

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

Ann Von Holle, Kari North, Ran Tao, UNC, Chapel Hill, NC; Sheila Gahagan, UCSD, San Diego, CA

Introduction

- Postnatal growth trajectory characteristics play an important role in life course analyses, and one common analytic approach is to assess growth differences 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: $y_{ij} = \beta_0 + \beta_1 \cdot t_{ij} + \beta_2 \cdot \ln(t_{ij}) + \frac{\beta_4}{t_{ij}} + \beta_5 \cdot \exp_i + \beta_3 \cdot t_{ij} \cdot \exp_i + e_{ij}$

- After simulating weight values (10,000 iterations) for four baseline weight and slope scenarios, we fit three models for each of the three outcomes and three samples:

Model 1

$$m_{ij} = \beta_0 + \beta_1 \cdot t_{ij} + \beta_2 \cdot \exp_i + \beta_3 \cdot t_{ij} \cdot \exp_i + \epsilon_{ij}$$

Model 2

$$m_{ij} = \beta_0 + \beta_1 \cdot t_{ij} + \beta_2 \cdot \exp_i + \beta_3 \cdot t_{ij} \cdot \exp_i + \beta_4 \cdot t_{ij}^2 + \epsilon_{ij}$$

Model 3

$$m_i = \beta_0 + \beta_1 \cdot m6_i + \beta_2 \cdot \exp_i + \beta_3 \cdot m6_i \cdot \exp_i + \epsilon_i$$

Model Terms

y_{ij}	weight for person i and time j
t	age (months)
m_{ij}	weight, WHO Z-score based on simulated weight, 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, $\rho=0.5$ and $\sigma=0.75$

