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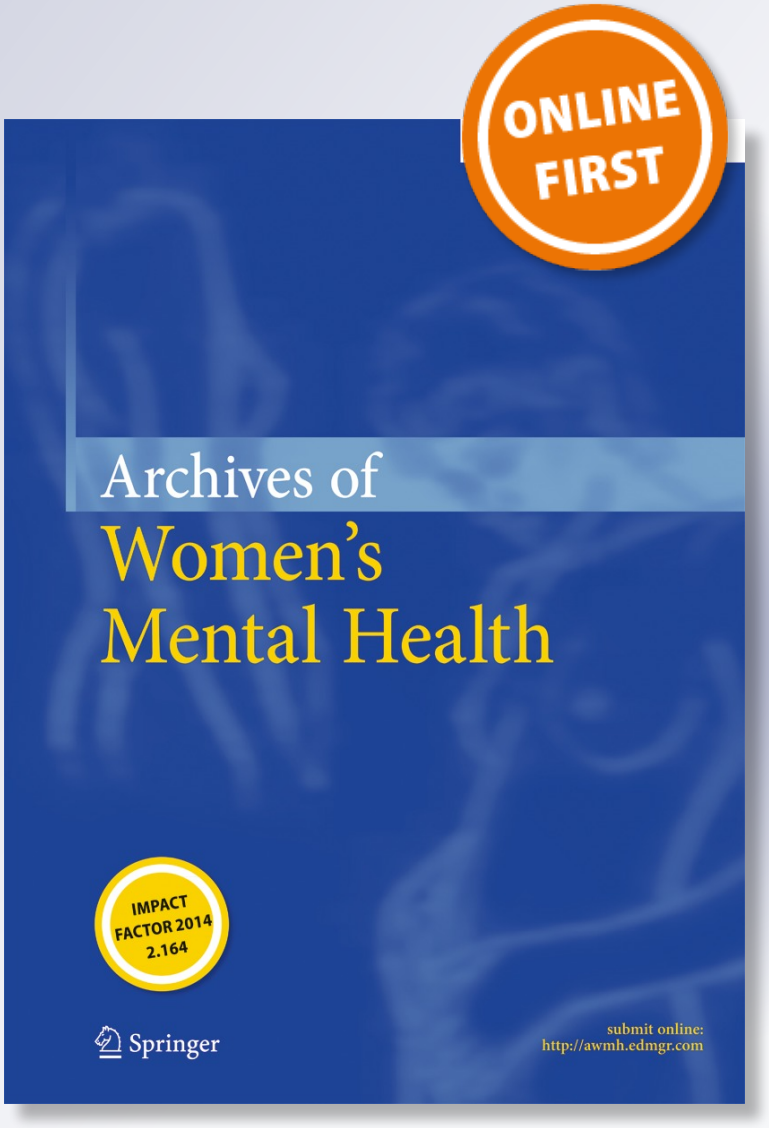
Archives of Women's Mental Health
Official Journal of the Section on Women's Health of the World Psychiatric Association

ISSN 1434-1816

Arch Womens Ment Health
DOI 10.1007/s00737-015-0554-8



Springer

Arch Womens Ment Health
DOI 10.1007/s00737-015-0554-8

ORIGINAL ARTICLE

Objective and subjective sleep during pregnancy: links with depressive and anxiety symptoms

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Received: 25 February 2015 / Accepted: 8 July 2015

