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RESEARCH ARTICLE

The influence of sexual activity on sleep: A diary study

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Summary

Aiming to promote overall health and well-being through sleep, the present studies examine to what extent sexual activity serves as a behavioural mechanism to improve sleep. The relation between sexual activity, i.e., partnered sex and masturbation with or without orgasm, and subjective sleep latency and sleep quality is examined by means of a cross-sectional and a longitudinal (diary) study. Two hundred fifty-six male and female participants, mainly students, completed a pre-test set of questionnaires and, thereafter, a diary during 14 consecutive days. The cross-sectional study was analysed using analysis of covariance and demonstrated that both men and women perceive partnered sex and masturbation with orgasm to improve sleep latency and sleep quality, while sexual activity without orgasm is perceived to exert negative effects on these sleep parameters, most strongly by men. Accounting for the repeated measurements being nested within participants, the diary data were analysed using multilevel linear modelling (MLM). Separate models for subjective sleep latency and sleep quality were constructed, which included 2076 cases at level 1, nested within 159 participants at level 2. The analyses revealed that only partnered sex with orgasm was associated with a significantly reduced sleep latency ($b = -0.08$, $p < 0.002$) and increased sleep quality ($b = 0.19$, $p < 0.046$). Sexual activity without orgasm and masturbation with and without orgasm were not associated with changes in sleep. Further, no gender differences emerged. The present studies confirm and significantly substantiate findings indicating that sexual activity and intimacy may improve sleep and overall well-being in both men and women and serve as a directive for future research.

KEYWORDS

gender differences, multilevel linear modelling, orgasm, sexual behaviour, subjective sleep latency, subjective sleep quality

1 | INTRODUCTION

Healthy sleep is essential for physical and mental well-being and for the quality of life. Short and disturbed sleep are associated with negative health outcomes, including obesity, hypertension, diabetes mellitus, and mortality (e.g., Anothaisintawee et al., 2015; Itani et al., 2017; Bertisch et al., 2018). Insomnia symptoms, i.e., difficulties initiating or maintaining sleep, constitute an established risk factor for the development of diverse mental disorders, such as depression, anxiety, and posttraumatic stress disorder (Hertenstein et al., 2019), and may aggravate psychopathology and impede recovery (e.g., Belleville et al., 2011; Gee et al., 2019; Ho et al., 2016; Scott et al., 2021).

Further, insomnia symptoms negatively impact quality of life (Lee et al., 2022) and increase the risk for suicidal behaviours (Winsper & Tang, 2014). Research indicates that over 30% of the general population experiences insomnia symptoms and ~6% suffers from insomnia disorder (Ohayon, 2002). Considering the large proportion of people affected by poor sleep and its negative effects on health and quality of life, investigations of behaviours and interventions that may improve sleep are paramount.

It is a widely held notion that sexual behaviour, and particularly orgasm, have a positive influence on subsequent sleep. However, only a few studies have aimed to establish the association between sexual activity and sleep (Brisette et al., 1985; Lastella et al., 2019; Pallesen et al., 2020). Brisette et al. (1985) investigated the effects of bedtime sexual activity, in the form of masturbation with and without orgasm, on polysomnographically recorded sleep but did not find differences in sleep latency or sleep duration compared with reading neutral texts. Recently, three cross-sectional studies examined the perceived influence of sexual behaviour on subjective sleep variables. A large Norwegian population survey found that masturbation and, even more so, sexual activity with a partner (herein referred to as "partnered sex") resulting in orgasm were experienced to exert positive effects on "subjective sleep latency" and "subjective sleep quality" (Pallesen et al., 2020). These effects were significantly stronger in men than in women. Sexual activity without achieving orgasm was reported to have negative effects on both sleep variables. This negative association was stronger in men and diverges from the previous findings of Lastella et al. (2019), who found that sexual activity is perceived to improve subjective sleep latency and sleep quality, independent of whether orgasm occurred. When asked about the perceived influence of partnered sex with orgasm, comparable proportions of men and women reported a positive impact. A survey among U.S. college students on the sleep-promoting properties of sexual activity revealed that intercourse, particularly with orgasm, reportedly increases sleep propensity in both men and women. Although there was no gender difference in experienced somnolence following masturbation, men were more likely to use masturbation to promote sleep (Gallop Jr et al., 2021). Thus, research consistently shows that sexual activity with orgasm positively affects sleep, but several discrepancies have emerged from the scarce literature. Namely, it remains to be ascertained to what extent the type of sexual activity (i.e., partnered sex versus masturbation) impacts the effects on sleep, whether having an orgasm is necessary for such effects to become apparent, and lastly, whether the effect of sexual activity on sleep differs between men and women. Moreover, the subjective effects of sexual behaviour on sleep were evaluated retrospectively and may be influenced by heteronormative expectations as well as recall bias, thereby limiting the validity of earlier findings. The aim of the present study is to investigate the effects of sexual behaviours on sleep more thoroughly by combining a cross-sectional survey based on the previous work by Pallesen et al. (2020) and Lastella et al. (2019) with a longitudinal design in the form of a diary study. Based on the literature, it was hypothesised that sexual activity decreases sleep latency and increases sleep quality. These effects are suggested to be stronger if sexual activity involves a partner, relative to masturbation. Moreover, it is anticipated that this effect is stronger in men than in women, and only detectable if sexual activity resulted in orgasm.

