

Don't worry, sleep well: predictors of sleep loss over worry

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Abstract In this study, our aim was to explore the relationship between sleep quality/quantity, chronotype, pre-sleep arousal, arousability, stress, coping, neuroticism, extraversion, mood/affect, perceived health and sleep loss due to worry in college students. A total of 713 students (mean age 19.29 ± 1.256 years) completed a set of questionnaires that assessed sleep loss over worry (item from the General Health Questionnaire), other sleep–wake aspects (e.g., habitual sleep duration, sleep needs, sleep depth, subjective sleep quality, sleep latency, night awakenings, daytime sleepiness, sleep flexibility, sleep reactivity to stress), pre-sleep arousal (cognitive/somatic arousal), arousability, coping, neuroticism, extraversion, perceived physical/mental health, academic stress and positive/negative affect. Sleep disturbance due to worry was reported by 40.6 % of female and 19.2 % of male students. It was significantly correlated with perceived health and the majority of sleep–wake variables. Almost all correlations between the

psychological traits under study and sleep loss over worry were significant. Results from the stepwise regression analyses, however, showed that only cognitive arousal ($\beta = .353$; $p < .001$), perceived academic stress ($\beta = .129$; $p < .01$), arousability ($\beta = .127$; $p < .01$), worry tendency ($\beta = .153$; $p < .001$), gender ($\beta = .118$; $p < .01$) and perceived physical health ($\beta = -.093$; $p < .01$) were significant predictors of sleep loss over worry. Together, these variables accounted for 40.3 % of the total variance in sleep disturbance due to worry. Our findings suggest that cognitive arousal, academic stress, arousability, tendency to worry, gender and perceived physical health may be important determinants of sleep loss over worry. These results may have important implications for prevention and intervention to improve sleep quality in young adults.

Keywords Sleep · Sleep loss over worry · Perceived insomnia · Perceived health

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A rich man loses weight by wakeful nights, (...) sleepless worry keeps him wide awake, just as serious illness banishes sleep—Ecclesiasticus, 190 B.C.

Worry is perhaps the biggest single factor behind sleeplessness—Peter Tyrer (1978).

Introduction

Worry is a central construct in human psychological functioning. Its connection to sleep and sleep dysfunction has been observed by clinicians and writers since more

than 2000 years [1, 2]. However, research regarding the key role that worry may play in sleep behavior is scarce.

Regarding clinical settings, we found two researches exploring more explicitly this topic: in a study of primary care patients ($n = 157$), the most common perceived causes for their disturbed sleep were “nerves” (34.2 %) and “worries/problems” (32 %) [3]. Carvalho, Ribeiro, Martins, Ferreira and Azevedo [4] carried out a study about sleep disturbances in a sample of 131 cancer patients undergoing chemotherapy. Forty-two percent of the participants reported sleep problems. In their opinion, the principal causes of sleep problems were worries related to the disease/treatment (38.3 %), anxiety/preoccupations/grief and familial problems (21.8 %).

We have found only a single study which focuses on this matter in the community. In a recent population-based investigation in the UK ($n = 7.403$), among the respondents who offered a specific reason for their sleep problems, worry/thinking (37.9 %) was the most common, followed by illness/discomfort (20.1 %). It was also found that the prevalence of sleep disturbance because of worry was higher in women. The age distributions of the most common reasons provided by respondents showed that sleep disturbance through worry reached a peak in early working lives and then declined, whereas sleep problems through illness increased with age, plateauing in late middle age.

Since there was no formal scale to assess sleep loss due to worry, Kelly [5] developed the Sleep Disturbance Ascribed to Worry Scale (SAW). This is a self-report questionnaire comprising 5 items intended to evaluate the effects of worry on sleep. It has 11 response options (0 = never, 10 = very often). Higher scoring suggests higher sleep loss due to worry levels. A study by Kelly [6] evaluated the association among sleep loss due to worry, habitual sleep length and worry frequency measured by the Worry Domains Questionnaire (WDQ [7]) on a sample of 222 college students (152 females; mean 24 years). Forty-six of the participants were also invited to describe their quality of sleep (1 item) in a 11-point Likert-type scale ranging from “awful” to “great”. The results suggested the sleep disturbance attributed to worry impaired the quality and habitual sleep length; besides, it was associated with higher levels of worry.

