Preconception nutrition, physical activity, and birth outcomes in adolescent girls

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Abstract

Background—Recommendations for preconception care usually include optimal nutrition and physical activity, but these have not been tested extensively for their relationship with birth outcomes such as low birthweight and preterm birth.

Methods—Data from Waves I, II and IV of the National Longitudinal Study of Adolescent Health (Add Health) contractual dataset were utilized. In Wave I in-home interview, participants were asked to recall their frequency of having five types of food on the previous day, including milk, fruit, vegetables, grains, and sweets. At Wave II, participants reported the previous day's intake of 55 items, and results were categorized into high-calorie sweet, high-calorie non-sweet, and low-calorie food. At Wave I in-home interview, participants were also asked how many times in a week or during the past week they were involved in types of physical activity. At Wave IV, female participants reported pregnancies and birth outcomes. Multivariable linear regression analysis with survey weighting was used to predict birthweight and gestational age.

Results—There were no associations between reported food intake and birth outcomes. Girls who engaged in more episodes of active behavior had higher birthweights ($p < 0.01$), but hours of sedentary behavior was not associated with birthweight. Multivariable analysis also indicated a u-shaped association between BMI and birthweight (p for quadratic term = 0.01).

Conclusion—Adolescents who are more physically active prior to pregnancy have more positive birth outcomes as represented by birthweight.

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Conflict of Interest Statement:

The authors have no conflict of interests to disclose.

Keywords

Adolescents; birthweight; gestational age; preconception nutrition; physical activity

Introduction

Preconception health has been increasingly recognized as a predictor of, and opportunity for improvement of, pregnancy outcomes.¹ Recommendations for preconception care usually include optimal nutrition and physical activity.^{2,3} However, even among women who are actively planning pregnancy, nutritional intake is often below recommended daily allowances,⁴⁻⁶ and at least one study found that the majority of women do not meet recommendations for physical activity, either.⁵ The recommendations for preconception health behavior, while common-sense, have not been tested much for their relationship with birth outcomes such as low birthweight (LBW) and preterm birth (PTB).

A systematic review of periconceptional nutrition rated the quality of evidence for effects of preconceptional nutrition on birthweight and gestational age as low.⁷ Preconceptional vitamin use was associated with a reduced risk of PTB and small for gestational age (SGA) in the Danish National Birth Cohort, but associations were generally stronger for early postconceptional use rather than preconception.⁸ Almost all women who used vitamins preconceptionally also used them postconceptionally, making the independent effects difficult to determine.⁸ A recent study reported that prenatal dietary and vitamin C supplement intake reduced associations between nitrosatable drug exposures and certain birth defects.⁹ Studies of overall preconception diet, as opposed to supplements, are also few. Dietary patterns and nutrients have also been associated with success of assisted reproductive technology in some studies.¹⁰ No relationship was found between prepregnancy diet, including fruit and vegetable intake, meat intake, fats, and cholesterol, and glucose intolerance during pregnancy in one study.¹¹

Preconception physical activity is even less studied. In the HUNT study, pre-pregnancy leisure time physical exercise was not associated with overall birthweight.¹² However, women who reported no exercise were at a reduced risk of delivering a macrosomic (excessively large) infant, especially if they had higher body mass index (BMI).¹² Preconception physical activity has also been associated with a reduced risk of glucose intolerance during pregnancy.^{11,13}

The related factors of weight and adiposity have been linked to adverse birth outcomes. Malnourished and underweight women are at greater risk for LBW, SGA, and PTB.^{7,14} On the other end, obese women are at greater risk for preterm birth, particularly when medically indicated by complications such as pre-eclampsia.¹⁵ Obesity, especially with associated gestational diabetes, is associated with macrosomia in the infant.¹⁶ There is some evidence that pre-pregnancy eating disorders are associated with preterm birth, low birthweight, and small-for-gestational-age,^{14,17,18} even among those whose eating disorder occurred significantly prior to pregnancy.¹⁷ This is likely partly due to lower prepregnancy BMI;^{19,20} binge eating disorder is also sometimes associated with higher birthweights, due partly to higher BMIs in this group compared to other eating disorders.²¹

