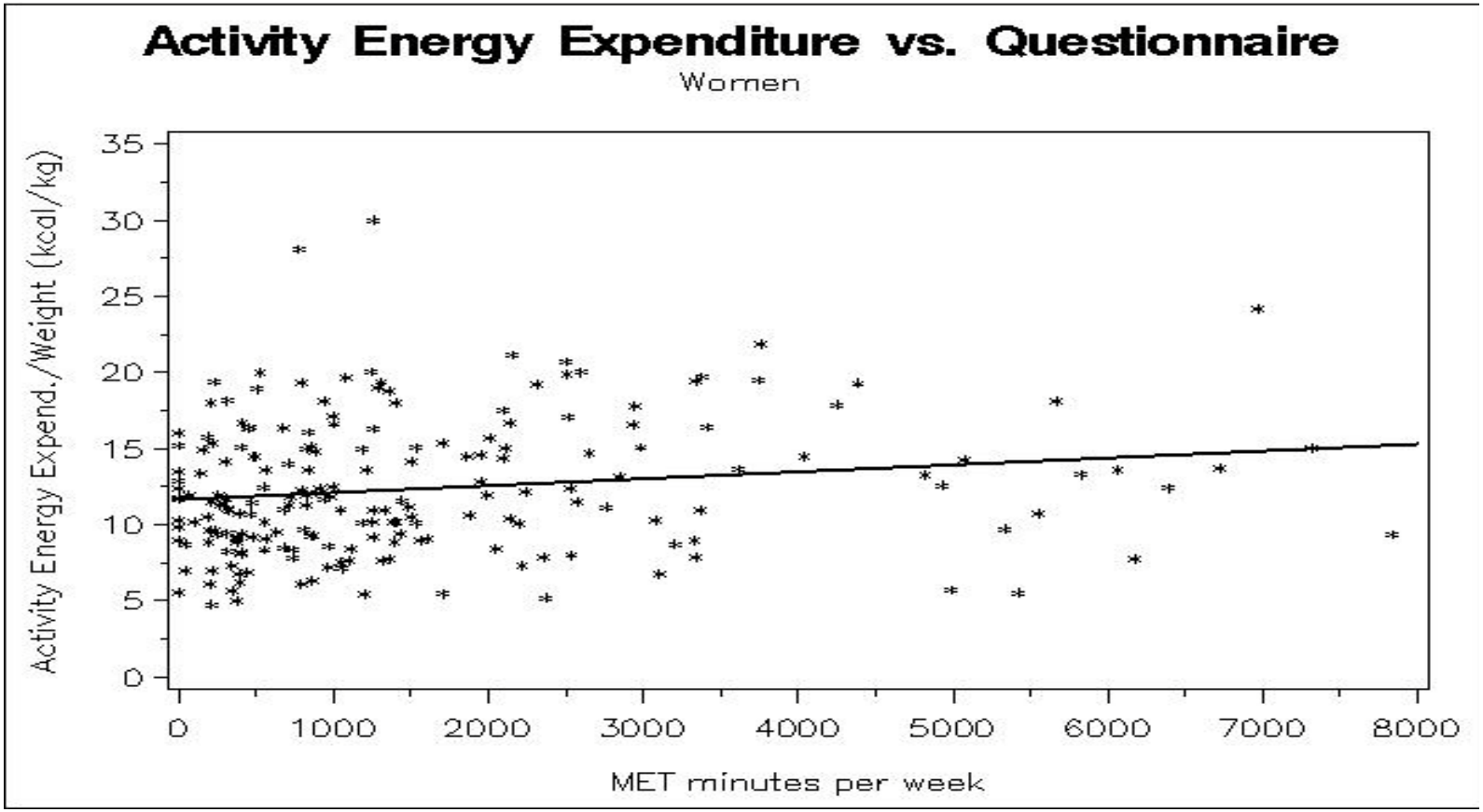
Agreement: Women Ages 60+ y

Accel. Categ	*Category Based on Self-Report*						
	0	1	2	3	4	5	Total
0	***24.41***	13.26	10.64	9.94	7.76	7.28	73.30
1	0.42	***0.87***	1.17	0.77	1.16	0.81	5.20
2	0.32	0.32	***1.60***	0.63	1.24	1.27	5.40
3	0.13	0.10	0.86	***1.35***	1.02	1.95	5.42
4	0.04	0.16	0.34	0.64	***2.31***	1.58	5.07
5	0.02	0.00	0.35	1.71	1.40	***2.14***	5.62
Total	25.35	14.72	14.96	15.04	14.89	15.03	100.0

Values are weighted percent within each cell

Questions vs. Metabolic Expenditure

Metabolic data



Questionnaire data

OPEN data, ages 40-69 y