Supplementary material for Husby et al,
Gestational age at birth and cognitive outcomes in adolescence:
population based full sibling cohort study

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Table S1. Supplementary characteristics of children in the sibling cohort.

Characteristic	Sibling cohort (%)		Percentage of children		
			Born prior to 37 weeks	Language z-score < 0	Math. z-score < 0
Paternal age at childbirth (years)					
< 20	3,023	(0.4 %)	6.7 %	70.5 %	75.5 %
20-24	63,519	(8.0 %)	6.1 %	59.8 %	63.2 %
25-29	246,361	(31.1 %)	5.4 %	48.3 %	49.5 %
30-34	282,401	(35.6 %)	5.3 %	44.1 %	44.8 %
35-39	139,277	(17.6 %)	5.8 %	43.6 %	45.0 %
≥ 40	58,143	(7.3 %)	6.7 %	45.4 %	48.5 %
Missing paternal age	3,023	(0.4 %)	6.7 %	70.5 %	75.5 %
Paternal educational level*					
Primary education	182,391	(23.0 %)	6.3 %	61.4 %	66.0 %
Upper secondary education	57,110	(7.2 %)	4.9 %	36.0 %	37.6 %
Vocational edu. and training	341,224	(43.0 %)	5.7 %	48.9 %	50.4 %
Short-term higher education	41,786	(5.3 %)	5.6 %	39.9 %	39.0 %
Vocational bachelor edu.	79,815	(10.1 %)	4.8 %	31.7 %	30.1 %
Academic bachelor's degree	8,893	(1.1 %)	5.1 %	29.0 %	27.0 %
Academic master's degree	64,176	(8.1 %)	4.5 %	26.1 %	22.5 %
PhD or other doctoral degree	3,500	(0.4 %)	5.1 %	22.3 %	15.8 %
No paternal education stated	13,829	(1.7 %)	6.3 %	67.6 %	73.8 %
Birth cohort					
1986-1991	218,754	(27.6 %)	4.9 %	47.7 %	45.9 %
1992-1997	320,924	(40.5 %)	5.3 %	47.6 %	50.3 %
1998-2003	253,046	(31.9 %)	6.5 %	44.9 %	47.4 %

* Paternal educational level defined as the highest educational level attained at the time of childbirth. Description and examples of specific educational categories are given in Table S3.

Table S2. Diagnostic codes used for characterization of prematurity-associated morbidity.

Diagnostic category	ICD-8 diagnostic codes (1986-1993)	ICD-10 diagnostic codes (1994-)
Neurological birth trauma	764.00, 764.01, 764.02, 764.03, 764.04, 764.05, 764.08, 764.09, 765.00, 765.01, 765.02, 765.03, 765.04, 765.05, 765.08, 765.09, 766.00, 766.01, 766.02, 766.03,	P10.0, P10.0A, P10.1, P10.2, P10.3, P10.4, P10.8, P10.9, P11, P11.0, P11.1 P11.9, P13.0, P13.1
Intracranial bleeding or thrombosis	766.04, 766.05, 766.08, 766.09, 767.00, 767.01, 767.02, 767.03, 767.04, 767.05, 767.08, 767.09, 768.00, 768.01, 768.02, 768.03, 768.04, 768.05, 768.08, 768.09, 772.00	P52, P52.0, P52.1, P52.2, P52.3, P52.4, P52.5, P52.6, P52.8, P52.9
Retinal impairment	377.04	H35.1
Other cerebral impairment	772.01, 772.08	P91, P91.0, P91.1, P91.2, P91.3, P91.4, P91.5, P91.6, P91.7, P91.8, P91.9
Respiratory impairment		P27, P27.0, P27.1, P27.8, P28.8A
Cardiovascular impairment	747.09	P29.3, P29.3A, P29.3B
Gastro-intestinal impairment		P77, P77.9

Table S3. Description of educational categories.

Educational category	Description	Examples
Primary education (i.e., 9th grade)	9th grade minimum educational level	
Upper secondary education	Secondary education qualifying for higher education	Technical, commercial, academic high school
Vocational education and training	Educations giving professional qualifications, typical without necessitating secondary education for entry	Carpenter, electrician, nursing aid
Short-term higher education	Typical one to two-year educational programs giving professional qualifications	IT-worker, financial analysist
Vocational bachelor education	Typical two to four-year educational programs giving professional qualifications	Nurse, schoolteacher
Academic bachelor's degree	Three-year academic education	Bachelor in economics and business administration, bachelor in English
Academic master's degree	Typical two to three academic education necessitating an academic bachelor degree	Dentist, medical doctor, priest
PhD or other doctoral degree	Postgraduate scientific university degree	PhD degree in physics, doctoral degree in veterinary medicine

Table S4. Estimates for children with missing gestational age compared with children born at 40 gestational weeks, in language, mathematics, and conscription intelligence test.

	Sibling cohort			Intelligence sub-cohort	
Gestational age category	Number of children	Language z-score (95% CI)	Mathematics z-score (95% CI)	Number of children	Intelligence z-score (95% CI)
40 weeks	240,045	0 (ref.)	0 (ref.)	67,613	0 (ref.)
Missing	12,947	0.02 (-0.01,0.04)	0.03 (0.01,0.05)	3,677	-0.03 (-0.08,0.02)

Table S5. Frequency of children without a registered result in language, mathematics, or the conscription intelligence test by gestational week of birth.

	Sibling cohort		Intelligence sub-cohort
Gestational week	**Language grade (%)**	**Mathematics grade (%)**	**Intelligence test score (%)**
≤ 27	24.3 %	23.2 %	49.6 %
28-31	17.2 %	16.2 %	38.0 %
32-33	14.2 %	14.1 %	33.5 %
34-36	11.6 %	11.3 %	33.3 %
37	11.1 %	10.8 %	32.0 %
38	10.1 %	9.9 %	30.0 %
39	9.1 %	9.0 %	27.7 %
40	8.8 %	8.7 %	27.1 %
41	8.4 %	8.2 %	26.9 %
≥ 42	8.9 %	8.7 %	26.9 %
Missing	11.0 %	10.7 %	30.9 %

Figure S1. Differences among post-term births. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with differentiation of post-term births into separate exposure categories.