In a subsequent study, Kelly [5] carried out two correlational studies using SAW as well. In the first one, comprising 95 college students (70 females; mean 26.5 years), the results showed that sleep loss due to worry was related with higher levels of general worry, anxiety and stress perception and lower levels of life satisfaction and happiness. In study 2, comprising also a college students sample ($n = 117$; 70 females), the correlations with stress, worry and somatic anxiety were replicated and it was found that

sleep loss due to worry was significantly associated with increased negative affect, depression, general sleep disturbance and decreased self-esteem.

Beyond Kelly’s works, we found only a single study on the association among sleep disturbance caused by worries and sleep and psychological variables. In the already mentioned study by Dregan et al. [8], sleep disturbance, general worry, depression, anxiety and poor health perception were differently distributed according to different reasons given for sleep problems. Sleep disturbance because of “worry/thinking” was often associated with sleep-onset problems (41 %) and waking up more than 2 h early (43 %).

Regarding the severity of sleeping problems, it was concluded that it was higher when the reason was illness, followed by “worry/thinking”. When the association pattern was analyzed between general worry, depression and anxiety and reasons for sleep problems, as expected, the highest percentage belonged to the group whose reasons were “worry/thinking” (32 %), with anxiety and depression represented in equal proportions (15 %). Finally, those with poor self-reported health status, as might be expected, were more likely to report sleeping problems if the reason was illness (9 %) or taking medication (8 %), but this group also scored highly if the reason was “worry/thinking” (6 %). Furthermore, as shown in several studies, worry-related sleep complaints is a predictor of cardiovascular morbidity and mortality [9, 10] and may increase alcohol-related risk [11].

Given this link with adverse clinical events, in a recent study, Salo et al. [12] examined the evolution of sleep loss due to worry across the lifespan of two large European cohorts (Whitehall II study and Finnish Public Sector study) by sex and age group. In both studies, sleep was assessed using a single item which asked participants to think about the past few weeks when responding to the question “Have you recently lost much sleep over worry?”. Responses were dichotomized to indicate the presence (“rather more than usual” and “much more than usual”) or absence (“not at all” and “no more than usual”) of sleep complaints.

In the UK study, the prevalence at baseline was 14 %, and 49 % of the participants reported sleep loss over worry at least once at some point during the study (mean 21.6 years of follow-up), whereas in the Finnish Public Sector study the baseline prevalence was 22 %, and 51 % of the participants reported sleep loss over worry at least once during the study (mean 10.9 years of follow-up).

In both studies, the prevalence of sleep disturbance due to worry was higher in women and decreased significantly with age in both sexes.

In Kelly’s studies [5, 6], there were some significant limitations: reduced sample size and absence of relevant

measures related to arousability, pre-sleep cognitions or sleep disturbances, to evaluate which variables account for sleep loss over worry [5]. Therefore, the aims of our study were (1) to examine the association among sleep–wake variables, arousability, cognitive/somatic pre-sleep arousal, personality traits, stress, coping, mood/affect, perceived health and sleep loss due to worry and (2) to explore which psychological variables constitute the most significant predictors of sleep loss due to worry in a sample comprising college students.

Method

This study was approved by the Ethical Committee and the Scientific Council of the Faculty of Medicine of the University of Coimbra.

Participants

In this study, 713 students participated (mean age 19.29 years; SD 1.256; range 17–24 years) from the first to third year of the medicine course. Two hundred and forty-five (34.4 %) were male (mean age 19.22 years; SD 1.227) and 468 (65.6 %) were female (mean age 19.34 years; SD 1.271). There was no significant difference between both groups ($p = .22$; NS).

Measures

NEO Personality Inventory Revised (NEO-PI-R)

The NEO-PI-R [13] operationalizes the five personality factors model and provides a comprehensive, multidimensional assessment of adult personality. For the present study purposes, we selected five facets of neuroticism: anxiety (N1), hostility (N2), depression (N3), impulsiveness (N5) and vulnerability (N6).

