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Winter is coming: nightmares and sleep problems during seasonal affective disorder

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SUMMARY

Sleep problems, especially nightmares and insomnia, often accompany depression. This study investigated how nightmares, symptoms of insomnia, chronotype and sleep duration associate with seasonal affective disorder, a special form of depression. Additionally, it was noted how latitude, a proxy for photoperiod, and characteristics of the place of residence affect the prevalence of seasonal affective disorder and sleep problems. To study these questions, data from FINRISK 2012 study were used. FINRISK 2012 consists of a random population sample of Finnish adults aged 25–74 years ($n = 4905$) collected during winter from Finnish urban and rural areas spanning the latitudes of 60°N to 66°N. The Seasonal Pattern Assessment Questionnaire was used to assess symptoms of seasonal affective disorder. Participants with symptoms of seasonal affective disorder had significantly increased odds of experiencing frequent nightmares and symptoms of insomnia, and they were more often evening chronotypes. Associations between latitude, population size and urbanicity with seasonal affective disorder symptoms and sleep disturbances were generally not significant, although participants living in areas bordering urban centres had less sleep problems than participants from other regions. These data show that the prevalence of seasonal affective disorder was not affected by latitude.

INTRODUCTION

Seasonal affective disorder (SAD) is a mood disorder with seasonal pattern, with symptoms often beginning in autumn and remitting in spring. The symptoms include depressive mood accompanied by a lack of energy as well as hypersomnia and an increased appetite (Rosenthal *et al.*, 1984). The prevalence of SAD varies across regions and populations, from 0% to 9.7%, whereby women generally experience higher prevalence than men and the disorder appears to be more common in North America than in Europe (Magnusson, 2000; Magnusson and Boivin, 2003; Magnusson and Partonen, 2005; Patten *et al.*, 2016).

Seasonal affective disorder is hypothesized to be triggered by changes in the amount of light between seasons (Rosenthal *et al.*, 1984). Because photoperiodic variation is more profound at high latitudes; if this hypothesis holds, then the prevalence and severity of symptoms of SAD should correlate with latitude. However, evidence for this effect remains mixed (Mersch *et al.*, 1999; Rosen *et al.*, 1990).

Circadian phase delay may play a part in SAD aetiology, and bright-light therapy alleviates SAD symptoms, at least partly, due to the normalization of the circadian rhythm (Lewy *et al.*, 1987, 2006). Therefore, evening chronotype may be related to seasonal problems (Lee *et al.*, 2011; Murray *et al.*, 2003; Natale *et al.*, 2005; Tonetti *et al.*, 2012; Zhang *et al.*,

2015), and eveningness has also been associated with multiple sleep problems as well as higher risk for depression (Barclay *et al.*, 2010; Merikanto *et al.*, 2012, 2013).

Insomnia and nightmares commonly occur among individuals with non-seasonal depression. Insomnia represents one of the symptoms of depression, but may also precede its onset (Baglioni *et al.*, 2011; Paunio *et al.*, 2014). The few studies published on the association between depression and nightmares have found nightmares to be a common problem among people with symptoms of depression (Nielsen and Levin, 2007; Sandman *et al.*, 2015; Swart *et al.*, 2013). Nightmares also frequently co-occur with insomnia (Nielsen and Levin, 2007; Sandman *et al.*, 2015) and, as such, these problems form a strongly interconnected symptomatic triad.

In addition to latitude, the urbanicity of the place of residence may be associated with the prevalence of affective disorders. A recent meta-analysis suggests that mental disorders, especially mood disorders, more commonly occur in urban than rural areas (Peen *et al.*, 2010). Two studies also found nightmares to be more common in urban areas compared with sparsely populated areas (Schredl, 2013; Stepansky *et al.*, 1998). Some evidence also exists that evening chronotypes are more prevalent in urban areas, while morning chronotypes more frequently reside in rural areas (Carvalho *et al.*, 2014; Roenneberg *et al.*, 2007).

In an earlier study (Sandman *et al.*, 2015), the authors found an association between frequent nightmares and experiencing seasonal variation in mood and sleeping patterns. Given this finding, the aims in the current study were twofold. First, the relationship between SAD, nightmares, insomnia, chronotype and the duration of sleep was investigated, paying special attention to nightmares and insomnia as these are strongly associated with depressive symptoms. Second, it was analysed whether the prevalence of SAD and sleep disturbances was higher among individuals living at higher latitudes compared with those in areas further south or among participants living in urban as compared with rural areas.