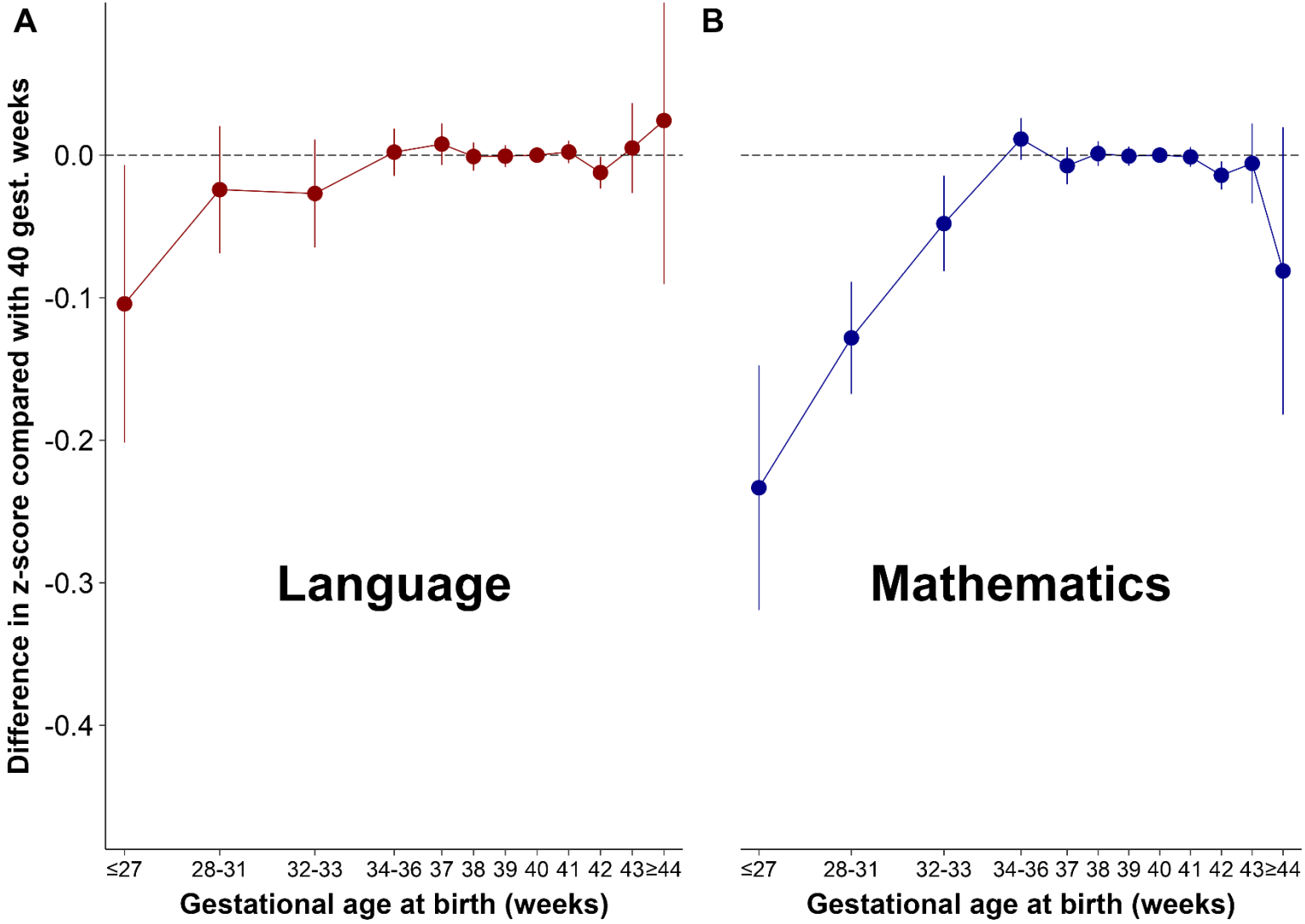

Figure S2. Differences by morbidity status. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, stratified by diagnosis of morbidity associated with prematurity (see Table S2 for definitions of morbidities).

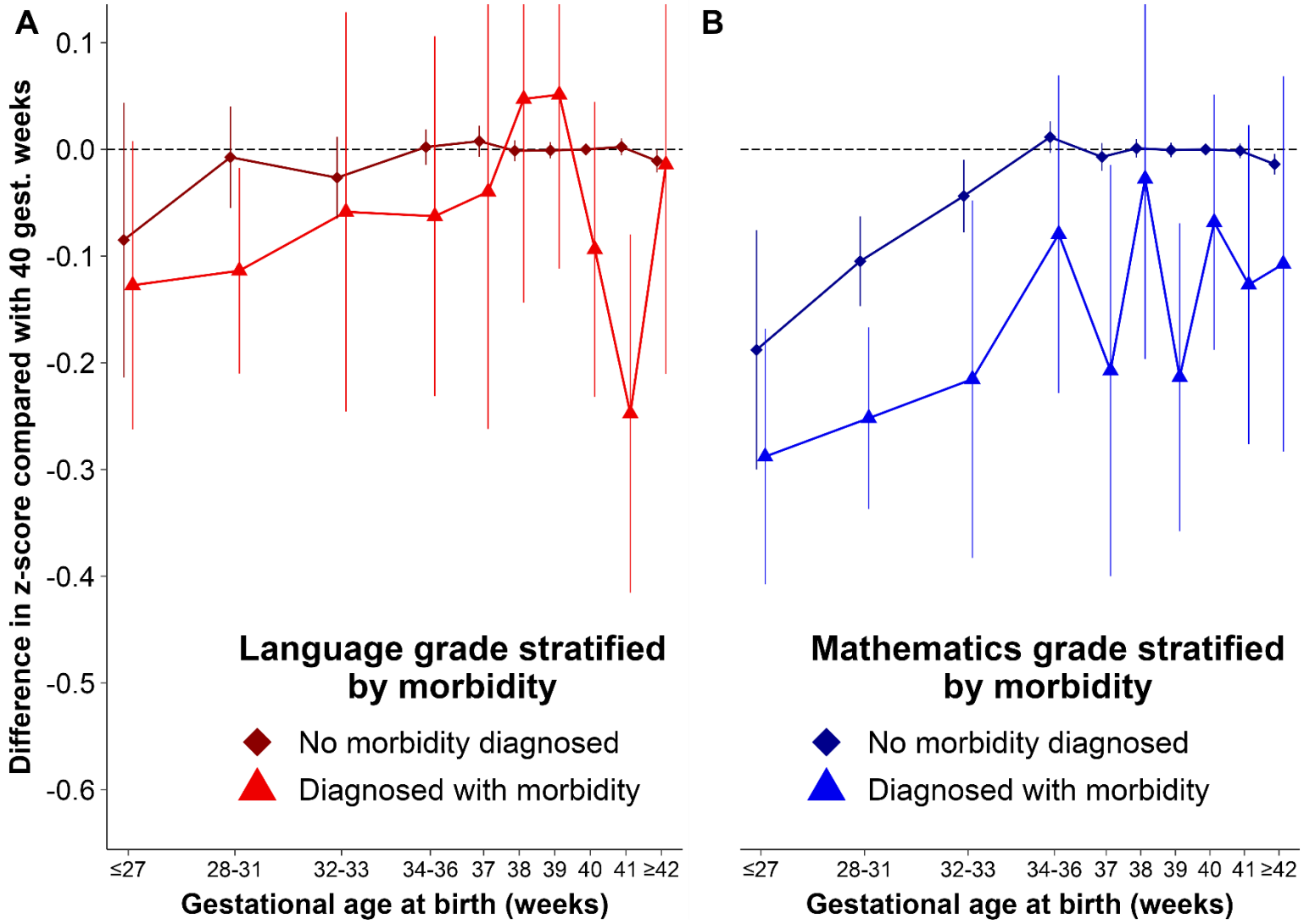

Figure S3. Differences by sex. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with interaction by sex. Test for interaction gives p = 0.17 in language and p = 0.02 in mathematics.

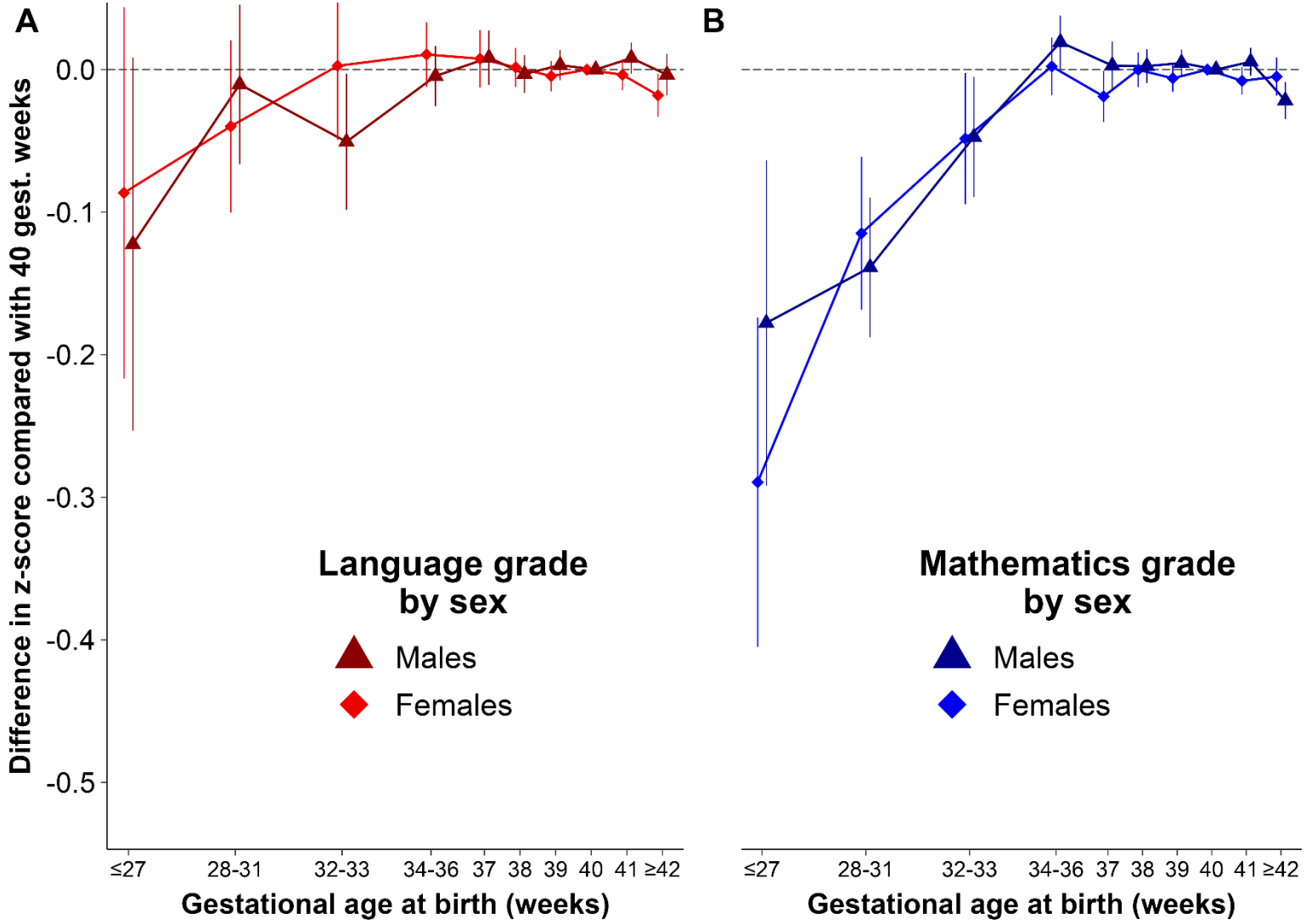

Figure S4. Differences by relative birthweight. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with interaction by relative birthweight (grouped by 0-9%, 10-49%, and 50-100% percentiles) according to gestational age in weeks. Test for interaction gives $p = 0.95$ in language and $p = 0.002$ in mathematics.