Eysenck Personality Inventory (EPI)

The short version of the EPI (EPI-12) [14] was used to evaluate extraversion (*E*) and neuroticism (*NE*). The item “I suffer from sleeplessness” was removed from *NE*, as it might constitute a confounding variable.

Repetitive thought

The general tendency to worry and overthinking/rumination was measured with a scale comprising four items: two items assess the tendency to worry: (“I worry a lot”, “The people around me consider that I worry a lot”) and two

items assess the tendency to overthinking/rumination (“I think a lot over things”, “The people around me consider that I think a lot over things”). Each item is scored from 1 = almost never to 4 = almost always [15].

Arousal Predisposition Scale (APS)

The APS is constituted by 12 items measuring predisposition to arousability. Each item is answered on a 4-point scale (1 = almost never to 4 = almost always). The higher the scores, the more is the predisposition to arousability [16].

Pre-sleep Arousal Scale (PSAS)

The PSAS contains 16 items, each rated on a 5-point scale that describes the symptoms of arousal at bedtime [17]. Eight items evaluate cognitive arousal and eight evaluate somatic arousal. Higher scores suggest higher pre-sleep arousal.

Profile of Mood States (POMS)

The POMS [18] is constituted by 65 adjectives describing feelings and emotions that people usually experience. Each item is responded on a 5-point scale: 0 = by no means to 4 = very much. Seven mood states are evaluated: tension–anxiety, depression–rejection, fatigue–inertia, anger–hostility, vigor–activity, agreeableness and confusion–disorientation. In this study, subjects should consider the previous month (not the previous week, as originally requested), as we wanted to evaluate the affect associated with traits, and not transitory states of humor [18]. The “Negative Affect” (NA) dimension was constituted by summing the scores from anxiety, depression, fatigue and anger scales; the “Positive Affect” dimension (PA) summed the scores on the vigor and friendliness scales.

Emotion Regulation Questionnaire (ERQ)

The ERQ [19] assesses two emotion regulation strategies: cognitive reappraisal and expressive suppression. Response options range from 1 = strongly disagree to 7 = completely agree.

Stress Sources Inventory (SSI)

SSI assesses the main perceived stressors of university students in the Portuguese context [20]. It comprises 24 items, rated on a 5-point scale (from 1 = strongly disagree to 5 = strongly agree). In our study, only Academic Stress subscale (factor 1–13 items) was used.

Preferences Scale (PS)

The PS [21] is a measure of morningness, comprising six questions about time for preferences for mental work and six about physiological rhythms. Each question is answered in a 5-point scale: much earlier than other people = 1 to much later than other people = 5.

Morningness/eveningness

Morningness/eveningness (chronotype) was assessed using the following question: “Do you think you are a more morning or nocturnal-type person?” The response categories were: definitely a morning-type = 1, more matinal than nocturnal = 2, neither matinal nor nocturnal = 3, more nocturnal than matinal = 4, definitely a nocturnal-type = 5. We explored the association between this item and the two factors from PS ($r = .4$; $p < .001$).

Sleep–wake variables

1. Habitual sleep duration—“How many hours do you usually sleep per night?” (scored 1 = 5 h or less to 9 = 11 h or more);
2. Sleep depth—“Ever since you can remember how has been the depth of your sleep?” (scored 1 = very deep to 5 = so light that anything wakes me);
3. Subjective sleep quality—“Ever since you can remember how has been your sleep quality?” (scored 1 = very good to 5 = very poor);
4. Sleep needs—“In your case how many hours do you need to sleep to feel good and function well during the day?” (scored 1 = 5 h or less to 9 = 11 h or more);
5. Sleep flexibility—“Do you think you are the kind of person for whom it is very easy to fall asleep at any time of day and anywhere?” (scored 1 = never/almost never to 4 = always/almost always).
6. Sleep latency—“How long does it take to you to fall asleep?” (scored 1 = 1–14 min to 5 = 60 min or more);
7. Nocturnal awakenings—“How many times do you wake up at night?” (scored 1 = 0 times to 7 = 6 times or more).
8. Time to get-up—“How long does it take you to get up after waking up? (scored 1 = 1–14 min to 5 = more than 60 min).