Abstract The aims of this paper are to study the associations between objective and subjective sleep in pregnant women, to examine which specific aspects of women's sleep are associated with depressive and anxiety symptoms and to test the moderating role of depressive and anxiety symptoms in the relations between objective and subjective sleep. The sample included 148 pregnant women. Objective sleep was measured by actigraphy for five nights at the participants' home, and subjective sleep was measured with the Pittsburgh sleep quality index. Depressive symptoms were assessed with the Edinburgh postnatal depression scale and anxiety symptoms with the Beck anxiety inventory. Significant associations were found between the subjective sleep measures and the depressive and anxiety scores, but there were no significant associations between actigraphic sleep measures and the depressive and anxiety scores. Depressive and anxiety scores emerged as significant moderators of the links between objective and subjective sleep. The findings suggest that emotional distress (i.e., depressive and anxiety symptoms severity) during pregnancy is associated with subjective sleep disturbances but not with objective sleep disturbances. Importantly, only among women with higher levels of emotional distress was subjective sleep quality associated with objective sleep quality. These findings may suggest that women with higher levels of emotional distress are not necessarily biased in their perception of sleep quality. However, they may perceive fragmented sleep as more detrimental to their wellbeing.

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Keywords Sleep · Women · Pregnancy · Actigraphy · Depression · Anxiety

Introduction

Pregnancy is characterized by substantial changes in sleep patterns, such as increased frequency of insomnia symptoms, including night-wakings, daytime fatigue, and in some cases, also difficulties falling asleep and waking up too early in the morning (Manber et al. 2013; Mindell and Jacobson 2000; Skouteris et al. 2009a; Tsai et al. 2012). Although most of the studies in this field are based on self-reported measures of sleep, studies that used objective sleep measures, such as actigraphy and polysomnography (PSG), support these findings and suggest that in comparison to nonpregnant women, pregnant women have lower sleep efficiency, more frequent night-wakings and longer night-wakings and spend more time in light sleep and less time in deep sleep and REM sleep (Hertz et al. 1992; Wilson et al. 2011).

Research on pregnant women's mental health in relation to sleep consistently demonstrates that self-reported poor sleep of pregnant women is concurrently and prospectively associated with higher depressive symptoms during pregnancy (Manber et al. 2013; Skouteris et al. 2008; Skouteris et al. 2009a; Swanson et al. 2011). In contrast, relatively few studies examined, in addition to the subjective links, the links between objective measures of sleep and mood during pregnancy. These studies have generally failed to find significant associations (Bei et al. 2010; Coo et al. 2013; Park et al. 2013; Wilson et al. 2011). There are probably multiple reasons for the discrepancy in findings between the studies using subjective and objective methods to assess sleep in relation to emotional distress. First, most of the studies using objective sleep measures included relatively small samples and hence had low

Published online: 08 August 2015

statistical power. Second, studies based on self-report are limited by the possibility that shared method variance inflate the observed associations (Werner et al. 2008; Wilson et al. 2013). Third, the discrepancy in the findings between these two lines of research might be due, in part, to low agreement between objective and subjective measures of sleep. Indeed, past research has found varying levels of agreement between subjective and objective sleep measures depending on the population studied, with respect to age and level and type of sleep disturbance (Baker et al. 1999; Pinto et al. 2009; Tikotzky and Sadeh 2001). To the best of our knowledge, only one study assessed the agreement between objective and self-reported sleep during pregnancy; this study found that at the beginning and end of pregnancy, pregnant women were inaccurate in their estimations of sleep latency and total sleep time as compared to Polysomnography (PSG) (Wilson et al. 2013). For further understanding of the discrepancies in findings, the triadic relationships between objective sleep, subjective sleep, and emotional distress during pregnancy should be examined. For example, a study of insomnia patients not including pregnant women found complex interactions between these three variables (Edinger et al. 2000). The importance of studying the relationship between sleep and emotional distress during pregnancy is underscored by the high prevalence of depression during pregnancy and the risks associated with maternal poor sleep, in addition to the possible influence of prenatal depression and anxiety on infant and child development and on the mother-infant relationship (Field 2011; Kinsella and Monk 2009).