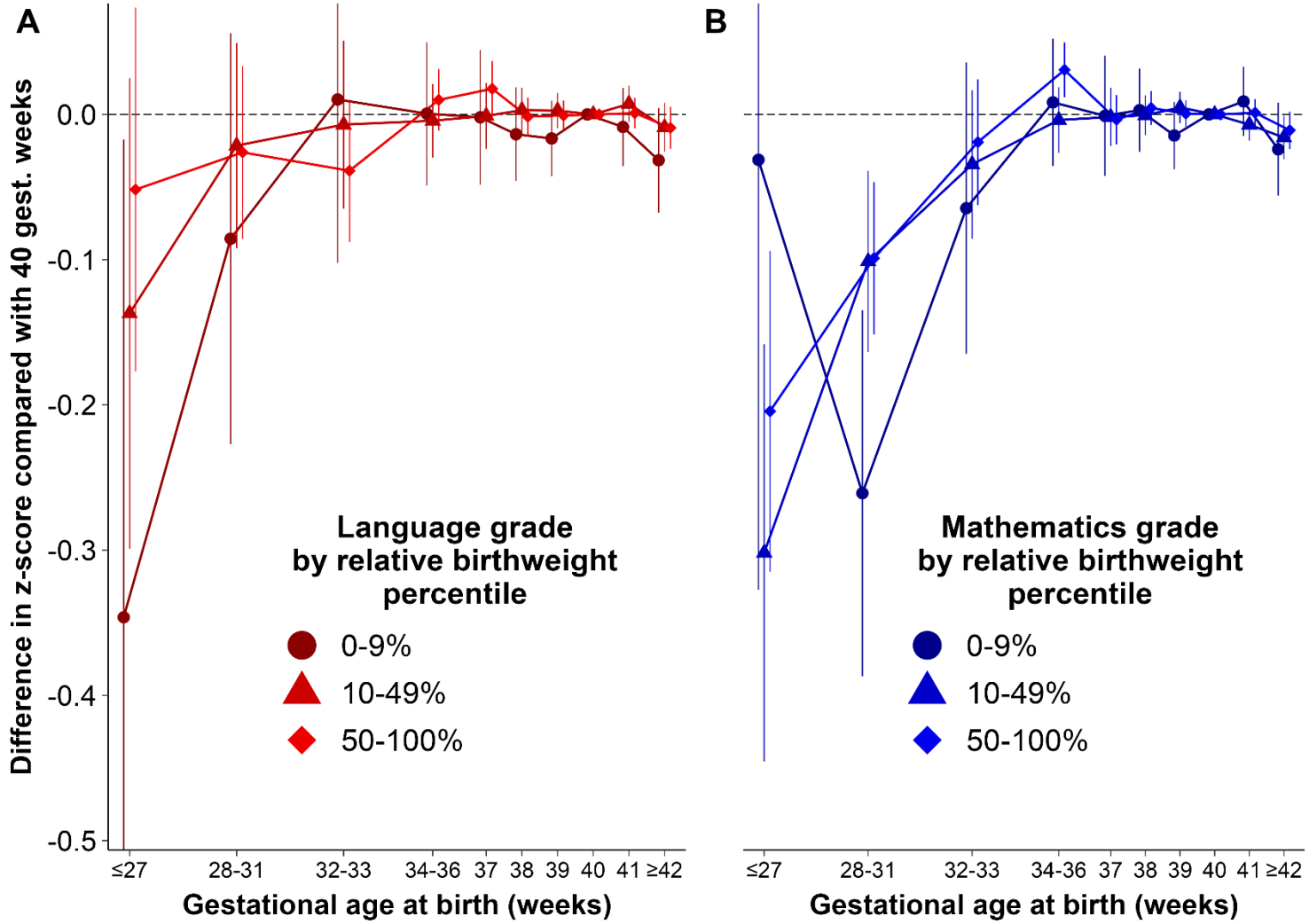

Figure S5. Differences by maximal age difference between siblings. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, stratified by maximal age difference in sibling group (categorized by less than 4 years age difference or 4 years or more in age difference).

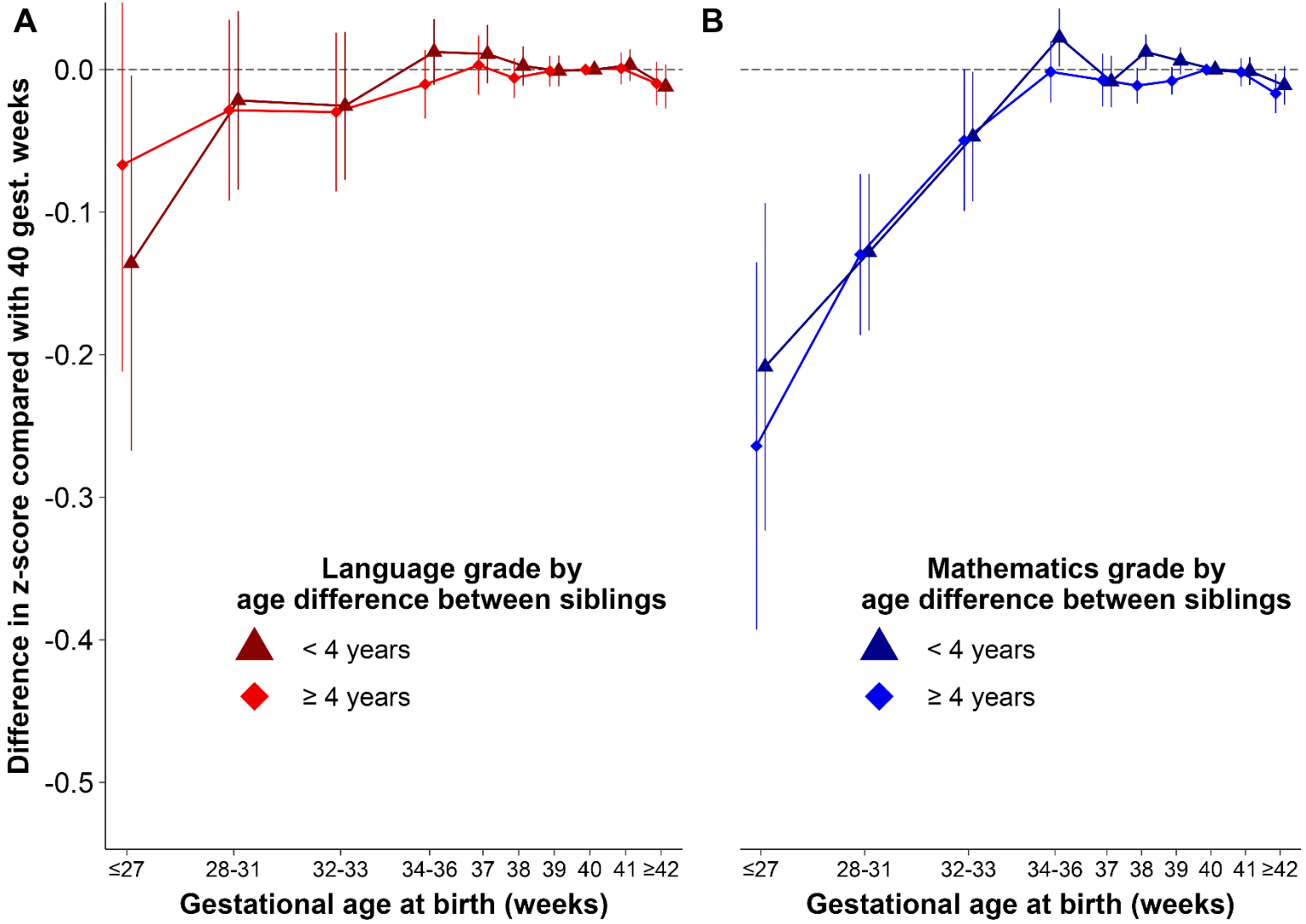

Figure S6. Differences by birth cohort. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with interaction by birth cohort (1986-1991, 1992-1997, 1998-2004). Test for interaction gives $p = 0.34$ in language and $p \leq 0.0001$ in mathematics.