Compared with adult pregnancies, adolescent pregnancies have disproportionately high rates of negative birth outcomes, such as infant mortality,²²⁻²⁴ stillbirth,²⁵ congenital anomalies,²⁶ PTB, and LBW.²⁷ However, potential determinants or risk indicators of birth outcomes, including preconception nutrition and physical activity, have been less studied in adolescent mothers compared to in adult mothers. Nutrition is of particular concern in adolescent mothers, who may still be growing themselves, and who may have poor diet quality and limited nutritional knowledge.²⁸⁻³⁰ Physical activity during adolescence also has positive effects on both physical and psychological well-being, such as reduced obesity and relieved symptoms of depression,^{31,32} which have been found to be associated with birth outcomes.^{33,34} The purpose of the present study was to examine how maternal preconception nutrition and physical activity are related to birth outcomes among adolescent mothers. Our hypotheses were a) adolescents who ate more fruits and vegetables would have higher birthweight and gestational age; and b) adolescents who performed more physical activity and were less sedentary would have a higher birthweight and gestational age.

Materials and Methods

Data

Data from Waves I, II, and IV of the National Longitudinal Study of Adolescent Health (Add Health) contractual dataset were utilized. Add Health is a prospective cohort study of a nationally-representative sample of young persons enrolled in grades 7-12 in the 1994-95 school year (Wave I).³⁵ Follow-up interviews were conducted in 1996 (Wave II), 2001 (Wave III), and 2007-08 (Wave IV). Add Health utilized a multistage probability clustered sampling design to obtain its original Wave I sample. The first stage of sampling was a stratified, random sample of all public and private high schools in the United States. A middle school whose students largely attended the selected high school was also recruited from each participating community. In-school surveys were attempted with all students attending participating schools; a total of 90,118 were completed. In the second Wave I sampling stage, a sample of adolescents was drawn for in-depth in-home interviews, consisting of a random core sample plus selected special oversamples; a total of 20,745 interviews were conducted at this stage. At Wave II, most students (except Wave I seniors) were eligible for re-interview. At Wave IV, all respondents to the Wave I in-home interview were eligible for re-interview. A total of 15,701 interviews were conducted at Wave IV (80.3% response rate). Mean and median age at this interview was 28 (range 24-32). Sampling weights adjusted for both unequal probabilities of selection into the original sample and for loss to follow-up.

Our focus was on predictors of adolescent birth outcomes, so several exclusions were applied to the dataset. First, we limited to females who participated in Wave IV, as that was the only Wave by which all respondents had completed their teenage years and thus had complete data on teen births. Second, we limited our analysis to participants with valid sampling weights in order to make generalizations to the wider U.S. population. Third, we limited to women whose first pregnancies occurred after Wave I, occurred during their adolescence, and ended with a singleton livebirth to ensure the temporal ordering of predictors and outcomes (n=978). Finally, we limited to women with complete information

on all covariates (n=833) for analysis of Wave I predictors. There was no significant difference in any of the variables when comparing included (n=833) versus excluded (n=145) adolescents. For analyses of Wave II predictors, the dataset was limited to births after wave II (n=756) and 572 girls had complete data on all covariates. Analyses comparing included (n=572) versus excluded (n=184) adolescents indicated no significant difference in any of the variables except for age at Wave I (14.98 vs. 16.42 in included and excluded sample, respectively; $p<0.001$).

Measures

Outcomes—At Wave IV girls were asked about previous pregnancies and their outcomes. If they indicated they had given birth, they were asked “How much did the baby weigh at birth?”, “Was [baby's name] born before or after [his/her] due date?” and then “How many weeks or days early/late was [baby's name] born?” This was subtracted from 40 weeks to calculate gestational age. Birthweight was examined in kilograms and gestational age was examined in weeks.

Predictors

Nutrition—In Wave I in-home interview, girls were asked to recall their frequency of having five types of food on the previous day: milk/yogurt/cheese, fruit/fruit juice, vegetables, bread/cereal/pretzels/rice/pasta, and cookies/doughnuts/pie/cake. Response options were “0=Didn't eat”, “1=Ate once”, and “2=Ate twice or more”. Responses were analyzed as continuous variables.

