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Original Article

Longitudinal associations between sleep and anxiety during pregnancy, and the moderating effect of resilience, using parallel process latent growth curve models

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Background: For many women, pregnancy-related sleep disturbances and pregnancy-related anxiety change as pregnancy progresses and both are associated with lower maternal quality of life and less favorable birth outcomes. Thus, the interplay between these two problems across pregnancy is of interest. In addition, psychological resilience may explain individual differences in this association, as it may promote coping with both sleep disturbances and anxiety, and thereby reduce their mutual effects. Therefore, the aim of the current study was to examine whether sleep quality and sleep duration, and changes in sleep are associated with the level of and changes in anxiety during pregnancy. Furthermore, the study tested the moderating effect of resilience on these associations.

Methods: At gestational weeks 14, 24, and 34, 532 pregnant women from the FinnBrain Birth Cohort Study in Finland filled out questionnaires on general sleep quality, sleep duration and pregnancy-related anxiety; resilience was assessed in week 14.

Results: Parallel process latent growth curve models showed that shorter initial sleep duration predicted a higher initial level of anxiety, and a higher initial anxiety level predicted a faster shortening of sleep duration. Changes in sleep duration and changes in anxiety over the course of pregnancy were not related. The predicted moderating effect of resilience was not found.

Conclusions: The results suggested that pregnant women reporting anxiety problems should also be screened for sleeping problems, and vice versa, because women who experienced one of these pregnancy-related problems were also at risk of experiencing or developing the other problem.

1. Introduction

For many women, pregnancy is a period associated with sleep disturbances [1,2] as well as pregnancy-related anxiety and worries [3]. These pregnancy-related problems seem to be more contextually based than sleeping problems and anxiety in non-pregnant

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populations [4,5]. For example, during pregnancy, sleep may be affected by nocturnal urination or unpleasant sleeping positions, and pregnancy-related anxiety and worries may be enhanced by experiences such as ultrasound measures. Research indicates that both poor sleep and high levels of pregnancy-related anxiety can negatively affect maternal wellbeing and health, as well as birth outcomes; moreover, prenatal anxiety can also have long-lasting effects on the child's development after birth [4,6–8]. It can therefore be assumed that concomitant severe sleep disturbances and high levels of anxiety are detrimental for the health of both the mother and her child. To understand which of both problems is driving the other – if any – and which therefore should be addressed first to prevent the negative effects related to both problems, it is important to investigate how both types of complaints are associated with each other and whether they are mutually aggravating. Furthermore, it is important to identify factors that moderate the mutual influences of sleep and anxiety. Resilience, defined as a general capacity to cope with adverse situations, may constitute such a factor. Both resiliency to the effects of poor sleep and resiliency to the effects of pregnancy-related anxiety may explain individual differences in the association between sleep and anxiety during pregnancy. To gain more insight into the mutual relation between sleep disturbances and pregnancy-related anxiety, and the potentially mitigating effect of resilience, the current study addressed their associations longitudinally during pregnancy.

Both sleep and pregnancy-related anxiety change over time during the pregnancy period. Previous research has consistently reported an increase in fragmentation of nighttime sleep, and worsening of general sleep quality from the second trimester onwards [1,9–12]. However, studies have also found that at least some women report consistently stable, poor sleep quality throughout pregnancy [13]. For sleep duration, several studies have reported an initial lengthening in the first trimester, after which it shortens during the rest of pregnancy [9,11,14]. Others, however, have found no change in sleep duration [12].

With respect to the trajectories of pregnancy-related anxiety, Blair et al. [15] reported a decrease in pregnancy-specific anxiety during the second and third trimesters of pregnancy, while others have found that pregnancy-related anxiety is stable throughout pregnancy [16,17]. However, specific aspects, such as fear of giving birth, might increase [16] or decrease [17] as pregnancy progresses. Since both sleep and pregnancy-related anxiety can change during the course of pregnancy, it is of interest to examine whether and how the two are related.

