Maternal sleep duration and child birth weight: A population-based cohort study

Financial Disclosure: The authors did not report any potential conflicts of interest.

Disclaimer: All authors have read and approved the contents of the submitted manuscript and have nothing to disclosure.

Word Count:

Abstract: 257

Text: 239

Short Running Title: Sleep duration and birth weight

Précis:

The longitudinal association between maternal sleep duration before and during pregnancy and child birth weight is an inverse U-shape.

Abbreviations:

GAM (Generalized Additive Models); INMA (Infancia y Medio Ambiente [Environment and Childhood] Project); SCL-90-R (Revised Symptom Checklist); SD (Standard Deviation).

ABSTRACT

Objective: This cohort study used repeated maternal sleep duration measurements at baseline and during pregnancy to evaluate the potential association with child birth weight.

Methods: This is a birth cohort study from the Spain. The study sample included 2,536 mothers. The exposure was self-reported measures of sleep duration before and during pregnancy. The primary outcome was Z-score birth weight.

Results: In women sleeping less than 7 hours per day, each additional hour of sleep increased birth weight by 44.3 g, although findings were not statistically significant ($p >$ 0.05). However, increasing sleep duration for the group of mothers who slept more than 9 hours per day at baseline decreased birth weight by 39.1 g per addional hour ($p =$ 0.002). Findings were similar after adjusting for several socio-demographic confounders and maternal psychopathological symptoms as an intermediate factor. Similar but attenuated associations were observed with sleep duration in the second pregnancy trimester.

Conclusions: The relationship between maternal sleep duration before and during pregnancy and child birth weight is an inverse U-shape. Excessive sleep duration may adversely affect child health through its impact on birth weight.

INTRODUCTION

Humans sleep one third of their lives and adequate sleep is an important factor in preventing a variety of metabolic and psychiatric disorders. Sleep disturbances including alterations in sleep duration, poor sleep quality, restless leg syndrome, and breathing sleep disorders caused by hormonal, metabolic, and psychological changes, are common during pregnancy.[1,2] Alterations in sleep duration during pregnancy may include both longer naps and shorter sleep duration at night.[3]

Beside the limited number scientific publications, recent studies have considered diverse aspects of the potential association between sleep disturbances during pregnancy and birth weight.[4-6] A cross-sectional study of 457 women of gestational age ≥ 37 weeks in Iran reported a positive correlation between sleep quality (as defined as self-reported refreshing sleep) but not sleep duration and neonatal birth weight.[6] A prospective study of 1,091 women in Greece reported a positive association between being a severe snorer during the third trimester of pregnancy and low birth weight (below 2500 grams).[5] There was no association with reported sleep length.

In a longitudinal study of 885 pregnant mothers in Sri Lanka recruited up to 16 weeks of gestation, sleeping eight or less hours per day during either the second or the third trimester was related to a lower child birth weight.[4]

Other recent reports have also highlighted the potential role of increased sleep duration in poor health and mortality outcomes among adults[7-10]. A meta-analysis of 16 studies reported a U-shaped association between sleep duration and the risk of all cause-mortality[7]; in particular shorter sleepers (< 7 hours per night) had a 12% greater mortality risk and longer sleepers (> 8 - 9 hours per night) a 30% greater mortality risk compared to those sleeping between 7 to 8 hours per night. However it remains unclear whether oversleeping is a marker for other health issues, such as depression or reduced physical activity. Oversleeping may also be related with the use of alcohol or some medications.[11] However, the potential association between oversleeping and birth outcomes has not yet been examined.

The aim of this study was to evaluate the association between maternal sleep duration at baseline and second trimester of pregnancy, including its reduction or increase, and weight at birth. We used birth weight data from four Spanish cohorts with detailed information on important socio-demographic and lifestyle factors during pregnancy, as well as maternal psychopathological symptoms.

