The utility of standardized or crude weight measures in modeling of postnatal growth trajectories: Are there differences?

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Introduction

- Postnatal growth trajectory characteristics play an important role in life course analyses, and one common analytic approach is to assess differences in growth according to prenatal exposures.
- Z-scores are a frequent outcome choice when modeling weight growth trajectories. **Advantages** include sex- and age-independent measures free of dimension. **Disadvantage** is measure designed for cross-sectional use.
- Compared to crude measures of weight, the advantages of standardized measures, such as Z-scores, are unclear.

Aim

- Estimate group differences in postnatal weight change across three different outcomes and three models to assess precision, type I error and parameter estimate values via Monte Carlo simulations.

Samples

- Growth trajectory parameters for baseline exposure correspond to estimates for three samples: Italy, Portugal and Chile [1].

Method

- We generated fixed effects infant growth data with a Reed first order parametric model

  Source: $y_{ij} = \beta_0 + \beta_1 \cdot \mathtt{t}_{ij} + \beta_2 \cdot \mathtt{ln}(\mathtt{t}_{ij}) + \frac{\beta_4}{\mathtt{t}_{ij}} + \beta_5 \cdot \mathtt{exp}_i + \beta_3 \cdot \mathtt{t}_{ij} \cdot \mathtt{exp}_i + e_{ij}$

- After simulating weight values (10,000 iterations), we converted weight to WHO Z-score and percentiles and fit three models:
- **Model 1**

  $m_{ij} = \beta_0 + \beta_1 \cdot \mathtt{t}_{ij} + \beta_2 \cdot \mathtt{exp}_i + \beta_3 \cdot \mathtt{t}_{ij} \cdot \mathtt{exp}_i + \epsilon_{ij}$
- **Model 2**

  $m_{ij} = \beta_0 + \beta_1 \cdot \mathtt{t}_{ij} + \beta_2 \cdot \mathtt{exp}_i + \beta_3 \cdot \mathtt{t}_{ij} \cdot \mathtt{exp}_i + \beta_4 \cdot \mathtt{t}_{ij}^2 + \epsilon_{ij}$
- **Model 3**

  $m_i = \beta_0 + \beta_1 \cdot \mathtt{m6}_i + \beta_2 \cdot \mathtt{exp}_i + \beta_3 \cdot \mathtt{m6}_i \cdot \mathtt{exp}_i + \epsilon_i$

Model Terms

y_{ij}	weight for person *i* and time *j*
t	age (months)
m_{ij}	weight, Z-score, or percentile for person *i* and time *j*
exp	a binary exposure factor
m6	a binary variable for time with 1=month 6 and 0=month 0
e_{ij}	error term with covariance following an autocorrelation structure, ρ=0.5 and σ=0.75

Results

Figure 1: Sample of simulated weight growth curves (n=10) with corresponding Z-score and percentile outcomes using Chilean growth parameters