Although the associations between sleep and anxiety during pregnancy have not been tested, studies in non-pregnant samples suggest a bidirectional relationship between sleep and anxiety. For instance, Jansson-Fröjmark and Lindblom [18] showed in a general population sample that high anxiety predicted new cases of insomnia 1 year later, and insomnia predicted new episodes of high anxiety after 1 year. Doane et al. [19] found that subjective sleeping problems at the end of high school predicted anxiety in the fall of the first year of college, and that anxiety in fall of the first year of college predicted sleeping problems in the subsequent spring. However, these findings may not extend to pregnant women, since sleep and anxiety during pregnancy differ from sleep and anxiety during other time periods. Also, whether the trajectories of sleep and anxiety during pregnancy are related to each other, or whether the initial level of one is related to distinct trajectories in the other and vice versa have not been studied. Therefore, the first aim of this study was to assess whether the level of and changes in sleep disturbances during pregnancy are related to the level of and changes in pregnancy-related anxiety.

The second aim was to examine whether psychological resilience could buffer against a potential mutual influence of sleep disturbances and pregnancy-related anxiety. Resilience is the ability to properly adapt to adverse situations. Characteristics of resilience include a sense of control, commitment, self-efficacy, and dispositional optimism [20,21]. Lobel et al. [22] reported that optimism has a protecting effect against prenatal anxiety. Furthermore, McDonald et al. [23] showed that dispositional optimism buffers the effect of anxiety on preterm birth. These findings suggest that aspects of resilience may not only protect against anxiety, but also buffer against the negative effects of anxiety on other processes. Following this line of reasoning, resilience may buffer the mutual influences of sleep and anxiety during pregnancy, and explain individual differences in the association between sleep and anxiety.

To address these two study aims, this study focused on two sleep aspects – general sleep quality and sleep duration – and on pregnancy-related anxiety. No research has been found that studied the mutual relationship between the development of sleep disturbances and that of pregnancy-related anxiety in parallel. Therefore, the current study applied an exploratory approach in statistical analyses, and expected no specific direction in the relationship between sleep and anxiety measures. In contrast, previous research supports beneficial effects of resilience during pregnancy. Therefore, it was expected that high resilience may buffer against the effect of one difficulty on the other (ie, of sleep disturbances on anxiety, and vice versa).

2. Material and methods

2.1. Participants

The study population was derived from the FinnBrain Birth Cohort Study that follows families throughout pregnancy and years thereafter. Recruitment took place between December 2011 and June 2015. Pregnant women were informed of the study after their first ultrasound at gestational week (gwk) 12. Families were excluded from the study if they had insufficient knowledge of Finnish or Swedish to fill in the study questionnaires, or in case of a miscarriage or stillbirth.

The initial sample consisted of 3803 pregnant women who received questionnaires at gwk 14, 24, and 34 (T1, T2, and T3, respectively). The Pregnancy Related Anxieties Questionnaire – Revised 2 (PRAQ-R2) [24], was added to the T1 measurement in May 2014 and, therefore, the present study comprised the 599 women who entered the study thereafter. Additionally, data on resilience were required for inclusion, as well as data on at least two time points for sleep and pregnancy-related anxiety. The final sample consisted of 532 participants.

Demographic characteristics of the FinnBrain sample are shown in Table 1; included and excluded participants are shown separately. On average, included participants were 1 year older, had a higher educational level, and worked more often compared to participants who were excluded from the study. No differences were found between the groups on general sleep quality, sleep duration and resilience at T1, and pregnancy-related anxiety at T2 (all p-values >0.13).

Of the 532 included participants, 67 dropped out after the second assessment. No differences were found between participants who dropped out and those who did not for any of the variables at T1 or T2 (all p-values >0.16).

2.2. Procedure

Participants filled out a set of questionnaires at T1 (mean gwk 15.5, SD 1.5), T2 (mean gwk 25.2, SD 1.3), and T3 (mean gwk 35.4, SD 1.2). This set included questions on age, parity (first child or

Table 1
Demographic characteristics of included and excluded[a] participants at T1 (gestational week 14).

