ORIGINAL ARTICLE

Sleep Science

Subjective sleep quality, unstimulated sexual arousal, and sexual frequency

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ABSTRACT

Introduction: REM sleep deprivation increases unstimulated erections in rats, and total sleep deprivation increases erections during audiovisual sexual stimulation in men, but the effects of sleep problems on human unstimulated sexual arousal are unknown. **Objective:** We examined the associations of subjective sleep quality with unstimulated sexual arousal, satisfaction with sex life, and sexual frequency and desire over the past month. **Methods:** 275 Portuguese (169 women) reported their anxiety, sexual arousal and sexual desire during a resting state, and completed the Pittsburgh Sleep Quality Index, the sexual satisfaction subscale of the LiSat scale, the Desire dimensions of the Female Sexual Function Index (women only) and International Index of Erectile Function (men only). They additionally reported how many days in the past month they engaged in penile-vaginal intercourse, noncoital sex, and masturbation. Salivary testosterone (T) was assayed by luminescence immunoassays. **Results:** Poorer sleep quality correlated with greater unstimulated sexual arousal in men with higher T levels and in women with higher T levels not taking oral contraceptives. In women with lower T, poorer subjective sleep quality correlated with greater sexual dissatisfaction. In both sexes, sleep quality was uncorrelated with sexual desire and sexual frequency over the past month. **Discussion:** Consistently with other studies in humans and animals, the findings are congruent with the notion that lack of sleep can increase sexual arousal, but not sexual frequency. T might play a role in the sexual arousal caused by lack of appropriate sleep.

Keywords: Sleep. Coitus. Sexual Dysfunctions, Psychological

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Received: July 16, 2017; Accepted: October 31, 2017.

DOI: 10.5935/1984-0063.20170026

INTRODUCTION

Poor sleep quality has been related to sexual difficulties[1-9], but case studies suggest that chronic insomnias sometimes increase sexual desire and arousal[10]. In fact, there is accumulating research suggesting that lack of sleep can increase sexual arousal in humans and animals. The present study aimed at better understanding this intriguing phenomenon in men and women.

In male rats, REM sleep deprivation increased spontaneous erections and ejaculations, that is, without the presence of females[11,12], but effects on copulation were found to be mixed with REM sleep deprivation either increasing or reducing copulatory behavior[11,13-16]. In one study, both REM sleep deprivation and general sleep restriction lowered sperm viability, but increased inducible nitric oxide synthase[13], which can enhance erections[17,18]. General sleep restriction did not interfere with copulation in male rats[13]. Increased genital excitation and sexual behavior were also observed in male cats deprived of REM sleep[19,20]. In female rats, REM sleep deprivation either increased or reduced proceptivity and receptivity with lower progesterone levels possibly enhancing sexual responsiveness under conditions of REM sleep deprivation[21,22].

In men with psychogenic erectile dysfunction, total sleep deprivation increased erections in response to audiovisual sexual stimuli[23], and in a nonclinical male sample, both REM sleep deprivation and non-REM awakenings increased visual attention to images of women, but the non-REM awakenings implied REM deprivation[24]. In women, poorer subjective sleep quality over the past month correlated with greater increases in subjective sexual arousal during fantasy[25]. Moreover, in a study with women reporting daily sleep duration and sexual responses and behaviors in the next day, shorter sleep duration correlated with greater perceived genital arousal (lubrication) in the next day, but to lesser desire and less likelihood of having sex[26]. In contrast, others found that sleep disorders and shorter sleep duration are uncorrelated with coital frequency[27,28]. Taken together, all these findings in humans and animals suggest that lack of sleep can facilitate sexual arousal with unclear effects on sexual interactions.

Because animal studies show that lack of REM sleep increases spontaneous erections[11,12], we tested the hypothesis that, in men and women, poorer subjective sleep quality over the past month correlates with greater unstimulated sexual arousal, that is, arousal in a resting state without external sexual stimulation. Because studies in humans and animals have yielded mixed findings regarding the effects of sleep deprivation on sexual interactions and motivation to pursue sexual activity, we additionally examined the associations of poorer subjective sleep quality with sexual desire and frequency over the past month, as well as with sexual satisfaction, with no a priori hypotheses.

