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Gestational weight change and childhood body composition trajectories from pregnancy to early adolescence

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Abstract

Objective: We developed a mother-child dyad trajectories model of weight and body composition spanning from conception to adolescence to understand how early life-exposures shape childhood body composition.

Methods: African American (49.3%) and Dominican (50.7%) pregnant mothers (n=337) were enrolled during pregnancy, and their children (47.5% female) were followed from ages 5 to 14. Gestational weight gain (GWG) was abstracted from medical records. Child weight, height, percentage body fat (%fat) and waist circumference were measured. GWG and child body composition trajectories were jointly modeled with a flexible latent class model with a class membership component that included prepregnancy BMI.

Results: Four prenatal and child body composition trajectory patterns were identified, and sex-specific patterns were observed for joint GWG-postnatal body composition trajectories with more distinct patterns among girls but not boys. Girls of mothers with high GWG across gestation had the highest BMIZ, waist circumference and %fat trajectories from ages 5 to 14; however, boys in this high GWG group did not show similar growth patterns.

Conclusions: Jointly modeled prenatal weight and child body composition trajectories showed sex-specific patterns. Growth patterns from childhood though early adolescence appear to be more profoundly affected by higher GWG patterns in females, suggesting sex-differences in developmental programming.

Keywords

Obesity; pregnancy; body composition; growth; methods; trajectories

Introduction

Obesity is widespread and disproportionately affects certain racial/ethnic groups. The prevalence obesity in the United States and globally has markedly increased over the past several decades among children, adolescents and adults.(1, 2) In the United States, prevalence of obesity is 14% among preschool aged children, 18% among school aged children (6-11 years), 21% among adolescents (12-19 years), and 40% among adults.(2, 3) Obesity prevalence is higher among Non-Hispanic Black children (22%) and adults (47%), and Hispanic children (26%) and adults (47%), when compared to Non-Hispanic White children (14%) and adults (38%).(2)

Pregnancy is a critical period for shaping later health and obesity risk.(4) Prepregnancy BMI and gestational weight gain (GWG) are potentially modifiable indicators of nutritional availability to support the growing fetus that are routinely assessed as part of prenatal care.(5, 6) The Institute of Medicine (IOM) GWG guidelines aim to optimize maternal and child health outcomes.(7) However, in the United States over half of pregnant women gain in excess of these guidelines,(8) and women with overweight or obesity are more likely to gain above recommendations. While non-Hispanic black and Hispanic women are more likely to gain below the guidelines compared to non-Hispanic White women,(9, 10) over 40% of non-Hispanic black and Hispanic women still gain above the guidelines.(10, 11, 12) Substantial literature has shown that excessive total GWG is associated with greater neonatal adiposity,(13, 14, 15, 16, 17, 18, 19). Longer-term effects of excessive gestational weight gain have been observed for childhood overweight, obesity, and body composition, (12, 16, 20, 21, 22, 23), as well as adverse cardiometabolic indicator profiles.(21, 23, 24) Associations have been observed sometimes only in certain prepregnancy BMI subgroups and have been more commonly observed among women with prepregnancy normal weight and overweight BMI values. How the pattern of GWG relates to these health outcomes is less clear.

The IOM report recommended researchers examine how the pattern of GWG, rather than total GWG, relates to maternal and child health outcomes beyond the neonatal period, such as longer-term growth and development.(7) The GWG pattern—or trajectory showing the timing and magnitude of GWG across pregnancy—reflects different body compartments. Earlier weight changes reflect shifts in maternal components (adipose tissue, blood, extracellular fluid, uterus and breast) while weight changes later in pregnancy reflect contributions from maternal components, the supporting components (placenta, amniotic fluid) and increasingly the fetus as gestation progresses (Figure 1).(25) The primary component of GWG that is likely modifiable is the adipose tissue, which contributes a larger proportion to the weight gained in earlier pregnancy compared to later gestation.(25, 26) In previous epidemiologic research, GWG patterns have been modeled using latent class analysis,(27, 28) or trimester(26, 29, 30) or gestational age specific periods (i.e., early vs.

late pregnancy)(13, 31, 32) in relation to child health outcomes. Use of trimester or early vs. late gestation also does not reflect the entire pregnancy, but modeling the overall GWG pattern with methods like latent class analysis leverage the entire shape of the weight change across gestation. Patterns with high GWG in early pregnancy, and sometimes also mid-pregnancy, appear to be positively associated with offspring size(27) and adiposity,(13, 24, 31, 33), while patterns with higher early pregnancy weight gain(34, 35) or in other reports, higher mid-pregnancy weight gain(24) are associated with more adverse cardiometabolic profiles. These previous studies have examined associations between GWG patterns with child growth and body composition at one time point in childhood, rather than examining the pattern between GWG with growth and body composition trajectories across childhood, and no previous work has examined sex-specific associations.

To better understand how the patterns of gestational weight changes over time are linked to childhood body composition and growth pattern, we developed a mother-child dyad weight and body composition trajectories model from conception to child age 14. This will allow us to examine how the pattern of maternal GWG relates to child adiposity and metabolic health, and to evaluate the prenatal biological underpinnings of growth and body composition development. A joint mother-child trajectories model allows the child outcomes to inform maternal GWG classification, and to obtain a more nuanced understanding of how the prenatal environment shapes subsequent growth. We hypothesized that weight trajectories characterized by high gain across pregnancy, as well as trajectories with higher rates of weight gain in the second and third trimester, would linked to more obesogenic body composition trajectories and adverse cardiometabolic risk indicator profiles in childhood.

