A Measurement Error Model for Physical Activity Data

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Motivation

Accurate assessment of usual or habitual energy expenditure (EE) is important for understanding the links between physical activity and health. Monitoring devices and self-report instruments provide imperfect measurements of usual daily energy expenditure due to errors, e.g. measurement error (ME), noncoverage and nonresponse. We develop a method to estimate usual daily energy expenditure that accounts and adjusts for sources of variation and bias in observed monitor- and self-report-based energy expenditure data. We illustrate our methodology using data from the Physical Activity Measurement Survey (PAMS)*.

PAMS Summary

- Four counties in Iowa were split into tracts to achieve a representative sample
- Data collection was evenly distributed over two years, partitioned into eight quarters
- 1400 individuals were included in the study
- Selected individuals wore SenseWear Monitor for 24 hours on two non-consecutive days
- Minute by minute energy expenditure information is recorded
- The individual also reports how much PA they got on the measured day
- We consider 786 female participants who provided two complete observations grouped by age

Below are some relevant summary statistics. Notice that the mean recall values are consistently less than the monitor measurements.

Age Gp.	n	Age Range	Mean Age	Mean BMI	Mean Monitor EE	Mean Recall EE
1	133	21-39	32	30.1	2639.9	2550.2
2	185	40-49	44	31.0	2618.1	2448.5
3	225	50-59	54	30.7	2514.7	2341.9
4	243	60-70	64	31.2	2261.3	2168.4

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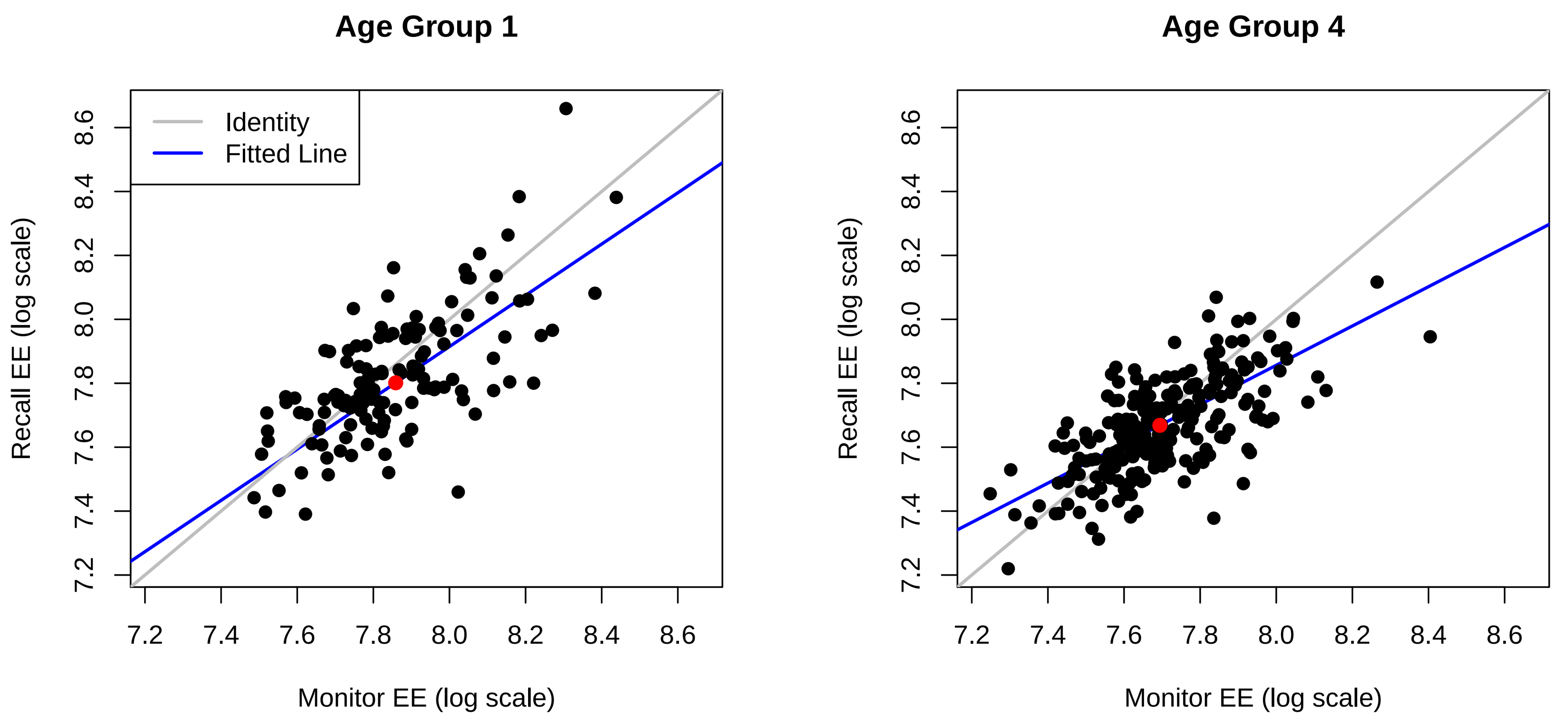
Measurement Error Model