2 | METHODS

2.1 | Participants

A total of 256 participants was recruited using availability sampling. The majority ($n = 201$) consisted of undergraduate psychology students, who received course credits as compensation for their participation. The remaining participants ($n = 55$) were randomly recruited by means of social media platforms such as Facebook and LinkedIn. Participants who did not have a stable internet connection ($n = 3$), were under 18 years of age ($n = 1$), or had indicated that they were diagnosed with and were currently in treatment for a psychological, sexual, or sleep disorder ($n = 14$) were excluded. An additional $n = 14$ participants had to be excluded as they had not given informed consent. The statistical analysis of the cross-sectional study was conducted on the remaining sample of 224 participants (67 men, 153 women, 4 other), aged between 18 and 58 years ($M = 21.93$, $SD = 6.46$). For analysis of the diary data, participants who had completed less than 50% of the diary (i.e., < 7 days), took antidepressant medication, or indicated the use of hard drugs (i.e., cocaine, mushrooms, MDMA, speed) were excluded ($n = 65$). Thus, 2076 cases nested within 159 individuals (103 women, 53 men, 3 other, age $M = 22.01$, $SD = 6.52$) were analysed. The study was approved by the Ethics Committee of the Behavioral and Social Sciences (ECP: PSY-2021-S-0024).

2.2 | Procedure

All participants received the pre-test including the informed consent, as well as the daily diary, via Qualtrics® (Qualtrics, 2014). If inclusion criteria were met, the participants were asked to enter their email address before the remaining items of the cross-sectional questionnaire were made available to them. Via email, eligible participants received information concerning the study procedure immediately after sign-up. From the following day on, a daily reminder email including an individualised survey link was sent to every participant at 5 a.m. for 14 days, starting the day after pre-test administration. Thus, the diary was completed once a day upon awakening. Qualtrics generated an individual code for each participant to ensure anonymity, enabling deletion of all email addresses once data collection had come to an end. If inclusion criteria were not met, participants immediately received an email explaining the reason(s) for their exclusion, after which no further emails were scheduled, and no data were stored.

2.3 | Measures

2.3.1 | Cross-sectional study

The cross-sectional study consisted of items assessing gender, age, email address, available internet connection, diagnosis, and current treatment of mental health or sleep disorder or sexual dysfunction, use of hormonal contraception, medication, and habitual alcohol and caffeine consumption. Insomnia was measured using the Insomnia Severity Index (ISI; Morin et al., 2011), a 7-item self-report

questionnaire assessing insomnia symptoms during the past two weeks. The items are rated on a 5-point Likert scale ranging from 0 (no problem) to 4 (very severe problem). The total score (0–28) can be interpreted as: ≤7 no insomnia; 8–14 sub-clinical insomnia; ≥15 clinical insomnia (≥22 very severe insomnia).

To enable partial replication of the results appraised by Pallesen et al. (2020), their self-constructed cross-sectional survey (see Appendix S1: Supplement 1) was employed to assess how sexual activity is retrospectively perceived to impact sleep. The survey consists of eight items on the perceived effects of sexual intercourse and masturbation− both with and without orgasm − on subsequent sleep latency and sleep quality. Response options ranged from −2 ("much longer than without sex" for sleep latency and "much worse than without sex" for sleep quality) to 2 ("much shorter than without sex" for sleep latency and "much better than without sex" for sleep quality). For an overview of all items of the cross-sectional study, see Appendix S1: Supplement 2.

2.3.2 | Longitudinal study

Sleep

Following the cross-sectional study, participants completed a daily diary assessing sleep and sexual activity for the next 14 days. To assess sleep variables, the Core Consensus Sleep Diary (CCSD; Carney et al., 2012) was utilised. Participants were asked about various aspects of their sleep, including sleep latency and sleep quality. Furthermore, the CCSD was supplemented with items measuring alcohol consumption, the presence of menstruation, and whether unusual events had occurred that might have influenced participants' sleep during the past 24 h.