Methods

Data from the Columbia Center for Children's Environmental Health (CCCEH) Mothers and Newborns Study, a prospective birth cohort based in Northern Manhattan and the South Bronx followed since 1998, has been previously described.(12) Dominican and African American mothers were enrolled during the third trimester from prenatal care clinics at New York Presbyterian Medical Center and Harlem Hospital. Eligibility criteria included first prenatal visit <20 weeks, age 18-35 years, and no self-reported diabetes, hypertension, HIV, drug use, or smoking during pregnancy.

An initial visit was conducted in the third trimester and included a researcher administered interview that assessed marital status, parity, maternal education, age and self-reported prepregnancy weight and maternal height. After delivery, medical records were abstracted to ascertain prenatal medical history, including weight measurements from prenatal and gestational age at delivery. Breastfeeding status was obtained by self-report at follow-up visits during infancy at 3, 6, 9 and 12 months, which was used to derive breastfeeding duration in weeks up to 12 months. Self-report of maternal height was obtained during pregnancy, and height was measured at postnatal visits. Measured height was used if available; data cleaning for height has been described in detail.(12)

Up to 7 child height and weight measurements were obtained at standard study visit ages 5, 7, 9, and 11, and other project visits at age ranges of 8.5-12 years, 9.2-14 years, and

11.3-14.5 years.(36) Weight was measured to the nearest 0.1 kg with a Detecto Cardinal 750 digital scale at age 5, and thereafter was measured with a Tanita scale (BC-418). Height was measured with a wall mounted SECA stadiometer. At study visits at ages 7, 9, and 11, bio-impedance analysis (BIA) estimates of percentage body fat were collected using the Tanita BC-418 Segmental Body Composition Analyzer (Arlington Heights, IL) with the participants wearing light clothing, without shoes or socks. The follow-up visits often involved the collection of urine samples which typically occurred at the beginning of the data collection protocol. However, especially at the younger ages, sometimes the participants were unable to urinate prior to the BIA measurement. Recent work in adults shows that BIA measures are not sensitive to whether or not the participant has urinated before the BIA measurement.(37) Waist circumference was measured with a non-stretchable tape measure at child age 7, 9, 11 and the 8-12.5 year visit. Fasting blood samples were collected in the participants' homes by the study phlebotomist approximately 2 weeks prior to the 8.5-12 year appointment. After collection, samples were transferred on ice to the Biomarkers Core Laboratory at the Irving Institute at Columbia University. Biomarker assays included insulin with the Immulite 1000 (Siemens Healthcare Diagnostics), and glucose, triglycerides, HDL cholesterol and LDL cholesterol with the Cobas Integra 400 Plus (Roche Diagnostics).

This study was approved by the Institutional Review Board at Columbia University. Written informed consent was obtained from all participating mothers prior to child age 7, and assent was obtained from the children after age 7.

Data analyses were conducted in R. To be included in the analysis, four prenatal weight measurements and at least one child size measurement were needed. Preterm infants (n=11) were excluded from analyses due to potential impact of preterm birth on long-term adiposity (i.e., less time to accrue adipose tissue in utero).

A latent class model was used to jointly fit prenatal weight and sex-specific child body composition trajectories for percentage body fat, waist circumference and BMI Z-score. The probability of belonging to each latent class in the joint model was estimated using a multinomial logit regression with pre-pregnancy BMI as the only predictor. Prenatal weight changes were modeled using flexible low-rank thin-plate splines with five knots at 0, 10, 20, 30, and 40 weeks and random individual slopes. Child size was modeled with a quadratic polynomial (in age) and a random intercept. Within each latent class, weight change trajectories and each child size outcome were assumed to be independent; the error variances were allowed to vary across classes. Models with three, four, and five latent classes of prenatal-postnatal sex-specific body composition trajectories were fit using the expectation–maximization algorithm. Bayesian Information Criterion (BIC) along with sample size in each latent class group was used to guide the choice of the number of latent classes. The four-class model was selected because it had a lower BIC than the three-class model (4-class BIC = 38038.19 vs. 3-class BIC = 41543.8); although the five-class model had an even lower BIC (5-class BIC = 37776.18), this model included one class with only 7.8% of participants. The standard errors of the estimated parameters for the trajectories were calculated by assuming all the other parameters were known.

For each mother-child dyad, latent class membership was estimated using the posterior probability of class membership, with partial assignment allowed (i.e., participants could be 75% in one class and 25% in another), and sample weights for partial assignments were used in all analyses. After fitting the joint model, descriptive maternal and child characteristics were estimated for each GWG-child body composition class and also for the entire sample. Weighted-least squares was used to compare continuous mother-and child characteristics.