Given that lack of sleep increases anxiety[29] and moderate levels of anxiety may facilitate sexual arousal[30-33], we examined if state anxiety explains the hypothesized relation between unstimulated sexual arousal and poorer subjective sleep quality.

Testosterone (T) administration to REM-sleep deprived male rats stimulated copulatory behavior[34], and greater T rises were found to have a slight explanatory effect in the relationship between women's poorer sleep quality and fantasy-induced sexual arousal[25]. Therefore, we hypothesized that the relation between unstimulated sexual arousal and severity of sleep problems is observed among those with higher T levels, but not among those with lower T levels.

Because oral contraceptives seem to facilitate REM sleep[35,36], it is likely that sleep problems of oral contraceptive users involve less REM sleep disturbances; because specifically lack of REM sleep might increase unstimulated sexual arousal, we tested if unstimulated arousal and poorer subjective sleep quality are correlated, and if this association is moderated by T levels, in naturally cycling women and oral contraceptive users separately.

METHODS

Participants

The study had the participation of 338 Portuguese from the Lisbon area. Exclusion criteria applied to those not reporting data on sleep quality (N = 2), describing their sexuality as totally or almost totally with the same sex (N = 18), taking psychotropic medications or having health conditions that could interfere with sexuality (except one participant complaining from chronic insomnia; N = 29), not reporting data on hormonal contraception (N = 6), and for whom there were no data on T (N = 8). The final sample consisted of 169 women and 106 men. The samples sizes were chosen, because they have adequate power (.80) to detect modest effect sizes: in the case of women until r^2 = .045. In the case of men until r^2 = .070. Descriptive statistics are depicted in Table 1.

Measures

The Pittsburgh Sleep Quality Index (PSQI)[37] was used to measure subjective sleep quality. The PSQI has 19 items tapping seven components of sleep quality: overall subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Higher scores indicate poorer sleep quality.

Unstimulated sexual arousal, desire, and anxiety, were measured by asking "In this precise moment, describe to what extent are you feeling sexual arousal, desire, and anxiety. Responses were given on a scale from 1 (absolutely nothing) to 7 (extremely)[25,38]. These questions were made shortly after participants having arrived to the laboratory, when they were in a resting state. In fact, these questions were meant to assess baseline psychological state before exposition to stimuli as part of a study not reported here. Baseline (unstimulated) desire and arousal measured with this scale were significantly increased by induction of a sexual fantasy[25] and visualization of a romantic movie scene[38], which supports their validity as measures of resting state.

Sexual satisfaction was measured with the respective single-item scale of the LiSat (Life Satisfaction) scale, which is rated on a scale ranging from 1 (very dissatisfying) to 6 (very satisfying)[39]. Several studies support the utilization of this measure in sexual assessment[39-42].

Table 1. Descriptive statistics. Demographics.

	Women (N = 169) Mean (SD) or %	Men (N = 106) Mean (SD) or %
Age (years)	23.08 (5.44)	24.06 (7.05)
Occupation		
University student	74.6	71.2
Employed	24.8	27.9
Unemployed	.6	.9
Education		
High school	3.6	6.6
University attendance	52.1	48.1
University degree or more	44.3	43.3
Relationship characteristics		
With regular sexual partner	63.9	61.3
Relationship duration (months)	36.34 (30.31)	35.86 (34.47)
Cohabiting	16.6	17.0
Taking oral contraception	61.5	-

SD = standard deviation

Participants were asked about their frequency in days in the past month of penile-vaginal intercourse, masturbation, and noncoital sex without same day vaginal intercourse[43]. In addition, female sexual desire was assessed with the Desire subscale of the Female Sexual Function Index (FSFI)[44], which has 2 items asking respondents to rate their level and frequency of sexual desire or interest over the past four weeks on a scale from 1 to 5. Male sexual desire was additionally measured with the Desire dimension of the International Index of Erectile Function (IIEF)[45]. This subscale is composed of 2 items asking respondents to rate their level and frequency of sexual desire in the preceding four weeks on a scale from 1 to 5.