Sexual activity

Within the same time period, the participants were first asked whether any kind of sexual activity had taken place during the preceding 24 h. If sexual activity had occurred, a 9-item self-constructed sexual activity scale was displayed, assessing how often and at which times of the day, and whether sexual activity had taken place within 2 h of going to sleep. Four items served the appraisal of the type(s) of sexual activity participants had engaged in (masturbation or partnered sex with oral/vaginal/anal sex) and whether an orgasm had occurred. To achieve homogeneity between the cross-sectional and longitudinal study, the items were constructed so that their structure resembled the cross-sectional survey assessing the perceived influence of sexual activity on sleep of Pallesen et al. (2020). If sexual activity had taken place more than once, participants were asked to refer to the last sexual encounter or activity that day. On day 14, additional items were presented assessing the honesty and social desirability of the answers given, the occurrence of life-altering events, and the perceived influence of their study participation on sexual activity and sleep–wake behaviour (for items, see Appendix S1: Supplement 3 and 4).

2.4 | Statistical analysis

2.4.1 | Cross-sectional study

To determine whether the perceived effect of sexual activity on sleep differs between men and women, an analysis of covariance (ANCOVA) with ISI total score as covariate was conducted. In line with Pallesen et al. (2020), follow-up analyses consisted of the calculation of weighted means (separately for men and women) with 95% confidence intervals to evaluate whether sexual activity was perceived to improve sleep latency and sleep quality.

2.4.2 | Longitudinal study

Accounting for the time-nested structure of the diary data, analyses were conducted using multilevel linear modelling (MLM; Singer & Willett, 2003). Two models were constructed using SPSS Linear Mixed Models, version 28, to investigate whether partnered sex with orgasm, partnered sex without orgasm, masturbation with orgasm, and masturbation without orgasm prior to sleep possess predictive qualities regarding subjective sleep latency (Model 1) and sleep quality (Model 2). Gender was added as a level 2 predictor, and an interaction effect between gender and partnered sex with orgasm was included to test whether the relationship between sexual activity and sleep is moderated by gender. Outcome variables were checked for multivariate normality, which was violated in sleep latency data. Therefore, subjective sleep latency was log-transformed.

For each outcome variable, a two-level random-intercept model was built. Random intercepts were added to account for random between-subject variance at the mean level of subjective sleep latency and sleep quality. Other predictors were entered as fixed effects. To ensure that differences between models did not result from differences in the covariance structure of the repeated measures factor, models were tested with a diagonal covariance structure (i.e., heterogeneous variances with zero correlations), compound symmetry (i.e., constant variance and covariance), and AR1, which is a first-order autoregressive structure with homogenous variances. The model of best fit according to Akaike's Information Criterion (AIC) values was used. Before adding predictors to the model, the intraclass correlation (i.e., the ratio of variance between individuals to variance within individuals) was calculated to establish whether measurements were significantly clustered within individuals, which justifies the use of MLM instead of aggregating scores and analysing the data on a single level. To analyse whether a model including predictors provides a better fit than the intercept-only model (i.e., a random-intercept model with no predictors) and therefore predicts dependent variables better than chance, the X^2 Likelihood-ratio test of difference was used. Relevant covariates were determined by predicting each outcome variable by alcohol, caffeine, menstruation, insomnia, and contraception. Significant predictors were used as control variables in respective models.

3 | RESULTS

3.1 | Cross-sectional study

For the distribution of the answers for each item of the cross-sectional study, broken down by gender, see Appendix S1: Supplement 5. When examining the means, it becomes apparent that both partnered sex and masturbation with orgasm resulted in reduced subjective sleep latency and increased subjective sleep quality compared with sexual activity without orgasm or no sexual activity at all. Table 1 presents the means and standard deviations of subjective sleep latency and sleep quality for all levels of sexual activity. Further, the number of occurrences of sexual activity and masturbation with and without orgasm are displayed and depict differences between men and women. It is noteworthy that, despite women being overrepresented in the present sample ($n = 153$ women vs. $n = 67$ men), men reported higher numbers of sexual activities with orgasm than women. Table 2 depicts gender differences in mean subjective sleep latency and sleep quality, showing that while men on average report a shorter sleep latency than women, women indicated higher sleep quality. People who indicated "other" reported both higher sleep latency and lower sleep quality than men and women.