METHODS

Design and Study Participants

The Spanish Infancia y Medio ambiente (Environment and Childhood) Project (INMA) is a mother-and-child cohort study established in different areas of Spain following a common protocol (recruitment period: 2003-2008).[12] This study included the INMA cohorts of Asturias (n = 489), Guipuzkoa (n = 574), Sabadell (n = 652) and Valencia (n = 821) with repeated measures on maternal sleep duration. Pregnant women agreed to participate and met the inclusion (≥16 years of age, singleton pregnancy, intention to deliver at the reference hospital) and exclusion (no communication handicap, no fetuses with malformations, no assisted conception) criteria.

In total, 2,375 children with no missing data on birth weight, (463 from Asturias, 533 from Guipuzkoa, 599 from Sabadell, and 780 from Valencia) were included in the present study. The study was approved by the appropriate ethical committees, and written informed consent was obtained from the parents of all children prior to enrollment into the study.

MEASURES

Assessment of sleep duration

Sleep duration of the mother was assessed by in-person questionnaires at the moment of recruitment into the study during the first trimester according to the following open-ended question: How long did you sleep during the day (minutes) and during the night (hours) before getting pregnant? And again at the second trimester of pregnancy, but in terms of current sleep duration. Here we refer to sleep duration assessed at recruitment as baseline sleep duration. Total sleep duration, including both naps and sleep at night, either at baseline or during the second trimester, was expressed in hours per day (h/d).

As mothers answered this question when they were already pregnant, we speculate that women may have the influence of current (pregnancy) sleep habits on recalling the past (pre-pregnancy)[13], a phenomenon known as “recall bias”. Consequently, sleep duration before pregnancy could be partly considered as a proxy of sleep duration at first trimester.

Assessment of birth weight

Birth weight was measured in grams by trained midwives. Gestational age was estimated from the date of the last menstrual period (LPM) reported at recruitment and was confirmed using ultrasound examination in week 12 of gestation. If gestational age (based on reported LMP and ultrasound) differed ≥7 days (12% of newborns), the duration of gestation was recalculated using a formula with crown-rump length from an early ultrasound measurement[14]. We standardized the measure of birth weight at 40 weeks to control for gestational week of pregnancy (Z- score birth weight). Each birth weight was expressed in 40 weeks gestational age using the Box-Cox power exponential models (BCPE) considering the reference study group. Models were adjusted for sex and cohort.[15]

Covariates

Questionnaires administered to mothers during pregnancy and at delivery collected information on smoking status (yes/no), alcohol consumption (grams per day), medical conditions and pregnancy complications, maternal diet and medication use during pregnancy, maternal ethnicity and education (primary or less, secondary school, or university), maternal age at birth, and parity (0, 1, ≥2 children). Maternal height and weight during pregnancy were measured and pre-pregnancy weight reported by the mother at the first trimester visit and were used to calculate pre-pregnancy BMI (kg/m^2) and weight gain during pregnancy. Mother's social class was obtained according to the UK Registrar General's 1990 classification according to current ISCO88 parental occupation. Maternal marital status (whether the parents were living together or not) and history of depression or anxiety was recorded by in person questionnaire during the first trimester of pregnancy. Paternal weight and height were reported by the mother and used to calculate paternal BMI (kg/m^2). At week 32 of prenancy, information on whether the mother worked during pregnancy (yes/no) was collected as well as physical activity level during pregnancy as measured by metabolic equivalent of task (MET's hour/day).

At the 4-year follow-up, we also assessed maternal psychopathological symptoms using the Revised Symptom Checklist (SCL-90-R).[16] Since no psychometric data of maternal mental health was collected during pregnancy, we supposed that trends of symptomatic traits of psychopathology could be detected years after pregnancy. This is a self-reported questionnaire widely used in both general and distressed populations for its demonstrated reliability, validity, and utility. Ninety items are classified into 9 domains including: somatization, obsessive–compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. A general score is also obtained. Here, an indicator of internal reliability was measured; a SCL-90-R general score α coefficient was 0.97.