Aims of the present study

Although there is evidence for a deterioration of both objectively and subjectively measured sleep during pregnancy, very few studies directly compared the clinical relevance of objectively and subjectively defined poor sleep during this period. Incongruence between objective and subjective findings needs to be further explored to identify to what extent the links between emotional distress (i.e., depressive and anxiety symptoms) and sleep are related to the method of sleep measurement. Thus, our aims were (a) to assess and evaluate the agreement between objective and subjective sleep (using actigraphy and a sleep questionnaire) in a relatively large sample of pregnant women (n=148); (b) to explore whether the relationship between poor sleep and emotional distress during pregnancy is different for self-reported compared to objective measures of sleep; and (c) to examine the triadic relationships between objective sleep, subjective sleep, and emotional distress. Particularly, we aimed at assessing whether emotional distress moderates the relationship between objective and subjective sleep.

Methods

Participants and procedure

One hundred and forty-eight pregnant women expecting their first child were recruited during their third trimester of pregnancy through childbirth preparation classes, announcements on Internet forums for expectant parents, and social networks. Inclusion criteria were (1) two-parent families expecting their first child and (2) singleton pregnancy. Participants were excluded if they had a chronic health condition (by self-report).

The study was approved by a hospital's Helsinki committee. All women signed informed consent before assessment. A research assistant visited the participants during the third trimester of pregnancy (weeks 34–37) and instructed them about actigraphy use and questionnaire completion. After completing the assessments, participants received a graphic report of their actigraphic sleep and a small gift (value of about $20).

Measures

Sleep assessment

Actigraphy Actigraphy has been established as a valid and reliable method for studying and assessing sleep-wake patterns in adults (Ancoli-Israel et al. 2003). The actigraph is a miniature wristwatch-like device attached to the adult's wrist during the recording period. The device records movement continuously for extended period of time with minimal disruption of ongoing sleep in the subject's natural environment. In the present study, we used the micro motion logger sleep watch (Ambulatory Monitoring Inc., Ardsley, New York) with a 1-min epoch interval according to the standard mode for sleep-wake scoring. Data were analyzed with Sadeh's scoring algorithm (Sadeh et al. 1994). Sleep diaries were used to identify possible actigraphy errors and artifacts. Participants were asked to attach the actigraph to their nondominant hand 15 min before they went to sleep and to take it off 15 min after morning awakening. Actigraphic sleep measures included in the study: (1) night duration—from sleep onset to morning awakening marked by the end of the last sleep segment (15 min of continuous sleep), (2) sleep percent—percentage of true sleep time (excluding nighttime wakefulness) relative to night duration, and (3) number of night-wakings (lasting 5 min or longer). Each of the actigraphy variables was averaged across five non-weekend nights of assessment. To evaluate the reliability of using a mean over five-night, we calculated the intraclass correlations for each actigraphic variable (Winer 1971). The intraclass correlations for all three variables reflect adequate reliability (Acebo et al. 1999): night duration=.69; sleep percent=.84; number of night-wakings=.79.

The Pittsburgh sleep quality index (Buysse et al. 1989) The Pittsburgh sleep quality index is a validated self-rated questionnaire which assesses sleep quality and disturbances over a 1-month time interval. Seven component scores were generated from 19 individual items: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The seven component scores of the PSQI show an overall reliability coefficient (Cronbach's α) of 0.83 indicating a high degree of internal consistency (Buysse et al. 1989). The sum of scores for these seven components yields one global PSQI score. A global PSQI score >5 indicates sleep disturbance (Buysse et al. 1989). The PSQI has been used before in pregnant women and shows good internal consistency and construct validity in this population (Skouteris et al. 2009a). The use of sleep medication component was not included in the analyses because of zero means. In the present study, the global score of the PSQI showed an overall reliability coefficient (Cronbach's α) of 0.70.

Assessment of emotional distress

The Edinburgh postnatal depression scale (Cox et al. 1987) Originally developed and validated as a screen for postnatal depression, the Edinburgh postnatal depression scale (EDPS) has been validated for use during pregnancy (Bergink et al. 2011). The scale consists of ten short statements asking about depressive symptoms during the past week. Scores range from 0 to 30 with a higher score (after reversal of several items) representing greater depressive symptom severity. In the present sample, Cronbach's α was 0.8.