3.1.1 | Subjective sleep latency

Both men ($p < 0.001$) and women ($p < 0.001$) perceived partnered sex with orgasm to reduce sleep latency, and ANCOVA did not yield a significant gender difference ($p < 0.550$). In contrast, partnered sex without orgasm was reported to have a negative effect, increasing sleep latency in both men ($p < 0.001$) and women ($p < 0.001$), while this effect was significantly stronger for men ($p < 0.004$). An identical pattern was

TABLE 2 Mean sleep latency and sleep quality of men and women

Gender	N	Mean	SD
Men			
Sleep latency	702	18.58	19.44
Sleep quality		0.52	0.95
Women			
Sleep latency	1338	21.12	22.45
Sleep quality		0.59	0.94
Other			
Sleep latency	40	26.22	21.72
Sleep quality		0.28	0.82

TABLE 1 Means and standard deviations of sleep variables for levels of sexual activity

Sexual activity	N (m/f/o)	N_{total}	Mean	SD
Partnered sex				
Sleep latency (min)				
Did not engage	(597/1182/39)	1818	20.89	20.59
Did engage	(13/71/1)	85	17.91	18.78
Did engage, orgasm	(92/81/0)	173	16.46	21.69
Total		2076	20.39	21.52
Sleep quality (−2) low – (2) high				
Did not engage	(597/1182/39)	1656	0.53	0.93
Did engage	(13/71/1)	85	0.76	0.92
Did engage, orgasm	(92/81/0)	173	0.75	1.04
Total		2076	0.56	0.94
Masturbation				
Sleep latency (min)				
Did not engage	(480/1140/36)	1656	20.48	22.06
Did engage	(5/20/0)	25	26.16	18.57
Did engage, orgasm	(217/174/4)	395	19.70	22.04
Total		2076	20.39	21.52
Sleep quality (−2) low – (2) high				
Did not engage	(480/1140/36)	1656	0.55	0.96
Did engage		25	0.44	0.92
Did engage, orgasm	(5/20/0)	395	0.59	0.89
Total	(217/174/4)	2076	0.56	0.94

TABLE 3 Effects of sexual activity on sleep latency in men and women including weighted means and confidence intervals

Sexual activity	Gender difference F_{df}	Men		Women	
		Mean	95% CI mean	Mean	95% CI mean
Partnered sex with orgasm	$F_{1,352} = 0.036$	0.49	0.30, 0.69	0.54	0.44, 0.64
Partnered sex without orgasm	$F_{1,352} = 8.24$*	−0.45	−0.61, −0.28	−0.15	−0.24, −0.06
Masturbation with orgasm	$F_{1,352} = 0.626$	0.52	0.33, 0.72	0.65	0.55–0.75
Masturbation without orgasm	$F_{1,352} = 6.09$*	−0.33	−0.50, −0.16	−0.11	−0.18, −0.04

Note: −2 = strong negative effect, 0 = no effect, 2 = strong positive effect.
*Significant at $\alpha = 0.05$.

TABLE 4 Effects of sexual activity on sleep quality in men and women including weighted means and confidence intervals

Sexual activity	Gender difference F_{df}	Men		Women	
		Mean	95% CI mean	Mean	95% CI mean
Partnered sex with orgasm	$F_{1,352} = 2.77$	0.48	−0.30, 0.65	0.32	0.24, 0.41
Partnered sex without orgasm	$F_{1,352} = 0.381$	−0.18	−0.35, −0.01	−0.10	−0.17, −0.03
Masturbation with orgasm	$F_{1,352} = 0.331$	0.27	0.13, 41	0.32	0.26–0.38
Masturbation without orgasm	$F_{1,352} = 4.51$*	−0.21	−0.34, −0.08	−0.09	−0.13, −0.04

Note: − 2 = strong negative effect, 0 = no effect, 2 = strong positive effect.
*Significant at $\alpha = 0.05$.

observed for masturbation: Both men ($p < 0.001$) and women ($p < 0.001$) perceived masturbation with orgasm to reduce sleep latency without a significant difference between them ($p < 0.444$). Masturbation without orgasm was found to have a significantly stronger ($p < 0.014$) negative effect on sleep latency in men ($p < 0.001$), although women ($p < 0.001$) also reported prolonged sleep latency (see Table 3).

3.1.2 | Subjective sleep quality

When indicating whether subjective sleep quality changes following partnered sex with orgasm, both men ($p < 0.001$) and women ($p < 0.001$) reported an increase in sleep quality ($p < 0.097$). Further, also without significant differences between genders ($p < 0.537$), both men ($p = 0.039$) and women ($p < 0.006$) perceived partnered sex without orgasm to negatively affect sleep quality. Masturbation with orgasm was found to improve both men's ($p < 0.001$) and women's ($p < 0.001$) subjective sleep quality ($p < 0.565$). Masturbation without orgasm was perceived to have a negative effect on sleep quality in men ($p < 0.002$) and women ($p < 0.001$), albeit subjective sleep quality was affected more strongly in men ($p < 0.034$, see Table 4).