Statistical Analysis

Univariate mixed regression models were used to examine the association between selected parental and child characteristics and Z- score birth weight adjusting for cohort as a random intercept[17,18] (to adjust for potential confounding by unmeasured cohort characteristics).

The association between maternal sleep duration both at baseline and during the second trimester of pregnancy and Z-score birth weight was examined using mixed regression models. Analyses included child sex, pre-pregnancy maternal BMI, paternal BMI, gestational weight gain, and maternal age as mandatory covariates and adjusted for cohort as a random intercept[17,18]. We also considered potential confounding by alcohol consumption, smoking status, parity, maternal marital status, social class, education level, total physical activity and working activity during pregnancy. Further the impact of including maternal depression and anxiety diagnosed during the first trimester of pregnancy as intermediate variables was also assessed as well as maternal psychopathological symptoms measured at child age 4 years. Other collected variables mentioned before were not included in the final models due to show no crude statistical relation with the determinant and/or outcome (data not shown).

Generalized additive models (GAM) were used to examine the shape of the relationship between sleep duration and Z-score birth weight. We found evidence of non-linearity in both models and therefore we fitted a piecewise regression model to estimate adjusted slopes of sleep duration < 7, 7 to 9, and >9 hours per day. Cut-off points were chosen based on visual inspection of the GAM plot, consideration of the distribution of the variable, and in accordance with previous published results. [7]

RESULTS

Median sleep duration was 8 hours in all cohorts both at baseline and in the second trimester of pregnancy (Table 1). Z-score birth weight decreased with maternal alcohol consumption, smoking status during pregnancy, and lower social class (III, IV-V). Z-score birth weight increased in male children, with increasing maternal age, higher pre-pregnancy maternal BMI, higher weight gain during pregnancy, higher paternal BMI, higher maternal education level, and higher parity (Table 2). We found a significant curvilinear relationship between baseline sleep duration and birth weight (Figure 1). In women sleeping less than 7 hours per day, each hour of sleep increase increased birth weight by 44.3 g, although the finding was not statistically significant (Table 3). In contrast, in women reporting more than 9 hours of sleep, birth weight decreased by 39.1 g per additional hour of sleep (p=0.002). The association between sleep duration and Z-score birth weight was similar but attenuated and was no longer significant during the second trimester of pregnancy (Table 3; Figure 2).

Associations were similar after adjusting for additional confounders including maternal alcohol consumption during pregnancy, smoking habits, education level, parity, marital status, working activity during pregnancy, maternal social class and physical activity during pregnancy (Table 4). Only after adjusting for maternal smoking status during pregnancy, a change in the coefficient of the exposure at baseline higher than 10% was observed. Following this criterion, smoking habits during pregnancy appeared as an important confounder and was maintained in further sensitivity analyses.

We also considered the potential intermediate role of anxiety and depression diagnosed during the first trimester of pregnancy and maternal psychopathological symptoms at child age 4 years (Table 5). However, we found similar associations as those in the main analysis.

DISCUSSION

We observed an inverse U-shaped association between maternal sleep duration at baseline and child birth weight. Similar, but weaker associations were observed during the second trimester of pregnancy. Consequently a background of excessive sleep duration (higher than 9 hours per day) may result in adverse impacts on child health. To our knowledge this is the first prospective study assessing the association between repeated measurements of sleep duration, in terms of both reduced and excessive sleep, and birth weight. Further adjustments with important socio-demographic confounders did not alter the findings; neither maternal depression nor anxiety diagnosed at the first trimester of pregnancy and maternal psychopathological symptoms 4 years later explained such associations.

In agreement with previous studies, birth weight increases with the age of the mother, a higher maternal BMI, the sex of new born (male) and reporting a higher parity. [4] Abeysena et al.[4] studied whether sleep duration during the second, third or both trimesters together affected birth weight. They observed a reduced child birth weight (<2500 gr.) among women sleeping less than 8 hours per day.