MATERIALS AND METHODS

This study utilizes data from the National FINRISK 2012 study. Participants of the FINRISK 2012 were randomly drawn from the population registers of the study regions to collect representative random population samples (for additional information, see Borodulin *et al.*, 2015). Data collection took place during the winter months in Finland: 23.6% of participants completed the questionnaire in January, 43.8% in February, 32.4% in March and 0.2% in early April. Surveys completed in April were merged with those completed in March. From the beginning of January to the end of March, the southern parts (60°N) of the study region received 6–13 h of daylight, while the northern regions (65°N) received from 4 to 13 h. A map of the study regions is presented in Fig. 1, and a high-resolution version is available in the supplement (Fig. S1).

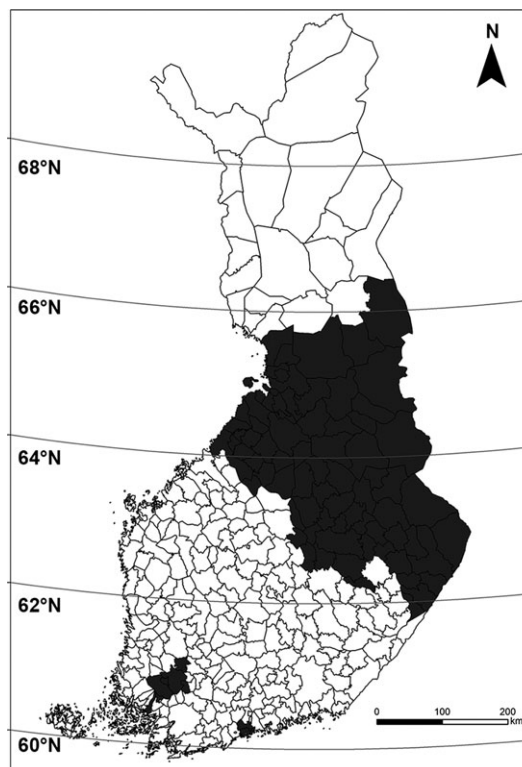


Figure 1. Sampling regions of FINRISK 2012 (©University of Turku, UTU-GIS 2015 and National Land Survey of Finland 2012).

In total, 10 000 individuals were invited to take part in the FINRISK 2012, of whom 65% participated. Of these participants, 86% completed all questionnaires included in the survey and the total number of participants available for the current study was 4905. Participants were aged 25–74 years [standard deviation (SD) 13.9, mean 52.45, median 54], and 54.5% were women.

The FINRISK 2012 survey received approval from the Coordinating Ethics Committee of Helsinki and the Uusimaa Hospital District, and written informed consent was obtained from participants.

Seasonal Pattern Assessment Questionnaire (SPAQ)

Symptoms of SAD were investigated using a modified version of SPAQ (Rintamäki *et al.*, 2008; Rosenthal *et al.*, 1984). SPAQ consists of six questions in which participants self-evaluate the magnitude of seasonal changes in sleep duration, social activity, mood, weight, appetite and energy level. From these questions, the Global Seasonality Score (GSS) is calculated, varying from 0 to 18 points in this version of SPAQ. In addition to GSS, SPAQ includes a question that assesses whether the participant experiences seasonal changes as a problem. SPAQ can be divided into two factors: factor 1 measuring seasonal variation in psychological and sleep-related issues; and factor 2 measuring seasonal changes in weight and appetite (Magnusson *et al.*, 1997).

Cases of SAD were identified using the so-called Kasper criteria (Kasper *et al.*, 1989) scaled to fit the SPAQ version used. Participants who scored at least 8 from GSS and experienced seasonal changes as a moderate to severe problem were classified as SAD cases. Those with a GSS of 8 or more but who experienced seasonal changes only as a mild problem and those who scored 6 or 7 from GSS but experienced seasonal changes as a mild or more severe problem were classified as suffering from subsyndromal seasonal affective disorder (S-SAD).