3.2 | Longitudinal study

3.2.1 | Subjective sleep latency

The intercept-only model yielded an intraclass correlation of 0.41 (i.e., 41% of the variance in subjective sleep latencies is at an individual level), which demonstrates the value of building a nested model with participants as a second-level unit. Alcohol consumption and the level of insomnia appeared to be significant predictors and were thus controlled for when building the model. Increased alcohol consumption starting at 4–7 units ($b = 0.72$, t (−5.307,1), $p < 0.001$) predicted shorter sleep latency, while subclinical and clinical insomnia ($b = 0.26$, t (3.993,1), $p < 0.001$) predicted longer sleep latency. In the following step, partnered sex and masturbation were added to the model as level-one predictors with ISI total score and alcohol consumption as covariates. Comparing AIC values showed that using covariance structure AR1 resulted in the best-fitting model (AIC = 1218.695). The model was a significantly better fit than the intercept-only model, as χ^2 (3) = 1331.138–1192.695 = 138,443. Partnered sex was found to significantly affect subjective sleep latency ($F_{2,1948}$=5.480, $p = 0.004$), while masturbation did not ($F_{2,1920}$=1.710, $p = 0.181$). The estimates of fixed effects yielded a significant difference between engaging in partnered sex with orgasm and not engaging in sexual activity. Compared with no sexual activity, partnered sex with orgasm significantly shortened sleep latency ($b = −0.08$, t (−3.155,1), $p < 0.002$), while partnered sex without orgasm did not significantly affect sleep latency ($b = −0.05$, t (−1.338,1), $p < 0.181$). Between-subject variance in subjective sleep latency was 0.05.

To assess gender differences in the effect of sexual activity on sleep, an interaction effect of gender with partnered sex was included while also adding gender as a main predictor. No significant main ($F_{2,478}$=0.231, $p = 0.793$) or interaction ($F_{3,1919}$=0.821, $p = 0.482$) effect of gender on subjective sleep latency was found. Therefore, the observed effect of partnered sex on sleep was not moderated by

TABLE 5 Final multilevel linear model for effect of sexual activity variables on sleep latency

Variable	Coefficient (Log10)	*t*	*p*-value
Fixed part			
Intercept	1.09	40.169	0.001
Sexual activity			
Did not engage	0		
Did engage without orgasm	−0.05	−1.338	0.181
Did engage and reached orgasm	−0.08	−3.155	0.002
Masturbation			
Did not engage	0		
Did engage without orgasm	−0.11	1.727	0.084
Did engage and reached orgasm	−0.01	0.745	0.456
Alcohol			
Does not drink	0		
1–3 units	−0.01	−0.702	0.483
4–7 units	−0.14	−4.911	0.001
More than 18 units	−0.20	−5.865	0.001
Insomnia			
No insomnia	0		
Subthreshold insomnia	0.14	3.186	0.002
Clinical insomnia	0.26	4.068	0.001
Random part			
σ_e^2	0.09		0.001
σ_u^2	0.06		0.001

Abbreviation: σ_e^2 = variance at level one (repeated measures); σ_u^2 = variance at level 2 (individuals).

gender, and gender was not included in the parsimonious model (see Table 5).

3.2.2 | Subjective sleep quality

The null model with subjective sleep quality as a dependent variable yielded an intraclass correlation of 0.24; therefore, it was considered valuable to proceed with building a multilevel linear model. Alcohol ($p < 0.001$) and the level of insomnia ($p < 0.001$) were identified as relevant control variables. Increased alcohol consumption (4–7, 8 or more units; $b = -0.59$, t (−6.332,1), $p < 0.001$), and subclinical and clinical insomnia scores ($b = -0.65$, t (−5.374,1), $p < 0.001$) significantly predicted reduced sleep quality. Next, the level 1 predictors partnered sex and masturbation, and insomnia score and alcohol as control variables, were entered into a two-level random-intercept model. The model fit increased significantly by adding predictors: X^2 (3) = 5348.133–5236.371 = 111,762. A diagonal covariance structure (AIC = 5286.371) appeared to be the best-fitting covariance matrix. Analysis revealed that partnered sex significantly affected sleep quality, while masturbation did not. Following partnered sex, subjective sleep quality increased when an orgasm had occurred ($b = 0.19$, t (1.993,1), $p < 0.046$), while its effect approached but did not reach significance in the absence of orgasm ($b = 0.14$, t (1.954,1), $p < 0.051$). Masturbation did not affect subjective sleep quality ($b = 0.05$, t (1.004,1), $p < 0.315$). To test for sex differences in how sex with a partner influences subjective sleep quality, gender was addedto the model. Although there is a significant main effect of gender on sleep quality ($F_{1,662} = 4.581$, $p = 0.033$), indicating that women, on average, report a higher sleep quality than men (see Table 4), no significant interaction effect was found ($F_{1,1756} = 1.321$, $p = 0.267$). Thus, no evidence for gender moderating the relationship between partnered sex and subjective sleep quality emerged. Therefore, the final parsimonious model does not include gender as a variable (for an overview of the final Model, see Table 6).