	Participants included $n = 532$	Participants excluded $n = 3271$	T or χ^2	p	Effect size[b]
Age (years) (mean, SD)	31.6 (4.4)	30.6 (4.7)	T (743.37) = −4.89	<0.001	0.22
Level of education[c] (n, %)					
Low	151 (28.4)	1019 (31.2)	χ^2 (1) = 24.90	<0.001	0.08
High	380 (71.4)	1529 (46.7)			
Unknown	1 (0.2)	723 (22.1)			
Work (n, %)					
Full-time	412 (77.4)	1856 (56.7)	χ^2 (2) = 6.73	0.035	0.03
Part-time	48 (9.0)	263 (8.0)			
At home	67 (12.6)	427 (13.1)			
Unknown	5 (0.9)	726 (22.2)			
Parity (n, %)					
Nulliparous	289 (54.3)	1292 (39.5)	χ^2 (1) = 2.06	0.152	0.02
Primi- or Multiparous	243 (45.7)	1246 (38.1)			
Unknown	0 (0.0)	733 (22.4)			

[a] Exclusion criteria for the current sample: absence of PRAQ-R2 or resilience data at T1, or missing data for more than one assessment.
[b] Cohen's *d* or Cramer's *V*.
[c] Low education: 9 years or less, high school and lower vocational school; High education: higher vocational school and university.

more than first child), education level (low or high) and resilience at T1, and sleep and pregnancy-related anxiety at T1, T2, and T3. All participants gave written informed consent. The study was approved by the Ethical Committee of the Southwestern Finland Hospital District (number 57/180/2011).

2.3. Questionnaires

Sleep disturbances were assessed using the Basic Nordic Sleep Questionnaire (BNSQ) [25]. The BNSQ consists of 27 items on several sleep aspects; two items were selected for the current study: 1) general sleep quality, and 2) average sleep duration per night (rounded to the nearest half hour). For general sleep quality, participants indicated their sleep quality over the past month on a five-point Likert scale, ranging from 1 (well) to 5 (poor). The scores were reversed, and thus a higher score indicated better sleep quality.

Pregnancy-related anxiety was measured with the 10-item PRAQ-R2 [24]. The PRAQ-R2 includes three subscales, but only the total mean score was used in this study. Items were rated on a five-point Likert scale, ranging from 1 (absolutely not applicable) to 5 (very applicable). Internal consistency in the present sample was good ($\alpha = 0.82$ at T1, $\alpha = 0.83$ at T2, $\alpha = 0.85$ at T3).

Resilience was measured using the 10-item version of the Connor–Davidson Resilience Scale (CD-RISC) [26]. Participants rated positively phrased statements on a five-point Likert scale, ranging from 0 (not true at all) to 4 (true nearly all of the time). Internal consistency in the present sample was good, with $\alpha = 0.84$.

2.4. Statistical analyses

In a parallel process latent growth curve model (LGCM), the repeated measurements of sleep and pregnancy-related anxiety were represented by two latent growth parameters each: an intercept and a linear slope. The intercepts represent the initial level of sleep and anxiety at T1. The linear slopes represent the change over time in sleep and anxiety. To assess the predictive effect of the level of and changes in sleep on the level of and changes in anxiety, directional paths were included from the growth parameters of sleep to the growth parameters of anxiety. Finally, the moderating effect of resilience on the relation between sleep and anxiety was assessed by adding resilience as a moderator to all directional paths from growth parameters of sleep to growth parameters of anxiety (all interactions were included simultaneously). An example of the final model is shown in Fig. 1.

With two variables for sleep (quality and duration) and one variable for pregnancy-related anxiety, this resulted in four models: two parallel process LGCMs without moderators and two with moderators. To assess the predictive effect of anxiety on sleep the same four models were used, only now with directional paths from the growth parameters of anxiety to the growth parameters of sleep. In each model, the intercepts and slopes were controlled for age, parity and education level (low/high). Age was centered so that a value of zero for this covariate corresponded with the mean age of the sample (31.61 years).

All preliminary analyses were conducted in SPSS version 23.0 with α set to 0.05. All LGCM analyses were conducted in Mplus 7.4 [27] using maximum likelihood estimation with robust estimators (MLR), which provides standard errors and a Chi-square that is robust to non-normal distributions. Model fit was determined via the Chi-square, the Comparative Fit Index and Tucker Lewis Index (CFI/TLI) with values >0.95 indicating good fit and >0.90 as acceptable fit, the Root Mean Squared Error of Approximation (RMSEA) with values ≤0.06 indicating good fit and ≤0.08 as acceptable fit, and Standardized Root Mean Square Residual (SRMR) with values ≤0.08 as acceptable fit [28]. Additionally, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) were given. Missing data were handled using full information maximum likelihood estimation (FIML) [27].