Previous research has showed that using SPAQ as a screening tool for SAD yields a good specificity but a questionable sensitivity, tending to overestimate the prevalence of SAD in a population sample (Mersch *et al.*, 2004; Thompson *et al.*, 2004). For the purposes of the current research, SPAQ was considered a sufficiently accurate screening tool, keeping in mind that the prevalence of SAD may be overestimated.

Questionnaire items

Nightmares and symptoms of insomnia were investigated using similar questions: 'During the past 30 days, have you had nightmares/insomnia?', with response options often, sometimes or never. The duration of sleep was self-assessed as the number of hours slept during an average night. The use of hypnotics and antidepressants was also self-reported.

The questionnaire also included a self-report of the presence or absence of a depression diagnosis by a clinician within the past 12 months. This question did not specify whether the diagnosis was for seasonal or non-seasonal depression and therefore some of the participants with depression diagnosis may have suffered from SAD, others from non-seasonal depression.

Morningness–Eveningness Questionnaire (MEQ)

A modified version of the MEQ was used (Horne and Ostberg, 1976) to assess the personal timing preference for daily activities. This version consisted of six original MEQ items that correlated best with the sum score of the original 19 items (Hätönen *et al.*, 2008). The sum score was categorized into three classes reflecting the original MEQ sum score scaling: definite or moderate morning type; intermediate type; and definite or moderate evening type.

Place of residence and latitude

FINRISK included the coordinates of participants' residential buildings. This information was used in the following three ways.

First, information was obtained on population size (Väestörekisterikeskus, 2012) and population density (Maanmittauslaitos, 2012) for the municipality in which the participant lived. However, due to the almost perfect positive linear

correlation between population density and population size in these data [$r(4893) = 0.98, P < 0.0001$], population size only was used in the current analyses. Population size was analysed both as a continuous variable and as a categorical variable divided into four classes: less than 50 000 inhabitants (mean population density of 19/km²); 50 000–99 999 (45/km²); 100 000–203 000 (590/km²); and 596 000 (2792/km²). These categories correspond to the sizes of cities in Finland. In the current sample, only one city had 596 000 inhabitants and no cities had a population size between 203 000 and 596 000 inhabitants.

Second, the urban–rural classification of the Finnish Environmental Institute was applied. This classification uses information on population size, population density, area density, city plans, workforce and commuting (Helminen *et al.*, 2014) to classify 250 × 250 m² of Finland into different degrees of urbanicity. Because the original classification is very detailed, some of the categories were merged to form five categories for the analysis.

Finally, information was obtained on the latitude of the participants' places of residence from the coordinates of the residential buildings. Latitude was used as a continuous variable in the regression analyses and as a categorical variable in other analyses.

Statistical methods

Associations between single categorical variables were analysed using the Pearson's chi-square (χ^2) and Cramer V measure of effect size. For multivariate modelling, multinomial logistic regression was used. To correct for tests of multiple hypothesis using the same data, an alpha level of 0.001 was chosen to signify statistical significance. Analyses were performed using SPSS 21.

RESULTS

The mean GSS among all participants was 5.11 (SD 3.30, median 5, range 0–18). Women showed a significantly higher mean score (5.70) than men (4.41; $F_{1,4768} = 190.27, P < 0.0001$). Seasonality was experienced as a moderate or worse problem by 8.6% of participants (5.7% men and 11% women).

Overall, 6.5% of participants met the Kasper criteria for SAD and 17.2% met the criteria for S-SAD. A significant gender difference was found, whereby, among women, 8.6% met the SAD criteria and 20.3% met the S-SAD criteria compared with 3.9% and 17.2% among men, respectively [$\chi^2(2, n = 4689) = 92.76, P < 0.0001, \text{Cramer } V = 0.14$]. The month during which participants completed SPAQ did not affect the prevalence of SAD or S-SAD [$\chi^2(2, n = 4905) = 6.512, P = 0.164, \text{Cramer } V = 0.02$].

The prevalence of nightmares, symptoms of insomnia, distribution of chronotypes, sleep duration, the use of hypnotics and antidepressants as well as the presence of a diagnosis of depression are shown in Table S1.