4 | DISCUSSION

The present cross-sectional and longitudinal (diary) studies aimed to investigate whether specific sexual activities (i.e., partnered sex and masturbation with or without orgasm) affect subjective sleep latency and sleep quality. The cross-sectional study showed that partnered sex with orgasm as well as masturbation with orgasm are perceived to reduce sleep latency while increasing sleep quality in men and women. Both men and women found that partnered sex and masturbation without orgasm increased sleep latency and decreased sleep quality, albeit men perceived stronger negative effects. The longitudinal study yielded diverging results. Specifically, while partnered sex with orgasm significantly shortened sleep latency and improved sleep quality,

TABLE 6 Final multilevel linear model for effect of sexual activity variables on sleep quality

Variable	Coefficient (Log10)	t	*p*.
Fixed part			
Intercept	0.77	14.616	0.001
Sexual activity			
Did not engage	0		
Did engage without orgasm	0.14	1.954	0.051
Did engage and reached orgasm	0.19	1.993	0.046
Masturbation			
Did not engage	0		
Did engage without orgasm	−0.04	−0.215	0.830
Did engage and reached orgasm	0.05	1.004	0.315
Alcohol			
Does not drink	0		
1–3 units	−0.01	−0.076	0.940
4–7 units	−0.18	−2.463	0.014
More than 8 units	−0.57	−6.184	0.001
Insomnia			
No insomnia	0		
Subthreshold insomnia	−0.36	−4.422	0.001
Clinical insomnia (moderate)	−0.64	−5.172	0.001
Random part			
σ_e^2	0.66		0.001
σ_u^2	0.17		0.001

Abbreviation: σ_e^2 = variance at level 1 (repeated measures); σ_u^2= variance at level 2 (individuals).

masturbation with orgasm did not affect the respective sleep variables. The effects of partnered sex without orgasm and masturbation without orgasm did not have strong enough effects on sleep latency or sleep quality to be detectable in the present design. Although women indicated a higher average sleep quality than men, gender was not found to significantly moderate the relation between sexual activity and sleep.

The present results largely support the hypothesis that sexual activity with orgasm results in reduced subjective sleep latency and increased subjective sleep quality in both men and women. While both studies found significant effects of partnered sex, masturbation – though retrospectively perceived as sleep-promoting – did not exert detectable effects in the longitudinal study. As masturbation with orgasm was indeed perceived to effectively promote sleep when assessed in retrospect, the results may suggest that, in fact, both sex with a partner and masturbation impact sleep latency and sleep quality, while the effect of partnered sex may be stronger and thus more salient. This postulate aligns with findings by Brody and Krüger (2006), who have shown that orgasm following sexual intercourse results in a 400% higher post-coital prolactin surge than masturbation-induced orgasm. As prolactin promotes sleep and is part of a feedback loop communicating sexual satiety, the increased post-coital surge of prolactin may explain why partnered sex is often perceived as more satisfying than masturbation and why the sleep-facilitating effect of sexual activity with orgasm is more salient when a partner is involved, as also found by Pallesen et al. (2020) and Gallop et al. (2021).

The finding that both partnered sex and masturbation without orgasm yielded no – or even negative – effects on sleep point to the relevance of orgasm and its concomitant psychophysiological effects. As orgasm is established to increase the heart rate and blood pressure and results in the release of oxytocin and prolactin – hormones, both postulated to influence sleep (Brody & Krüger, 2006; Fekete et al., 2014; Gianotten et al., 2021; Lipschitz et al., 2015) – neuroendocrine changes following orgasm may contribute to the reduction in sleep latency and increase in sleep quality following partnered sex with orgasm. The present observations are in accordance with earlier findings by Pallesen et al. (2020). Although Lastella et al. (2019) found that sexual activity is also reported to affect sleep when orgasm is not taken into consideration, the percentage of men and women reporting improved sleep latency and sleep quality increased when specifically asked about sex with orgasm. Further, reported gender differences indicating that perceived effects of sex on sleep are stronger in men were non-apparent when orgasm was assessed and may therefore emanate from a gap in orgasm frequency between men and women. Therefore, the discrepancy in results may also stem from less nuanced wording of items applied by Lastella et al. (2019). In a more recent study, Sprajcer et al. (2022) found that orgasm frequency explained 3.1% of the variance in subjective sleep latency, as participants reporting an orgasm "every time" sexual activity occurs fell asleep on

average 12 min faster than those who less frequently or never report orgasm.