In Wave II in-home interviews, adolescents recalled their intake (Yes/No) on the previous day of 55 food and beverage items that represented 76 variables on consumption and types.³⁶ These 55 items were grouped into three categories based on a previous analysis: high-calorie sweet, high-calorie non-sweet, and low-calorie food.³⁷ High-calorie sweet category includes foods such as doughnuts, ice cream, chocolate candy, regular candy, and cookies. High-calorie non-sweet items include steak, fried chicken, fried fish, pizza, hot dogs, sausage, cheese, whole milk etc. Low-calorie category includes foods such as low fat and skim milk, grilled chicken, grilled fish, apples, and breakfast cereal. The three food indices were examined in continuous form and 572 girls had complete data on them. Participants were also asked “Do you currently take vitamins or minerals?” and “In the last seven days, on how many days did you take vitamins or minerals?”.

Physical activity—The Add Health questionnaire in Wave I in-home interview included a recall on *active behaviors*. Girls were asked how many times during the past week they were involved in three types of activities: roller-blading /roller-skating/skate-boarding/ bicycling, baseball/softball/basketball/soccer/swimming/football, and jogging/walking/karate/jumping rope/gymnastics/dancing. Response options included “0=Not at all”, “1=1 or 2 times”, “2=3 or 4 times”, and “3=5 or more times”. Responses were summed, and analyzed as both continuous and median-dichotomized (high active behavior: score ≥ 3 vs. low active behavior: score <3). Total number of physical activity bouts was also estimated by using 0 for category “Not at all”, 1.5 for category “1 or 2 times”, 3.5 for category “3 or 4 times”, and 5.5 for category “5 or more times”. In Wave I in-home interview, girls also self-reported

number of hours in a week they spent on three *sedentary behaviors*, including watching televisions, watching videos, and playing video or computer games. Responses were summed and analyzed as both continuous and median-dichotomized (high sedentary behavior: score ≥ 17 vs. low sedentary behavior: score <17).

Confounders—Confounders were chosen based on factors previously determined to be associated with birth outcomes in this cohort, including race, age at wave I, age at pregnancy, BMI, and parental education.³⁸ Self-reported race at Wave I was specified as Black / non-Black. Pre-pregnancy BMI was measured at Wave I (a previous analysis of BMI closer to the pregnancy indicated no differences in results). Parent education was based on the higher reported of either co-residential mother or father at Wave I. Previous analysis had not found smoking or prenatal care to be a risk factor for adverse birth outcomes in this dataset,³⁸ and models run adjusting for the factors did not change the results and thus were not presented.

Statistical Analyses

All analyses were conducted in SAS (SAS Institute, Cary, North Carolina) using survey procedures, which apply population weights and adjust standard errors for non-independence between observations due to school-based sampling. Bivariate relationships between nutrition/physical activity variables and birth outcomes (birthweight and gestational age) were examined using ANOVA/t-tests. Baseline age, age at pregnancy, BMI, and parental education were included a priori in models, based on their predictive value in previous analyses.³⁸ Due to a possible curvilinear relationship between BMI and birth outcomes, inclusion of a quadratic term (BMI^2) was also tested, and included if significant. Multivariable linear regression was used. We tested Wave I diet, Wave II diet, and Wave I physical activity with birth outcomes separately. Models including both Wave I diet and Wave I physical activity, or both Wave II diet and Wave I physical activity, yielded similar results and were not presented. For analysis of physical activity, results were similar in continuous and dichotomized forms, and only dichotomized results are presented. No significant interactions with race were found.

The Add Health Study was approved by the Institutional Review Board of the University of North Carolina at Chapel Hill, and this secondary analysis was deemed exempt by the Institutional Review Board of Tulane University.

Results

Wave I nutrition data showed that 12.67% of the participants reported eating no fruits and vegetables, while 21.62% reported eating only once on the previous day. 345(39.70%) of the sample reported eating twice or more of fruit, and 208 (27.70%) reported eating twice or more of vegetables, while 13.49% reported eating twice or more of both. The mean $\pm$ SD for the three Wave II nutrition indices was 2.16 $\pm$ 1.36, 5.21 $\pm$ 2.45, and 1.99 $\pm$ 1.40 for high-calorie sweet, high-calorie non-sweet, and low calorie food, respectively, representing the average number of food types in each category. Wave I physical activity showed that 37% of the participants reported an estimated seven or more bouts of physical activity during a week.

The distribution of the Wave I nutrition and physical activity variables is presented in table 1.