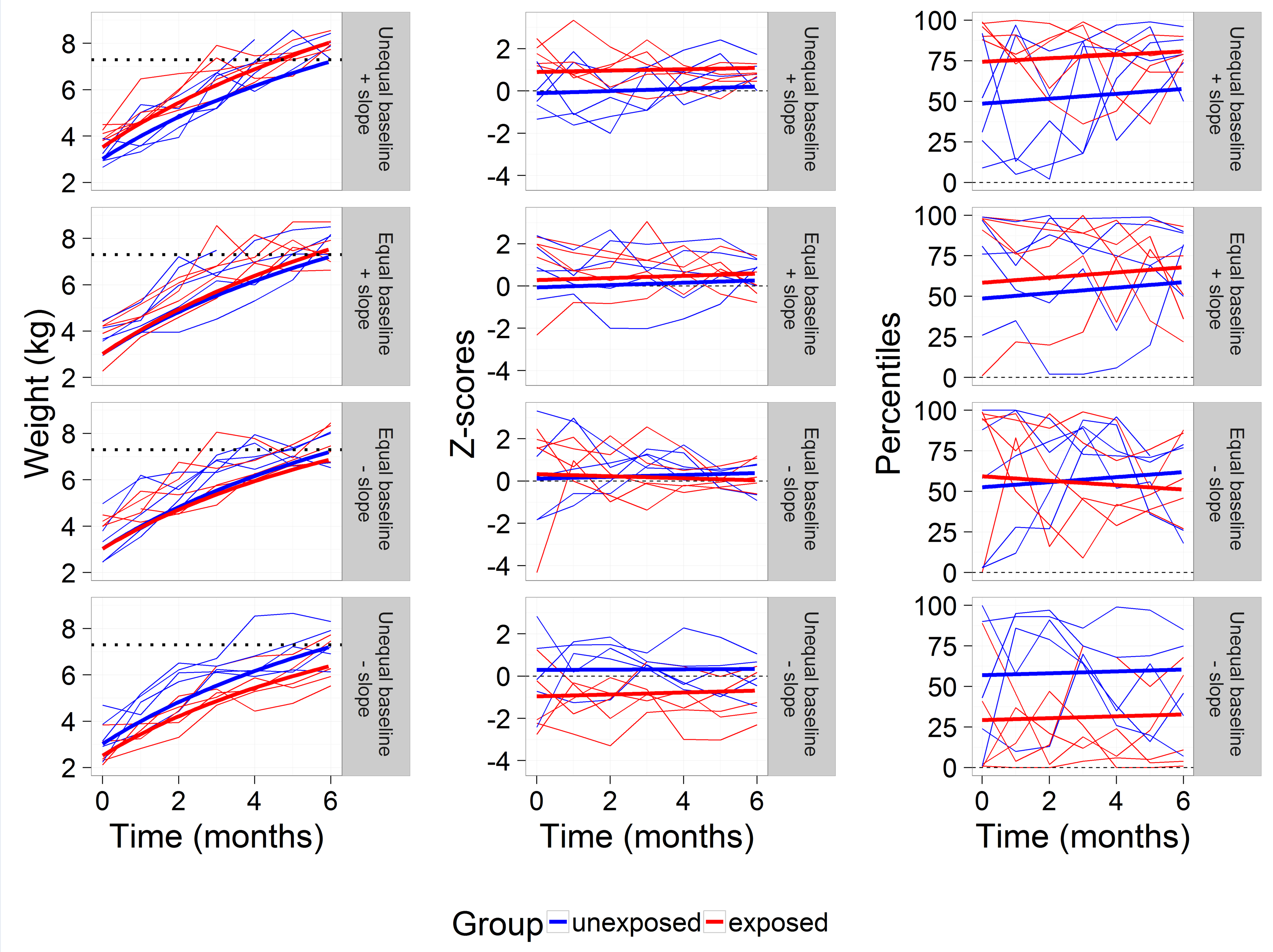
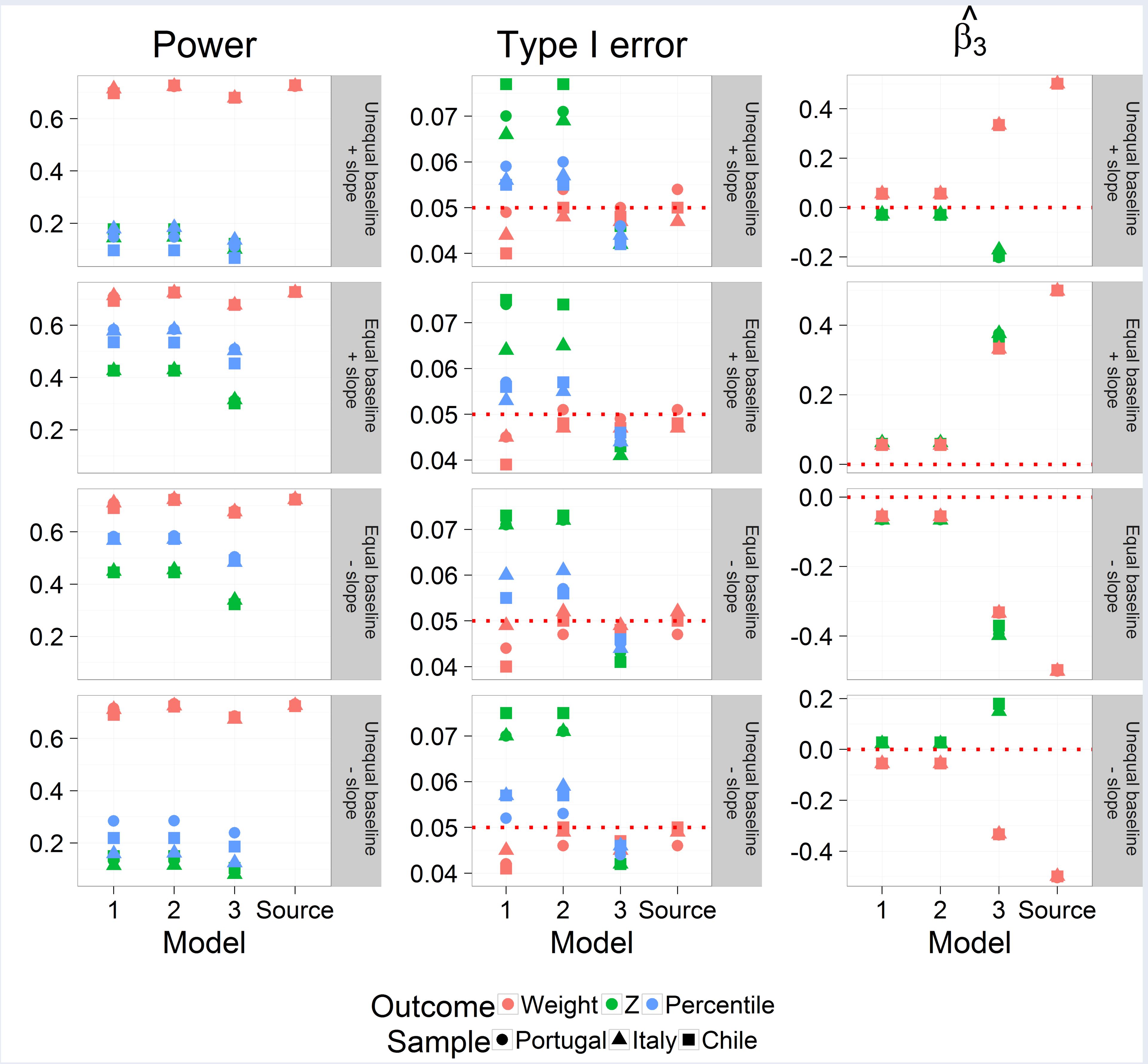