To examine how prenatal-postnatal trajectories related to child cardiometabolic indicators, we separately conducted model-based cluster analysis with the five child cardiometabolic outcomes (HDL and LDL cholesterol, Triglycerides, homeostatic measure of insulin resistance (HOMA-IR), and fasting glucose) using the R package *mclust*. Each of the cardiometabolic indicators was centered and scaled. Seven participants were excluded from this analysis due to extreme outlier values for HOMA-IR and LDL. The best model parameterization and number of clusters for the cardiometabolic outcomes were selected based on BIC. The four-cluster ellipsoidal model with varying volume, shape, and orientation was selected for the cardiometabolic outcome model-based clustering because it had the lowest BIC. In addition to the model-based cluster analysis, after fitting the joint model, each cardiometabolic outcome was modeled using weighted least squares for each trajectory class group, adjusting for age, sex, and gestational age at delivery. An expanded methods section is available in the online supplemental materials.

Results

Of the 727 dyads originally enrolled in the CCCEH study, prenatal weight and body composition trajectories were estimated for 337mother-child dyads (Figure 1). Many characteristics, including prepregnancy BMI and total GWG were similar between those who were included and not included in the analysis; however, those included had a lower prevalence of marriage/cohabitating, a lower mean gestational age at delivery, and a higher proportion were African American (Table S1). During pregnancy, almost 80% of women enrolled in the study were not married or cohabitating, ~73% had less than high school education, and 74% had more than one previous pregnancy (Table 1). A majority of women had a normal weight prepregnancy BMI (54.0%), with a smaller proportion with prepregnancy overweight (23.1%) or obesity (22.8%).

The joint latent class model identified four prenatal-postnatal trajectory classes—the model has a prenatal weight component that is shown in Figure 2 and a child body composition component shown in Figure 3 and Figure 4, as well as a membership class component that was a function of prepregnancy BMI. Figure 2 shows the four estimated pregnancy weight gain trajectory classes from the joint model with child body composition. Table 2 provides the estimated rates of GWG by trimester for each class to allow for contextualization of the weight change patterns over time. In most classes, some weight gain was observed in the first trimester. **LossModerateRapid** showed some weight loss followed by higher weight gain rates in the second and third trimesters, while **SlowModerateModerate** showed low gain in the first trimester then rates above 1 lb/wk in the 2nd and 3rd trimesters. **AlwaysSlow** showed moderate gain in the 1st trimester then more moderate rates in the 2nd and 3rd trimesters, whereas **RapidSlowModerate** showed very high gain in the 1st trimester then

lower velocities in the 2nd and 3rd trimesters. The estimated total GWG for the fitted model was highest for **RapidSlowModerate** and lowest for **AlwaysSlow** (Table 2). Participants in **RapidSlowModerate** had the highest mean prepregnacy BMI values and almost two-thirds of the women in this group had prepregnacy overweight or obesity, whereas women in **SlowModerateModerate** had the lowest mean prepregnacy BMI values and a majority of women with prepregnancy normal weight.

Figure 3 shows the four child body composition trajectories from the joint model stratified by sex, Table S2 shows estimates for each outcome, and Figure 4 shows the same trajectory curves for boys and girls stratified by class. For many of the prenatal-postnatal classes, the boys and the girls' growth trajectory pattern confidence intervals were overlapping, while in a few groups, divergent growth patterns (i.e., not overlapping confidence intervals providing evidence of differences at these portions of the growth curves) were observed for boys and girls (Table S2 & Figure 4). Specifically, the growth patterns are the most divergent between the boys and girls for **RapidSlowModerate** (i.e., most confidence interval separation) for both percentage body fat and waist circumference with increasing age, with less striking sex-specific differences in trajectories for **AlwaysSlow** for waist circumference and **SlowModerateModerate** for BMIZ (Figure 4).

Strikingly, the GWG and child body composition trajectory patterns show greater differences by the GWG classes for girls' body composition and growth outcomes compared to boys' (Figure 3). In boys, the body composition trajectory patterns for each class have much more overlap of confidence intervals for each of the childhood body composition measures compared to the girls, particularly for the measures obtained in earlier childhood for boys before age 10 (Figure 3). The most notable difference by sex was observed in the **RapidSlowModerate** group. Among girls, the **RapidSlowModerate** trajectory groups showed higher estimates for BMIZ, waist circumference, and percentage body fat, and with increases in these values over time as the girls grew. Whereas for boys, exposure to **RapidSlowModerate** is associated with the second highest estimated BMIZ score trajectories after age 10, while waist circumference is lower than the other groups after this age and decreases with increasing age. Girls exposed to **LossModerateRapid** had the lowest estimated trajectories for BMIZ, waist circumference and percentage body fat with greater differences in adolescence compared to the other GWG class groups, while in boys, body composition trajectories of those in the **LossModerateRapid** group were not markedly different from the others. Boys in **SlowModerateModerate** showed the highest estimated BMIZ score and body fat percentage in early adolescence, but their waist circumference was not markedly different from **LossModerateRapid** and **AlwaysSlow**. **AlwaysSlow** and **SlowModerateModerate** showed mostly overlapping confidence intervals for girls' body fat percentage, waist circumference, and BMIZ scores—with separation in the curves for waist circumference and BMIZ in early adolescence. While for boys, **AlwaysSlow** showed lower trajectories for child BMIZ and percentage fat, but the largest estimated waist circumference in early adolescence.