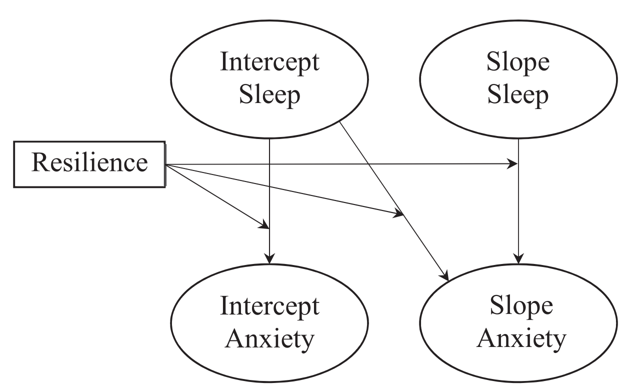

Fig. 1. Example of the full model with directional pathways from the growth parameters of one variable, in this case sleep, to those of the second variable, in this case anxiety, and resilience as a moderator.

3. Results

3.1. Preliminary analyses

Table 2 shows means and SDs of the main variables at T1, T2, and T3 for the included participants, as well as correlations between variables. All variables showed statistically significant correlations with each other in the expected directions, with the exception of sleep duration at T1 and T2 (Table 2). Sleep duration at T1 and T2 did not correlate with pregnancy-related anxiety or resilience.

3.2. Latent growth curve models

Model fit indices and parameter estimates for the single process LGCMs are shown in Table 3. The single process LGCMs for sleep duration and pregnancy-related anxiety showed good fit, whereas the model for general sleep quality showed insufficient fit. Further inspection of this model demonstrated a non-linear growth curve, indicating that general sleep quality got worse at a faster rate later in pregnancy. However, at least four time points are needed for a quadratic model to be identified, and thus sleep quality could not be used in the subsequent parallel process LGCMs. The significant slope factors of sleep and anxiety of all three single process LGCMs indicate that general sleep quality and duration decreased over time, while anxiety increased.

Table 4 shows the regression coefficients of the parallel process LGCMs with sleep duration and pregnancy-related anxiety, both without and with resilience. Fit indices for models 1 and 2 pointed toward good fit (RMSEA and SRMR <0.03, CFI and TLI >0.98). For models 1, 2, 3, and 4, AICs were 6000.93, 5992.04, 5972.34, and 5998.69, and BICs were 6129.17, 6120.29, 6123.95, and 6148.31, respectively. For the directional paths, the statistically significant negative intercept effect of sleep duration on anxiety indicates that a shorter initial sleep duration was associated with a higher level of initial anxiety (model 1). Furthermore, a higher initial level of anxiety was associated with a faster shortening of sleep duration, indicated by the statistically significant negative effect of the intercept of anxiety on the slope of sleep duration in model 2. The other directional pathways in these two models were non-significant.

None of the interaction terms showed an effect on the directional pathways between sleep and anxiety in model 3 and 4 (all *p*-values >0.14), indicating that resilience did not moderate any of the relationships between sleep duration and pregnancy-related anxiety during pregnancy.

4. Discussion

The aim of this study was to examine whether the level of and changes in sleep quality and duration are associated with the level of and changes in pregnancy-related anxiety across pregnancy. Additionally, it assessed the potentially moderating effect of resilience on these associations. The findings confirmed the expected worsening of general sleep quality and shortening of sleep duration along pregnancy. Simultaneously, pregnancy-related anxiety increased. Initial shorter sleep duration was associated with a higher initial level of anxiety, while being more anxious initially was associated with a faster shortening of sleep duration across pregnancy. No other associations between sleep duration and pregnancy-related anxiety were found. Finally, resilience did not moderate the relationship between sleep duration and pregnancy-related anxiety.

The findings of decreasing sleep quality and shortening of sleep duration during pregnancy are consistent with previous literature [1,10,14]. The increase in pregnancy-related anxiety, however, is in contrast with the findings of Blair et al. [15] who reported a decrease in pregnancy-related anxiety across pregnancy, as well as with Rothenberger et al. [16] and Huizink et al. [17] who found no significant change in the PRAQ-R total score during pregnancy. These dissimilarities were most likely results of differences in design and differences in instruments. Rothenberger et al. [16], for instance, only included the first two trimesters, and Blair et al. [15] used a questionnaire for pregnancy-related anxiety that included the health of the mother.