In multivariable analyses, there were no associations between reported food intake and birth outcomes at either Wave 1 or 2 (tables 2 and 3), nor was there any relationship with vitamin use (data not shown). We examined Wave I nutrition variables in categorical forms and found similar results (data not shown).

Multivariable analyses on Wave I physical activity and birth outcomes indicated a u-shaped association between BMI and birthweight (p for quadratic term=0.01), and thus the quadratic term was kept in the model. Girls who engaged in more episodes of active behavior had higher birthweights ($p<0.01$), but hours of sedentary behavior was not associated with birthweight (table 4). There were no associations with gestational age, although the tendency was also for a longer gestational age in girls who exercised more. When examining physical activity in continuous form (i.e., in number of bouts), we also found that there was a positive linear relationship between number of bouts and birth weight ($\beta=0.02$, $SD=0.01$, $P=0.02$), but not gestational age.

Discussion

We found low levels of fruit and vegetable intake among the adolescent mothers. Only 54% of the sample reported eating two or more servings of either fruit or vegetables, and only 13.5% reported eating two or more servings of both, indicating that it is unlikely that many were meeting the recommendation of 5 servings per day of fruits or vegetables. Similarly, only 37% of the sample reported seven or more occasions of physical activity during a week, which possibly indicates that the number meeting the Centers for Disease Control and Prevention's recommendation of at least one hour a day of activity³⁹ was low. Adolescents who become pregnant generally have increased needs for calories, certain vitamins and minerals.⁴⁰ Appropriate types and amount of physical activity are also beneficial to adolescent mothers in that it increases energy, reduces discomforts of pregnancy such as bloating and swelling, and improves mood and sleep quality.⁴⁰ It is recommended that pregnant teen girls discuss a plan for healthy diet and safe exercise with their primary healthcare provider.⁴⁰

Few studies have directly examined prepregnancy nutrition in adolescents, although in developing world settings, nutritional supplementation in girls and teenagers is associated with increased weight and height in their offspring.⁴¹ "Health-conscious" or Mediterranean diets during pregnancy have also been associated with better birth outcomes,⁴²⁻⁴⁴ while "junk food" diets (calorie-dense, nutrient-poor) are associated with higher birthweight.⁴⁵ In this analysis, we did not find any association between Wave I or II nutrition variables and birth outcomes. It is possible that the one-time measure of diet does not reflect a full profile of their nutrition intake, as the adolescents' eating habits may fluctuate in relation to psychological and appetite change. Nutritional intake may also change when a woman becomes pregnant, and the postconceptional nutrition may have a stronger association with birth outcomes,⁸ although studies have found that there was little change in dietary patterns from before pregnancy to during pregnancy.^{46,47}

We found that pre-pregnancy physical activity was positively associated with birthweight in pregnant adolescents. Pre-pregnancy physical activity has not been previously studied in adolescents to our knowledge. Generally leisure-time physical activity during pregnancy has not been associated with changes in birthweight or gestational age in observational studies,⁴⁸ although a few studies have found decreased risk of preterm birth or macrosomia.⁴⁹ Associations are more ambiguous for work-related physical activity.^{50,51} Physical activity may directly improve pregnancy health, or associations could be the result of residual confounding. Physical activity may improve preconception and pregnancy risk factors like blood pressure, BMI, and glucose tolerance. Women who exercise prior to pregnancy also likely carry those habits into pregnancy (though they may reduce in intensity).¹³ On the other hand, women who are sedentary, have poor diets or skip meals during pregnancy are also more likely to have associated risk factors such as smoking, low social support, poor mental health, and poor overall health.⁵²⁻⁵⁴

The u-shaped association with pre-pregnancy BMI also should perhaps be noted. This is consistent with previous studies finding higher risk of low birthweight in underweight teens,⁵⁵ as well as the increased risk for both tails of the distribution (low birthweight and macrosomia) among obese pregnant women.⁵⁶ A previous analysis of the Add Health data found increased risk of macrosomia only among the infants born to those with adult-onset obesity.⁵⁷