SAD and sleep disturbances

As Table 1 shows, SAD was significantly associated with various sleep and dream-related variables: 16.2% of participants with SAD based on the Kasper criteria experienced frequent nightmares and 25.0% reported frequent symptoms of insomnia, numbers that were considerably higher than those reported by participants without SAD (2.4%, $P < 0.0001$, Cramer V = 0.159 for nightmares and 7.6%, $P < 0.0001$, Cramer V = 0.144 for insomnia). The association between nightmares and symptoms of insomnia with SAD is also shown in Fig. 2. Participants with SAD were more often evening chronotypes (35.6%) and less frequently morning types (21.2%) than participants without SAD (9.6% evening

types, 48.4% morning types, $P < 0.0001$, Cramer V = 0.173). It was also found that participants with SAD reported short or long sleeping times more frequently than participants without seasonal problems ($P = 0.025$, Cramer V = 0.035).

Participants with SAD frequently used medication for sleep and mood-related problems: 26.3% of participants with SAD reported using hypnotics and 24.3% reported taking antidepressants during the last month, while only 7.6% of participants without seasonal problems had used hypnotics and 3.6% antidepressants during the same time period ($P < 0.0001$, Cramer V = 0.136 for hypnotics and $P < 0.0001$, Cramer V = 0.206 for antidepressants).

Among participants with SAD, 30.4% had received a depression diagnosis from a clinician during the past 12

Table 1 Associations between symptoms of SAD, sleep disturbances and depression

	Seasonal affective problems			n	χ^2
	SAD	S-SAD	No problems		
Nightmares				4596	$P < 0.0001$, Cramer V = 0.159
Often	16.2%	5.2%	2.4%	174	
Sometimes	56.9%	53.1%	41.8%	2054	
Never	26.9%	41.7%	55.8%	2368	
Insomnia				4617	$P < 0.0001$ Cramer V = 0.144
Often	25.0%	14.1%	7.6%	456	
Sometimes	51.0%	52.1%	42.0%	2048	
Never	24.0%	33.8%	50.3%	2113	
Chronotype				4358	$P < 0.0001$, Cramer V = 0.173
Evening	35.6%	22.3%	9.6%	588	
Intermediate	43.2%	46.4%	41.9%	1865	
Morning	21.2%	31.3%	48.4%	1905	
Sleep length				4591	$P = 0.025$, Cramer V = 0.035
6 h or less	16.6%	11.0%	11.7%	546	
7–8 h	64.9%	71.2%	72.6%	3300	
9 h or more	18.6%	17.7%	15.7%	745	
Hypnotics				4385	$P < 0.0001$, Cramer V = 0.136
During the last month	26.3%	12.5%	7.6%	425	
More than a month ago	24.2%	22.0%	15.2%	743	
Never	49.5%	65.5%	77.2%	3217	
Antidepressants				4352	$P < 0.0001$, Cramer V = 0.206
During the last month	24.3%	9.2%	3.6%	259	
More than a month ago	23.2%	14.6%	6.5%	392	
Never	52.5%	76.2%	89.8%	3701	
Depression diagnosis				4644	$P < 0.0001$, Cramer V = 0.262
Yes	30.4%	10.9%	4.1%	325	
No	69.6%	89.1%	95.9%	4319	

SAD, seasonal affective disorder; S-SAD, subsyndromal seasonal affective disorder.

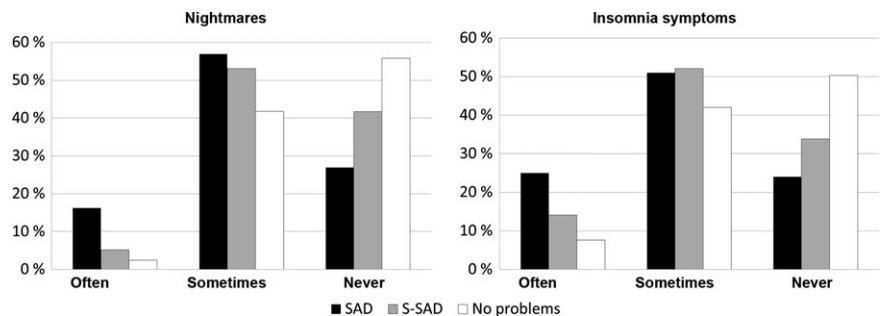


Figure 2. Prevalence of nightmares ($n = 4596$) and symptoms of insomnia ($n = 4617$) among participants with and without seasonal affective disorder (SAD).

months. This represents a considerably higher prevalence than 4.1% among participants without seasonal problems ($P < 0.0001$, Cramer $V = 0.262$). However, a majority of participants who met the criteria for SAD did not report a depression diagnosis, and it cannot be inferred from the available data whether the diagnosis was for seasonal or non-seasonal depression. The exact figures are shown in Table 1.