In the current study, sleep duration was not associated with the course of pregnancy-related anxiety, but it did find that women with shorter sleep duration were more anxious compared to women with longer sleep duration. Furthermore, the initial level of anxiety was not associated with the initial sleep duration, but rather with the course of sleep duration, indicating that a higher initial level of anxiety was associated with a steeper decrease in sleep duration. The latter result supports the finding of Okun et al. [29], showing that sleep of anxious women was negatively affected over a longer period than in less anxious women.

These findings indicate that reducing anxiety may diminish the decrease of sleep duration along pregnancy. Moreover, given the association between the two complaints it would be expected that alleviating one complaint would diminish the other complaint as well. However, since this was an observational study, additional experimental or intervention research is needed to examine the effect of a reduction in prenatal anxiety on sleep duration during pregnancy.

In contrast to the current expectations, changes in sleep duration and changes in anxiety were not associated with each other. A possible explanation for this finding could be that the single process LGCM for sleep duration did not show a significant variance around the slope (Table 3), signifying that the inter-individual variation in changes in sleep duration during pregnancy was marginal. This might also explain the lack of correlation between sleep

Table 2
Means and standard deviations of general sleep quality, sleep duration, pregnancy-related anxiety and resilience at different assessment waves (T1, T2, and T3), and the correlation between variables.

	Mean	SD	N	SlQ T1	SlQ T2	SlQ T3	SlDur T1	SlDur T2	SlDur T3	PrAnx T1	PrAnx T2	PrAnx T3
SlQ T1	3.79	1.03	532									
SlQ T2	3.68	1.03	517	0.59**								
SlQ T3	3.16	1.15	464	0.49**	0.59**							
SlDur T1	7.87	0.97	530	0.23**	0.17**	0.13**						
SlDur T2	7.76	0.97	517	0.23**	0.33**	0.19**	0.61**					
SlDur T3	7.75	1.13	459	0.27**	0.35**	0.42**	0.48**	0.56**				
PrAnx T1	2.23	0.65	532	−0.12**	−0.17**	−0.14**	−0.01	−0.06	−0.14**			
PrAnx T2	2.30	0.67	516	−0.13**	−0.18**	−0.14**	−0.05	−0.06	−0.12*	0.78**		
PrAnx T3	2.32	0.68	463	−0.15**	−0.17**	−0.19**	−0.08	−0.08	−0.12*	0.70**	0.75**	
Res T1	28.03	5.07	532	0.21**	0.16**	0.20**	0.06	0.01	0.09*	−0.20**	−0.18**	−0.17**

PrAnx = pregnancy-related anxiety; Res = Resilience; SlDur = sleep duration; and SlQ = general sleep quality; T1 = gestational week 14; T2 = gestational week 24; T3 = gestational week 34.
$^{*}p < 0.05$; $^{**}p < 0.01$.

Table 3
Model fit indices and parameter estimates for unconditional single process latent growth curve models.

	Model fit								Parameter estimates			
	Chi-squared (df = 1)	*p*	RMSEA	CFI	TLI	SRMR	BIC	AIC	Intercept	Slope	Intercept variance	Slope variance
SlQ	36.15	<0.001	0.26	0.89	0.67	0.06	4119.16	4153.38	3.84**	−0.30**	0.66**	0.07
SlDur	2.13	0.144	0.05	0.99	0.98	0.01	3911.70	3945.91	7.86**	−0.07**	0.62**	0.07
PrAnx	1.66	0.198	0.04	1.00	0.99	0.01	2171.59	2205.80	2.23**	0.05**	0.36**	0.03*

AIC = Akaike information criterion; BIC = Bayesian information criterion; CFI = Comparative Fit Index; PrAnx = pregnancy-related anxiety; RMSEA = Root Mean Squared Error of Approximation; SlDur = sleep duration; SlQ = general sleep quality; SRMR = Standardized Root Mean Square Residual; TLI = Tucker Lewis Index.
*$p < 0.05$; **$p < 0.01$.

Table 4
Unstandardized parameter estimates and standard errors for the directional pathways of the parallel process LGCMs, with directional pathways from sleep duration to pregnancy-related anxiety (1), from pregnancy-related anxiety to sleep duration (2), from sleep duration to pregnancy-related anxiety with resilience as a moderator (model 3), and from pregnancy-related anxiety to sleep duration with resilience as a moderator (model 4).

