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Self-reported short sleep duration and insomnia symptoms as predictors of post-pregnancy weight change: Results from a cohort study

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Abstract

This study aims to investigate whether change in sleep duration and insomnia symptoms in the postpartum period is related to change in body mass index from before to 2 years after pregnancy. This study is based on self-report data from a Norwegian cohort, the AHUS Birth Cohort Study. Data were collected at 8 weeks (T1) and 2 years (T2) postpartum. Data from 812 women were analyzed. The results showed that only women with symptoms of insomnia at both T1 and T2 (persistent symptoms) had a greater increase in body mass index compared to women with no insomnia symptoms at T1 or T2.The results indicate that persistent insomnia symptoms are related to a greater increase in body mass index.

Keywords

body mass index, insomnia symptoms, postpartum sample, postpartum weight change, short sleep duration

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Background

The postpartum period is associated with considerable alterations in sleep–wake cycles,[1] and reporting poor sleep quality is more common than not; in a population-based study, almost 6 out of 10 women reported sleeping problems postpartum.[2] A number of studies of the general population have found a relationship between poor or insufficient sleep and weight gain.[3–8] This suggests the possibility that women in the postpartum period may be particularly susceptible to gaining weight.

Given that there is a relationship, the degree to which short sleep duration causes weight gain is a different matter. A systematic review from 2012 of the longitudinal studies in the general population concluded that the prospective relationship in adults remains unclear.[9] Of the 13 reviewed longitudinal studies, 4 studies found a prospective relationship between short sleep duration and weight gain,[10–13] 4 studies found a relationship between both short and long sleep duration and subsequent weight gain,[14–17] whereas 5 studies did not detect a prospective relationship.[18–22] Lack of adjustment of confounding factors, such as mental health problems, in some of the studies may partly explain the inconsistencies in the research findings.

To our knowledge, only four studies have investigated the relationship between short sleep duration and postpartum weight retention (the difference in weight at some

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		The present study		
Week 17 pregnancy	**Week 32 pregnancy**	**Delivery**	**Eight weeks postpartum** **T1**	**Two years postpartum** **T2**
Questionnaire	Questionnaire	Partus information	Questionnaire	Questionnaire, including self-reported prepregancy weight

Figure 1. The design of the study.

time after delivery and weight prior to pregnancy), and a recently published systematic review concludes that the research investigating the relationship is limited.[23] The results of the existing research indicate that there is a relationship over time between short sleep duration and postpartum weight retention. Sleeping 5 h or less per night was found to be related to postpartum weight retention 3 months,[24] 1 year[11,25] and 3 years postpartum.[26] Also, one of the studies found that women who reduced their sleep duration between 6 months and 1 year postpartum had two times higher odds of substantial weight retention 1 year after giving birth compared to women who did not change their sleep duration.[11] Despite the prospective nature of the existing studies, *changes* in sleep with regard to the prospective effect on change in weight were not investigated.

Sleep in the postpartum period is probably most often disrupted and consequently curtailed as a result of feeding and caring for the infant.[27] However, the mother may struggle with sleep problems of her own, such as problems initiating or maintaining sleep or non-restorative sleep. These are symptoms of the sleep disorder insomnia.[28] About 10%–15% of the adult population meets the diagnostic criteria for insomnia.[29] However, the effects on weight of losing sleep due to caring for a child or losing sleep due to symptoms of insomnia may not be the same. To our knowledge, only two studies have investigated the prospective effect of symptoms of insomnia on change in weight. In a study based on respondents aged 40–60 years, Lyytikäinen et al.[8] found that women, but not men, experiencing insomnia had 1.25 higher odds of gaining 5 kg or more during the follow-up period, after adjusting for mental health problems. In contrast, Björkelund et al.[30] did not find a prospective relationship between insomnia and weight gain in their study on sleep disturbances in midlife. The utilization of mainly middle-aged samples limits the generalizability of the studies. To the best of our knowledge, no studies have prospectively explored the link between insomnia and weight change in postpartum women.