For salivary T determination, approximately 1ml of saliva was collected into a polypropylene tube for each participant, and conserved at -20º. Afterwards, samples were centrifuged for ten minutes at 2245 g, and T was assayed with luminescence immunoassay kits from IBL-International (RE62031). Inter and intra-assay coefficients were 7.17% and 2.28%, respectively. All samples were collected in the afternoon (between 2 pm and 5 pm), because T collected during this time of the day has been more consistently related to behavioral variables[46-48]. We did not control for menstrual cycle, because it was shown not to meaningful affect correlations between T and behavioral and cogntive variables[49,50]. Because we wanted to test that the relation between unstimulated arousal and poorer sleep is moderated by T levels, we distributed the male and female samples in subgroups with higher and lower T levels based on a median split.

Procedure

Upon arriving at the laboratory, participants provided written informed consent and reported to what extent they were feeling sexual arousal, sexual desire, and anxiety. Immediately afterwards, they provided a saliva sample for T determination. This procedure had the objective of assessing baseline T and psychological state before exhibition of experimental stimuli as part of a study not reported here (the stimuli consisted of an excerpt of romantic movie showing the initial emotional involvement between a man and woman, and of a short movie showing explicit sexual activity between a man and a woman). The saliva samples were collected before questionnaires being applied. After the experimental task, participants completed the battery of questionnaires including the questions of interest for the present study. Participants received course credits or a ten-euro shopping voucher. The advertisement of the experiment was done through the internet and directed at the general population. The study had the approval of the local Ethics Committee, and followed the Declaration of Helsinki principles.

RESULTS

Sleep problems correlated with greater T levels among naturally cycling women (r = .24, p = .051), but not in men (r = .06, p = .551) and women taking oral contraception (r = -.11, p = .280). Women taking oral contraception were more likely to have T below the median (57.7 % vs. 36.9 %, chi square = 6.90, p = .009).

As displayed in Table 2, unstimulated sexual arousal correlated with greater severity of sleep problems in women. When women were allocated to subgroups with higher and lower T levels, unstimulated arousal correlated with sleep problems only among women with higher T. We did a further allocation of the female sample into four subgroups according to T levels

Table 2. Correlations between subjective sleep quality (PSQI) and sexual variables and anxiety (women)

	All women N = 169	Women (Lower T) N = 84	Women (Higher T) N = 85
Unstimulated sexual arousal	.20**	.06	.30**
Unstimulated sexual desire	.10	.11	.10
Unstimulated anxiety	.24**	.28**	.21#
Sexual satisfaction	-.18*	-.27**	-.10
Sexual desire (FSFI)	.05	.02	.07
Sexual frequency (days in past month)			
Penile-vaginal intercourse	-.12	-.17	-.07
Noncoital sex	-.05	-.20	.11
Masturbation	.15	.18	.12

PSQI = Pittsburgh Sleep Quality Index; FSFI = Female Sexual Function Index; T = testosterone
** p ≤ .01; # p ≤ .05

and oral contraception use (lower T and no contraceptive use, higher T and no contraceptive use, lower T and contraceptive use, higher T and contraceptive use). Sleep problems correlated with unstimulated arousal only in the subgroup with higher T and not taking oral contraception (see Table 4).

As depicted in Table 3, unstimulated sexual arousal correlated with greater severity of sleep problems in men. When the men were allocated to subgroups with higher and lower T levels, unstimulated arousal correlated with sleep problems only among men with higher T.

As depicted in Table 2, greater severity of sleep problems correlated with greater sexual dissatisfaction among the entire group of women, and in the female subgroup with lower T. For both sexes, severity of sleep problems was uncorrelated with unstimulated desire as well as with sexual frequency and desire over the past month (see Tables 2, 3 and 4).

In backward multiple regressions done for the subgroups of men with higher T levels and women with higher T levels taking oral contraception, severity of sleep problems was predicted by greater unstimulated arousal, but not by unstimulated anxiety, and age (see Tables 5 and 6).