Given that masturbation with orgasm did not produce significant changes in longitudinally assessed sleep, orgasm per se does not sufficiently explain the reduction of sleep latency and increased sleep quality following partnered sex with orgasm. Other factors accompanying partnered sex with orgasm may also contribute to its positive effects on sleep, such as the mere experience of intimacy with one's partner promoting couple bonding (Kruger & Hughes, 2011), well-being, and emotion regulation (Gianotten et al., 2021) and may thereby improve sleep. Germane to this, non-sexual touch and cuddling have been shown to have calming, sleep-promoting effects, especially for women (Dueren et al., 2022). Compared with masturbation, partnered sex is often associated with more intense and longer-lasting physical activity – resulting in a heightened relaxed state afterwards – which may explain why partnered sex without orgasm resulted in a borderline-significant effect on sleep quality in the diary study despite being reported significantly less frequently than partnered sex with orgasm ($n = 85$ vs. $n = 173$). Lastly, the psychological effects of relationship satisfaction, loving and feeling loved, as well as having a sense of belonging or security also warrant consideration and have been shown to impact sleep (Kent et al., 2015; Troxel et al., 2007). Sprajcer et al. (2022) found that individuals who are emotionally satisfied fall asleep on average 10–12 min faster than emotionally unsatisfied individuals, and that orgasm frequency and emotional satisfaction are higher if sexual activity occurrs with a long-term partner, compared with casual sexual relationships. These findings highlight the importance of considering emotional and relationship factors when deriving inferences on the effects of sexual activity on sleep. Anyhow, if penetration has occurred, the positive effects of intimacy on sleep may be undermined if women, and even more so men, do not achieve orgasm. Both women and men retrospectively reported negative effects of sexual activity without orgasm on sleep. This negative perception, although not supported by the longitudinal findings, may be attributed to adjuvant emotions such as frustration, dissatisfaction, uncomfortable bodily sensations resulting from sexual arousal without orgasm, or confounding events that prevented sexual activity from resulting in orgasm.

The hypothesised gender difference suggesting that the effects of sexual activity on sleep are stronger in men than in women was not supported, as changes in subjective sleep latency and sleep quality following partnered sex with orgasm did not differ between men and women. This finding corresponds to results of Kruger and Hughes (2011), who also did not find any gender differences in the influence of sexual activity on sleep, and of Lastella et al. (2019), who did not find a gender difference when sex with orgasm had occurred. The absence of gender differences in the sleep effects of sexual activity with orgasm may be due to comparable endocrine processes following orgasm in men and women (Georgiadis et al., 2009; Mah & Binik, 2002). The widely held notion that men fall asleep faster than women after sexual activity may have emanated from the existing gender gap in achieving orgasm, i.e., women are less likely to reach orgasm during heteronormative sexual activity than men (Blair et al., 2018). Case numbers of the present study corroborate this notion, as although the sample consists of more than twice as many women as men, men reported a higher number of occurrences of both partnered sex and masturbation with orgasm. While following heteronormative scripts, women tend to engage in sexual activities that frequently result in orgasm for men but less often for women (e.g., vaginal penetration only, which does not suffice to achieve orgasm for most women; Lloyd, 2022). Research has further shown that the male orgasm frequently signifies the end of sexual intercourse (Opperman et al., 2014), which decreases the opportunities to achieve an orgasm for women. Women might simply reach orgasm less often and, therefore, less frequently benefit from the sleep-promoting effects of orgasm, which, in turn, may explain why society and cross-sectional research relying on self-report data postulate that men fall asleep faster following sexual intercourse with orgasm.

4.1 | Limitations and future directions

While the results of the present study underpin the positive effect of sexual activity on sleep, several aspects may limit the interpretability of the findings. The convenience sampling procedure that also made use of a university-student participant pool of a Dutch University possibly limits the generalisability of the results, as most of the participants are young adults from western countries. As the understanding of sexuality concepts varies greatly across cultures (Hall & Graham, 2012), using a more diverse, inclusive sample is encouraged in future replications to increase external validity. Furthermore, suggestive wording in the pre-test items and normative responding based on the general widespread opinion of the sleep effects of sexual activity possibly resulted in recall and acquiescence bias and might contribute to the variability in results between the cross-sectional and longitudinal analysis. The longitudinal study was a preliminary attempt to bring a more thorough and objective insight into the impact of sexual activity on sleep. Yet, the borderline-significant effect of sexual activity without orgasm on sleep quality warrants further investigation, as it may point to a possible effect in the population that was underpowered (power = 0.51) and not detectable due to a small number of cases of partnered sex without orgasm ($n = 85$), of which the majority ($n = 71$) was reported by women. Thereby, examining this effect with a higher number of cases may be valuable, especially for female samples in which sexual activity without orgasm is particularly frequent, compared with male samples.