In order to further understand how GWG trajectories and child body composition patterns related to child cardiometabolic health, an additional analysis was conducted to determine whether membership in a GWG-child body composition trajectory group was

associated with cardiometabolic risk patterns in mid-childhood. Table S3 shows adjusted and unadjusted values for HOMA-IR, triglycerides, HDL and LDL cholesterol and fasting glucose by the prenatal-postnatal trajectory class groups. Values are strikingly similar across classes for all cardiometabolic outcomes. Cluster analysis of child metabolic scores revealed four risk patterns (Figure S1), including the higher risk-pattern (HighInsulin-Triglycerides & low HDL), Healthiest Cardiometabolic Pattern (LowInsulinGlucTriglycerides), Healthy Pattern (HighHDL - Moderately-Low HDL HighGlucose). However, the proportion of membership in each cardiometabolic risk pattern group did not vary by GWG trajectory class membership and was similar across the classes (Table S4).

Discussion

In this cohort of Dominican and African American mother-child dyads, we developed a joint model of prenatal weight and child body composition trajectories from conception to child age 14. This novel modeling approach allows for examining prenatal-postnatal patterns and can be applied to understand how the intrauterine environment shapes later health. Our model identified four trajectory patterns of GWG and body composition change from the prenatal period through childhood and early adolescence with differential patterns by child sex.

Prenatal weight change patterns characterized by high GWG across gestation (**RapidSlowModerate**) showed accelerated increases in waist circumference and body fat percentage in girls as they grew older, while for boys the change in waist circumference and body fat percentage was flatter with increasing age. The most notable sex-differences for other GWG class groups were seen for **AlwaysSlow** (moderate first trimester GWG) and %fat, and then for **SlowModerateModerate**(low gain first trimester and steady gain thereafter) and BMIZ. For the other GWG pattern groups, the boys and the girls' predicted curves showed overlapping confidence intervals or mostly parallel curves, which suggests growth programming in girls may be more vulnerable to high weight gain exposure in first trimester or across pregnancy, as girls exposed to these high weight change patterns showed more suboptimal body composition change patterns across childhood compared to boys.

The adverse growth patterns observed among girls whose mothers had high GWG patterns that were not observed among boys suggests that growth programming may be affected by certain weight gain patterns in a sex-specific manner. It is well recognized that males and females grow differently starting in utero and continuing thereafter,(38) and, additionally, that males and females respond differentially to prenatal nutritional supplementation and environmental (stress) exposures with more sensitivity to these exposures occurring among males.(39) Our findings suggest that the timing of the higher weight change exposure may differentially play a role in girls' growth pattern trajectories across childhood and early adolescence, which may reflect differences in programming of growth and adiposity, or pubertal differences. Previous evidence in both humans and animals has shown sex dimorphic phenotypes of adiposity by prenatal exposure to people with obesity and prenatal diabetes/sugar exposure.(40) For prenatal exposure to obesity, some studies have only found adverse effects for females and others only for males, while for prenatal diabetes/high sugar diet exposure, females seem to be more susceptible to increased adiposity, compared to

males.(40) Several biological mechanisms—including epigenetic, metabolic hormones and placenta related pathways—are believed to contribute to these sex-differences in adiposity programming.(40) Additionally, human and rodent studies have suggested females are particularly vulnerable to high prenatal glucose exposure, even at levels below diagnostic cutpoints for gestational diabetes.(40, 41, 42, 43) High GWG patterns, especially those similar to our **RapidSlowModerate** group, could be indicative of elevated glucose levels below this clinical threshold. Our findings could also reflect sex-differences in other post-natal factors that may influence growth and development, such as eating behaviors and physical activity.

Our findings are consistent with prior evidence showing that patterns with high GWG in early pregnancy or mid-pregnancy are associated with larger body size, BMI, and body composition in neonates and children.(27, 28, 29, 31, 32) Prior research that examined GWG patterns with more long-term body composition outcomes has focused on early and mid-childhood. In ProjectViva, a Boston based cohort, faster first trimester GWG rates were associated with higher BMIZ and height-adjusted fat mass at child age 8.(33) In a clinical trial focused on fatty acids during pregnancy and lactation, greater weight gain in mid-pregnancy was associated with greater abdominal adipose depots (assessed with MRI) at child age 5.(32) Most of these other studies did not test for effect modification of the relationship between GWG patterns and child body composition by child sex, but did account for sex as a covariate. These studies focused on measures obtained in early and mid-childhood (i.e., prior to puberty in most participants) and did not examine growth trajectories; thus, they support but are not directly comparable to our findings.

While joint prenatal weight-child body composition trajectories have not been previously reported, two studies have reported relationships between total pregnancy weight gain and offspring growth patterns during and beyond childhood. In the Jerusalem Perinatal Study, higher prepregnancy BMI and total pregnancy weight gain were each associated with greater gains in BMI in offspring from child age 17 to age 32 years.(44) In this cohort, there was no evidence of effect modification by sex with either GWG or maternal BMI with sex included as a covariate in analyses.(44) In the Copenhagen Perinatal Cohort, total GWG was positively associated with BMIZ-scores at child ages 1 to 14 years, and was also associated with risk of obesity and overweight at adult age 42.(45) Similar to the Jerusalem Perinatal Study, sex-specific interactions between GWG and child BMI were not observed. Our study examined GWG trajectories with multiple measures across pregnancy rather than total GWG, and we also reported child WHO BMI Z-scores, which are not directly comparable to the BMI values in the Jerusalem and Copenhagen studies. Beyond BMIZ, we also reported several body composition outcomes, including waist circumference as an indicator of abdominal adiposity, and overall percentage body fat, that reflect both regional and overall adiposity.