DISCUSSION

The present study confirmed that poorer subjective sleep quality is related to greater unstimulated sexual arousal, and that this relation was mostly driven by men with higher T levels and women with higher T levels not taking oral contraception. These findings extend previous ones showing that 1) severity of women's subjective sleep problems correlated with greater fantasy-induced subjective sexual arousal[25], 2) perceived genital arousal was greater, when the duration of sleep was shorter in the previous night[26], and 3) sleep deprivation in men increased erections in response to erotica[23] and visual attention to images of women[24]. Our findings are also consistent with studies in male rats showing that unstimulated erections are facilitated by REM sleep deprivation[11,12], a consequence of general sleep deprivation.

As predicted, severity of sleep problems correlated with unstimulated arousal only in the male and female groups with higher T levels. The facilitating role of T in increasing sexual arousal in rats and humans with lack of adequate sleep was previously reported[25,34]. In addition, enhanced dopaminergic activity appears to be a mechanism by which REM sleep deprivation increases sexual arousal[14,51,52], and REM sleep is likely more disturbed in many people with sleep problems. Ferini-Strambi and colleagues proposed that sleep deprivation reduces psychological inhibitions[23].

In addition, the relation between female unstimulated arousal and sleep quality was further moderated by oral contraception: we found that unstimulated arousal and poorer sleep quality correlated in naturally cycling women with higher T levels, but not in women taking oral contraceptives, even if they had higher T levels, which argues against the possibility that the decrements in T commonly observed in women taking oral contraception[53] (and replicated in the present study) drive the relation between sleep quality and sexual arousal. There is evidence that oral contraception favors REM sleep[35,36]; therefore, it is possible that sleep problems in oral contraceptive users are less likely to reflect REM sleep disturbances, and thereby less likely to have a sexually arousing effect. Also, it has been found, that, in female rats, REM sleep deprivation either facilitates or inhibits proceptive and receptive sexual behavior, with lower

Table 3. Correlations between subjective sleep quality (PSQI) and sexual variables and anxiety (men)

	All men N = 106 r (p)	Men (lower T) N = 53 r (p)	Men (higher T) N = 53 r (p)
Unstimulated sexual arousal	.31***	.18	.40**
Unstimulated sexual desire	.17	-.01	.35**
Unstimulated anxiety	.15	.26 #	.06
Sexual satisfaction	-.01	-.11	.07
Sexual desire (IIEF)	.01	-.02	.05
Sexual frequency (days in past month)			
Penile-vaginal intercourse	-.12	-.07	-.17
Noncoital sex	-.14	-.09	-.19
Masturbation	.15	.22	.12

PSQI = Pittsburgh Sleep Quality Index; FSFI = Female Sexual Function Index; IIEF = International Index of Erectile Function
*** p < .001; ** p = .01; # p = .057

Table 4. Correlations between subjective sleep quality (PSQI) and unstimulated arousal, unstimulated desire, and satisfaction (women).

	Naturally cycling/ lower T N = 24	Naturally cycling/ higher T N = 41	Oral contraception/ lower T N = 60	Oral contraception/ higher T N = 44
Unstimulated arousal	.22	.45**	.03	-.03
Unstimulated desire	-.11	.07	.16	.02
Sexual Satisfaction	-.26	-.06	-.28*	-.03

PSQI = Pittsburgh Sleep Quality Index; T = testosterone
** p < .01; * p < .05

Table 5. Backward multiple regressions predicting sleep quality from unstimulated sexual arousal, unstimulated anxiety, and age, in naturally cycling women with higher T levels (partial correlations at last step).

Predictors of PSQI	
Unstimulated sexual arousal	.45**
Unstimulated anxiety	.13
Age	-.10

PSQI = Pittsburgh Sleep Quality Index; T = testosterone
** p < .001

Table 6. Backward multiple regressions predicting sleep quality from unstimulated sexual arousal, unstimulated anxiety, and age in men with higher T (partial correlations at last step).

Predictors of PSQI	
Unstimulated sexual arousal	.40**
Unstimulated anxiety	.02
Age	-.08

PSQI = Pittsburgh Sleep Quality Index; T = testosterone
** p < .01

progesterone possibly increasing sexual behavior under REM sleep deprivation[21,22]. This raises the possibility that the hormonal changes caused by the pill may attenuate or impede the enhancing effect of sleep deprivation on sexual arousal. Future research is needed to clarify this question. Future research might address the role of type and duration of contraception.