The quality of sleep has a important effect on low birth weight as reported by Zafarghandi et al [6], where women with refreshing sleep were at statistically significantly lower risk to give birth of neonates' with low birth weight in comparison with women with relatively or not refreshing sleep. Micheli et al [5] reported no relationship between sleep duration and child low birth weight. However they found a relationship between the quality of sleeps in terms of severe snoring and child low birth weight. We did not assess such markers of sleep quality.

One of the main strengths of the present study is its prospective design, using repeated measurements of sleep duration at baseline and again during pregnancy. Furthermore, the exhaustive range of potential confounders described above weakens the possibility of residual confounding playing an important role here. Additionally, results were also unchanged after adjusting for one of the potential explanatory pathways, maternal mental health status (as diagnosed at first trimester and as a scale assessed at 4 years of the child). Finally, since this study is based on four population-based birth cohorts with a high participation rate[12]; the findings can be considered to imply a certain degree of external validity.

This study also has some limitations: sleep duration at baseline and second trimester was self-reported by the mother. However self-reported sleep abnormalities in young adults were highly correlated with objective measurements of sleep status.[19] Little is known about the validity of self-reported survey assessments of sleep time in pregnancy. A recent study reported no correlation between self-reported and actigraphy measures but it seemed biased by the missing internal validation of actigraphy and the heterogenous small sample of low-income, urban mothers. [20] Finally, more detailed data on the quality of sleep was not available in order to examine factors beyond duration and their potential impact on birth weight.

A range of mechanisms have been proposed to explain the negative health effects of oversleeping: sleep fragmentation, fatigue, immune function (e.g., change to immune function), photoperiodic abnormalities, lack of challenge (e.g., lack of physiological challenge), or an underlying disease process such as sleep apnea, heart disease, or failing health.[21] Moreover the use of certain substances such as alcohol and drugs may be the cause for fatigue and sleep problems, however in our data set; alcohol use did not affect the findings on oversleeping and birth weight. A possible explanation for the negative association observed between oversleeping and birth weight is pre-pregnancy depression of the mother. Antenatal depressed pregnant women gain less weight[22] and sleep more[23]. Also stress can have a similar short term effect on sleeping habits. Stressed women are overly tired at the end of the day and tend to sleep more. However we could not confirm such pathways in present data related to these factors. Although it is difficult to evaluate whether increased sleeping duration is related to changes in hormone levels or a sign of other health problems, in this study, the strongest associations with sleep duration occurred at the beginning, or before pregnancy, rather than in the middle of the pregnancy, suggesting that this was not the reason for birth weight differences.

Further longitudinal studies are needed to confirm the association between sleep duration and birth weight in different populations using repeated measurements of sleep duration at baseline and during the entire pregnancy period, and to better understand the underlying mechanisms. The increasing interest of studying sleeping patterns and their link with health outcomes is changing the priorities of the health science community, but the scarcity in the present literature makes this a priority in public health research.

CONCLUSIONS

This longitudinal study showed that excessive maternal sleep at baseline and probably during pregnancy is associated with lower birth weight in children after adjusting for various potential confounding and intermediate factors. Further prospective studies are required to confirm these findings and to investigate the mechanisms that may underline the possible association. Sleep duration is becoming an important health indicator for the general population.

Figure 1: Association between sleep duration at baseline (hours) and Z-score birth weight (GAM model)

Figure 2: Association between sleep duration at 2nd trimester (hours) and Z-score birth weight (GAM model)

Table 1. Distribution of sleep duration by cohort, INMA Study (2003-2008).