Beck anxiety inventory (Beck et al. 1988) The BAI was developed to address the need for an instrument that would reliably discriminate anxiety from depression. The BAI consists of 21 questions about how the subject has been feeling in the last week. All items are rated on a four-point scale ranging from 0 (not at all) to 3 (severely, I could barely stand it). Most items describe physiological symptoms, five describe cognitive aspects of anxiety and three items have a physical as well as a cognitive component (Fydrich et al. 1992). The questionnaire shows high internal consistency (α = .92). In our study, Cronbach's α was 0.9.

Background questionnaire

Participants were also asked to complete a background questionnaire assessing the expecting parents' age, education, employment status, and number of rooms at home.

Data analysis

Pearson product-moment correlation coefficients were used to examine the associations between actigraphic sleep measures and the emotional distress measures (EPDS, BAI). The associations between the PSQI factor and emotional distress measures were examined with Spearman rank order correlations. Two-step hierarchical multiple regressions were conducted in order to test whether EPDS and BAI scores moderate the relationship between subjective (PSQI) and objective (actigraphy) sleep measures. Statistical significance was set to a P value lower than 0.05.

Results

Sample characteristics

The mean age of the women was 29.0 years (SD=3.0; range=22–39 years). Mean participants' education was 15.7 years (SD=2.3; range=12–22 years). Eighty percent of the participants were employed at the time of the assessment (52.9 % were fully employed and 27.1% worked part-time). Two women were excluded from the analyses due to incomplete actigraphic data (measurement of only two nights). Half (50.3%) of the pregnant women experienced poor sleep quality, defined as PSQI global score >5. According to actigraphy, 45% of the women were awake on average more than 30 min during the night and 27% had an average of more than three night-wakings that lasted at least 5 min per night. Means, standard deviations, and ranges of sleep measures and emotional distress (EPDS and BAI) are presented in Table 1.

Correlations between the sleep measures

Table 2 summarizes the correlations between actigraphic sleep measures and the PSQI components. Statistically significant correlations were found between the number of actigraphic night-wakings and three PSQI components (sleep efficiency, night duration, and sleep quality). Significant correlations were also found between actigraphic sleep percent and the sleep disturbances component of the PSQI and between actigraphic night duration and the PSQI night duration component.

Sleep and emotional distress

Demographic variables

To test whether any demographic variables should be controlled for in the analyses of the links between sleep and

Table 1 Descriptive statistics of sleep measures and depressive and anxiety scores (N=146)

	Mean±SD	Range
Sleep		
Actigraphic night duration (hour)	7.40 (.91)	5.15–10.05
Number of actigraphic night-wakings	2.33 (1.4)	0–8.33
Actigraphic sleep percent (%)	91.79 (7.0)	55.6–99.43
Sum PSQI	5.7 (2.7)	1–14
Emotional distress		
EPDS	4.74 (3.9)	0–15
BAI	7.27 (6.4)	0–37

Night duration refers to the number of hours from sleep onset until morning wake-up, *night-wakings* refers to the number of night-wakings lasting 5 min or longer, *sleep percent* refers to the percent of sleep minutes during the night relative to night duration

PSQI Pittsburgh sleep quality index, *EPDS* Edinburgh postnatal depression scale, *BAI* Beck anxiety inventory

emotional distress, we examined the correlations between the demographic variables (i.e., participants' age, education, pregnancy week, and number of rooms at home) and the sleep and emotional distress measures. As none of these variables was correlated with the emotional distress measures or sleep measures, they were not controlled for in further analyses.