Sleep Quality Index (SQI)

Based on the scores on sleep depth, subjective sleep quality, sleep latency and nocturnal awakenings, we

created an SQI. The score varies from 3 to 21. Higher scores suggest greater sleep disturbance. The Cronbach’s alpha coefficient of SQI was acceptable ($\alpha = .65$). One should note that Cronbach’s alpha coefficients $>.7$ are normally the guideline when one is developing or adapting a scale, for example. For exploratory studies, for instance, values of $\alpha \geq .60$ are considered acceptable.

Perceived Daytime Sleepiness (PDS)

To evaluate PDS, the sum of the scores on four items was used: during the day I feel excessively sleepy, full of sleep; being sleepy during the day is a problem for me; during the day I feel that my performance is impaired by being sleepy; during the day I feel the need to take a nap. All items are scored from 0 = never to 5 = always. No specific time frame is specified.

Epworth Sleepiness Scale (ESS)

The ESS [22, 23] assesses the propensity of “dozing or falling asleep” in common situations of daily living such as sitting and reading; watching TV; sitting in a public place. It has eight items scored from 0 to 3, with scores ranging from 0 to 24 points. The normal upper limit of ESS total score is generally considered to be 10 points.

Sleep loss over worry

Sleep loss over worry was evaluated with a single item, “I lose sleep over worries” (adapted from General Health Questionnaire-12) rated on a four-point scale from 1 = almost never to 4 = almost always. No specific time frame is specified. Higher scores denote greater worry-related sleep disturbance.

Self-perceived insomnia

The self-perception of insomnia was assessed with a single item from the EPI-12: “I suffer from sleeplessness” [14], rated on a four-point scale with 1 = almost never, 2 = quite seldom, 3 = quite often and 4 = almost always.

Self-perceived health

Self-perceived physical and mental health status was assessed with two questions: “Generally, what has your physical health been like?” and “Generally, what has your psychological (mental) health been like?”. The responses could range between very poor = 1, poor = 2, neither good nor poor = 3, good = 4, very good = 5.

Procedure

First, we contacted the professors of the first 3 years of the Faculty of Medicine of University of Coimbra to obtain authorization to administer the questionnaires at the beginning/ending of practical lessons. After the aims of the study had been explained to the students, they were invited to fill out the set of questionnaires. This occurred out of the evaluations period. It was emphasized that their cooperation was voluntary, and confidentiality was ensured. All students present in class returned the questionnaires. Thus, the adhesion rate was of 100 %.

Statistical Analysis

All statistical analyses were computed using IBM Statistical Package for Social Sciences (SPSS) Statistics, version 20. We calculated frequencies, mean, standard deviations and range of variables. To analyze association among the different variables we calculated the Pearson's product-moment coefficient. Cohen's criteria [24] were used to interpret the effect sizes (.10 = small; .30 = medium; .50 = large). Furthermore, Student's *t* tests were computed to examine the eventual differences between sexes and one-way ANOVAs to explore differences among the different groups created from "sleep loss due to worry" dependent variable. When the results were significant, Tukey's-*b* test was used as a post hoc measure. Finally, a stepwise linear regression it was applied to identify the psychological predictor variables of sleep loss due to worry.

Results

Sleep loss due to worry prevalence

As shown in Table 1, 17.6 % of males and 34 % of females reported sleep disturbance due to worries "Many times". On the other hand, 1.6 % of males compared to 6.6 % females reported "Almost always". 33.2 % of participants were considered in the joint category "Almost always + many times", of which 40.6 % were female and 19.2 % were male.