We did not observe associations between our prenatal-postnatal trajectories with our four distinct groups of child metabolic indicators, despite other studies showing relationships between maternal weight gain patterns and child cardiometabolic health. The ALSPAC study in England evaluated whether early, mid, and late pregnancy weight gain was associated with cardiometabolic indicators at age 9, and found that weight gain in mid-pregnancy

(>14-36 wk) was associated with higher triglyceride values and lower HDL values.(24) In Generation R, based in the Netherlands, and RAINE, based in Western Australia, early pregnancy weight gain was associated with adverse cardiometabolic risk factor profiles at child age 6,(34) and in adolescence.(35) Our modeling approach with the inclusion of postnatal child size may have attenuated associations and may have limited our ability to detect differences, and we had few children with adverse cardiometabolic values (data not shown). Additionally, our sample of predominately low-income African American and Dominican mother-child dyads may not be comparable to these other studies due to health disparities.

This mother-child dyad joint model offers a new approach to characterizing how body composition develops over time by allowing postnatal body composition changes to drive groupings of prenatal weight to understand the drivers of growth and adiposity development. We developed this mother-child dyad modeling approach to gain more insight into how prenatal and postnatal body composition are interrelated. Prior research in this area is limited by not allowing postnatal factors to guide groupings of prenatal exposures, thereby limiting our ability to detect prenatal factors associated with better or worse outcomes in childhood. The latent classes identified from the joint model are determined more by the gestational weights than the body composition trajectories, given there are more datapoints for the former; however, the child values (up to 7 per child) still contribute to how the prenatal weight trajectories group together, albeit less so than the prenatal weights.

There are several limitations of this work. Our sample size of 337 and 11% of children with one of each body composition measure may have limited our ability to detect more than 4 groups. Moreover, some characteristics were different between those included in analysis versus those enrolled in the study at baseline, including race-ethnicity. More sensitive body composition measures, and pregnancy body composition and body water were not assessed, and GWG was abstracted from medical charts. We have included the cardiometabolic indicator results to illustrate how this method can be used to examine the associations between prenatal-postnatal growth and body composition patterns with later health; however, child body composition may be a mediator of this relationship. Due to limited data and the complexity of the model, we were unable to account for prenatal and postnatal factors that may be associated with GWG and more adverse growth patterns, such as prenatal and postnatal diet, physical activity and household behaviors, as these were not measured. Unfortunately, data are not available on pubertal timing at each of the study follow-up visits so we were unable to account for pubertal staging in our analyses, and differences in puberty between our study boys and girls could have affected our findings.

Conclusion

Prenatal weight changes and child body composition trajectory classes from ages 5 to 14 can be jointly modeled using a complex latent class model. Higher overall GWG patterns and patterns with high GWG in the first trimester showed larger child body composition values and more suboptimal growth and body composition patterns from ages 5 to 14. These growth patterns from childhood through early adolescence in girls appear to be more sensitive to higher prenatal GWG patterns, suggesting sex-differences in developmental

programming. Our work shows that examining GWG patterns concurrently with child body composition trajectories offers insights about the developmental origins of obesity and sex differences in prenatal exposure to high GWG in different periods of gestation. Future research should examine sex-specific associations and evaluate how prenatal-postnatal curves relate to later health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclosure:

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Study Importance Questions

What is already known about this subject?

The pattern of gestational weight gain is associated with childhood body size and composition; however, it is unclear whether the pattern of gestational weight gain is associated with growth and body composition trajectories from childhood into early-adolescence.

What are the new findings in your manuscript?

In this observational study of 337 mother-child dyads, four distinct pregnancy weight change and sex-specific child body composition trajectory groups were identified. Pregnancy weight change patterns with high pregnancy weight gain showed more obesogenic body composition trajectories from ages 5 to 14 in females, but not males. This study suggests that in utero exposure to high weight change trajectories across pregnancy show sex-specific patterns in child body composition changes.

How might your results change the direction of research or the focus of clinical practice?

Here we propose a new way of examining prenatal to postnatal growth, and have identified sex-specific patterns between pregnancy weight gain and childhood growth that were previously unobserved.