Correlations between emotional distress (EPDS, BAI) and sleep measures

None of the actigraphic sleep measures was significantly correlated with the EPDS or BAI scores (all P values >.29). However, PSQI global score and sleep disturbance, daytime dysfunction, and sleep quality component scores were statistically significantly correlated with the EPDS and the BAI in the expected direction (i.e., poorer sleep was associated with higher depressive and anxiety symptom severity scores). The PSQI sleep latency component was significantly correlated with a higher BAI score but not with higher EDPS scores. The correlations between the sleep and emotional distress measures are presented in Table 3.

Emotional distress as a moderator of the links between subjective and objective sleep

To examine whether the link between subjective and objective sleep is moderated by EPDS and BAI scores, we followed the process recommended by Aiken (Aiken and West 1991) and conducted a series of two-step hierarchical multiple regression models, each predicting a global PSQI score. To test if EPDS was a moderator of the relationship between actigraphic sleep percent and global PSQI score, we first entered EPDS and actigraphic sleep percent as predictors (step 1) and then entered EPDS, actigraphic sleep percent, and their interaction term (step 2). Similar models were conducted separately to examine if EDPS moderates the relationship between the two other actigraphic sleep parameters (i.e., the number of night-wakings and night duration) and PSQI. We used the same procedures to examine if BAI moderates the relationships between each of the three actigraphic sleep measures and PSQI scores. All variables were centered prior to computing the interaction term. The results are summarized in Table 4. As the results for EPDS and BAI were similar, we use the term "emotional distress" to describe the findings for

Table 2 Spearman correlations between actigraphic sleep measures and PSQI components/global score (N=144)

		PSQI						
		Sleep disturbance	Sleep latency	Sleep efficiency	Daytime dysfunction	Night duration	Sleep quality	Sum PSQI
Actigraphy	1. Night duration (H)	.07	.10	.10	−.15	.54**	−.04	−.08
	2. Night-wakings	.25**	.03	.17*	.02	.18*	.22**	.15
	3. Sleep percent (%)	−.20*	−.06	−.12	−.05	−.07	−.16	−.12

Actigraphy: night duration refers to the number of hours from sleep onset until morning wake-up, *night-wakings* refers to the number of night-wakings lasting 5 min or longer, *sleep percent* refers to the percentage of sleep minutes during the night relative to night duration

PSQI Pittsburgh sleep quality index

*P<.05; **P<.005

Table 3 Correlations between sleep measures and depressive and anxiety scores (N=144)

		BAI	EPDS
Actigraphy	1. Night duration (H)	.04	−.07
	2. Night-wakings	.09	.04
	3. Sleep percent (%)	−.05	−.02
PSQI[a]	4. Sleep disturbance	.42**	.34**
	5. Sleep latency	.22*	.15
	6. Sleep efficiency	.15	.04
	7. Daytime dysfunction	.38**	.52**
	8. Night duration	.04	−.04
	9. Sleep quality	.31**	.26**
	10. Global PSQI	.40*	.35**

Actigraphy: night duration refers to the number of hours from sleep onset until morning wake-up, *night-wakings* refers to the number of night-wakings lasting 5 min or longer, *sleep percent* refers to the percent of sleep minutes during the night relative to night duration

PSQI Pittsburgh sleep quality index, *EPDS* Edinburgh postnatal depression scale, *BAI* Beck anxiety inventory

*P<.05; **P<.005

[a] Spearman correlation for PSQI measures and emotional distress measures

both measures. For actigraphic sleep percent and night-wakings (but not for sleep duration), the interaction term added significant and unique explanation of the variance over the previous step of the model. This means that the association between actigraphic sleep and the PSQI was different for women with higher and lower emotional distress scores.

Significant interactions were plotted (i.e., graphed) by using high (one standard deviation above the mean) and low (one standard deviation below the mean) values for the moderator (depressive/anxiety score) and actigraphic sleep measures. Slopes in the graphs were examined to determine whether they were significantly different from zero (Aiken and West 1991). As illustrated in Fig. 1, for women with higher emotional distress scores (1 SD above the mean), but not for women with lower emotional distress scores (1 SD below the mean), lower actigraphic sleep percent was associated with a higher PSQI score. Similarly, for women with higher emotional distress scores, but not for women with lower emotional distress scores, a higher number of actigraphic night-wakings was associated with a higher PSQI score.