In summary, despite numerous studies on the topic, the degree to which there is a prospective relationship between sleep duration or insomnia symptoms and body mass index (BMI) remains unclear. Due to the limited number of published studies, the relationship is perhaps particularly unclear post-pregnancy. The aim of this study was to investigate the degree to which change in sleep duration or symptoms of insomnia from 8 weeks to 2 years postpartum is related to change in BMI from before until 2 years after the pregnancy, while adjusting for potentially confounding factors. It is particularly important to adjust for gestational weight gain and anxiety and depression, which are related to sleep duration, insomnia symptoms[31] and weight.[32] To our knowledge, no previous study has investigated the degree to which there are differential prospective effects of change in short sleep duration and symptoms of insomnia on change in BMI.

Methods

Sample

This study is based on questionnaire data from the AHUS Birth Cohort (ABC) study, which is a prospective cohort study of pregnant women giving birth at Akershus University Hospital (AHUS), Norway, in the period between November 2008 and April 2010. Eligible participants were women who were able to complete the questionnaire in Norwegian, and a total of 4662 women consented to participate. In Figure 1, the design of the study is displayed graphically.

As evident from Figure 1, this study is based on data collected postpartum, at 8 weeks (hereafter called T1) and 2 years after delivery (hereafter called T2). Also, information on weight at the time of the delivery was registered at the hospital, prior to giving birth. The rationale for including only the postpartum data is that this is sufficient for investigating the research questions of this study. All questionnaires were returned by mail. A total of 2386 women

(51% of the consenting sample) participated at T1 and 1480 (32% of the consenting sample) participated at T2. All women who were pregnant at T2 (n = 176) or had delivered another baby in the time since T1 (n = 116) were excluded from the analyses. Only complete cases were analyzed. This resulted in 812 respondents (55% of the respondents participating at T1 and T2) in the analyzed sample with complete data on all variables.

Measures

Main variables. *Sleep duration* was measured by two items from the Pittsburgh Sleep Quality Index (PSQI) asking about the approximate number of hours and minutes the respondent had slept per night during the previous month. The variables were dichotomized and the respondents sleeping <5 h were categorized as having short sleep duration, whereas the respondents sleeping >5 h were categorized as having normal sleep duration. The use of this particular cutoff simplifies comparison of the results of this study to the results of the existing studies on the relationship between postpartum weight retention and short sleep duration, as all the previous studies on the subject have compared respondents sleeping 5 h or less to respondents sleeping more than 5 h.[23] A Norwegian population-based study found that sleeping 5.5 h or less corresponds to the fifth percentile.[33] As long sleep duration (more than 9 hours) has been found to be positively correlated with BMI,[14] a curve estimation regression analysis was performed in order to investigate deviation from linearity for the effect of sleep duration on BMI. The R^2 of the functions allowing curve linearity was only marginally higher (by a difference of .001) than the R^2 of the linear regression analysis, and consequently, the respondents with long sleep duration were classified as having normal sleep duration. A categorical variable was created, combining the sleep duration responses from T1 and T2 in the following manner: (1) short sleep duration at both time points (persistent short sleep duration); (2) normal sleep duration at T1, short at T2 (incident short sleep duration); (3) short sleep duration at T1, normal at T2 (remitting short sleep duration) and (4) normal sleep duration at both time points (normal sleep duration/reference category).