Multivariable analysis of SAD, nightmares and insomnia

As presented in Table 2, the associations between SAD, nightmares and symptoms of insomnia remained significant in the multinomial regression model even when adjusted for sex, age, marital status, alcohol consumption during the last week, years of education, amount of physical exercise, smoking, population size of the place of residence, latitude and the month during which the survey was completed. Among participants who met the criteria for SAD, odds ratio (OR) for frequent nightmares was 14.19 [95% confidence interval (CI) 8.66–23.25], while for frequent symptoms of insomnia among participants with SAD OR was 6.32 (95% CI 4.18–9.55). Among participants with S-SAD, ORs were 2.97

(95% CI 1.87–4.72) and 3.23 (95% CI 2.40–4.34), respectively.

The associations between nightmares, insomnia and individual components of SPAQ were also investigated. In the model with a factorized SPAQ and full adjustment, a factor consisting of psychological questions significantly influenced both nightmares (OR 3.29, 95% CI 2.42–4.47) and insomnia (OR 3.01, 95% CI 2.44–3.72). It was found that a factor measuring changes in weight and appetite had no statistically significant association with nightmares or insomnia. The complete analyses are shown in Table S2.

A regression model that included all SPAQ questions as individual predictors showed that the two items with the highest OR for both nightmares and insomnia included seasonal variation in mood and seasonal variation as a problem for the participant. These analyses can be found in Table S3.

Effect of latitude and population size of the place of residence

The latitude of the permanent place of residence was not significantly associated with SAD, symptoms of insomnia,

Table 2 Multinomial logistic regression models for nightmares ($n = 3676$) and insomnia ($n = 3689$)

	<i>Frequent nightmares</i>		<i>Occasional nightmares</i>	
	P	OR (95% CI)	P	OR (95% CI)
Model 1				
SAD	<0.0001	13.82 (9.09–21.01)	<0.0001	2.82 (2.15–3.71)
S-SAD	<0.0001	2.86 (1.94–4.23)	<0.0001	1.70 (1.45–2.00)
No problems	–	1	–	1
Model 2				
SAD	<0.0001	13.48 (8.77–20.72)	<0.0001	2.74 (2.08–3.62)
S-SAD	<0.0001	2.84(1.91–4.22)	<0.0001	1.68 (1.43–1.97)
No problems	–	1	–	1
Model 3				
SAD	<0.0001	14.19 (8.6–23.25)	<0.0001	2.59 (1.90–3.53)
S-SAD	<0.0001	2.97 (1.87–4.72)	<0.0001	1.69 (1.41–2.03)
No problems	–	1	–	1
	<i>Frequent insomnia</i>		<i>Occasional insomnia</i>	
Model 1				
SAD	<0.0001	6.86 (4.85–9.72)	<0.0001	2.54 (1.91–3.39)
S-SAD	<0.0001	2.74 (2.13–3.54)	<0.0001	1.84 (1.56–2.18)
No problems	–	1	–	1
Model 2				
SAD	<0.0001	7.28 (5.08–10.42)	<0.0001	2.57 (1.92–3.45)
S-SAD	<0.0001	2.92 (2.25–3.79)	<0.0001	1.88 (1.58–2.24)
No problems	–	1	–	1
Model 3				
SAD	<0.0001	6.32 (4.18–9.55)	<0.0001	2.47 (1.79–3.41)
S-SAD	<0.0001	3.23 (2.40–4.34)	<0.0001	1.95 (1.61–2.36)
No problems	–	1	–	1

CI, confidence interval; OR, odds ratio; SAD, seasonal affective disorder; S-SAD, subsyndromal seasonal affective disorder.

Model 1: unadjusted.

Model 2: adjusted for sex and age.