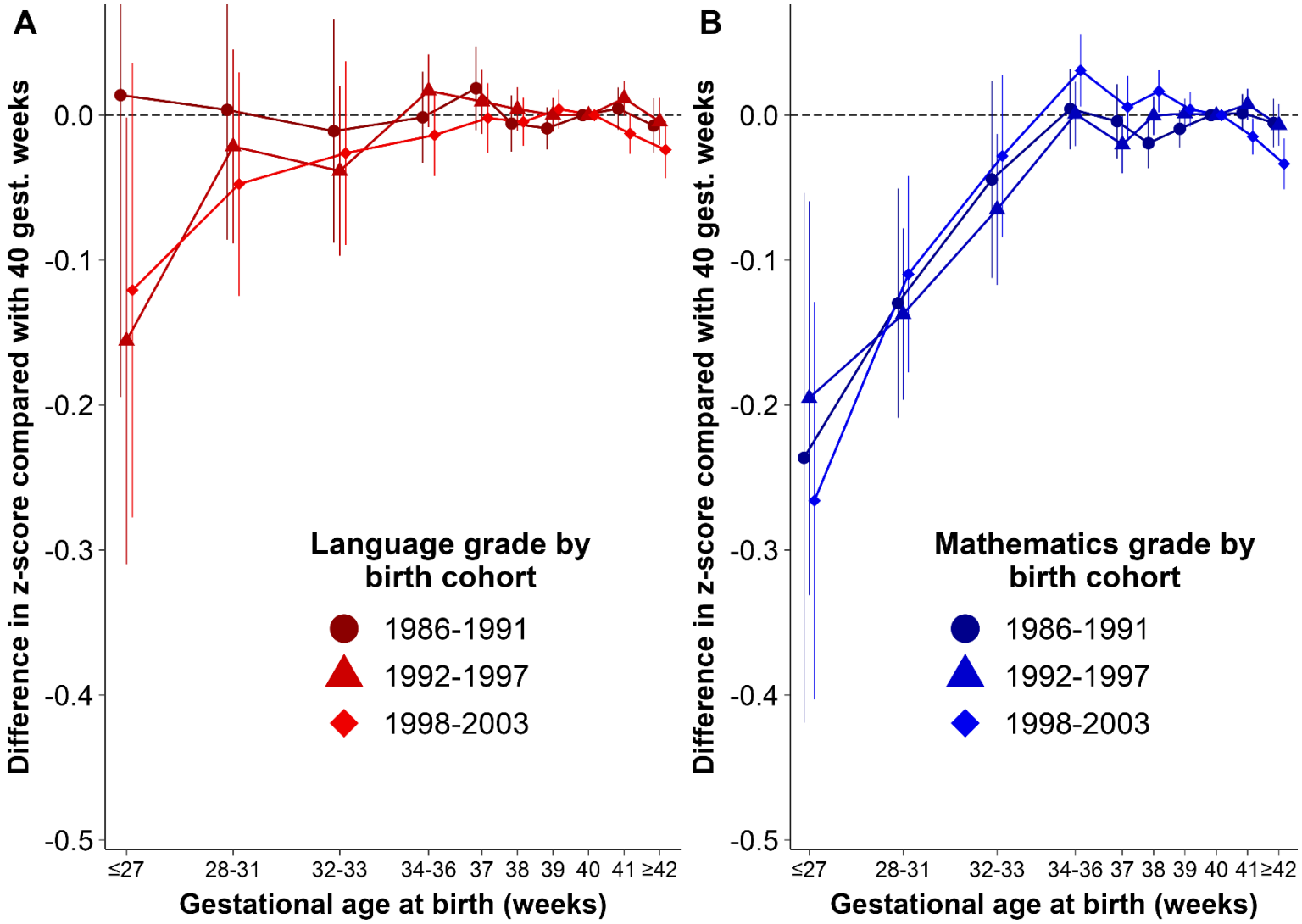

Figure S7. Differences by adjustment for relative birthweight versus estimated intrauterine growth restriction. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, malformations, parental age, parental educational level, number of siblings, shared family-factors, and adjustment for either relative birthweight or intrauterine growth restriction, respectively. Intrauterine growth restriction was defined as having a birthweight below two standard deviations of the mean ultrasound determined intrauterine gestational age-specific weight, as defined in K. Maršál et al, *Intrauterine growth curves based on ultrasonically estimated foetal weights*, 1996, Acta Paediatrica.

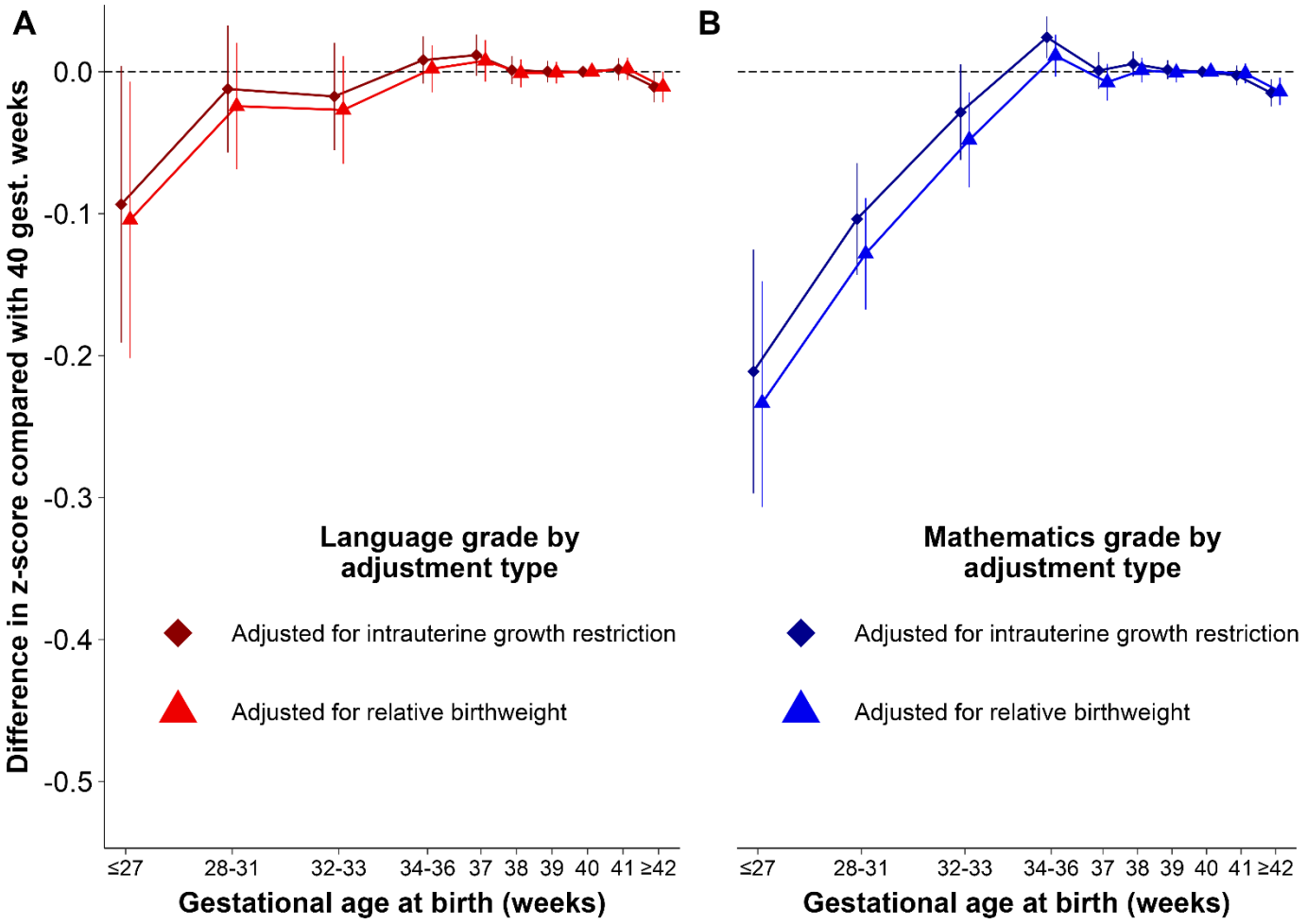

Figure S8. Differences by adjustment for maternal smoking. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with and without adjustment for maternal smoking during pregnancy for children born from 1991.