Symptoms of insomnia were measured by the Bergen Insomnia Scale (BIS),[34] consisting of six items asking about the frequency of long sleep-onset latency, sleep maintenance problems, early morning awakening, non-restorative sleep, daytime impairment due to sleepiness and dissatisfaction with sleep during the previous month. Response categories ranged from "No days" to "All days." A composite score was made and dichotomized so that the top 15% of the distribution at baseline and follow-up were categorized as having symptoms of insomnia, in accordance with the reported prevalence of insomnia in the general population.[29] A categorical variable was created, combining the symptom responses from T1 and T2 in the following manner: (1) insomnia symptoms at both T1 and T2 (persistent insomnia symptoms); (2) no insomnia symptoms at T1, symptoms at T2 (incident insomnia symptoms); (3) insomnia symptoms at T1, no symptoms at T2 (remitting insomnia symptoms) and (4) no insomnia symptoms at either T1 or T2 (no insomnia symptoms/reference group). The BIS has demonstrated good psychometric properties.[34]

BMI. At T2, the respondents were asked about weight and height and about their approximate weight prior to getting pregnant with the now 2-year-old child. BMI prior to the last pregnancy was calculated from self-reported height and pregestational weight, and BMI at T2 from self-reported height and weight at T2.

Covariates. *Number of hours awake per night because of the child*. One item asked the respondent to numerically indicate how many hours she is awake per night due to the child.

Gestational weight gain was calculated from subtracting the pre-pregnancy weight from the weight registered at the hospital prior to giving birth.

Anxiety at T2 was measured by the 10 items measuring anxiety in the Hopkins Symptom Check List-25 (SCL-25). The SCL-25 is a short version of the Symptom Check List-90 (SCL-90).[35] The anxiety dimension of the SCL-25 has been found to have good psychometric properties and to reliably measure the construct.[36] Responses were given on 4-point scales ranging from "Not at all" to "Extremely." The items were summed and standardized.

Depression at T2. Symptoms of depression during the past week were measured using the Edinburgh Postnatal Depression Scale (EPDS). The EPDS is a 10-item self-rating scale designed to identify symptoms of depression after delivery.[37] The scoring of each item ranges from 0 ("Absence of symptoms") to 3 ("Maximum severity of symptoms"). The EPDS has been found to reliably measure depression[38] among both postpartum[37] and non-postpartum women.[39] A composite measure was made and standardized.

Somatic health. In order to determine the extent to which the respondents had any somatic illnesses or complaints, a dichotomous variable was created indicating the presence of coronary heart disease, high blood pressure, metabolic disorder, asthma, allergy, skin disease/eczema, musculoskeletal disorders, kidney/urinary disorders, fibromyalgia, migraine, diabetes, stomach/intestinal disorders, or cancer during the past year (at T2).

Pain at T2 was measured by six items asking whether the respondent was bothered by stomachache, back pain, pain in the arms/legs/joints, pain or problems during intercourse, headache, or chest pain at the time of the study. A dichotomous variable was created.

Physical exercise. The frequency of physical exercise during the last year was measured using a single item

assessed at T2. The responses were coded on an 8-point Likert scale, ranging from "Never" to "More than seven times per week."

Lactation. Breastfeeding was measured by asking whether the child had been breastfed in the first week and when 1–2, 3–4, 5–6, 7–8, 9–10, 11–12, 13–14, 17–20 and 21–24 months old. The responses were summed, meaning that a high value indicated having breastfed the child for a longer period of time, although there may have been periods in which the child was not breastfed (for instance, the first week).

Demographic information was collected and included age, social status (married or cohabitating versus single/widowed/divorced) at T1, and level of education (elementary school, completed high school, or higher education) at T2. Also, the respondents were asked to indicate the year of birth of children born prior to the child of the pregnancy being studied. The respondents were dichotomized into primiparous and biparous/multiparous mothers.

Statistical analyses

IBM SPSS Statistics 22 for Windows (SPSS Inc., Chicago, IL) was used for all analyses. Mean hours of nocturnal sleep, anxiety and depression for the sleep duration and insomnia symptoms groups were investigated using univariate analysis of variance (ANOVA) in SPSS. In order to describe estimated marginal mean BMI before and 2 years after the pregnancy for the sleep duration and insomnia symptom groups, multivariate analysis of covariance (ANCOVA) were conducted. The mean group differences in BMI before and 2 years after the pregnancy were adjusted by age, marital status, education, anxiety, depression, lactation, primiparity, somatic health, pain, gestational weight gain and exercise. In addition, the mean BMI for the insomnia symptoms groups was adjusted for the number of hours the respondent was awake per night due to the child, in order to avoid bias caused by being awake during the night or waking up too early due to the child.