	N	Min	P25	Median	P75	Max
Sleep duration (h/d) **First Trimester**						
Sabadell	610	3	7	8	8.33	15
Valencia	758	3	7	8	9	16.5
Guipuzkoa	534	5	7	8	8.25	15
Asturias	439	3	7	8	9	14
Sleep duration (h/d) **Second Trimester**						
Sabadell	610	3	7	8	9	16
Valencia	758	3	7	8	9	14
Guipuzkoa	534	4	8	8	9	12
Asturias	439	3	7	8	9	14

Table 2. Association between selected parental and child characteristics and Z-score birth weight, INMA Study (2003-2008).

Variable	Mean Z-score birth weight (g)	β Coeff (95% CI)	N =2375
Child sex			
Female	3274.39	1 (Reference)	1155
Male *	3410.68	136.38 (104.60; 168.16)	1220
Age of the mother (years) *		7.52 (3.77; 11.29)	2375
Gestational weight gain (grams) * #		371.52 (245.03; 498.01)	2300
BMI before pregnancy * #		12.45 (8.74; 16.16)	2374
Paternal BMI * #		7.55 (2.84; 12.27)	2333
Alcohol consumption during pregnancy (grams/day) * #		-13.69 (-24.90; -2.49)	2370
Smoking during pregnancy #			
No	3374.05	1 (Reference)	1576
Yes *	3282.16	-90.82 (-125.87; -55.78)	738
Maternal educational level #			
≤Primary studies	3329.53	1 (Reference)	586
Secondary studies	3328.58	-3.21 (-44.34; 37.92)	976
University studies**	3373.24	38.77 (-4.45; 81.99)	809
Parity #			
First child	3286.13	1 (Reference)	1333
Second child *	3412.36	126.46 (92.80; 160.12)	880
> second child *	3459.10	175.04 (110.19; 239.89)	160
Marital Status			
Parents were living together	3345.12	1 (Reference)	2333
Parents were not living together	3304.43	-38.77 (-161.18 ; 83.64)	42
Mother's social class #			
Class I-II	3387.30	1 (Reference)	503
Class III *	3336.32	-48.32 (-95.54; -1.10)	613
Class IV-V *	3330.38	-54.54 (-96.14; -12.94)	1258
Working during pregnancy #			
Yes	3371.26	1 (Reference)	380
No	3339.46	-29.59 (-74.00; 14.82)	1933
Total physical activity (METs hour/day) during pregnancy		0.71 (-3.71; 5.14)	2375
Maternal psychopathological symptoms #			
Direct punctuation obsessions and compulsions		14.73 (-16.00; 45.46)	1586
Direct punctuation interpersonal sensitivity		13.77 (-18.65; 46.18)	1586
Direct punctuation depression		0.94 (-30.95; 32.82)	1586
Direct puntatuation anxiety		4.37 (-30.55; 39.30)	1586
Direct punctuation overall severity index		13.35 (-28.83; 55.53)	1586

Anxiety at first trimester #		2.10 (-43.76; 47.96)	2373
Depression at first trimester #		17.76 (-36.63; 72.14)	2373

* P-value < 0.05 in univariate mixed regression models adjusting for cohort as a random intercept.
** P-value < 0.10.
# Data are missings in some subject.

Table 3. Association (β Coeff. and 95 % CI) between sleep duration and Z-score birth weight , INMA Study (2003-2008).

Sleep duration	Z-score birth weight β Coeff (95% CI)
Sleep at baseline	
≤ 7 hours per day	44.30 (-0.27, 88.87)
> 7 and ≤ 9 hours per day	15.83 (-9.36, 41.03)
> 9 hours per day*	- 39.11 (-61.43, -16.81)
Sleep in 2nd trimester	
≤ 7 hours per day	15.95 (-13.57, 45.47)
> 7 and ≤ 9 hours per day	-13.80 (-39.53, 11.91)
> 9 hours per day	- 15.69 (-42.35, 10.96)
Models were adjusted for maternal age, gestational weight gain, maternal pre-pregnancy BMI, paternal BMI, sex of the infant and a random effect for cohort.	