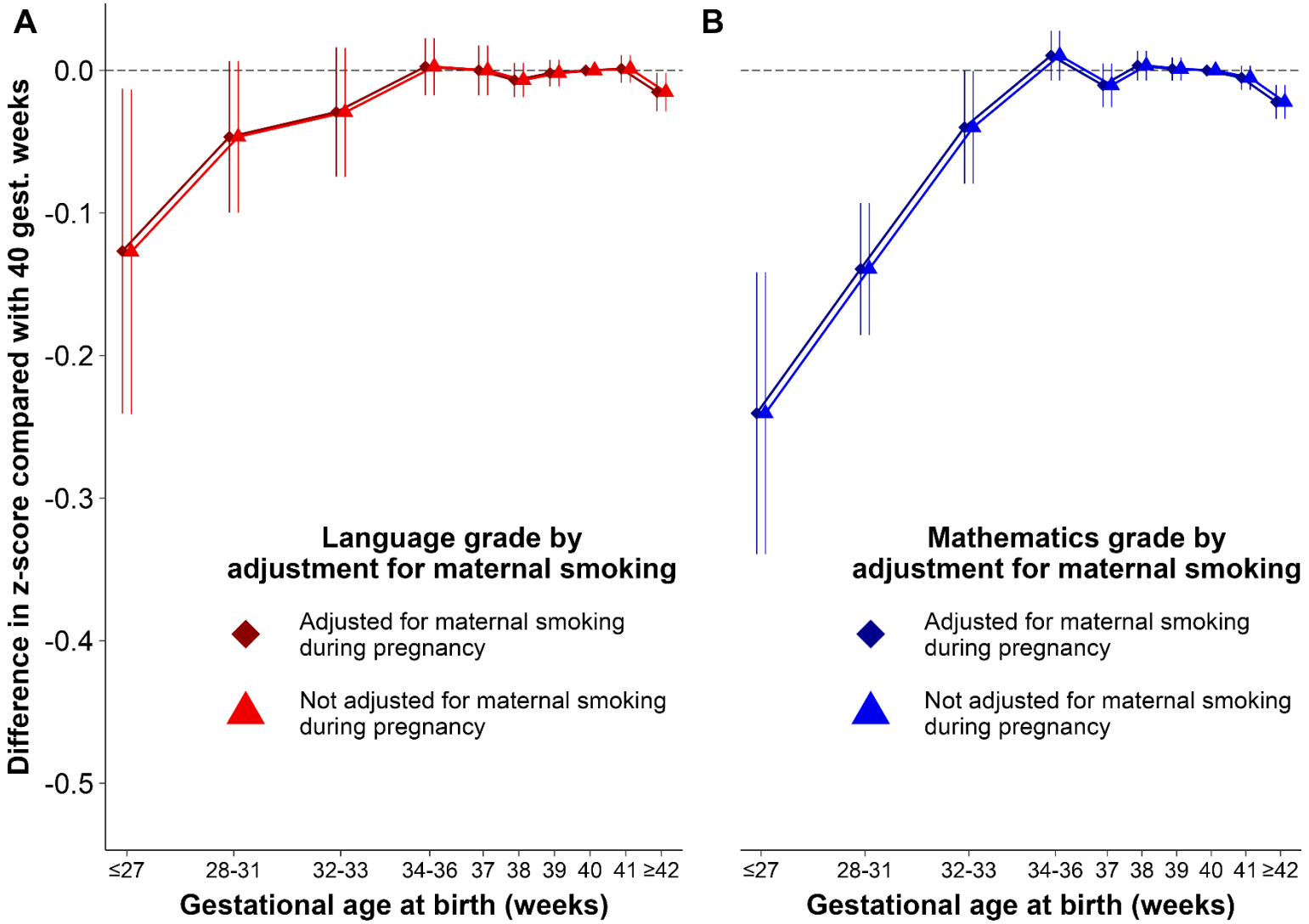

Figure S9. Differences by adjustment for pre-eclampsia and gestational diabetes mellitus. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with and without adjustment for pre-eclampsia and gestational diabetes mellitus.

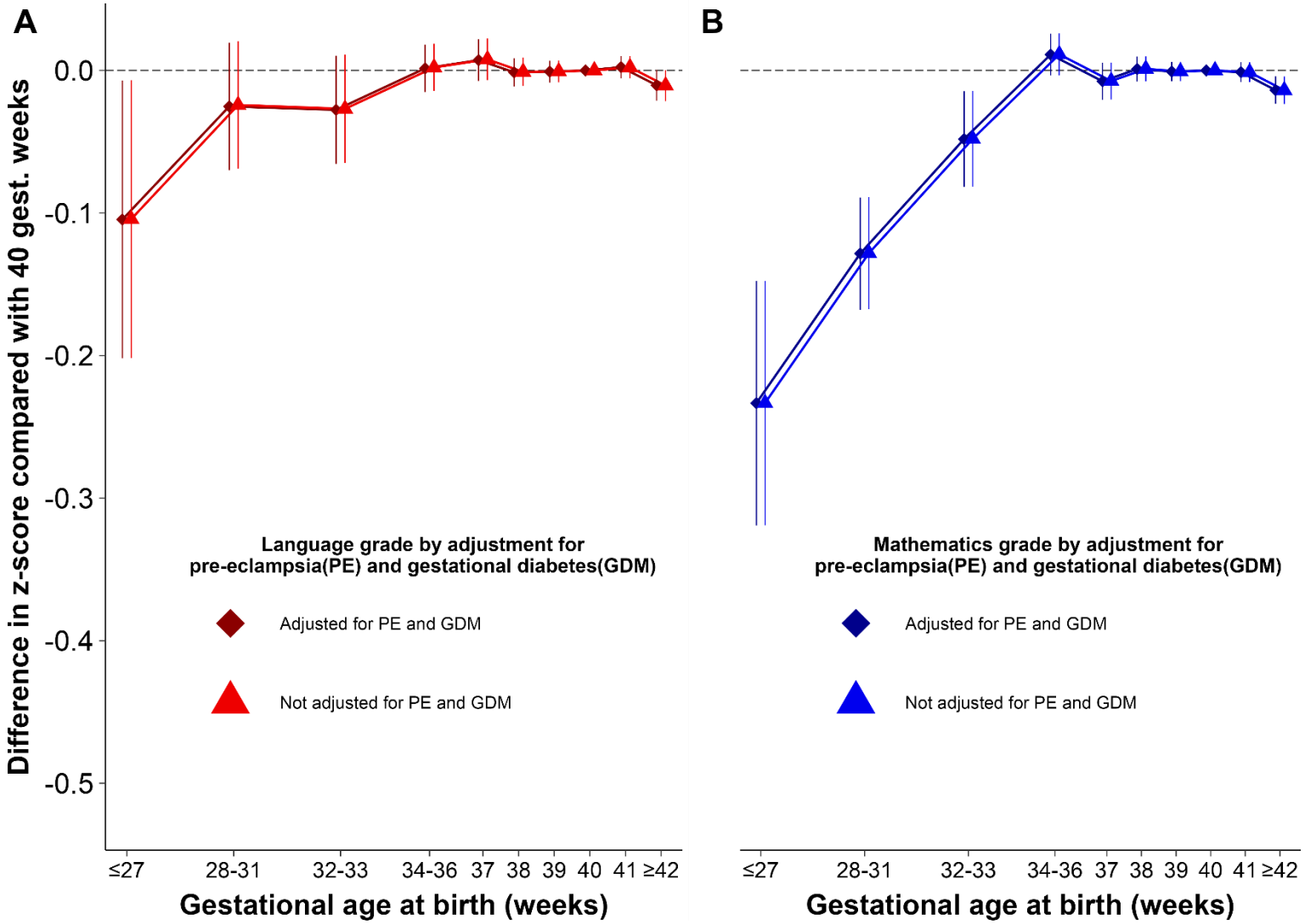

Figure S10. Differences by adjustment for twin status. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with and without adjustment for twin status (i.e., having 0, 1, 2, or more twins).