Discussion

This study has comprehensively assessed the relationships between objective and subjective sleep and emotional distress in women during the third trimester of pregnancy. Moreover, to the best of our knowledge, this is the first study to examine the role of anxiety and depressive symptoms as moderators of the links between objective and subjective sleep during pregnancy. Interestingly, we found that only when objective sleep quality was relatively low, women with higher levels of emotional distress perceived their sleep as more disturbed than women with lower emotional distress. When objective sleep quality was high, however, there was no significant difference in subjective perception of sleep between women with higher and lower emotional distress.

Objective and subjective sleep in pregnant women

Consistent with previous reports of high prevalence of subjectively disturbed sleep during the third trimester, including previous studies using the PSQI in pregnant women (Facco et al. 2010; Skouteris et al. 2009a), we found that 50.3% of third trimester pregnant women in our sample reported poor sleep quality (defined as global PSQI >5). We also found that according to actigraphy, 45% of the women were awake on average more than 30 min during the night and 27% had an average of more than three night-wakings per night. Although many women in our sample experienced poor subjective and objective sleep, the agreement between the two methods of assessment was generally low. Low agreement between the PSQI and objective sleep measures was previously observed in a general community sample, using actigraphy and polysomnography (Buysse et al. 2008). The low agreement is likely related to the fact that whereas actigraphy measures sleep in real time over several nights, the PSQI asks women to retrospectively rate their sleep during the last month. Retrospective recall and global assessment may hinder accuracy, as it could be impacted by a memorable particularly bad night and other reporting biases.

Sleep and emotional distress

Our findings revealed that emotional distress (i.e., anxiety and depressive symptom severity) was significantly associated with self-reported sleep disturbances. Links between subjective sleep and negative mood were previously found in non-pregnant samples (Alvaro et al. 2013; Manber and Chambers 2009), as well as among pregnant (Manber et al. 2013; Skouteris et al. 2008; Skouteris et al. 2009a) and postpartum (Goyal et al. 2009; Wolfson et al. 2003) women. However, links between objective sleep disturbances and the two measures of emotional distress in the present study were not significant. This finding from our relatively large sample of pregnant women confirms a similar finding from smaller studies of sleep and mood during pregnancy (Bei et al. 2010; Coo et al. 2013; Park et al. 2013). Thus, our findings suggest that emotional distress during pregnancy is associated with subjective sleep but not with objective sleep.

The components of the PSQI that were most strongly associated with anxiety and depressive symptoms were sleep

Table 4 Hierarchical multiple regression models testing the moderating effects of EDPS and BAI on the relationship between objective (the three actigraphic sleep measures) and subjective sleep (PSQI global score)

	Step	Predictor	Total adj R^2	ΔR^2	β	F (3, 142)
Model 1 night-duration and EPDS	Step 1	Night duration EPDS	.09	0	−.03 −.33***	5.9***
	Step 2	Night duration			−.05	
		EPDS			.33***	
		Night duration X EPDS			−.02	
Model 2 night-wakings and EPDS	Step 1	Night-wakings EPDS	.15	.03*	.17*** .33*	9.6***
	Step 2	Night-wakings			.17*	
		EPDS			.32***	
		Night-wakings X EPDS			.17*	
Model 3 sleep percent and EPDS	Step 1	Sleep percent EPDS	.16	.039*	−.15 .33***	9.82 ***
	Step 2	Sleep percent			−.19*	
		EPDS			.33***	
		Sleep percent X EPDS			−.20**	
Model 4 night-duration and BAI	Step 1	Night duration BAI	.15	0	−.08 .38***	8.2***
	Step 2	Night duration			−.07	
		BAI			.37***	
		Night duration X BAI			.08	
Model 5 night-wakings and BAI	Step 1	Night-wakings BAI	.17	.025*	.15 .36***	10.5***
	Step 2	Night-wakings			.15*	
		BAI			.33***	
		Night-wakings X BAI			.16*	
Model 6 sleep percent and BAI	Step 1	Sleep percent BAI	.20	.042**	−.14 .37***	11.6***
	Step 2	Sleep percent			−.17*	
		BAI			.35***	
		Sleep percent X BAI			−.20**	