Due to the purely observational nature of the present study, future research might benefit from investigating the relationship between partnered and solo sexual activity, genital responses, the endocrine processes possibly underlying the effect sex has on sleep, and the psychophysiological markers of sleep in an experimental setting, thereby furthering what has only been done by Brisette et al. (1985). Another pathway could be to use a multi-modal machine learning approach implementing wearable devices to detect whether subjective and objective relations of sex and sleep patterns correlate.

Self-monitoring the beneficial effect of sexual activity on sleep may have positive psychological effects and promote self-awareness.

Future research may consider differences between the effects in hetero- and homosexual couples and non-binary individuals, which were underrepresented in the present sample, as well as the effects different types of sexual activity have on sleep. Further, it is important to highlight that, by reducing sexual activity to partnered sex and masturbation, the present study applied a comprehensive – but restricted – definition of sexual activity. This served the extension of previous research in order to establish an underlying relationship between sexual activity and sleep. For future research, it would be important to apply a more inclusive, integrative conceptualisation of sexual activity by including a wide variety of sexual practices. Moreover, circumstantial factors such as having a new-born or small children, which possibly require frequent night-time engagement, may also be considered in future work, as both sex and sleep endure significant challenges and changes following the birth of a child (Kahn et al., 2022).

4.2 | Strengths and implications

As the first to build upon previously conducted cross-sectional studies while also including a longitudinal design, the present study corroborated and extended the evidence for a sleep-promoting effect of sexual activity on sleep. By conducting an analysis in which the data are not aggregated but analysed with respect to their nested structure using MLM, the present study offered the opportunity to clarify diverging results regarding gender differences, type of sexual activity (masturbation vs. partnered sex), and the role of orgasm appraised by prior research. Moreover, controlling for relevant covariates, especially alcohol consumption which appeared to obscure the relationship between sexual activity and sleep, was valuable in the present study and is recommended for future research. The 14-day duration of the diary study, that includes weekdays as well as weekends, demands increased commitment of participants and further increases the value of inferences.

By using a cross-sectional design resembling the study conducted by Pallesen et al. (2020), their main findings could be replicated. The present study shows that both men and women perceive sexual activity followed by orgasm to reduce sleep latency and increase sleep quality (Gallop Jr. et al., 2021; Lastella et al., 2019; Pallesen et al., 2020). The results of the diary study corroborate the finding that sexual activity improves sleep while highlighting the effect partnered sex has on sleep, compared with masturbation. The heightened effect of partnered sex may partly be explained by the increased neuroendocrine changes following intercourse-induced orgasm, in combination with the valuable effects of experiencing intimacy with one's partner. Penetration and sexual intercourse aligned to heteronormative scripts may not necessarily be required to experience the beneficial effects of sexual activity on sleep. This notion is supported by the borderline-significant effect of partnered sex without orgasm on sleep quality, which is frequently reported by women and shows that intimacy alone may be sufficient to experience positive effects on sleep.

The present discordance of results between the cross-sectional study measuring the perception of the effects and the longitudinal study measuring the actual experience underlines the importance of applying objective measures and prospective measures appraising the perceived effect to the concepts of interest, as the subjective experience of sleep was shown to be a strong predictor of physical and mental well-being and cross-sectional methods are prone to be influenced by expectations and norms surrounding sexuality. In general, the same heteronormative implications of sexuality that underlie the orgasm gap between women and men may influence conceptions about "normal" sexuality – thereby resulting in confounded popular notions, such as men falling asleep first following sexual intercourse. Therefore, culture-specific norms and beliefs surrounding sexuality warrant consideration when interpreting the results of subjective research on sexuality.

The outcomes of the present research have important implications for sleep- and sexual medicine, as they highlight the value of considering partnered sex, masturbation, orgasm, and intimacy as a means to promote good sleep. The establishment of a relationship between sexual activity and sleep serves as a directive for future research to identify possible underlying mechanisms, such as endocrine or social-psychological processes, and to attempt an establishment of the effect using objective measures.

5 | CONCLUSION

As the first to implement both cross-sectional and longitudinal measures to study the effects of sexual activity on sleep, the present study underpins the positive effect of sexual activity on sleep latency and sleep quality. Both studies found sexual activity involving a partner and resulting in orgasm to be perceived as sleep-promoting, while masturbation with orgasm was not found to significantly influence sleep in the longitudinal study. Sexual activity without orgasm was retrospectively reported to negatively affect sleep. While no gender differences in the positive effect of partnered sex with orgasm on sleep emerged, the negative effects of sexual activity without orgasm were stronger in men. The results of the present studies indicate that sexual activity, especially with a partner, may be a valuable behavior to promote good sleep and, thereby, overall health.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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