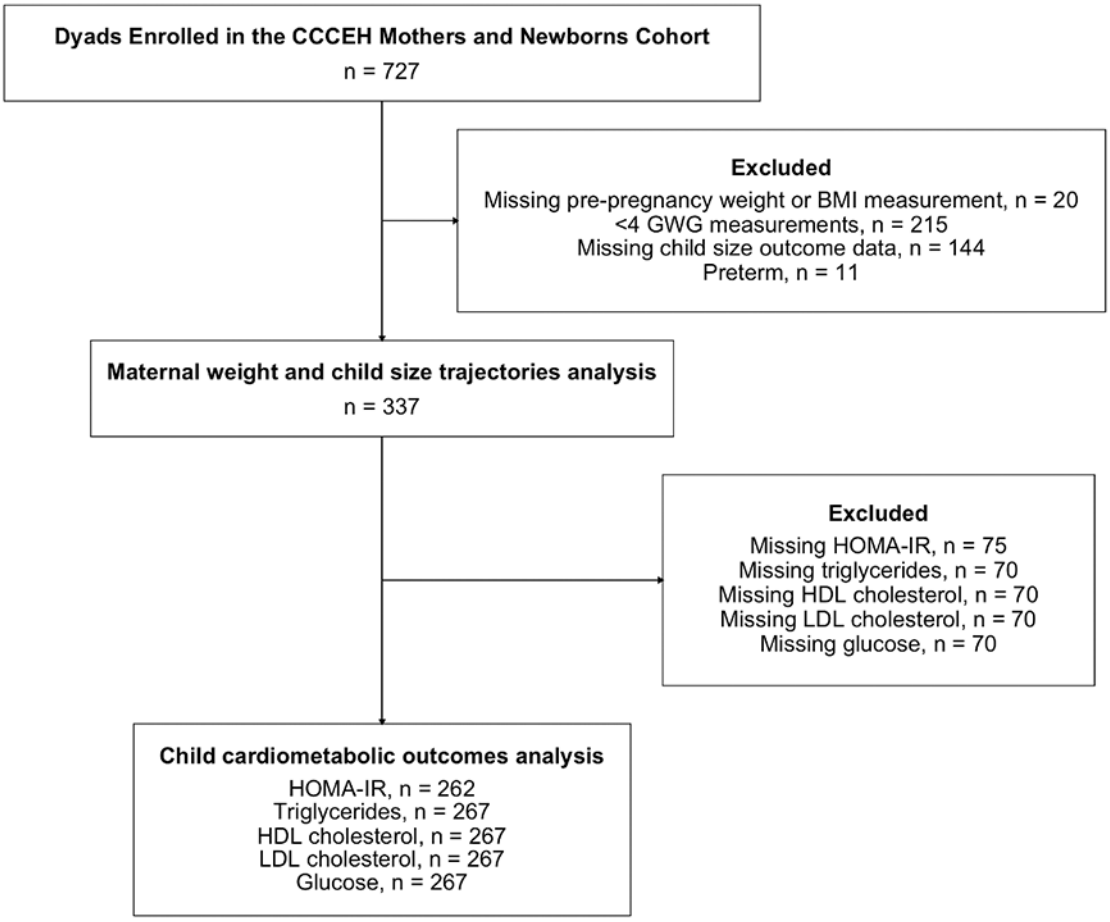

Figure 1.
Participant flow diagram

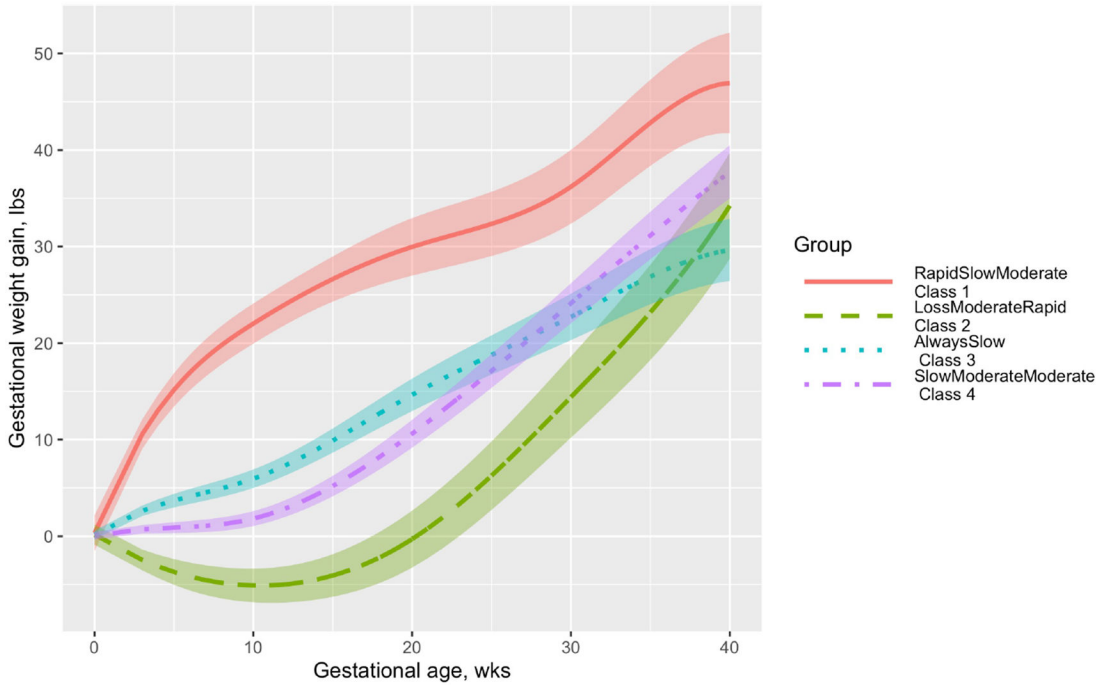

Figure 2.