Multivariate ANCOVAs were also conducted in two sets of analyses in order to investigate change in BMI from before pregnancy until 2 years after the pregnancy. BMI at T2 was the outcome variable, and change in sleep duration and symptoms of insomnia were predictor variables. The analyses were run in a hierarchical manner. First, the crude effect of change in sleep duration status on BMI at T2 was investigated. Next, in model 1, the effects of change in sleep duration on change in BMI were investigated by adjusting for BMI before the pregnancy, gestational weight gain, lactation, primiparity, marital status, education and age. Pregestational BMI was included as a covariate in order to obtain change statistics. The variables in model 1 were retained in all subsequent analyses. In model 2, anxiety and depression were included as covariates, whereas model 3 included somatic health problems; model 4 included pain; and model 5 included physical activity. Finally, all the variables included in models 1 through 5 were entered into the analyses, providing a fully adjusted effect of change in sleep duration status on change in BMI. The same procedure was followed for the analyses of the effects of change in symptoms of insomnia on change in BMI. The change analyses for insomnia symptoms were also adjusted for the number of hours the respondent was awake per night due to the child at T1 and T2, in addition to the variables from model 1.

Table 1. Descriptive statistics of the sample.

	M	%
Age	31.8	
Pre-pregnancy BMI	24.4	
BMI T4	24.9	
Gestational weight gain (kg)	14.5	
Married/cohabiting		95
Single		3.3
Divorced/separated		.9
Other		.8
Primary/lower secondary school		1.4
Upper secondary school		26
Higher education		72.7
Primiparity		49.4
Lactation 5–6 months postpartum		47.7
Lactation 11–12 months postpartum		28.8
Sleep duration T1 ⩽5 h		17.8
Sleep duration T1 5.1–7 hours		58.2
Sleep duration T1 7.1–9 h		22
Sleep duration T1 >9.1 h		2.1
Sleep duration T2 ⩽5 h		6.4
Sleep duration T2 5.1–7 h		60.1
Sleep duration T2 7.1–9 h		32.5
Sleep duration T2 >9.1 h		1

BMI: body mass index.

Ethics, consent and permissions

All women invited to participate were provided with written information explaining the purpose of the study and that participation was voluntary. Informed consent was obtained from all participants. This ABC study was approved by the Regional Ethics Committee for Medical Research in Norway (approval number S-08013a).

Results

Descriptive statistics

Descriptive statistics of the sample may be seen in Table 1.

Sleep duration and insomnia symptoms at T1 correlated r = −.40 (p = .000) and at T2 r = −.46 (p = .000). Mean hours of nocturnal sleep at T1 and T2 for the change in sleep

Table 2. Mean number of hours of sleep, anxiety and depression.

	Hours of sleep T1			Hours of sleep T2		
	M	SD	p	M	SD	p
			.000			.000
Persistent short sleep duration	4.38	.64	.000	4.45	.43	.000
Incident short sleep duration	6.33	.84	.049	4.56	.16	.000
Remitting short sleep duration	4.40	.56	.000	6.44	.82	.000
Normal sleep duration	6.56	1.04	Ref.	7.09	.80	Ref.
			.000			.000
Persistent insomnia symptoms	5.21	1.23	.000	6.06	1.10	.000
Incident insomnia symptoms	6.34	1.36	.490	6.29	1.06	.000
Remitting insomnia symptoms	5.24	1.10	.000	6.43	.84	.001
No insomnia symptoms	6.41	1.24	Ref.	7.06	.88	Ref.

SD: standard deviation.
Mean number of hours of sleep at T1 and T2, and anxiety and depression at T2 according to change in sleep duration and insomnia symptoms between T1 and T2.