Model 3: adjusted for sex, age, marital status, alcohol consumption during the last week, years of education, amount of physical exercise, smoking status, population size of the place of residence, latitude, and the month during which the survey was completed.

duration of sleep or the use of hypnotics. This was true both for the whole sample as well as different study months studied separately. Statistically significant findings with low effect size were that a depression diagnosis and the use of antidepressants were slightly more common in the southern regions than in the north, and that nightmares were more common at latitudes of 62°N to 64°N than regions further south or north. The only statistically significant association concerning latitude was found for chronotype. Evening types were more common in the south (60–61°N; 16.7%) than in the north [65–66°; 10.6–13.8%, $\chi^2(2, n = 4503) = 40.20, P < 0.0001$, Cramer V = 0.07]. The exact figures are shown in Table S4.

While the association between chronotype and latitude appeared significant, it was confounded by the population size of the place of residence. The largest population centres in Finland are situated in the southern part of the country; therefore, in these data, latitude correlates with the population size of the place of residence [$r(4891) = -0.64, P < 0.0001$]. Evening chronotypes were considerably more common in larger towns (16.0–17.2% of participants) than in rural areas (8.8%). Likewise, morning types were less common in towns (39.4–37.0%) than in rural areas (51.1%). This difference was statistically significant [$\chi^2(2, n = 4492) = 90.46, P < 0.0001$, Cramer V = 0.10].

The multinomial regression model predicting chronotype based on latitude and population size supported the interpretation that population size was a more significant predictor for chronotype. In this model, an increase in the population size increased the odds of a participant being an evening type (OR 2.62, $P < 0.0001$ per increase of 100), while the effect of latitude had no significant effect ($P = 0.522$).

Insomnia, sleep duration, SAD and the presence of a depression diagnosis were not significantly associated with the population size of the place of residence. Nightmares showed a weak U-shaped association with the population size, with higher prevalence associated with a very small or large population. The use of antidepressants [$\chi^2(2, n = 4521) = 22.95, P = 0.001$, Cramer V = 0.05] and hypnotics [$\chi^2(2, n = 4556) = 15.07, P = 0.02$, Cramer V = 0.04] was slightly more common in urban than rural areas. The complete analyses are shown in Table S5.

The associations with the urbanicity of the place of residence defined by the urban–rural classification revealed that the number of evening chronotypes increased towards the centre of towns even within urban areas [$\chi^2(2, n = 4503) = 111.08,$

$P < 0.0001$, Cramer V = 0.11]. In inner cities, 18.0% of participants were evening types, 12.9% on city outskirts, 10.6% within areas bordering urban areas, and 8.6% within rural centres and rural areas. A similar but reversed pattern was observed among morning types, as shown in Fig. 3.

Nightmares, symptoms of insomnia, sleep duration and SAD did not significantly associate with the urbanicity of the place of residence, although a tendency was found that participants living in areas bordering urban areas experienced fewer sleep disturbances than those living within towns or in rural areas. The use of hypnotics and antidepressants, as well as depression diagnoses, were more common within city centres than in any other area ($P < 0.0001$ for all, Cramer V = 0.059–0.072). Detailed analyses can be found in the supplement in Table S6.

DISCUSSION

As with non-seasonal depression, disturbances in sleep and dreaming are common symptoms in SAD. Those suffering from SAD frequently experience nightmares and symptoms of insomnia. Additionally, evening chronotypes reported more seasonal problems and other sleep problems compared with other chronotypes.

In the current data, the latitude of the place of residence and the month in which the questionnaire was completed (both of which serve as proxies for photoperiod) were not significantly associated with the prevalence of SAD, nightmares or symptoms of insomnia. Thus, the hypothesis that SAD is caused by a variation in the photoperiod was not supported in these data.

This result is consistent with earlier studies conducted in Finland at latitudes from 60°N to 70°N (Grimaldi *et al.*, 2009; Partonen *et al.*, 1993), and might point towards the possibility that the Nordic population is genetically or developmentally adapted to changes in photoperiod and some other factors would be more important in SAD aetiology. However, it should also be kept in mind that illumination outdoors is not affected only by the length of photoperiod but also by cloud and snow cover, and this study did not have information on these factors or on the actual personal exposure to light. The amount of light may not correlate directly with latitude, and this might give a false impression of light not affecting SAD.