Results

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

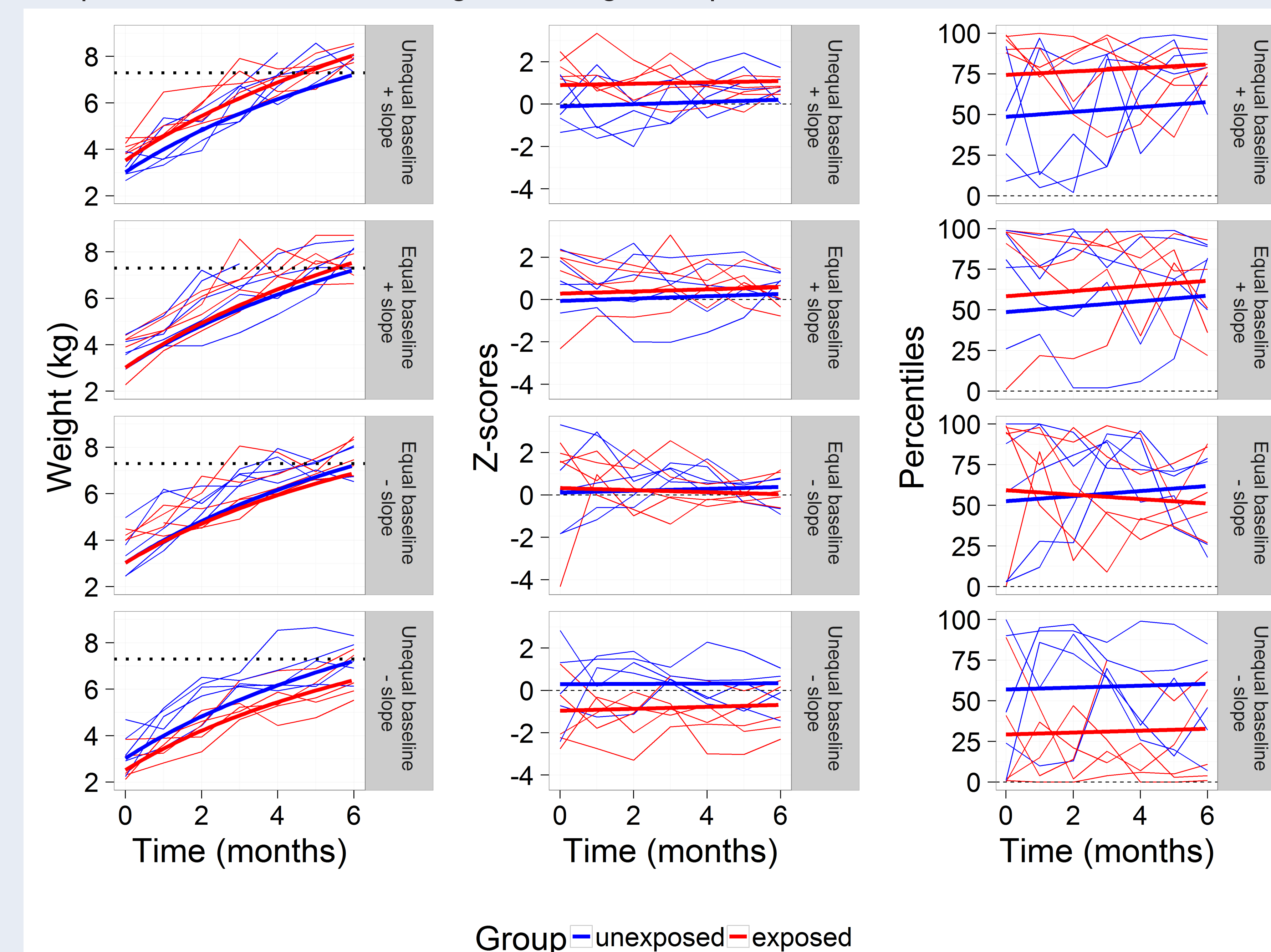
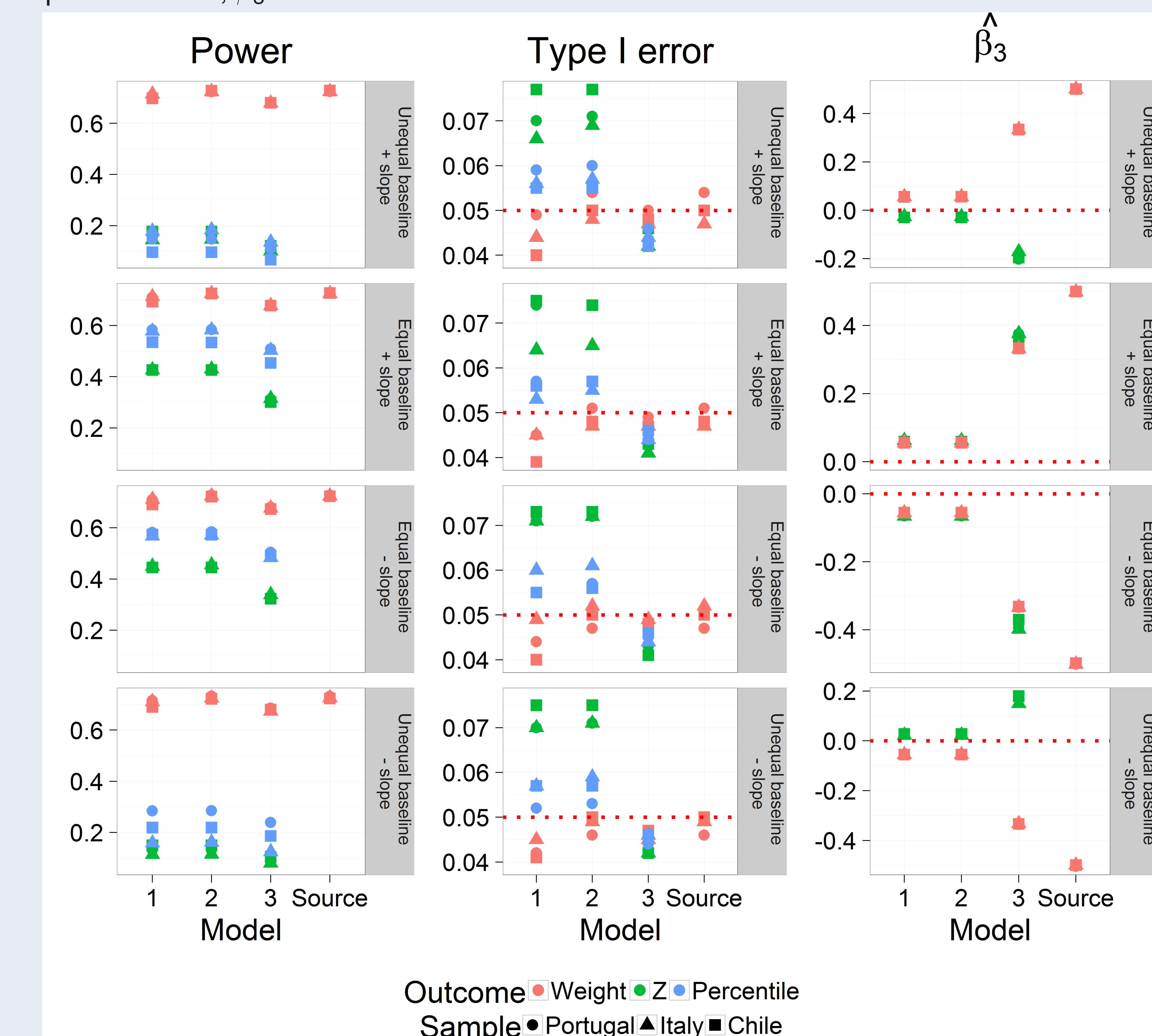


Figure 2: Comparison of power, type-I error and estimated product term for time and exposure effect, β_3 .



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 ($\hat{\beta}_3$):** Baseline weight differences lead to opposite direction of effect, group difference in weight change over time, 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 incorrectly can have adverse effects.
- Even at similar age and gender values, estimated group differences in weight change over time are not similar for standardized and crude weight outcomes.
- 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, i.e. what is the appropriate target population?
- If comparisons to a standard 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