Figure 2: Comparison of power, type-I error and estimated product term for time and exposure effect, β_3.



Results, cont . . .

Power Consistently greater with crude weight.
- Weight difference at baseline results in larger differential between crude and standardized.

Type I error Crude weight measure closest to nominal type I error of 0.05.
- Z-scores have greatest type I error for models 1 and 2.

Parameter estimates Baseline weight differences lead to opposite direction of effect for Z-score compared to crude weight outcomes.
- No weight differences at baseline leads to similar estimates between Z-score and original weight outcomes.

Conclusions

Each measure examined in this project: Z-scores, percentiles and crude weight measures, serves a purpose. However, these outcomes in growth trajectory analyses are not equivalent, and if used incorrrectly can have adverse effects.
- Even at similar age and gender values, reference to a standard, WHO Z-scores, is not similar to crude weight values when assessing group differences in weight change over time.
- Supporting this conclusion, estimated group differences in weight change for all three outcomes only coincide in direction under certain conditions – equivalent weight at baseline.
  - ⇒ Special attention needed when interpreting standardized measures in longitudinal models. What is your target population?
- If comparisons to a standard such as WHO are not an objective, using Z-scores instead of crude weight can lead to
  - ⇒ biased estimates and conflicting inference
  - ⇒ lower power and inflated type I error
- Findings replicate lower power for Z-scores found in adolescent age group [2].
- **Future efforts**: How does this discrepancy in parameter estimates extend to other contexts beside group comparisons in infant growth?

References

(1) C. Pizzi et al. “Prenatal Influences on Size, Velocity and Tempo of Infant Growth: Findings from Three Contemporary Cohorts”. In: *PLoS ONE* 9.2 (Feb. 27, 2014). DOI: 10.1371/journal.pone.0090291

(2) C. S Berkey and G. A Colditz. “Adiposity in adolescents: Change in actual BMI works better than change in BMI z score for longitudinal studies”. In: *Annals of Epidemiology* 17.1 (Jan. 2007), pp. 44–50. DOI: 10.1016/j.annepidem.2006.07.014

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