* P-value < 0.05 in multivariate mixed regression models adjusting for cohort as a random intercept

Table 4. Association ((β Coeff. and 95 % CI) between sleep duration at baseline and Z-score birth weight adjusted for potential confounders factors

Sleep duration	Sleep at baseline		
	≤ 7 hours per day	**> 7 and ≤ 9 hours per day**	**> 9 hours per day**
Model 1: Base model + alcohol	44.82 (0.27, 89.38) *	15.64 (-9.54, 40.83)	-38.73 (-61.03, -16.42) *
Model 2: Base model + smoking	39.41(-4.87, 83.69)	14.17 (-10.85, 39.20)	-33.11 (-55.36, -10.87) *
Model 3: Model 2 + maternal education	38.60 (-5.82, 83.03)	14.80 (-10.24, 39.85)	-31.76 (-54.08, -9.44) *
Model 4: Model 2 + parity	35.45 (-8.28, 79.18)	18.36 (-6.34, 43.06)	-33.22 (-55.15, -11.29) *
Model 5: Model 2 + marital status	39.95 (-4.18, 84.09)	14.12 (-10.81, 39.05)	-33.33 (-55.52, -11.14)*
Model 6: Model 2 + working during pregnancy	41.00 (-3.18, 85.19)	12.38 (-12.73, 37.49)	-35.06 (-57.45, -12.68)*
Model 7: Model 2 + mother's social class	38.88 (-5.25, 83.02)	14.13 (-10.78, 39.03)	-32.61 (-54.82, -10.41)*
Model 8: Model 2 + total physical activity (METs-hour-day) 32 weeks gestation	39.89 (-4.24, 84.03)	14.09 (-10.84, 39.03)	-33.21 (-55.39, -11.02) *

* P-value < 0.05 in multivariate mixed regression models adjusting for cohort as a random intercept

Table 5. Association ((β Coeff. and 95 % CI) between sleep duration at baseline and Z-score birth weight adjusted for potential maternal mental health, anxiety and depression intermediate factors

Sleep duration	**Sleep at first trimester**		
	≤ 7 hours per day	**> 7 and ≤ 9 hours per day**	**> 9 hours per day**
Model 1 + direct punctuation obsessions and compulsions	40.96 (-10.32, 92.25)	17.66 (-12.94, 48,25)	-30.56 (-58.63, -2.50) *
Model 1 + direct punctuation interpersonal sensitivity	41.22 (-10.07, 92.52)	17.54 (-13.06, 48.13)	-30.37 (-58.44, -2.30) *
Model 1 + direct punctuation depression	41.30 (-10.00, 92.61)	17.56 (-13.06, 48.18)	-30.13 (-58.23, -2.03) *
Model 1 + direct punctuation anxiety	41.22 (-10.07, 92.51)	17.50 (-13.09, 48.10)	-30.68 (-58.78, -2.58) *
Model 1 + direct punctuation overall severity index	41.40 (-9.89, 92.70)	17.75 (-12.85, 48.36)	-30.83 (-58.95, -2.71) *
Model 1 + anxiety at first trimester	39.97 (-4.23, 84.17)	14.02 (-10.94, 38.97)	-33.13 (-55.32, -10.93)*
Model 1+ depression at first trimester	39.95 (-4.25, 84.15)	14.10 (-10.85, 39.05)	-33.30 (-55.51, -11.09)*

* P-value < 0.05 in multivariate mixed regression models adjusting for cohort as a random intercept