Table 3. Mean z-score of depression and anxiety.

	Depression T2 (z-score)			Anxiety T2 (z-score)		
	M	SD	p	M	SD	p
			.000			.000
Persistent short sleep duration	.37	.85	.038	.62	1.38	.002
Incident short sleep duration	.62	1.45	.000	.66	1.61	.000
Remitting short sleep duration	.13	1.03	.007	.13	1.00	.006
Normal sleep duration	−.11	.95	Ref.	−.12	.93	Ref.
			.000			.000
Persistent insomnia symptoms	.82	1.25	.000	.72	1.38	.000
Incident insomnia symptoms	.87	1.40	.000	.95	1.61	.000
Remitting insomnia symptoms	.16	.99	.001	.19	.94	.000
No insomnia symptoms	−.22	.82	Ref.	−.22	.77	Ref.

SD: standard deviation.
Mean z-score of depression and anxiety at T2 according to change in sleep duration and insomnia symptoms between T1 and T2.

duration and insomnia symptoms groups are displayed in Table 2 and mean anxiety and depression at T2 is displayed in Table 3. All the main effects were significant.

The adjusted mean BMI before the pregnancy and 2 years postpartum are shown in Table 4. Only one significant group difference was found—the group with persistent insomnia symptoms had significantly higher BMI at T2 compared to the reference group (no insomnia symptoms at T1 or T2). All groups had increased BMI at 2 years postpartum compared to BMI prior to the pregnancy.

Relationship between change in sleep duration and change in BMI

Model-wise adjustments of the relationship between change in sleep duration and change in BMI from before until 2 years after the pregnancy were investigated using multivariate ANCOVA. The results are displayed in Table 5. The analyses did not show a significant difference in change in BMI according to change in sleep duration from 8 weeks to 2 years postpartum.

Relationship between change in symptoms of insomnia and change in BMI

The relationship between change in insomnia symptoms and change in BMI from before until 2 years after the pregnancy was investigated using multivariate ANCOVA. The results are shown in Table 6. All the main effects were highly significant. The group contrasts showed that only the group with persistent insomnia symptoms had a significantly higher increase in BMI compared to the reference group. This was true for both the crude analyses and the six models with various combinations of covariates included. Adding pain conditions in model 4 attenuated the effect the most. The incident insomnia symptom group had the second

Table 4. Mean BMI before pregnancy and 2 years postpartum.

		Pregestational BMI			BMI T2		
	N	M	SE	p	M	SE	p
				.896			.949
Persistent short sleep duration[a]	18	24.66	1.06	.821	25.44	1.14	.632
Incident short sleep duration[a]	26	23.92	.89	.599	25.13	.96	.804
Remitting short sleep duration[a]	140	24.19	.38	.587	25.04	.41	.736
Normal sleep duration[a]	628	24.42	.18	Ref.	24.88	.19	Ref.
				.554			.038
Persistent insomnia symptoms[b]	45	24.99	.69	.423	26.94	.73	.007
Incident insomnia symptoms[b]	67	23.96	.58	.460	24.66	.61	.793
Remitting insomnia symptoms[b]	75	23.98	.52	.431	24.58	.56	.638
No insomnia symptoms[b]	625	24.41	.18	Ref.	24.85	.20	Ref.

BMI: body mass index; SE: standard error.
Adjusted mean BMI pregestation and 2 years postpartum according to change in sleep duration and insomnia symptoms from 8 weeks to 2 years postpartum.
[a]Adjusted by social status, gestational weight gain, age, education, lactation, primiparity, anxiety, depression, somatic health, pain and exercise.
[b]Adjusted by number of hours awake per night due to child at T1 and T2, social status, gestational weight gain, age, education, lactation, primiparity, anxiety, depression, somatic health, pain and exercise.

highest group difference in change in BMI compared to the reference group. However, none of these group differences came close to a significant level of $p < .05$.