Using these data, it was not possible to replicate results, suggesting that mental health problems (Peen *et al.*, 2010)

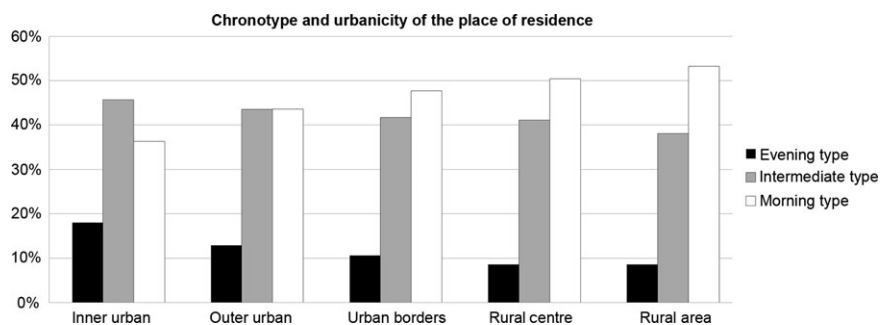


Figure 3. Distribution of different chronotypes and the urbanicity of the place of residence ($n = 4503$).

and nightmares (Schredl, 2013) are more common in urban than in rural areas. However, a tendency for more sleep and mood problems was found in urban areas, and the least problems in areas bordering urban areas. The lack of significance may be explained by the relatively low range of variation in the population sizes across study regions in the current sample. The difference between urban and rural areas might be more profound in countries with larger cities.

Chronotype showed a robust relationship with both the population size and the urbanicity of the place of residence. Evening types were more prevalent in urban than in rural areas, and morning types were more prevalent in rural than urban areas. The tendency towards eveningness in urban areas may be due to different lighting conditions between urban and rural areas: there is more light exposure in the evenings in cities and this may delay the circadian rhythm of people living in these environments.

The results about evening types being prone to seasonal problems as well as being more prevalent in an urban environment could point to a possibility that the circadian system of evening types is more sensitive and thus more easily affected by external cues such as light and temperature (zeitgebers) compared with circadian systems of morning types. Some evidence exists that among people with SAD, the sensitivity of the circadian system may change from season to season from supersensitive in the winter to subsensitive in the summer (Thompson *et al.*, 1990). A possible interpretation is that people with sensitive circadian systems might be more vulnerable to problems in environments with zeitgebers differing from those that were present in the environment of evolutionary adaptedness for the human circadian system.

Due to the nature of the current data, this study is subject to several limitations. Studies relying on retrospective questionnaires tend to overestimate the prevalence of SAD and underestimate the prevalence of nightmares. Further, most of the questions in the survey were self-reports. Also, the cross-sectional nature of the data does not allow inferring of causality. However, the data also lends to the study's strengths. The dataset is a large and representative sample of both urban and rural regions distributed over 6° of latitude within a rather homogenous cultural area. The possibility of combining information from SPAQ, MEQ, sleep items and location data allowed to explore research questions not easily investigated.

In conclusion, individuals with SAD experience problems with symptoms of insomnia and nightmares, and the evening chronotype appears to be a risk factor for seasonal problems. These associations are compatible with the view that a shared genetic risk factor may exist for SAD and other affective disorders as well as eveningness.

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AUTHOR CONTRIBUTIONS

The idea for the study came from NS and IM; data analyses were conducted by NS and HM; TL and TP were involved in data collection; and all authors were involved in study design and preparation of the manuscript.

CONFLICTS OF INTEREST

None.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article:

Figure S1. High-resolution map of the study regions (© University of Turku, UTU-GIS 2015 & National Land Survey of Finland 2012).

Table S1. Prevalence of seasonal affective disorder, sleep disturbances and depression.

Table S2. Multinomial regression models of continuous and factorised seasonal pattern assessment questionnaire, nightmares and insomnia.

Table S3. Associations between individual seasonal assessment pattern questionnaire items and nightmares and insomnia.

Table S4. Associations between the latitude of the place of permanent residence, seasonal variation, sleep disturbances and depression.

Table S5. Associations between the population of the place of permanent residence, seasonal variation, sleep disturbances and depression.

Table S6. Associations between the urbanicity of the place of permanent residence, seasonal variation, sleep disturbances and depression.