Gestational weight change trajectory classes estimated from the joint mother-child dyad trajectory model with 95% confidence intervals

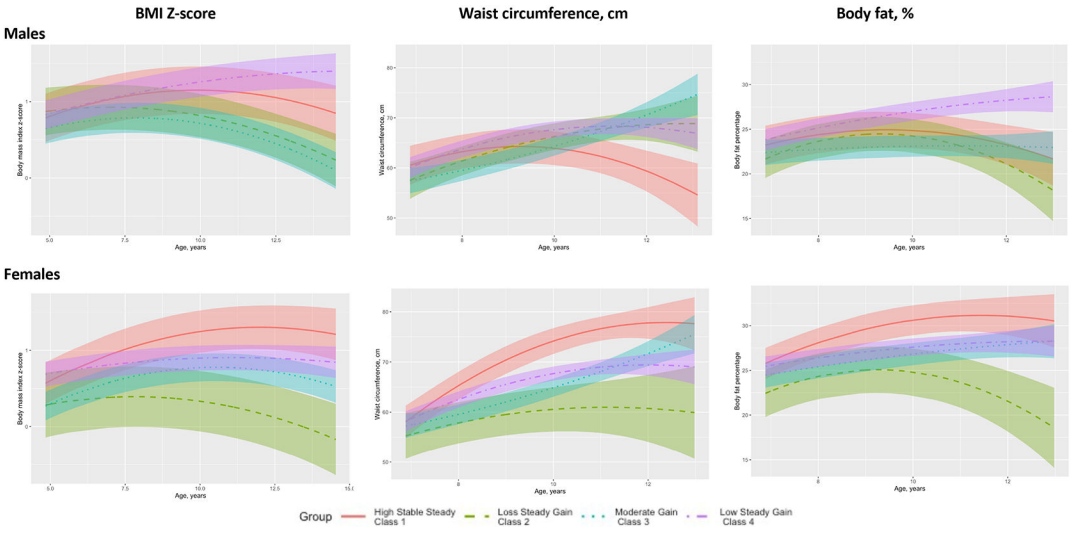

Figure 3.

Child body composition trajectories by prenatal-postnatal class estimated from the joint mother-child dyad trajectory model with 95% confidence intervals

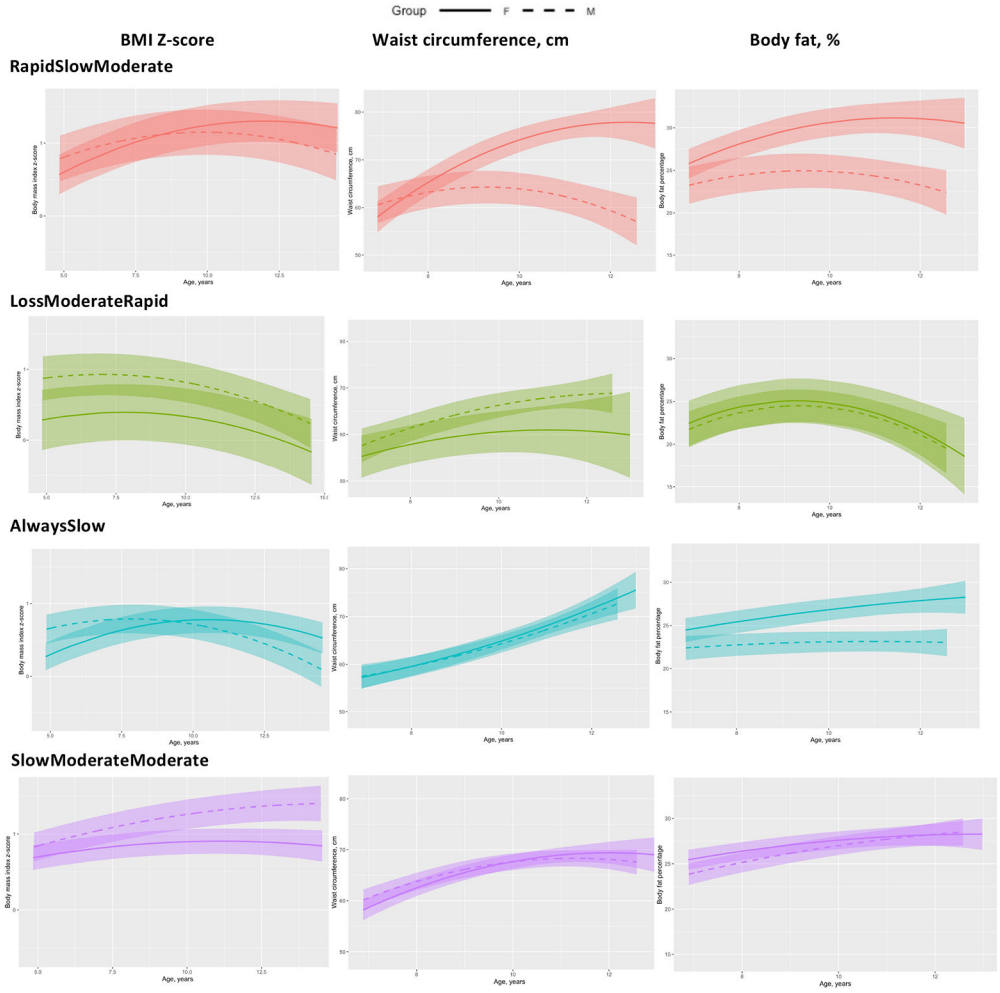

Figure 4.