Discussion

Previous studies on the prospective relationship between sleep duration or insomnia symptoms and BMI in the general population have yielded inconsistent results, which has made it difficult to conclude regarding the degree to which short sleep or insomnia contributes to increasing weight over time. This study aimed at investigating the degree to which change in short sleep duration or insomnia symptoms or persistent short sleep duration or insomnia symptoms (meaning short sleep duration or insomnia symptoms at both time points) from 8 weeks to 2 years postpartum were related to change in BMI from before until 2 years postpartum. The results showed that only the women experiencing persistent insomnia symptoms postpartum were found to have a higher increase in BMI compared to the reference group.

There are several mechanisms that may explain how persistent insomnia is related to subsequent weight gain. Although causality cannot be inferred from the results of this study, the subsequent discussion will reflect upon some possible causal pathways. The significant effect of persistent insomnia symptoms on increase in BMI may suggest that the insomnia symptoms must be present over time in order to increase weight. This deduction may be logical in light of the physiological changes following sleep curtailment—elevated levels of ghrelin, a peptide that stimulates appetite, and reduced levels of leptin, a hormone that suppresses appetite.[3] Sleep deprivation has also been related to consumption of high-caloric food, irregular eating habits, snacking between meals, and reduced consumption of vegetables.[40–42] Moreover, reduced levels of leptin may cause a reduction in energy expenditure,[43] and the elevated levels of ghrelin may be associated with a decrease in non-exercise activity thermogenesis.[44] For the changes in appetite and energy expenditure to affect weight, it seems only logical to assume that the change in behavior following sleep loss must be present for a certain period of time. However, it is important to notice that we do not have information regarding the duration of symptoms of insomnia, and the results need to be interpreted with this in mind. Nonetheless, the group categorized as having persistent symptoms of insomnia scored above a predetermined cut-off at both T1 and T2, which increases the probability that they have struggled with symptoms of insomnia more frequently or persistently than the other groups.

The lack of a significant effect of persistent and incident short sleep duration was somewhat surprising, as most previous studies indicate that there is a relationship over time. On the other hand, most of the existing studies have investigated baseline sleep duration as a predictor of postpartum weight retention rather than change in sleep duration as a predictor of change in weight over time. The former methodology provides less robust evidence regarding a factual prospective relationship than the latter, as an observed change in the outcome variable (BMI) after a change in the predictor variable (sleep duration) may suggest that the predictor in fact influences the outcome variable. Also, the statistical analyses of difference scores, such as analyses of baseline sleep duration on postpartum weight retention, are more readily influenced by regression towards the mean and measurement error. As such, the lack of a significant effect in this study may weaken the evidence regarding a causal link between sleep duration and weight gain. However,

Table 5. The relationship between change in sleep duration and change in BMI.

	B	CI	p
Crude			.276
Persistent short sleep duration	1.45	−.84 to 3.74	.214
Incident short sleep duration	1.00	−.92 to 2.92	.306
Remitting short sleep duration	.61	−.29 to 1.50	.183
Normal sleep duration	0		
Model 1 (BMI before pregnancy, gestational weight gain, social status, education, maternal age, lactation and primiparity)[a]			.120
Persistent short sleep duration	.44	−.70 to 1.58	.445
Incident short sleep duration	.75	−.21 to 1.70	.124
Remitting short sleep duration	.43	−.01 to .88	.057
Normal sleep duration	0		
Model 2 (model 1 + anxiety, depression)[a]			.151
Persistent short sleep duration	.42	−.72 to 1.57	.466
Incident short sleep duration	.72	−.25 to 1.68	.145
Remitting short sleep duration	.42	−.03 to .87	.064
Normal sleep duration	0		
Model 3 (model 1 + somatic health problems)[a]			.125
Persistent short sleep duration	.44.	−.70 to 1.57	.449
Incident short sleep duration	74	−.21 to 1.70	.127
Remitting short sleep duration	.43	−.02 to .88	.058
Normal sleep duration	0		
Model 4 (model 1 + pain)[a]	.35	−.79 to 1.48	.243
Persistent short sleep duration	.66	−.29 to 1.61	.549
Incident short sleep duration	.37	−.08 to .81	.179
Remitting short sleep duration	0		.110
Normal sleep duration			
Model 5 (model 1 + physical activity)[a]			.114
Persistent short sleep duration	.41	−.72 to 1.55	.474
Incident short sleep duration	.77	−.18 to 1.73	.111
Remitting short sleep duration	.43	−.01 to .88	.056
Normal sleep duration	0		
Model 6 (model 1 + model 2 + model 3 + model 4 + model 5)[a]			.228
Persistent short sleep duration	.35	−.80 to 1.49	.552
Incident short sleep duration	.70	−.26 to 1.66	.154
Remitting short sleep duration	.37	−.08 to .82	.106
Normal sleep duration	0		