The present study has the strength of the use of a large, nationally-representative dataset. It also allows for the temporal inference between nutrition and physical activity variables and the birth outcomes because measurement of exposures was made prior to outcome data. Our study also has several limitations. Firstly, report of diet and physical activity is notoriously prone to error,^{58,59} and both diet and physical activity vary extensively on a daily basis and over the years. Physical activity has been reported to decline over adolescence and into adulthood, especially in girls.^{60,61} In Add Health, questions on nutrition were different across Wave I and Wave II and it was difficult to examine any change in nutrition intake. Secondly, the possibility of residual confounding cannot be ruled out. Diet and physical activity are strong indicators of healthy lifestyle. While adjustment for smoking and prenatal care did not make a difference to these results, other lifestyle factors such as getting adequate sleep and/or avoiding noxious environments may also be correlated with these exposures. Lastly, the birth outcomes were self-reported, which may be subject to recall bias. However, past studies have found that mother's report of these outcomes is generally reliable.^{62,63} The relatively small sample size precluded an analysis of more directly clinically relevant outcomes, such as low birthweight or preterm birth.

Conclusions

Our results suggest that girls who engage in physical activity and later become pregnant are more likely to have better birth outcomes as represented by birthweight. Together with the previous findings that adolescent girls who engage in physical activity are also less likely to engage in sexually risky behavior and may be less likely become pregnant in the first place,⁶⁴⁻⁶⁶ our results add to the many reasons to encourage physical activity in adolescent girls.

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Table 1

Characteristics of women whose first pregnancy (singleton livebirth) occurred after Wave 1 at the Add Health Study, 1996-2007 (N=833).

	<u>Mean (SE)</u>
Birth weight (kg)	3.24(0.02)
Gestational age (weeks)	39.28(0.10)
Baseline age	15.42(0.14)
Age at pregnancy	17.8(0.08)
Baseline BMI	22.16(0.2)
	<u>N (%)</u>
Race	
Non-black	572(76.71)
Black	261(23.29)
Parental education	
high school	647(78.53)
less than high school	186(21.47)
Dairy	1.27±0.03
Fruit	1.15±0.04
Vegetable	0.88±0.03
Grains	1.41±0.03
Sweets	0.68±0.03
Active behavior	
Low active behavior	328(38.10)
High active behavior	505(61.90)
Sedentary behavior	
Low sedentary behavior	415(51.01)
High sedentary behavior	418(48.99)

Table 2

Multivariable associations between nutrition variables and birth outcomes in the Add Health study, 1996-2007 (N=833)

Nutrition variable [†]	Birthweight		Gestational age	
	β (se) [*]	P-value	β (se)	P-value
Dairy	0.05(0.03)	0.12	-0.06(0.12)	0.63
Fruit	0.01(0.03)	0.84	-0.07(0.14)	0.62
Vegetables	-0.01(0.04)	0.69	0.07(0.15)	0.62
Grains	-0.05(0.04)	0.19	-0.06(0.13)	0.65
Sweets	0.01(0.03)	0.67	0.12(0.15)	0.40

* adjusted for age at Wave I, age at pregnancy, BMI, BMI squared, race, and parental education.

[†] per level reported per day, response options=none, once, twice or more.

Table 3

Multivariable associations between nutrition variables measured at Wave II and birth outcomes in the Add Health study, 1996-2007 (N=572)

Nutrition variable [†]	Birthweight		Gestational age	
	β (se) [*]	P-value	β (se)	P-value
High-calorie sweet food	0.02(0.02)	0.33	0.03(0.10)	0.77
High-calorie non-sweet food	-0.004(0.01)	0.79	-0.06(0.04)	0.14
Low-calorie food	0.03(0.03)	0.23	0.11(0.08)	0.19

* adjusted for age at wave I, age at pregnancy, BMI, BMI squared, race, and parental education.

[†] Increase associated with a one-unit increase in the scale

Table 4

Multivariable analysis of physical activity variables and birth outcomes in the Add Health study, 1996-2007 (n=833)

	Birthweight		Gestational age	
	β (se) *	P-value	β (se) *	P-value
Active behavior [†]		0.01		0.14
Low active behavior	Ref		Ref	
High active behavior	0.14(0.05)		0.29(0.20)	
Sedentary behavior [§]		0.51		0.68
Low sedentary behavior	Ref		Ref	
High sedentary behavior	-		-0.10(0.24)	

* adjusted for age at wave I, age at pregnancy, BMI, BMI squared, race, and parental education.

[†] Increase associated with a one-unit increase in the scale.

[§] hours per week