Poorer sleep quality was associated with female dissatisfaction with sex life, and this relation was largely driven by women with lower T levels, regardless of oral contraception. Whereas lack of adequate sleep correlated with greater unstimulated arousal when there were higher T levels, lack of adequate sleep correlated with greater dissatisfaction with sex life, when there were lower T levels. Research in men has highlighted a possible interrelationship between sleep problems, erectile dysfunction, and lower T[54]. Future research is needed to unveil which factors moderate the effects of sleep disturbances on sexual responsiveness; with the present knowledge, lower T levels appear to increase the risk of sexual difficulties related to sleep problems.

According to our findings, poorer sleep quality does not reflect on greater sexual desire nor on greater frequency of sexual activities. If anything, there were nonsignificant correlations between poorer sleep quality and lesser frequency of sexual interactions. In rats, the effects of REM sleep deprivation on copulation are mixed[11,13-16,21,22]. In a study of women, shorter sleep duration reduced desire and likelihood of having sex in the other day, despite facilitation of lubrication[26], but others have found coital frequency to be uncorrelated with sleep disorders[27] and shorter sleep duration[28], which is consistent with our findings. It is likely that, even with increased sexual arousal, the tiredness that results from lack of sleep often interferes with intimacy, which might ultimately lead to sexual difficulties. Sleep problems have been related to erectile dysfunction and female sexual difficulties[1-9,26].

Unstimulated state anxiety did not explain the relationship between sleep problems and unstimulated arousal. This is consistent with a previous study, in which state anxiety did not explain the association between poor sleep quality and sexual arousal in response to fantasy[25].

In the naturally cycling female group, there was a significant direct correlation between higher T levels and poorer subjective sleep quality. The link between T and sleep quality in women remains understudied. In men, there is some evidence that lack of adequate sleep may cause T levels to diminish[55,56]. In the present study, T did not correlate with sleep problems in men, but this finding might be explained by the young age range of the present sample, as previous studies included older participants[55,56].

Unstimulated sexual arousal was reported with participants having no external stimulation, but they might have been aroused by fantasy. In fact, severity of subjective sleep problems was previously correlated with greater fantasy-induced sexual arousal[25]. If sleep deprivation enhances spontaneous sexual responses, it is possible that, in humans, there is a concomitant increase in internally-generated sexual imagery. Also, it could be argued that the unstimulated participants were still aroused to some degree by events that had occurred before they arrived to the laboratory. If that is the case, then sexual stimuli can exert a more persistent effect in persons with poorer sleep quality, even when they are already not present. Research is warranted on this topic.

Our study revealed that unstimulated arousal was more consistently correlated with sleep quality than unstimulated desire. This is consistent with previous research showing that poorer subjective sleep quality correlated with greater fantasy-induced subjective sexual arousal, but not desire[25], and that shorter sleep duration increased genital arousal, but not desire in the next day[26]. Desire and arousal may be contrasted as the former being a motivational state that drives the search for sexual activity, whereas the latter is a change in the physical and psychological state that prepares individuals for sexual activity[57], which does not contradict models of sexual response in which arousal precedes desire. Although, these definitions are not commonly provided to research participants, it is rather possible that most understand them that way, even if there are difficulties for lay people to express it in words. Also, the differential relations of desire and arousal with sleep quality found in humans seem consistent with animal models showing that REM sleep deprivation can enhance spontaneous erections (without presence of females)[11,12], but there are mixed findings regarding the effects on the pursuit of copulation, as indexed by reduced proceptive behavior in females[21,22], and greater mount and intromission latency, or reduced mount and intromission frequency in males[11,13-16].

Limitations of the present study include the lack of physiological measures of erection and vaginal vasocongestion, and the young, mostly non-cohabiting, sample. Also, the study was cross-sectional, and caution is needed regarding causal inferences. However, previous research shows that lack of appropriate sleep has an enhancing effect on sexual arousal[11,12,23,24,26], and that T administration facilitates sexual behavior in REM-deprived rats[34].

CONCLUSION

The findings are consistent with the notion that, in men and naturally cycling women, lack of adequate sleep facilitates unstimulated sexual arousal in those with higher T levels, but frequency of sexual interactions is not increased.

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