ANCOVA: analysis of covariance; CI: confidence interval; BMI: body mass index.
ANCOVA of the crude and model-wise adjusted effect of change in sleep duration between baseline and follow-up on change in BMI from before until 2 years after pregnancy.
[a]Covariates included in the model.

there are methodological aspects of this study that need to be considered. For one, this study is observational, and not experimental, which means that one cannot infer causality based on the presented results. However, as it is not possible to investigate the long-term effects of short sleep duration or change in insomnia experimentally, a prospective design provides the soundest data in terms of identifying causal links. Another limitation pertains to the fact that this study asked about nocturnal sleep duration only, which may underestimate total sleep duration in populations where napping may be common, such as women in the postpartum period. However, a study by Montgomery-Downs et al.[45] found that at 8 weeks postpartum, only about 46% of the mothers napped weekly, on average 1.6 times during a week, with a mean nap duration of 144 min per week. Therefore, it is unlikely that total sleep duration was significantly underreported. Approximately 50% of the sample were first-time mothers, and the results may be specific to the population investigated. All variables were based on self-report measures rather than on clinical diagnostic interviews or objective registrations. The self-reported weight prior to the last pregnancy, reported at T2, may be particularly susceptible to recall bias.[46] However, all expectant women in Norway are offered free prenatal examinations

Table 6. The relationship between change in insomnia status and change in BMI.

	B	CI	p
Crude			.001
Persistent insomnia symptoms	2.94	1.48–4.41	.000
Incident insomnia symptoms	.61	−.61–1.83	.329
Remitting insomnia symptoms	.07	−1.09–1.23	.907
No insomnia symptoms	0		
Model 1 (BMI before pregnancy, gestational weight gain, social status, education, maternal age, hours awake due to child T1/T2, lactation and primiparity)[a]			.001
Persistent insomnia symptoms	1.54	.80 to 2.27	.000
Incident insomnia symptoms	.21	−.40 to .82	.500
Remitting insomnia symptoms	.12	−.46 to .74	.677
No insomnia symptoms	0		
Model 2 (model 1 + anxiety, depression)[a]			.001
Persistent insomnia symptoms	1.57	.81 to 2.33	.000
Incident insomnia symptoms	.25	−.40 to .90	.447
Remitting insomnia symptoms	.14	−.45 to .72	.645
No insomnia symptoms	0		
Model 3 (model 1 + somatic health problems)[a]			.001
Persistent insomnia symptoms	1.54.	.80 to 2.27	.000
Incident insomnia symptoms	21	−.40 to .82	.502
Remitting insomnia symptoms	.12	−.46 to .70	.680
No insomnia symptoms	0		
Model 4 (model 1 + pain conditions)[a]			.002
Persistent insomnia symptoms	1.46	.73 to 2.20	.000
Incident insomnia symptoms	.14	−.47 to .75	.647
Remitting insomnia symptoms	.07	−.51 to .65	.820
No insomnia symptoms	0		
Model 5 (model 1 + physical exercise)[a]			.001
Persistent insomnia symptoms	1.56	.83 to 2.30	.000
Incident insomnia symptoms	.22	−.39 to .83	.475
Remitting insomnia symptoms	.15	−.43 to .73	.617
No insomnia symptoms	0		
Model 6 (model 1 + model 2 + model 3 + model 4 + model 5)[a]			.001
Persistent insomnia symptoms	1.56	.80 to 2.32	.000
Incident insomnia symptoms	.25	−.40 to .90	.450
Remitting insomnia symptoms	.12	−.46 to .71	.681
No insomnia symptoms	0		