True EE: $t_{ij} = \mu + t_i + d_{ij}$
Monitor EE: $x_{ij} = \mu + t_i + d_{ij} + u_{ij}$
Reported EE: $y_{ij} = \mu_y + \beta_1(t_i + d_{ij}) + r_i + e_{ij}$

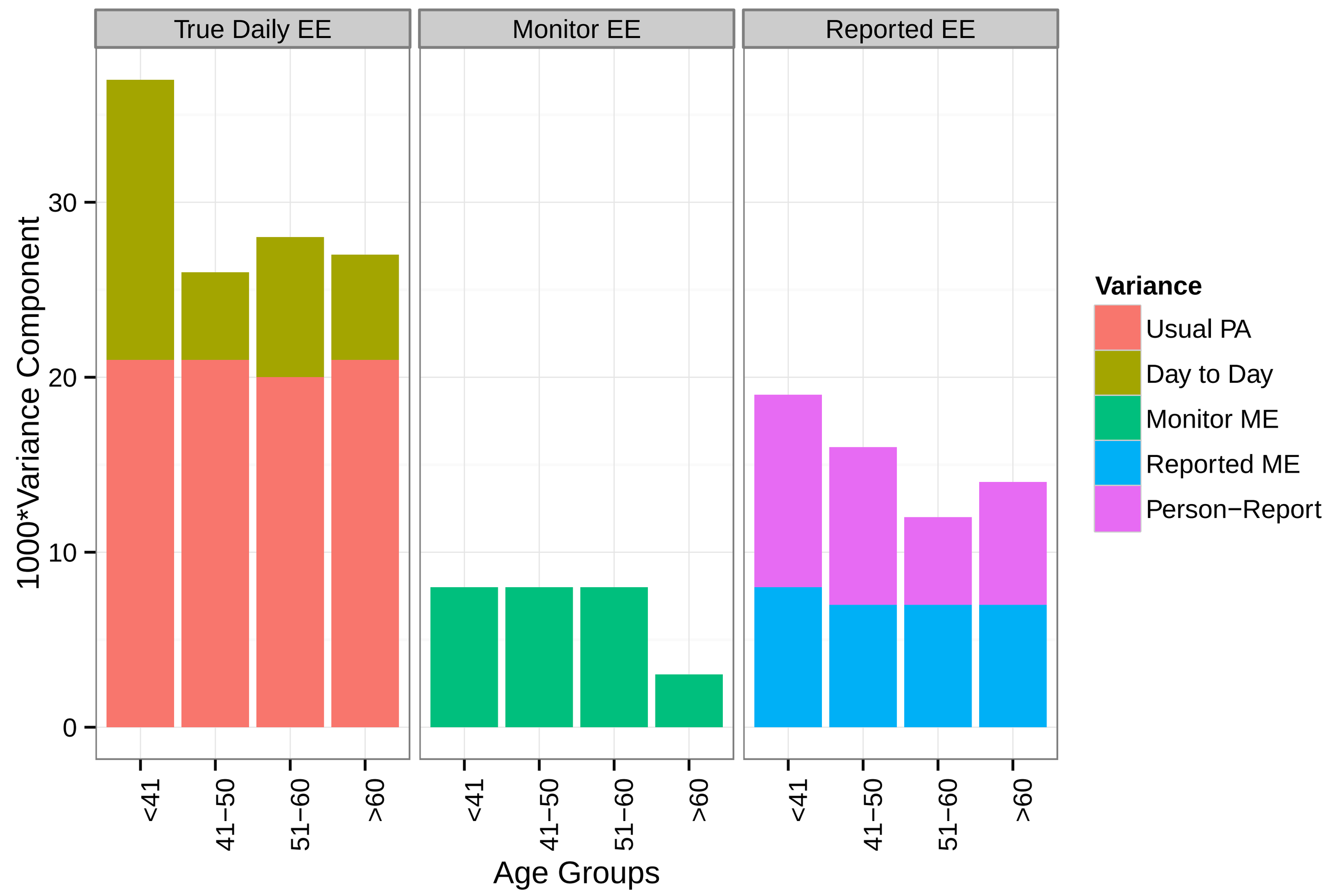
- ◇ t_{ij}, x_{ij} and y_{ij} denote the true, monitor and recall EE values for individual i, day j
- ◇ μ and μ_y denote the true and recall mean daily EE values
- ◇ t_i and r_i are indep. random effects for individuals associated with the truth and recall
- ◇ d_{ij}, u_{ij} and e_{ij} are indep. random effects for day j, monitor ME and recall ME
- ◇ The method of moments is used for parameter estimation