Group comparisons by sex

As shown in Table 2, there are significant differences between sexes in most of the psychological variables (12 in 19). The mean scores in these variables are significantly higher in females, with the exception of positive affect and cognitive reappraisal variables, whose values were higher

Table 1 Sleep loss due to worry prevalence

Frequency	Total, <i>n</i> (%)	Males, <i>n</i> (%)	Females, <i>n</i> (%)
Almost never	130 (18.2)	66 (26.9)	64 (13.7)
Few times	312 (43.8)	120 (49.0)	192 (41.0)
Many times	202 (28.3)	43 (17.6)	159 (34.0)
Almost always	35 (4.9)	4 (1.6)	31 (6.6)
Sleep loss due to worry (dichotomized)			
Yes	237 (33.2)	47 (19.2)	190 (40.6)
No	442 (62.0)	186 (75.9)	256 (54.7)
No response	34 (4.8)	12 (4.9)	22 (4.7)

Yes almost never + few times, *No* many times + almost always

in males. Concerning health and sleep variables, it was found that the mean values of self-perceived mental health and self-perception of overall health (mental health + physical health) were significantly higher in males (better health) than in females. In relation to self-perceived physical health, there were no significant differences between the sexes. With respect to sleep-related variables, significant differences were observed in seven of them (7 in 16), specifically in sleep depth, night awakenings, mental work, morningness/eveningness, sleepiness perception, quality of sleep and sleep loss due to worries, with females presenting the highest values in all variables, except mental work and morningness/eveningness, whose values were significantly higher in males (cf. Table 3).

Associations among age, psychological variables and sleep loss due to worry

Table 4 displays the correlations between age and psychological variables and sleep loss due to worry. The coefficients were significant and positive for most variables (18 in 20). The lowest correlation was $r = .091$ (age) and the higher $r = .512$ (cognitive arousal).

Associations among health self-perception, sleep variables and sleep loss due to worry

As shown in Table 5, the correlation coefficients between health self-perception and sleep loss due to worry are significant and negative (worse health), ranging from low magnitude in the case of self-perceived health physical ($r = -.224$) to moderate magnitude regarding global health self-perception (i.e., mental health + physical, $r = -.325$). The correlation between habitual sleep duration and sleep loss due to worry is also significant, negative and of low magnitude ($r = -.081$; $p < .05$). As expected, the coefficients are positive and significant with

Table 2 Group comparisons in psychological variables by sex

	Females, M (SD)	Males, M (SD)	<i>t</i> (<i>df</i>)	<i>p</i>
Arousal predisposition	26.895 (5.961)	22.382 (5.796)	−9.606 (495.606)	<.001
Academic stress	3.381 (.557)	3.002 (.624)	−7.683 (420.309)	<.001
Eysenck_extraversion	2.698 (.402)	2.701 (.442)	.073 (424.028)	NS
Eysenck_neuroticism	2.141 (.543)	1.956 (.558)	−4.119 (458.821)	<.001
NEO-PI-R_neuroticism	123.327 (12.967)	116.750 (14.999)	−5.506 (393.853)	<.001
NEO-anxiety (N1)	3.216 (.453)	2.948 (.462)	−7.156 (451.485)	<.001
NEO-hostility (N2)	2.811 (.412)	2.710 (.417)	−2.976 (664.000)	<.01
NEO-depression (N3)	2.850 (.615)	2.664 (.665)	−3.534 (439.687)	<.001
NEO-impulsivity (N5)	3.138 (.407)	3.073 (.436)	−1.875 (440.138)	NS
NEO-vulnerability (N6)	3.004 (.464)	2.767 (.520)	−5.809 (423.053)	<.001
Tendency to worry	2.319 (.748)	2.026 (.723)	−4.957 (485.999)	<.001
Cognitive arousal	19.451 (5.673)	18.747 (5.265)	−1.635 (520.989)	NS
Somatic arousal	10.329 (3.417)	10.029 (2.962)	−1.208 (554.207)	NS
POMS_fatigue/inertia	1.383 (.853)	1.386 (.831)	.037 (474.832)	NS
POMS_anger/hostility	.704 (.585)	.731 (.675)	.544 (663.000)	NS
POMS_negative affect	.980 (.573)	.924 (.606)	−1.134 (428.729)	NS
POMS_positive affect	2.244 (.548)	2.409 (.581)	3.525 (428.022)	<.001
Expressive suppression	28.208 (5.290)	26.622 (5.398)	−3.633 (457.606)	<.001
Cognitive reappraisal	13.717 (3.888)	15.192 (3.906)	4.598 (448.562)	<.001