ANCOVA: analysis of covariance; CI: confidence interval; BMI: body mass index.
ANCOVA of the crude and model-wise adjusted effect of change in symptoms of insomnia between baseline and follow-up on change in BMI from before until 2 years after pregnancy.
[a]Covariates included in the model.

from their general practitioner or a midwife, at which weight prior to the pregnancy, as well as weight at each prenatal examination, is registered. Thus, women who have given birth have at one point been aware of their pregestational weight. This means that remembering one's pregestational weight ought to be easier than remembering one's weight at any other time 3 years later. Shift-working women were not excluded from the study, nor were women diagnosed with a sleep disorder, which means that the variance in weight caused by shift-work or previous sleep disorders is not accounted for and the results need to be interpreted with this in mind. Also, we were unable to adjust for chronotype and sleep need, which may have influenced the results somewhat. However, the inclusion of a number of potentially influential covariates limits the degree to which the effects are confounded by other factors.

Sleep duration was measured by a single item from the PSQI. Single-item measures are generally considered to be less valid than more extensive measures, and although the sleep duration item from the PSQI has not been shown to correlate very highly with polysomnographic data, it corresponds well with sleep diaries, which is a tool commonly used in screening for sleep difficulties.[47] Although insomnia symptoms also were based on self-report, the BIS is a well-validated instrument, which has been shown to correspond well with polysomnographic sleep registration.[34]

However, the BIS has not been validated for postpartum insomnia symptoms.

There is a significant overlap between those who report insomnia and those who report short sleep duration,[33] but it is important to distinguish between these two groups. A diagnosis of insomnia requires sleep disturbance despite adequate opportunity and circumstances for sleep, in addition to the diagnostic criteria of difficulty falling asleep and maintaining sleep.[48] As such, voluntary or enforced sleep loss, such as sleep loss due to caring for or feeding a child, is not the same as sleep loss caused by insomnia. Distinguishing between short sleep duration and insomnia is also important when studying their respective consequences. For instance, whereas sleep deprivation has been consistently linked to poor neuropsychological performance,[49] the association is much less clear in the case of insomnia.[50] However, the consequences of insomnia on neuropsychological performance seem to be subtler and qualitatively different from the effects of sleep loss.[50] Beyond separating the effects of short sleep duration and insomnia, the estimates of change in BMI for insomnia symptoms were adjusted for the number of hours the mother was awake due to the child. This is an advantage, as it helps provide a distinction in the effects of change in sleep duration and change in insomnia symptoms on change in BMI, as well as removing the potentially confounding effect of being awake due to the child.

Conclusion

In conclusion, the results of our study indicate that persistent insomnia symptoms are related to a greater increase in BMI. Women in the postpartum period experiencing symptoms of insomnia may thus benefit from interventions targeting the insomnia, in order to prevent weight gain. However, there seems to be differential effects of insomnia compared to short sleep duration, as neither incident nor persistent short sleep duration was related to a higher increase in weight compared to the reference group. The existing studies on the prospective relationship have used a less sound methodology, and as such, the results of this study may cast doubt upon the existing evidence regarding a causal link between short sleep duration and subsequent weight gain. More research that includes data on change in sleep and weight over time is needed in order to gain additional knowledge and understanding of this particular relationship.

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