Directional pathways	Model 1: SlDur → PrAnx	Model 2: PrAnx → SlDur	Model 3: SlDur → PrAnx	Model 4: PrAnx → SlDur
	Estimate (*SE*)	Estimate (*SE*)	Estimate (*SE*)	Estimate (*SE*)
Intercept → intercept	−0.10 (0.05)*	−0.08 (0.08)	−0.07 (0.04)	−0.06 (0.08)
Intercept → slope	0.00 (0.02)	−0.14 (0.05)*	−0.01 (0.02)	−0.14 (0.06)*
Slope → slope	0.27 (0.27)	0.58 (0.48)	0.35 (0.27)	0.47 (0.54)
Intercept × Resilience → intercept			0.01 (0.01)	0.02 (0.02)
Intercept × Resilience → slope			−0.01 (0.00)	−0.01 (0.01)
Slope × Resilience → slope			0.10 (0.07)	0.02 (0.15)

All models were corrected for age, parity and education level (low/high), and the models showed good fit to the data.
SE = standard error; SlDur = sleep duration; PrAnx = pregnancy-related anxiety.
*$p < 0.025$ (corrected for multiple testing).

duration at T1 and T2 and the other variables. The absence of variance around the slope could imply that changes in sleep duration in a relatively healthy sample coming from the general population are mainly caused by common factors that apply to everyone, like nocturnal urination and restricted sleeping positions. Alternatively, it is possible that the self-report estimates on sleep duration are not reliable. Previous studies have shown that people generally tend to overestimate their sleep duration [30], while people with insomnia underestimate it [31]. Using objective measurements in further studies might enlighten this issue.

Resilience did not affect any of the relationships between sleep and anxiety, indicating that resilience did not protect against a deterioration in sleep duration or an increase in anxiety levels. These findings, however, may be an underestimation of the potential buffering effect. Typically, a buffering effect of resilience can only be expected in the occurrence of adverse situations; resilient people can adapt to adverse situations, but no adaptation is needed in the absence of adversity. In the current sample, severe sleep disturbances were relatively low in occurrence: the prevalence of poor sleep duration (≤6 h per night) was 4.3%, 5.4%, and 8.7% at T1, T2, and T3, respectively, while the prevalence of high pregnancy-related anxiety − indicated by a PRAQ-R2 mean score >3 (on a scale of 1−5) − was 10.7%, 12.4%, and 13.0% at T1, T2, and T3, respectively. This means that there were relatively few 'adverse situations' that needed buffering against through resilience, and thus small effects may have gone undetected in the current sample. In future studies it might therefore be worthwhile to study the buffering effect of resilience on the relationship between sleep and anxiety during pregnancy in a more at-risk sample (eg, pregnant women who report high levels of sleep disturbances and/or anxiety problems or high levels of adverse events). From a clinical perspective it would be important as well, since they can be the ones who would most benefit from preventive actions.

When interpreting the current findings, a few limitations have to be considered. Results with respect to general sleep quality and anxiety are inconclusive, since sleep quality showed a non-linear growth curve, which could not be analyzed using LGCM for three assessments. Furthermore, the results may only be generalizable to the general population, while the relationships may be different in at-risk samples (eg, due to differences in resilience). As strengths of the study, the sample size was large, and it assessed the concomitant development of sleep disturbances and pregnancy-related anxiety in a longitudinal setting, which has not been done before.

To summarize, the current study found that pregnant women with shorter sleep duration had a higher occurrence of anxiety, and sleep duration decreased faster over the course of pregnancy in women with higher anxiety levels. The course of sleep duration and that of pregnancy-related anxiety were not related to each other, and resilience did not affect any of these relationships. Accordingly, pregnant women with anxiety should be checked for reduced sleep duration and vice versa, since women who experience one of these pregnancy-related problems are at increased risk of suffering from the other problem as well, and they are at risk of developing the other problem later in pregnancy. Moreover, the prevention or treatment of sleeping and anxiety problems may be more effective if both aspects are treated simultaneously, as compared to treating only one of them, although additional experimental research is needed to confirm this hypothesis.

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Conflict of interest

The authors have no conflicts of interest to disclose.

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