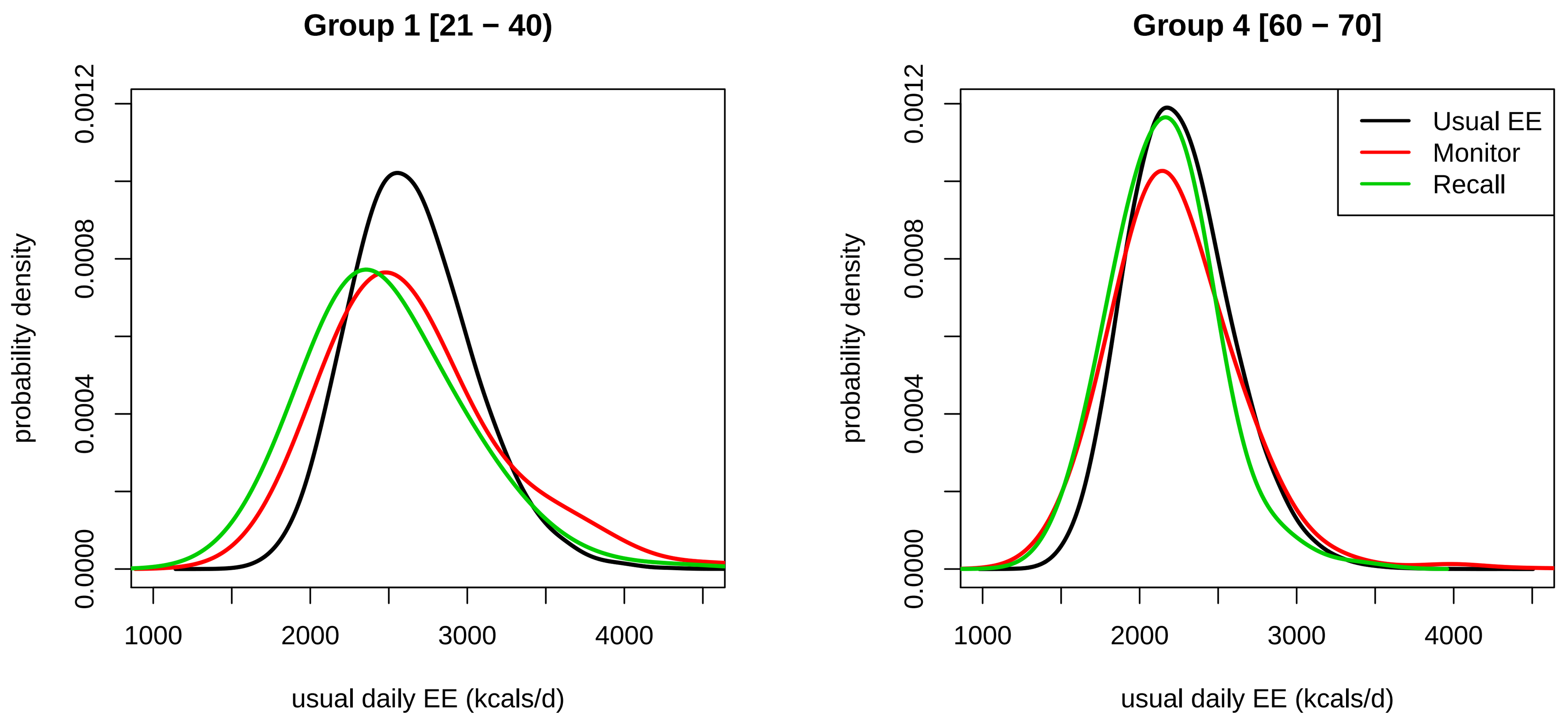


The person means for groups 1 and 4 are plotted above with the fitted line (blue). In both cases $\hat{\beta}_1 < 1$ indicating that as true EE increases their reported EE increases at a slower rate

Results

The five error terms for each group are illustrated below





The red and green curves are the EE distributions without error adjustment; the black curve is the estimated EE distribution after accounting for ME, nonresponse and noncoverage

Conclusions

Our results suggest that without adjustment the recall and monitor give biased and noisy estimates of usual EE. After accounting for common sources of error we often achieve a better estimate the true usual EE levels.