Child body composition trajectories by child sex from the joint mother-child dyad trajectory model with 95% confidence intervals

Table 1.

Characteristics of mothers and children by prenatal-postnatal trajectory pattern, Columbia Center for Children's Environmental Health Mothers and Newborns Cohort, New York, New York (n=337)

	All	GWG trajectory class			
		RapidSlowModerate Class 1	LossModerateRapid Class 2	AlwaysSlow Class 3	SlowModerateModerate Class 4
Maternal					
Age, y	24.9±0.3	25.4±0.3	24.9±0.3	25.0±0.3	24.7±0.3
Education > high school, %	26.9	25.8	26.9	26.7	27.3
Married or cohabitating, %	21.6	21.1	21.5	21.5	21.5
Parity > 0, %	74.1	77.2	74.0	74.3	73.0
Gestational age at delivery, weeks	39.5±0.1	39.5±0.1	39.5±0.1	39.5±0.1	39.5±0.1
African American, %	49.3	54.8	49.0	49.5	47.4
Dominican, %	50.7	45.2	51.0	50.5	52.6
Breastfeeding duration, weeks	10.4±0.8	10.0±0.7	10.4±0.8	10.4±0.8	10.6±0.8
Child					
Female Sex, %	47.5	46.2	47.4	47.2	48.1
Birthweight, g	3391.5±26.1	3424.6±26.6	3390.1±26.1	3393.1±26.1	3380.3±25.8
Body composition measurement at first childhood follow up visit					
BMIZ at age 5 visit	0.7±0.1	0.8±0.1	0.7±0.1	0.7±0.1	0.6±0.1
Waist Circumference at age 7 visit, cm	58.6±0.4	59.5±0.4	58.6±0.4	58.7±0.4	58.3±0.4
Percentage Body fat at age 7 visit, %	23.9±0.3	24.6±0.3	23.9±0.3	24.0±0.3	23.7±0.3
Fasting cardiometabolic indicators at age 10 visit					
HOMA-IR (n=262)	2.4±0.3	2.7±0.3	2.4±0.3	2.5±0.3	2.3±0.3
Triglycerides (n=267)	76.7±2.7	77.3±2.6	76.7±2.7	76.7±2.7	76.5±2.7
HDL cholesterol (n=267)	51.1±0.8	50.8±0.8	51.1±0.8	51.0±0.8	51.1±0.8
LDL cholesterol (n=267)	86.9±1.7	86.8±1.6	86.8±1.7	86.8±1.7	87.0±1.8
Glucose (n=267)	87.7±0.5	88.1±0.5	87.7±0.5	87.7±0.5	87.5±0.5

Values for each GWG trajectory class are estimated based on participants predicted probability of being in each class. Values shown as Mean±SE by trajectory class correspond to the estimated means based on the weighted least squares models and their corresponding standard errors. Values shown as % correspond to the proportion of participants who have the characteristic in each trajectory class, with each participant contributing her predicted probability of being in the class to the numerator of the proportion if she has the characteristic.

Table 2.

Characteristics of the pregnancy weight gain trajectory class groups (n=337)

	Pregnancy weight gain trajectory class groups			
	RapidSlowModerate Class 1 (n=46)	**LossModerateRapid Class 2 (n=33)**	**AlwaysSlow Class 3 (n=108)**	**SlowModerateModerate Class 4 (n=150)**
Proportion of participants, %	13.8	9.8	32.0	44.4
Prepregnancy BMI, kg/m2	29.5±.04	25.9±0.3	26.2±0.3	24.8±0.3
Prepregnancy BMI category, %				
Normal weight	34.3	54.0	51.7	61.8
Overweight	23.5	23.8	24.1	22.2
Obese	42.3	22.2	24.2	16.0
Height, cm	163.2±0.4	162.8±0.4	162.8±0.4	162.7±0.4
Estimated total GWG, lb	46.9±2.7	34.2±2.8	29.7±1.6	37.7±1.4
Adherence to IOM Guidelines for total GWG[1], %				
Adequate GWG	26.2	27.1	27.0	27.7
Inadequate GWG	16.7	15.8	15.9	16.0
Excessive GWG	57.2	57.0	57.2	56.3
Average weekly weight gain (lb/wk) by trajectory membership and trimester				
1st Trimester	1.92	-0.37	0.63	0.27
2nd Trimester	0.62	1.02	0.87	1.17
3rd Trimester	1.03	1.91	0.72	1.37

[1] IOM guidelines BMI category specific recommendations for total GWG

Values for each GWG trajectory class are estimated based on participants predicted probability of being in each class. Values for prepregnancy BMI and height by trajectory class correspond to the estimated means based on the weighted least squares models and their corresponding standard errors. Values for prepregnancy BMI category and adherence to IOM guidelines for total GWG correspond to the proportion of participants in each category or with each adherence in each trajectory class. Each participant contributes her predicted probability of being in the class to the numerator of the proportion if she is in that category or has that adherence, and the denominator for each class is the n for that class. Values for estimated total GWG correspond to the estimated weight gain at 40 weeks from the LCM for each trajectory class. Values for average weekly weight gain are based on the estimated weight gain at the beginning and end of each trimester from the LCM for each trajectory class.