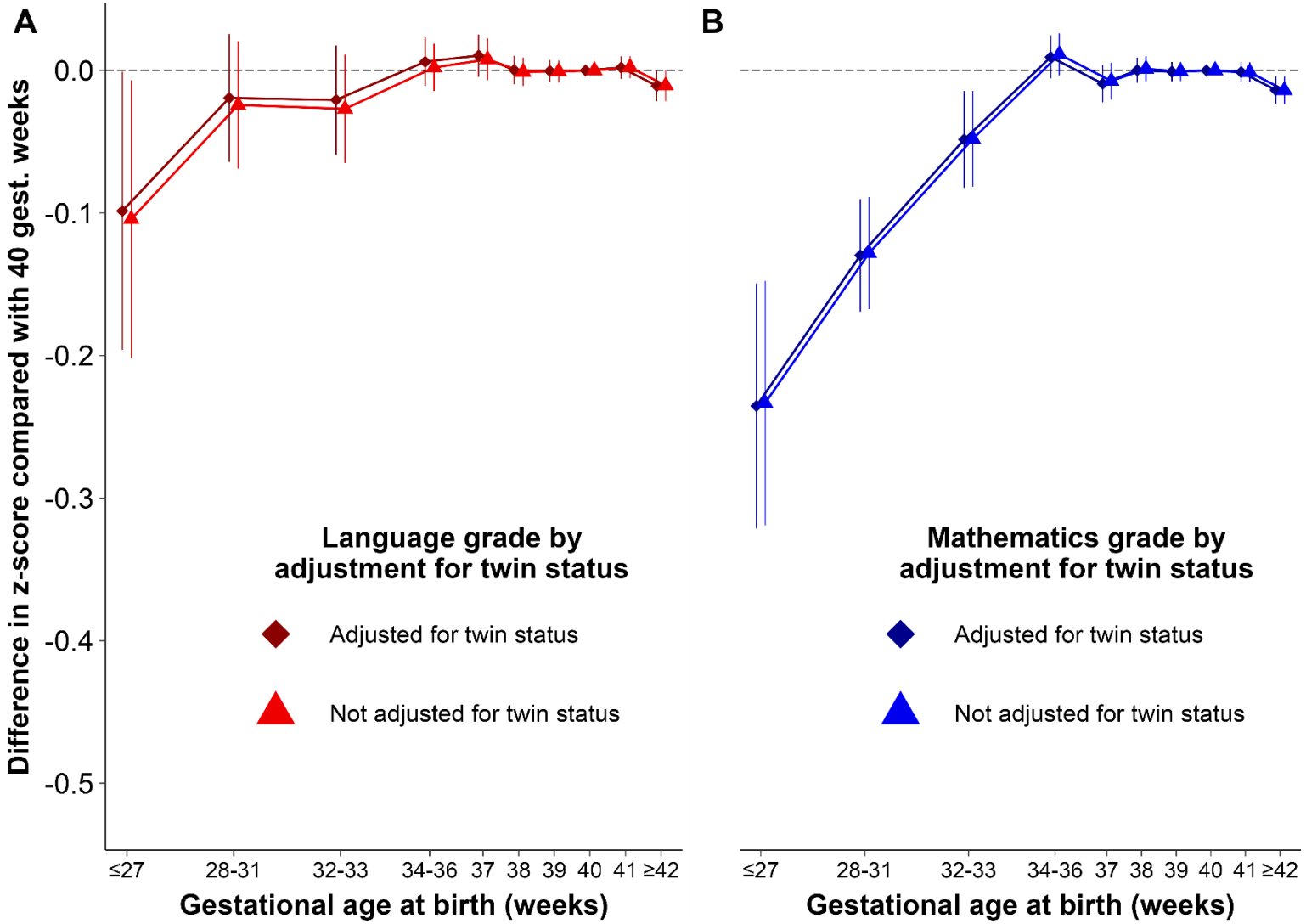

Figure S11. Differences by cohort type. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, and number of siblings, in population cohort and full-sibling cohort, respectively.

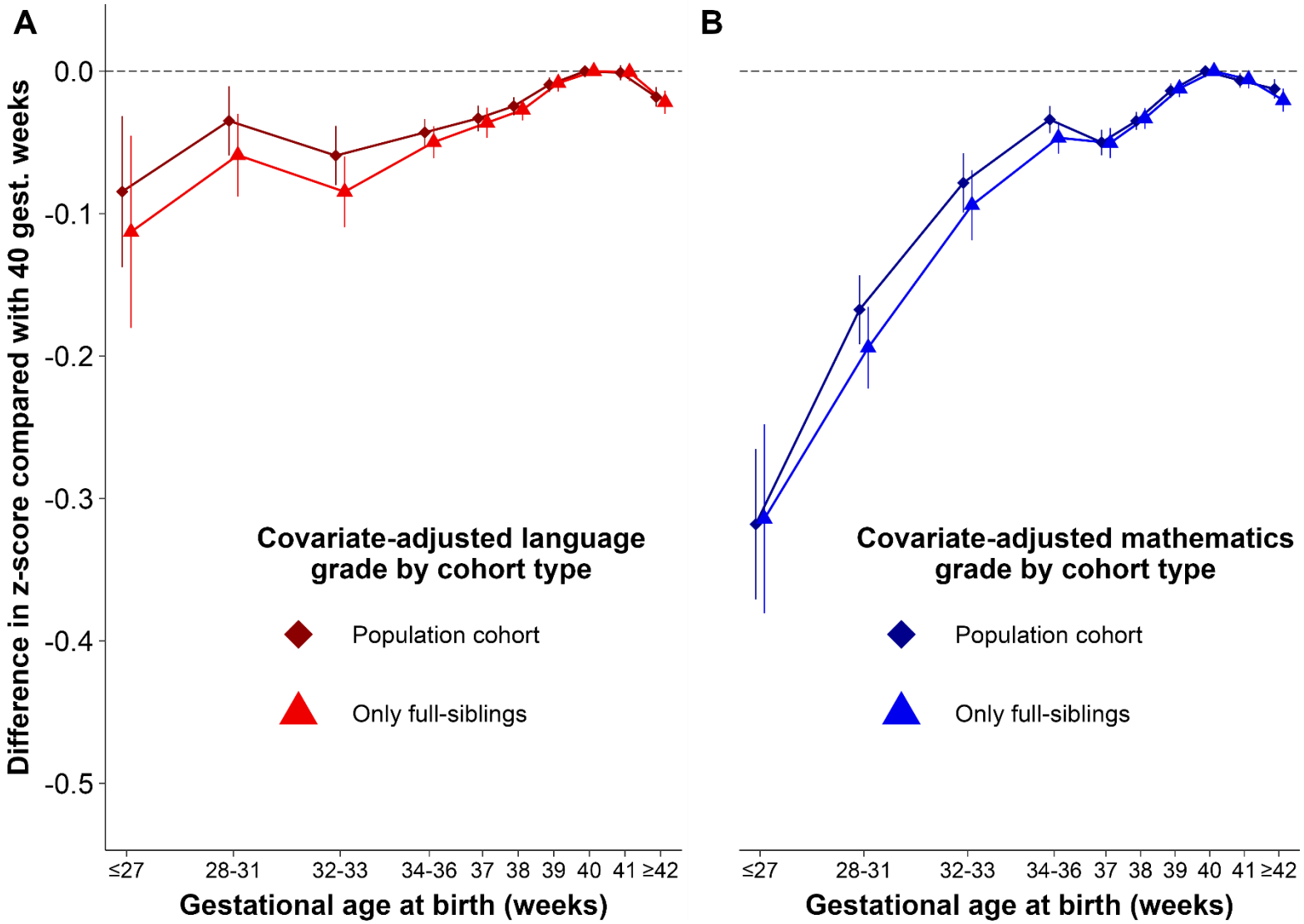

Figure S12. Differences by imputation method. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with children not taking exam not included, or imputed with quantile regression, 5% lowest percentile, 1% lowest percentile, or minimum z-score.