NS not significant, *df* degrees of freedom, *M* mean, *SD* standard deviation

Table 3 Group comparisons in health and sleep variables by sex

	Females, M (SD)	Males, M (SD)	<i>t</i> (<i>df</i>)	<i>P</i>
Physical health	4.050 (.692)	4.120 (.743)	1.139 (462.011)	NS
Mental health	3.890 (.737)	4.100 (.777)	3.381 (466.846)	<.01
Physical + mental health	3.974 (.612)	4.110 (.617)	2.773 (485.378)	<.01
Habitual sleep duration	3.890 (1.158)	3.850 (1.222)	−.419 (471.522)	NS
Sleep depth	2.250 (.668)	2.000 (.676)	−4.751 (706.000)	<.001
Subjective sleep quality	2.260 (.722)	2.220 (.846)	−.624 (705.000)	NS
Sleep needs	5.080 (1.308)	4.890 (1.488)	−1.716 (704.000)	NS
Sleep flexibility	2.110 (.848)	2.140 (.884)	.466 (473.576)	NS
Sleep latency	1.840 (.854)	1.730 (.862)	−1.752 (490.254)	NS
Nocturnal awakenings	1.020 (1.178)	.670 (.977)	−3.995 (706.000)	<.001
Time to get-up	1.320 (.572)	1.420 (.702)	1.966 (705.000)	NS
Mental work	2.510 (1.148)	2.900 (1.289)	3.960 (675.000)	<.001
Physiological timings	3.620 (.943)	3.740 (1.038)	1.461 (431.094)	NS
Morningness/eveningness	2.190 (1.142)	2.384 (1.248)	2.082 (704.000)	<.05
Sleepiness propensity	10.091 (5.279)	10.080 (5.171)	−.026 (488.434)	NS
Sleepiness perception	1.356 (.538)	1.269 (.483)	−2.166 (528.732)	<.05
Quality of sleep index	1.844 (.616)	1.654 (.580)	−3.986 (704.000)	<.001
Sleep loss due to worry	2.35 (.81)	1.94 (.73)	−6.57 (677.000)	<.001
Insomnia	.110 (.313)	.100 (.305)	−.276 (482.148)	NS

NS not significant, *df* degrees of freedom, *M* mean, *SD* standard deviation

high quality of sleep index ($r = .511, p < .001$) and self-perceived insomnia ($r = .541, p < .001$). A significant association was found between sleepiness perception and

sleep loss due to worry ($r = .154, p < .001$), albeit no significant association has been verified with sleepiness propensity.

Table 4 Associations among age, psychological variables and sleep loss due to worry

	Sleep loss due to worry, <i>r</i>
Age	.091*
Arousal predisposition	.491**
Academic stress	.469**
Eysenck_extraversion	-.115**
Eysenck_neuroticism	.409**
NEO-PI-R_neuroticism	.424**
NEO-anxiety (N1)	.422**
NEO-hostility (N2)	.299**
NEO-depression (N3)	.377**
NEO-impulsivity (N5)	.182**
NEO-vulnerability (N6)	.330**
Tendency to worry	.444**
Cognitive arousal	.512**
Somatic arousal	.349**
POMS_fatigue/inertia	.424**
POMS_anger/hostility	.267**
POMS_negative affect	.200**
POMS_positive affect	-.174**
Expressive suppression	NS
Cognitive reappraisal	NS

NS not significant

* $p < .05$, ** $p < .001$

Stepwise multiple linear regression

To examine which of the psychological variables under study constituted significant predictors of sleep loss due to worry, we carried out a stepwise multiple linear analysis. All the assumptions of the technique were assumed, namely absence of multicollinearity and outliers [25]. It was found that six variables explain 40.3 % of the variance in scores of sleep disturbance due to worries [$F_{(6, 520)} = 60,089$; $p < .001$]. The variable with the greatest weight in the model was the pre-sleep cognitive arousal (cf. Table 6).

