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

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Introduction

- Growth trajectory characteristics are frequently used in life course analyses as an exposure through which later life adverse events, such as cardiovascular disease, are linked.
- Z-scores are a frequent outcome choice when modeling weight growth trajectories. **Advantages** include linear sex- and age-independent measures of weight outcomes. **Disadvantage** is measure meant for cross-sectional use.
- Rationale frequently not clear in decision to use a standardized measure in longitudinal analyses instead of crude weight.

Aim

To determine precision, type I error and potential for biased estimates we use Monte Carlo simulations to compare three different weight outcome models when estimating group differences in weight change during infancy.

Samples

Growth trajectory parameters for baseline exposure correspond to published estimates for three samples: Italy, Portugal and Chile.

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). Ed. by G. Wang, e90291. DOI: 10.1371/journal.pone.0090291

Method

We generated fixed effects infant growth data with a Reed first order parametric model (**Source**):

$$y_{ij} = \beta_0 + \beta_1 \cdot \mathrm{t} + \beta_2 \cdot \ln(\mathrm{t}_{ij}) + \frac{\beta_3}{\mathrm{t}_{ij}} + \beta_4 \cdot \mathrm{group}_i + \beta_5 \cdot \mathrm{t} \cdot \mathrm{group}_i + e_{ij}$$

After simulating data, three models were fit with the simulated data:

Model 1

$$E(y) = \beta_0 + \beta_1 \cdot \mathrm{t} + \beta_2 \cdot \mathrm{group} + \beta_3 \cdot \mathrm{t} \cdot \mathrm{group}$$

Model 2

$$E(y) = \beta_0 + \beta_1 \cdot \mathrm{t} + \beta_2 \cdot \mathrm{group} + \beta_3 \cdot \mathrm{t} \cdot \mathrm{group} + \beta_4 \cdot \mathrm{t}^2$$

Model 3

$$E(y) = \beta_0 + \beta_1 \cdot \mathrm{month.6} + \beta_2 \cdot \mathrm{group} + \beta_3 \cdot \mathrm{month.6} \cdot \mathrm{group}$$

Model Terms

y_{ij}	weight for person i and time j, age (months)
y	outcome: weight, Z-score, percentile
group	a binary exposure factor
month.6	a binary variable for time with 1=month 6 and 0=month 0
e_{ij}	error term with variance following an autocorrelation structure, ρ=0.5 and σ=0.75

Results

Figure 1: Simulated weight growth curves with corresponding Z-score and percentile outcomes using Chilean growth parameters