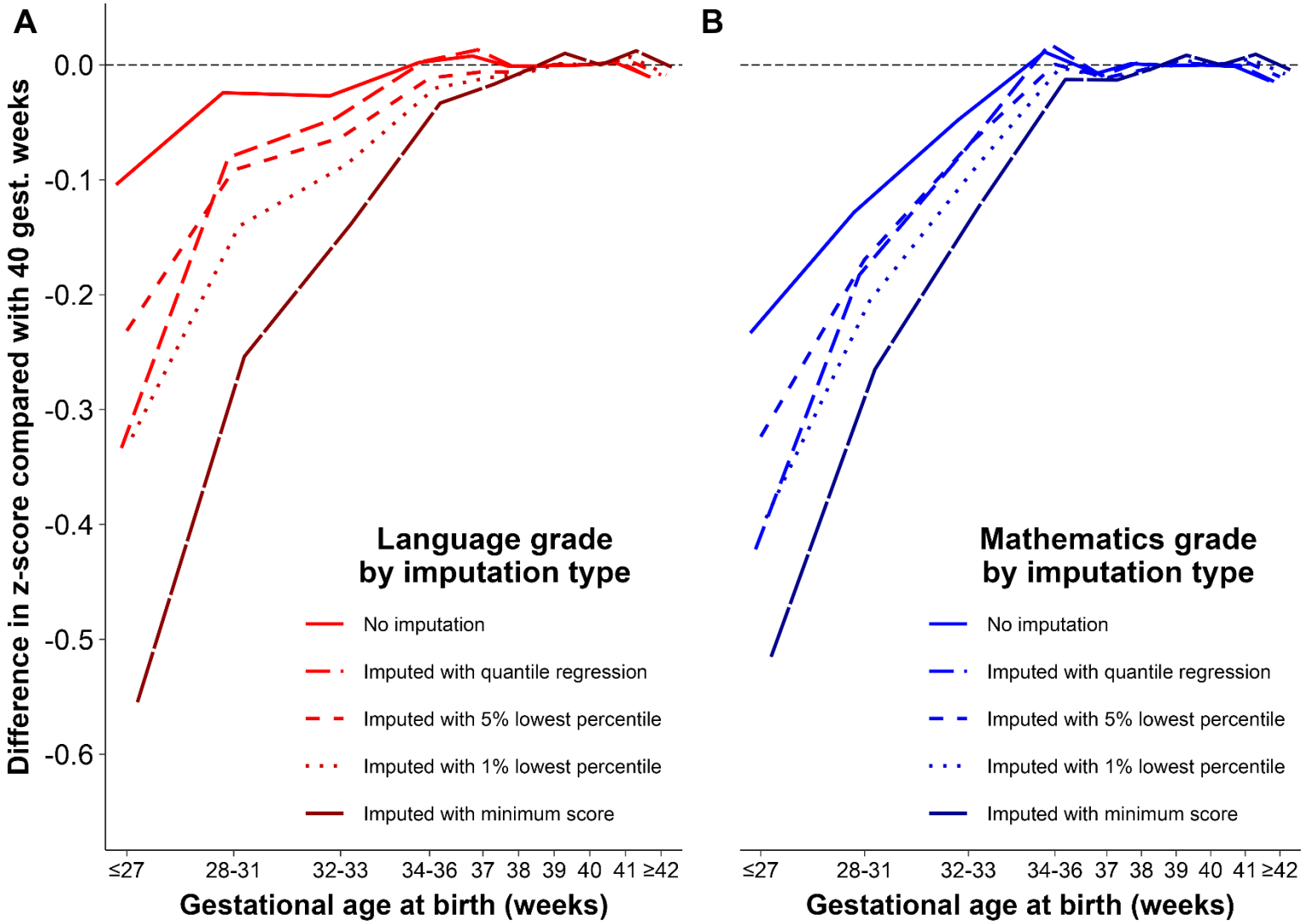

Figure S13. Differences by covariate adjustment type. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, and number of siblings, in models adjusted with clustering of covariates at the family-level using generalized estimating equations (GEE), models adjusted for covariates not using GEE clustering and models adjusting using both covariates and shared family-factors, respectively.

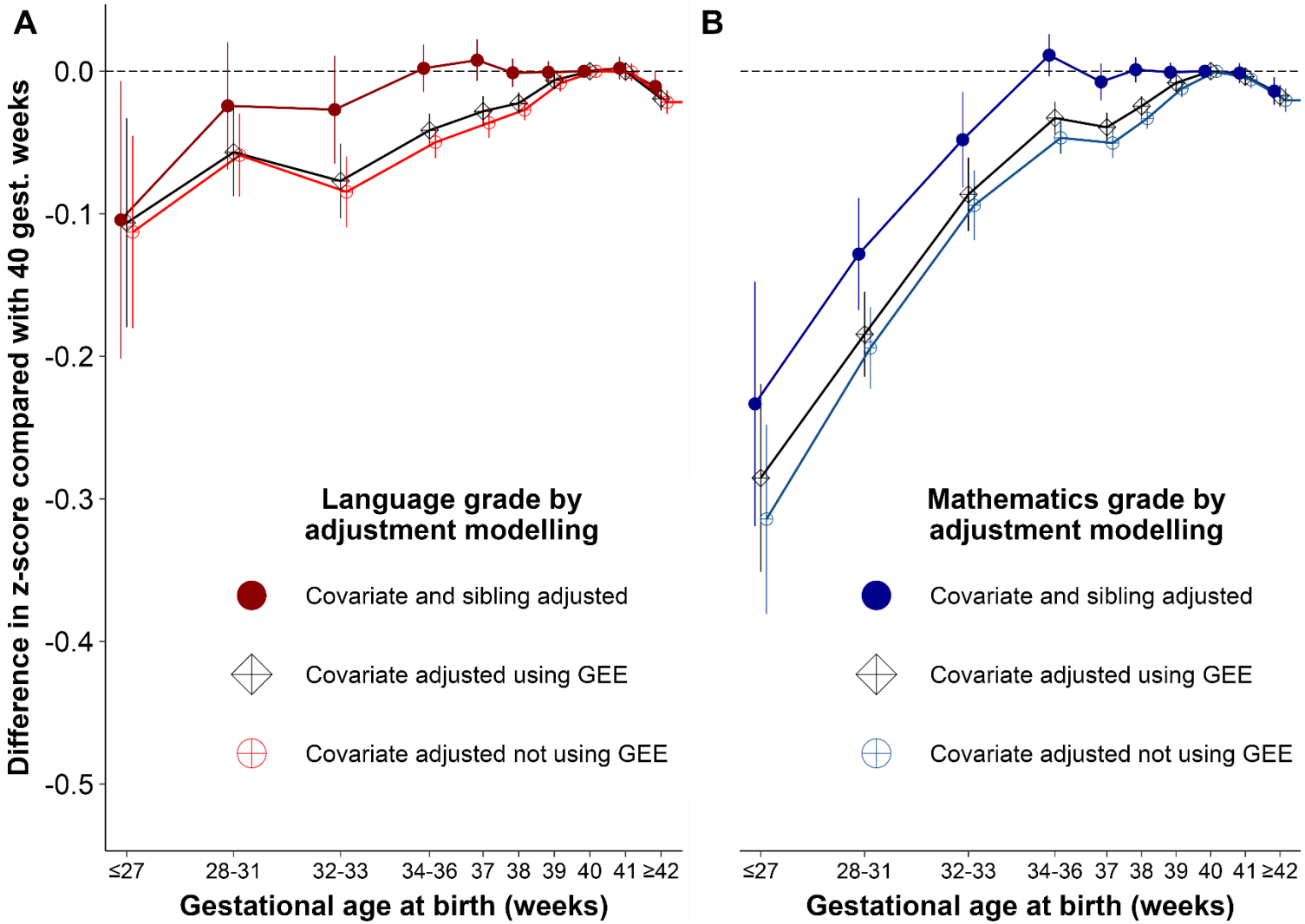

Figure S14. Differences by inclusion of children who died prior to the exam. Difference in standardized grade (z-score) in language (A) and mathematics (B) by gestational age at birth compared with 40 gestational weeks adjusted for sex, relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, including children not taking, or dying before, the exam with 1% percentile lowest z-score imputed.