Discussion and conclusions

In this work, we explored the relationship among psychological factors, sleep–wake variables, self-perceived health and sleep loss due to worries. As in recent studies performed in the general population, the prevalence rates for sleep loss over worries was higher in females (40.6 %) than in males (19.2 %) [8, 12]. Also, the girls reported more worry than boys, which is in agreement with most

Table 5 Associations among health self-perception, sleep variables and sleep loss due to worry

	Sleep loss due to worry, <i>r</i>
Physical health	-.224**
Mental health	-.320**
Physical + mental health	-.325**
Habitual sleep duration	-.081*
Sleep depth	.285**
Subjective sleep quality	.283**
Sleep needs	.101*
Sleep flexibility	-.193**
Sleep latency	.285**
Nocturnal awakenings	.283**
Time to get-up	NS
Quality of sleep index	.511**
Insomnia	.541**
Mental work	NS
Physiological timings	NS
Morningness/eveningness	NS
Sleepiness propensity	NS
Sleepiness perception	.154**

NS not significant

* $p < .05$, ** $p < .001$

published studies [26]. In our study, the overall prevalence of sleep loss due to worries was about 33 %, which is in accordance with the reported values in epidemiological studies [8, 12].

Similar to Kelly's studies [5, 6], our research also found that sleep disturbance related to worries negatively affect the quantity and quality of sleep; the association with quality of sleep index and self-perception of insomnia was also substantial.

An interesting finding is related with daytime sleepiness. It was found that sleepiness perception, but not propensity to daytime sleepiness was significantly associated with sleep loss over worries. Although no other study has investigated this topic, the observed discrepancy may be related to differences in the perception of sleepiness and subjective general propensity for sleepiness as measured by the Epworth Sleepiness Scale [27]. Our results and other studies [28, 29] support the need to include questions measuring both constructs in research and clinical settings that rely on self-report to assess sleepiness [30].

Low to moderate magnitude correlations were observed between most psychological variables and sleep disturbance due to worry. These variables (except extroversion and positive affect) were significantly higher in the groups with higher levels of sleep loss due to worries.

Table 6 Predictors of sleep loss due to worry

	<i>B</i>	Std. error	β	<i>t</i>	<i>p</i>
Constant	−.011	2.66		−.040	.968
Predictors, $R^2 = 40.3\%$					
Pre-sleep arousal	.047	.005	.353	8.989	<.001
Academic stress	.009	.004	.129	3.236	.005
Arousal predisposition	.014	.006	.127	2.708	.006
Tendency to worry	.166	.046	.153	3.634	<.001
Sex	.178	.061	.118	2.921	.001
Physical health	−.097	.039	−.093	−2.468	.008

As in previous works, we also found a significant association between worry-related sleep disturbance with anxiety, depression, negative affect and neuroticism [9, 10]. A new finding of this study is the observed association with fatigue–inertia and anger–hostility. However, in college students, fatigue and anger–hostility (also evaluated with the POMS) were associated with poorer quality of sleep [30, 31].

There was a significant negative association between extroversion and positive affect and sleep loss due to worries. Although Kelly [7] has not included these variables in his study, participants with higher levels of sleep disturbance attributed to worry reported significantly lower life satisfaction, lower levels of happiness and decreased self-esteem. All these variables are strongly associated with positive affect, extraversion, and sleep quality [30]. One should note that LeBlanc et al. [32] also found that extroversion levels were higher in the group of individuals who slept well compared to the group of individuals with insomnia, which, as we reported in our study, showed a substantial relationship with the measure of sleep loss over worry. In a sample of 736 individuals (250 women) aged 58–72 years, Steptoe et al. [33] observed that positive affect and sleep problems were negatively correlated, even when the effects of age and sex were controlled.

The similarity of our results concerning the association between the tendency to worry and sleep loss over worry is remarkable, with the findings known in the literature [9, 10], taking into account the considerable differences in the instruments used.

The perception of academic stress showed up consistently associated with sleep disturbance due to worries, a similar finding to the one described by Kelly [8].

The link between pre-sleep cognitive arousal and the predisposition to arousal with sleep loss over worry is a new finding, albeit expected. In a study by Azevedo et al. [34] comprising a subsample of self-reported “good sleepers” drawn from the current sample, cognitive and somatic pre-sleep activation were significantly associated with sleep quality and self-perception of insomnia; besides, these measures discriminated individuals who slept well

from those who slept poorly. These differences were more evident in the cognitive arousal domain. These measures were also positively associated with neuroticism (NEO-PI-R), depression and hostility/anxiety (POMS); the highest observed correlations were between depression and cognitive/somatic activation and hostility/anxiety and cognitive activation, whereas friendliness (positive affect) was only significantly associated with pre-sleep somatic arousal, that is, higher levels of positive affect associated with decreased somatic activation.