Actigraphy: night duration refers to the number of hours from sleep onset until morning wake-up, *night-wakings* refers to the number of night-wakings lasting 5 min or longer, *sleep percent* refers to the percent of sleep minutes during the night relative to night duration

EPDS Edinburgh postnatal depression scale, *BAI* Beck anxiety inventory

*P<.05; **P<.005

disturbance, daytime dysfunction, and sleep quality. These components reflect purely subjective aspects of sleep-related experiences and tap into symptoms of insomnia disorder (Lacks and Morin 1992). On the other hand, PSQI components that are more quantitative in nature, such as sleep efficiency, were not associated with depressive and anxiety symptoms in the present study. The fact that the correlations between emotional distress and the different aspects of subjective sleep, as assessed by the PSQI, varied in strength suggests that the findings are not merely a result of a self-report bias but probably reflect the complexity of the relations between sleep and emotional distress in pregnant women.

Emotional distress as a moderator of the links between objective and subjective sleep

To further elucidate the reason for the low agreement between objective and subjective sleep, we examined the moderating role that emotional distress may have on the links between these two different sleep assessment methods. Our moderation analyses revealed that only among women with higher levels of emotional distress was subjective sleep quality associated with objective sleep quality. These women were more likely to perceive their sleep as poorer when their objective sleep quality was low (i.e., low sleep percent and high number of night-