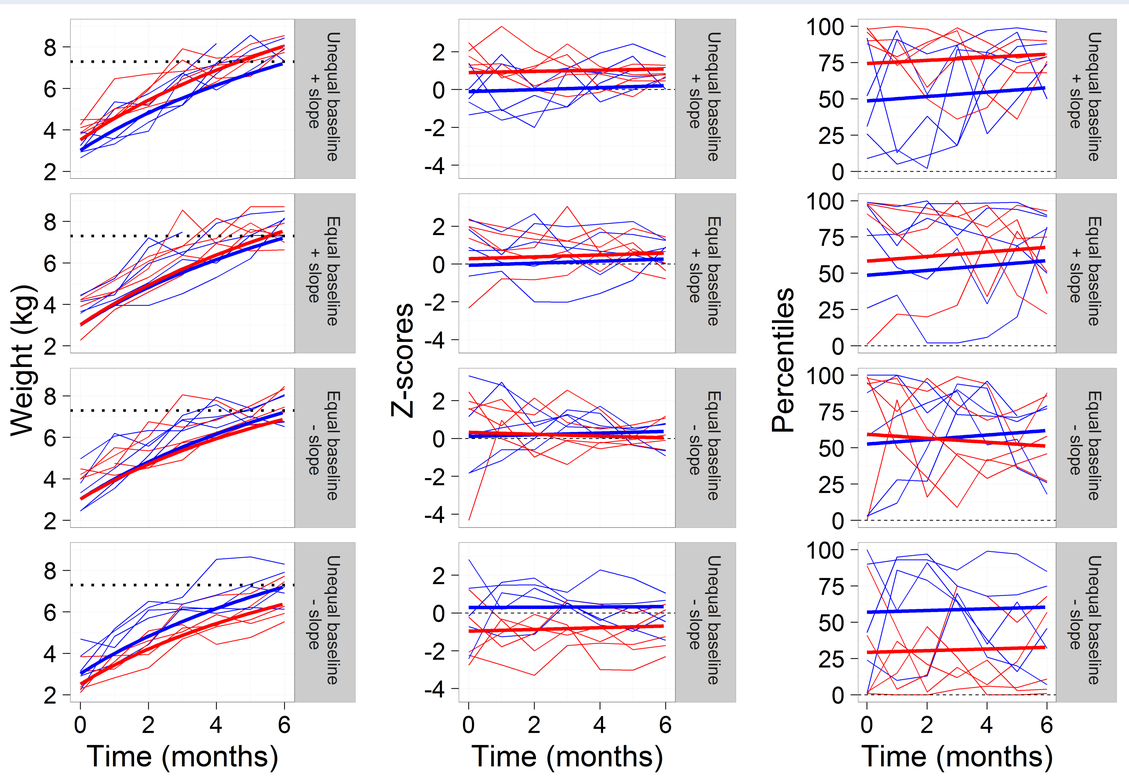
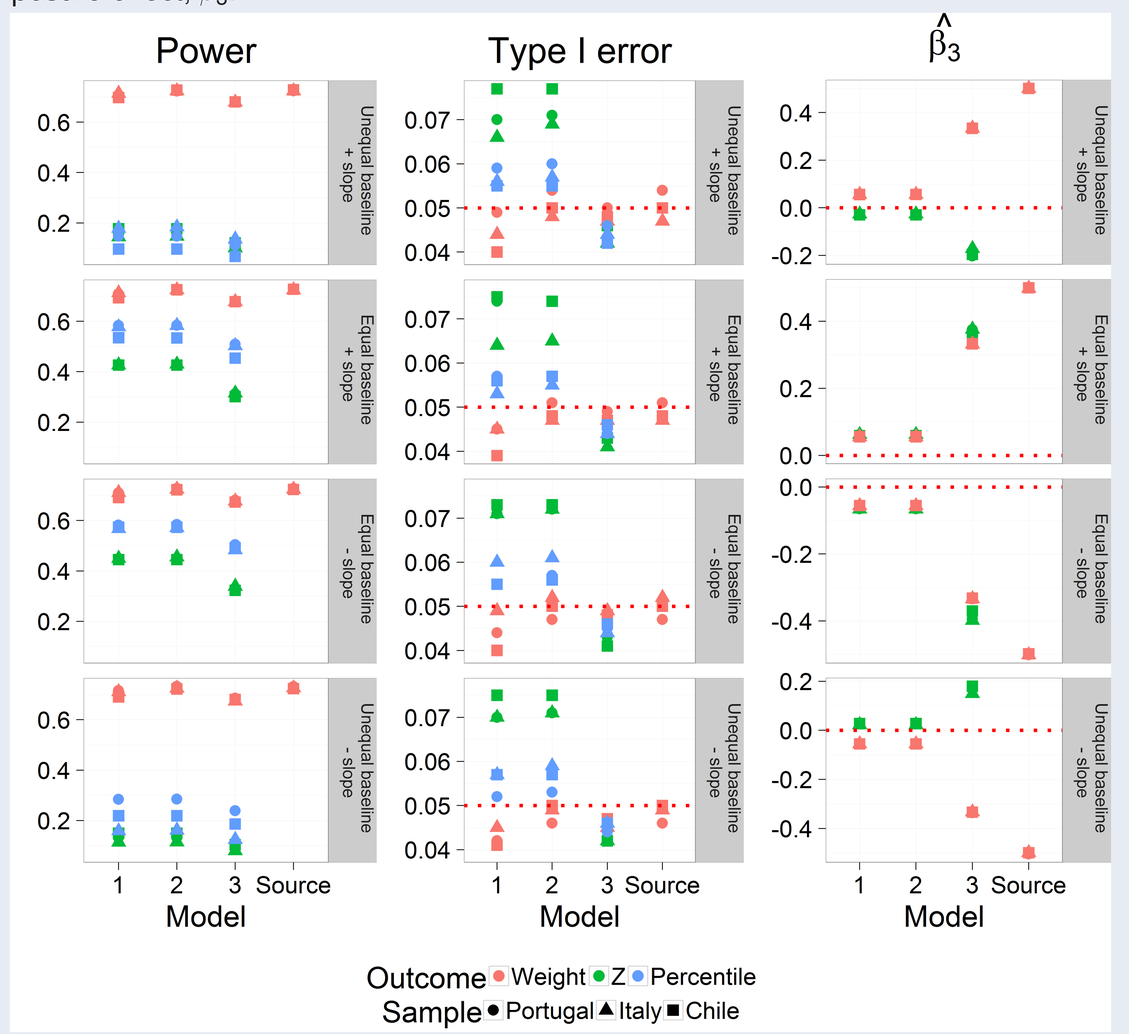


Figure 2: Comparison of power, type-I error and estimate for product term of time and exposure effect, β_3.



Results, cont . . .

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

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.

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

Summary

Z-scores or percentiles These measures provide a measure of weight relative to a referent population.
- Trajectory group differences using Z-scores or percentiles as outcomes can lead to estimates in opposite direction compared crude weight outcomes.
- Using these measures also leads to lower power to detect differences in slope and inflated type I error.

Conclusions

Each measure examined in this project: Z-scores, percentiles and crude weight measures, serves a purpose as needed in research.

- Transforming crude weight measures into Z-scores, as is commonly done in the literature, may provide benefits such as a reference point to a standard and comparability across genders, but it is important to note that this measure does not function the same as crude weight when examining growth trajectories.
- If reference to a standard is not an aim when examining group differences in growth trajectory patterns, crude weight measures as an outcome provide higher power and less inflated type I error.
- If growth trajectories serve as an exposure in life course analyses and comparison to a referent such as WHO is not an objective, Z-scores can lead to exposure misspecification and conflicting inference.

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