Regarding APS, we found that the mean scores were significantly higher in females than in males, which is in accordance with the scoring guidelines from APS based on results by 786 college students [35]. As indicated in the present study, the predisposition for arousal showed consistently an association with sleep disturbance due to worry. Coren [36], in two separate studies with college students (mean age 18 years), found that the scores of activation were positively and significantly associated with sleep disruption and the correlation coefficients were found to be similar to ours (study 1: $r = .51$, $n = 196$; study 2: $r = .45$, $n = 693$; both $p < .001$). In addition, the highest associations were with frequent nocturnal awakenings and sleep latency [35]. Recent studies with college students (good sleepers) suggest that cognitive–emotional hyperarousal is a premorbid characteristic of people vulnerable to stress-related insomnia [37, 38]. Azevedo et al. [37] analyzed both sexes separately and found that female pre-sleep cognitive arousal, predisposition to arousal (arousability), perceived academic stress and sleep loss due to worries were all associated with sleep disruption related to stress/transient insomnia. The association between pre-sleep cognitive activation, perceived academic stress and tendency to worry is consistent with the cognitive model of insomnia. According to this model, individuals prone to rumination and worry are more likely to react dysfunctionally to life stress events. The generated cognitive activation may interfere with sleep, consequently causing insomnia [39].

In our study, self-perceived health status and the tendency to worry proved to be consistently associated with

sleep loss due to worries. Also in the study by Dregan et al. [8], individuals with poorer perceived health had high values if the reason given for their sleep problems was worry/thinking. In this context, it is important to note that both worry as a trait and sleep disturbance are associated with somatic and psychological health subjective complaints [40, 41]. In the study by Kim et al. [41], conducted with participants from the general population, the complaints were more prevalent in younger females; furthermore, it was observed that sleeping problems (i.e., difficulty falling asleep, staying asleep and wake-up early) were significantly associated with back pain, epigastric discomfort, weight loss, headache, fatigue, worry, irritability and loss of interest. In the America Insomnia Survey [42], insomnia symptoms were significantly associated with decreased perception of physical/mental health—even after controlling multiple physical and mental comorbid conditions—and distress/daytime impairment (a scale composed of decreased motivation, performance at work, school or social activities, making mistakes or having accidents, irritability, nervousness, mood disorder, attention, concentration and daytime memory, daytime fatigue, daytime sleepiness, and tension headaches or digestive problems). In this study, the distress/daytime impairment turned out to be a powerful mediator of the association between insomnia and health perception.

Our study presents some limitations. The most important are that the study is based on self-report measures and the cross-sectional design that does not enable determining the causal order among variables. However, the agreement between our results and the ones documented in the literature is remarkable. Another limitation concerns the use of sleep–wake indicators as trait-like variables. This may be problematic, since the outcomes might have been influenced by recent stressors—such as life events—on sleep perception, for example. Finally, this study focused only on college students of medicine course, which may limit the generalization of our findings. However, our results seem to be in accordance with other studies comprising different samples (cf. “Introduction”). As main advantages, we outline the large nonclinical sample and the simultaneous analysis of a wide variety of sleep–wake and psychological variables. Future longitudinal studies may inform which sleep and psychological variables are crucial in developing this type of sleep disturbance.

In conclusion, consistent with previous studies, our results show that the sleep disturbance due to worries are significantly associated with poor quality of sleep, higher levels of psychological distress and reduced well-being. The present study suggests that trait characteristics of pre-sleep cognitive arousal, predisposition to arousal and tendency to worry may play an important role in the disruption of sleep due to worries. Intervention strategies focused on

worry, arousal and stress can improve sleep quality and well-being in young people, particularly in women.

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Compliance with ethical standards

Conflict of interest Daniel Ruivo Marques, Ana Allen Gomes, Manuela Frederico Ferreira and Maria Helena Pinto de Azevedo declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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