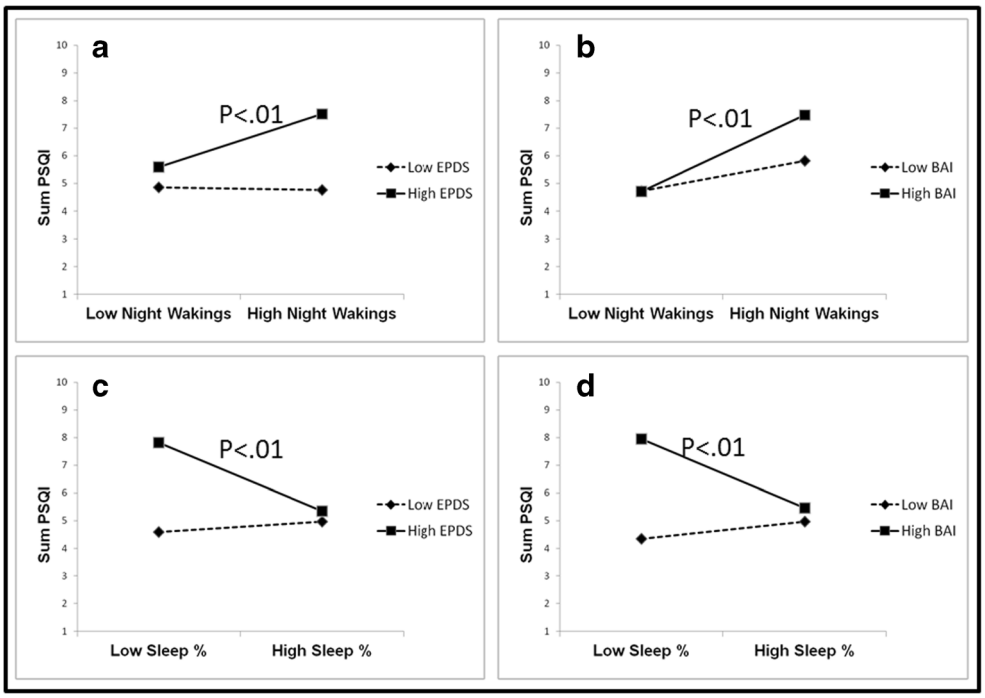

Fig. 1 Depressive (EPDS) and anxiety (BAI) scores as moderators of the associations between actigraphic sleep measures and PSQI global score. Actigraphic sleep variables are depicted on the X-axis, PSQI global sleep score is presented on the Y-axis. **a** EPDS as moderator of the association between actigraphic night-wakings and global PSQI. **b** BAI as moderator of the association between actigraphic night-wakings and global PSQI. **c** EPDS as moderator the association between actigraphic sleep percent and global PSQI. **d** BAI as moderator of the association between actigraphic sleep percent and global PSQI. For slopes that were significantly different from zero, the *P* value is presented next to the slope

wakings). In contrast, among women with lower levels of emotional distress, subjective sleep was not associated with these same two objective sleep parameters that assess sleep quality. This could suggest that women with higher emotional distress are not necessarily biased in their perception of sleep quality and they may even have a more accurate perception of their sleep disturbances than women who are lower on emotional distress. However, women with higher emotional distress may perceive night-wakings as more detrimental to their wellbeing, whereas women with lower emotional distress are possibly less likely to experience their night-wakings as a factor that has negative implications on their functioning.

Whereas the relationship between sleep and depression during the perinatal period has received substantial attention, less is known about the relationship between sleep and anxiety during this period (Paul et al. 2013). Our findings that anxiety symptoms are related to sleep in a manner similar to depressive symptoms extend results from past research and are of clinical importance. Anxiety symptoms have high prevalence during pregnancy and the interrelation with depressive symptoms among pregnant women is also high (Skouteris et al. 2009b). It is therefore important that research on mood and sleep during pregnancy includes measures of anxiety.

Limitations and future directions

This study has some limitations that need to be considered. The sample characteristics (e.g., medium to high socioeconomic status, expecting a first child, and relatively low incidence of women scoring in the clinical range of depression) limit the generalizability of the results. Results from our study may also not generalize to earlier stages of pregnancy since we focused on late pregnancy. Moreover, the correlational nature of the study precludes inferring about causality. To address these limitations, future research should include longitudinal and intervention studies with more diverse samples that ideally include the entire perinatal period. For example, it would be important to examine whether pregnant women suffering concomitantly from sleep disturbances and depressive and anxiety symptoms could benefit from short interventions targeted at ameliorating all three symptoms during pregnancy. One type of intervention that may be safe and effective is cognitive behavioral therapy for insomnia. This brief therapy has been established as an effective treatment for primary insomnia (Edinger et al. 2001) and insomnia comorbid with MDD (Manber et al. 2008). In addition to its focus on improving sleep, cognitive behavioral therapy for insomnia also addresses emotional reactions to and cognitions about poor sleep. However, its efficacy in pregnant women is still unknown.

Our study focused on pregnant women because of the high prevalence of sleep disturbances reported in this population, and in light of the possible adverse effects, maternal prenatal depression and anxiety may have on child development and on the mother-infant relationship. Nevertheless, the moderating role emotional distress seems to have in the relationship between objective and subjective sleep may not be specific to pregnant women and should be investigated in other populations as well. This could help in clarifying the inconsistencies found in previous studies regarding the links between emotional distress and subjective versus objective sleep.

Acknowledgments This study was supported by a grant from the Israel Science Foundation (grant number 1075/10).

The authors wish to thank all participating women. We are thankful to all the students who helped with data collection and to Dr. David Hamburger for his helpful comments.

Conflict of interests Dr. Manber receives Royalties from New Harbinger. Other authors have no conflict of interest to disclose.

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