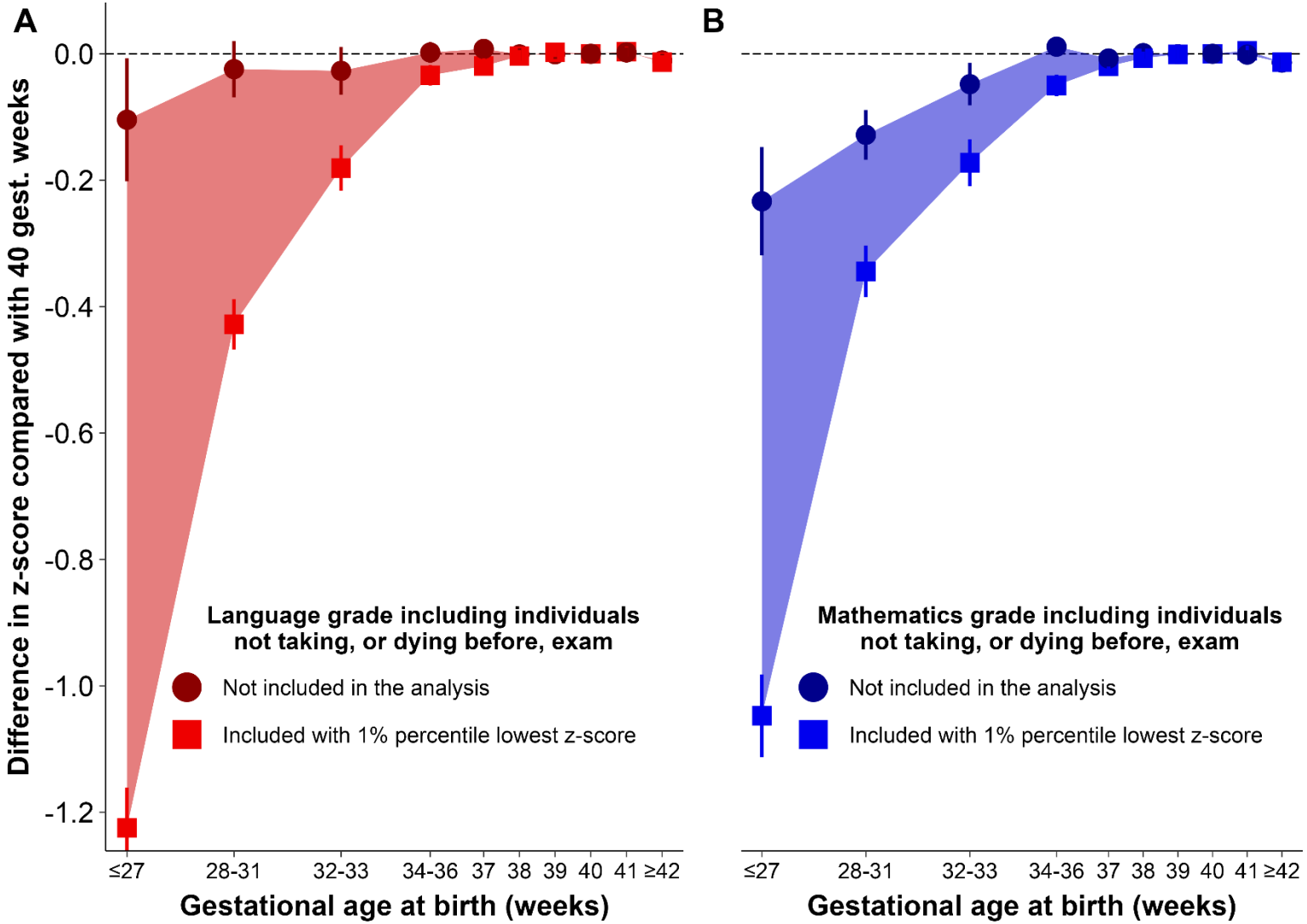

Figure S15. Differences by degree of adjustment and imputation of intelligence test estimate. Difference in standardized test score (z-score) in conscription intelligence test by gestational age at birth compared with 40 gestational weeks, with degree of adjustment (Panel A) and inclusion of children not taking exam (Panel B). 'Covariate adjusted only' specifies adjustment for relative birthweight, malformations, parental age, parental educational level, and number of older siblings, while 'Covariate and sibling adjusted' additionally includes adjustment for shared family-factors. For children not participating in conscription, we used their mathematics score if available (for children with both scores the correlation was 0.72), and if not available the 1% percentile lowest mathematics z-score. All analyses in panel B are covariate and sibling adjusted. Estimates are presented by difference in z-score (left y-axis) and difference in IQ (right y-axis).

(Figure S10 shown on next page)

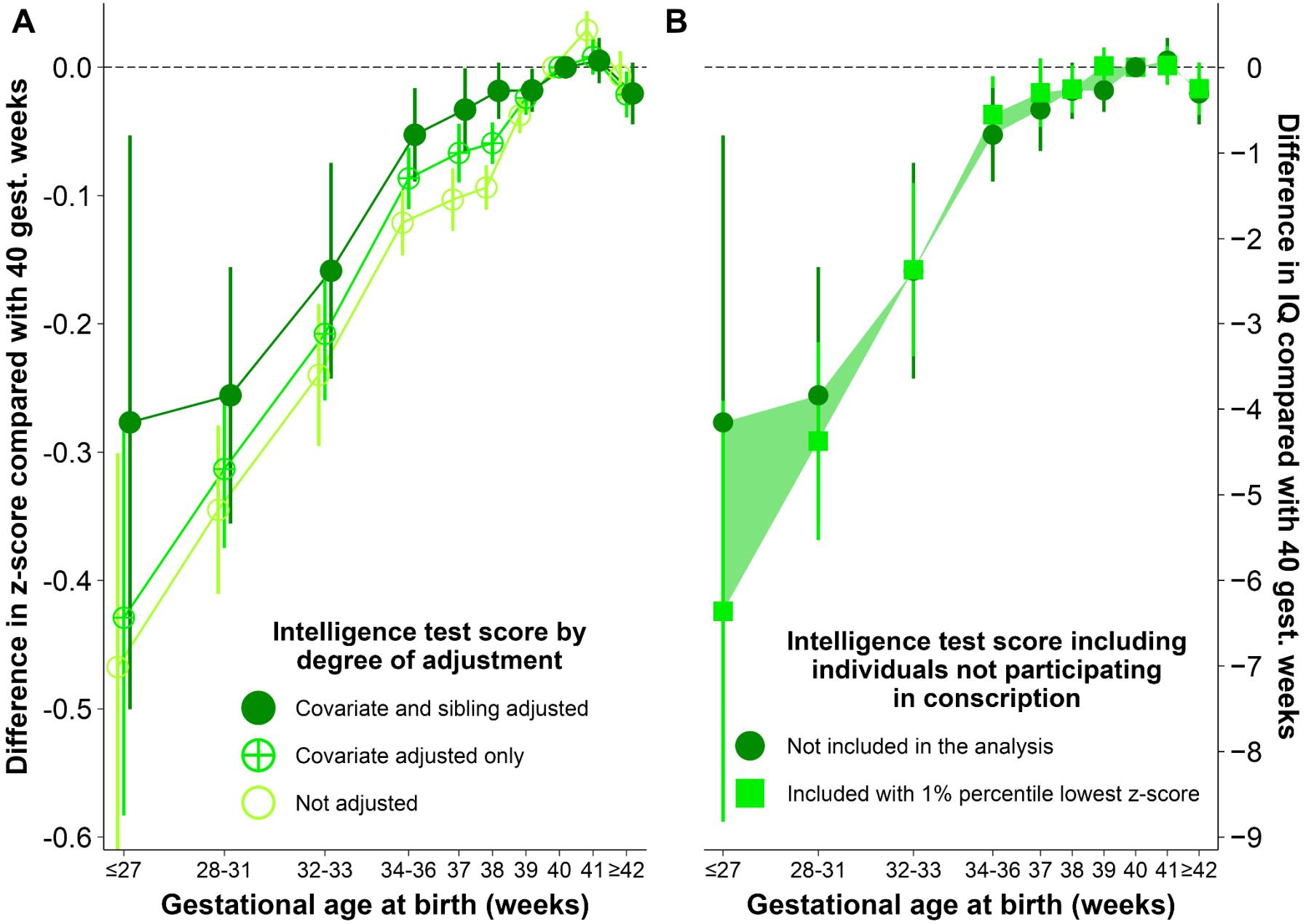
A
B
Difference in z-score compared with 40 gest. weeks
Difference in IQ compared with 40 gest. weeks
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
≤27
28-31
32-33
34-36
37
38
39
40
41
≥42
Gestational age at birth (weeks)
Intelligence test score by degree of adjustment
Covariate and sibling adjusted
Covariate adjusted only
Not adjusted
Intelligence test score including individuals not participating in conscription
Not included in the analysis
Included with 1% percentile lowest z-score

Figure S16. Differences among post-term births in the full-brother cohort. Difference in standardized test score (z-score) in conscription intelligence test by gestational age at birth compared with 40 gestational weeks adjusted for relative birthweight, malformations, parental age, parental educational level, number of siblings, and shared family-factors, with differentiation of post-term births into separate exposure categories.