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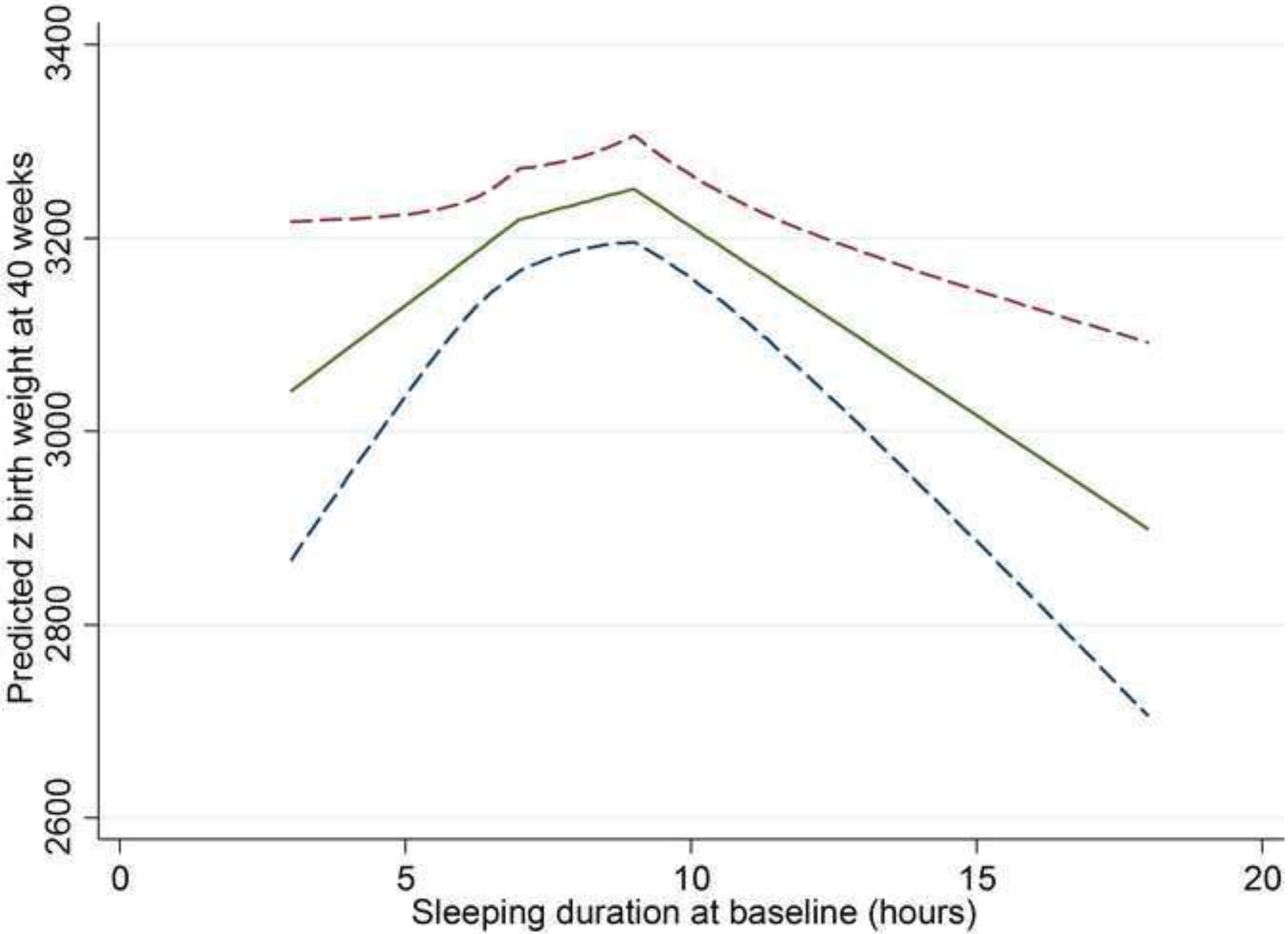
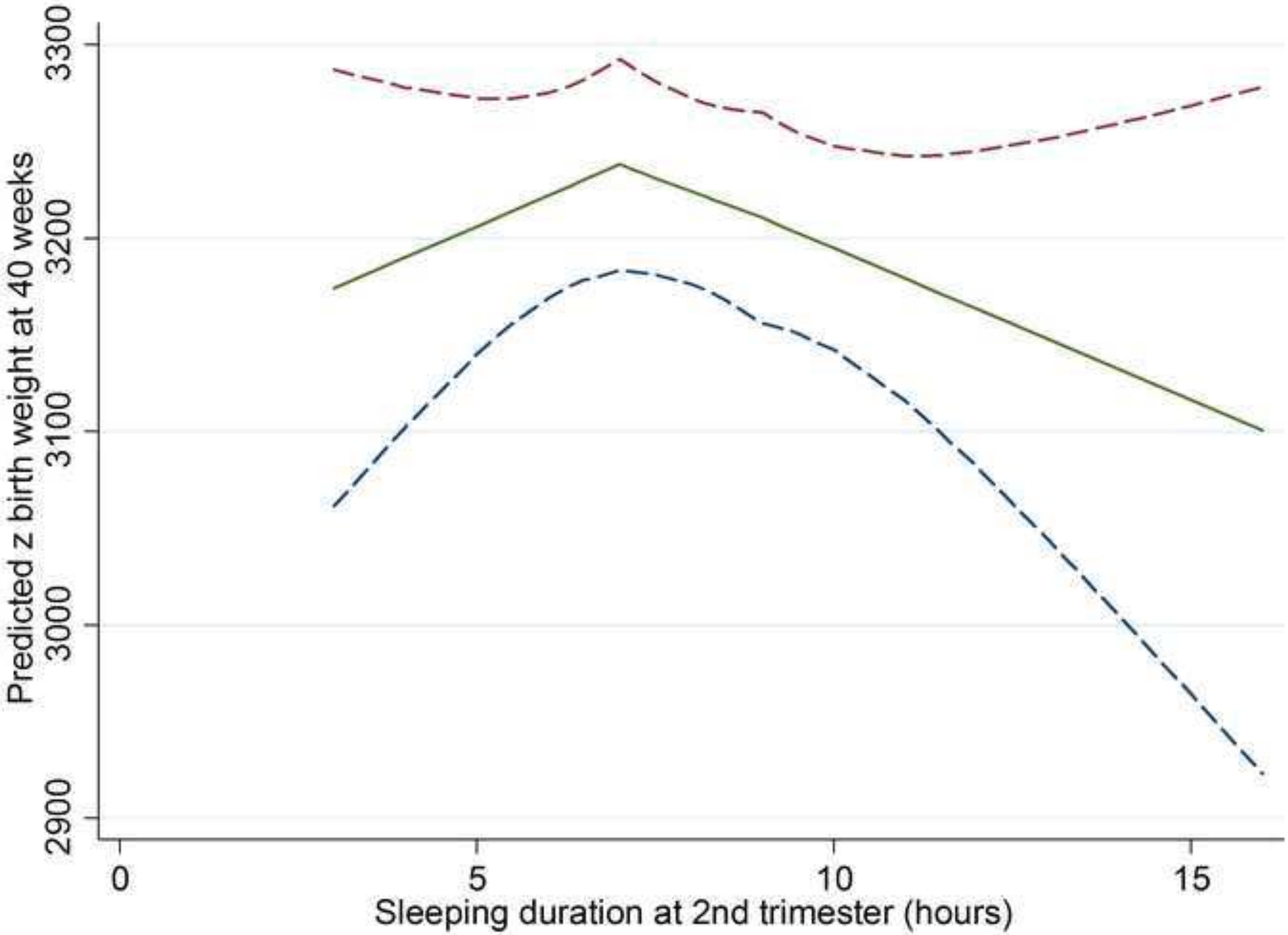


Predicted z birth weight at 40 weeks
3400
3200
3000
2800
2600
0
5
10
15
20
Sleeping duration at baseline (hours)


3300
3200
3100
3000
2900
Predicted z birth weight at 40 weeks
0
5
10
15
Sleeping duration at 2nd trimester (hours)