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Eveningness increases risks for depressive and anxiety symptoms and hospital treatments mediated by insufficient sleep in a population-based study of 18,039 adults

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Abstract

Background: Epidemiological data show that having the eveningness associates with poor mental health. For preventive measures it is important to know which underlying factors mediate these associations and the burden posed to public health. This study examines at a population-based level, whether (1) circadian type and the sleep-wake behavior-based phase entrainment similarly associate with mental health problems, (2) there are differences in hospital treatments due to mental disorders between chronotypes, and (3) the association of chronotype with mental health is mediated by insufficient sleep.

Methods: The study sample ($N = 18,039$) consisted of population-based sample of Finnish adults, aged 25–74 years, with information on their circadian type and sleep patterns, mental health symptoms, and diagnosis as reported in a health examination survey, as well as hospital treatments as recorded on the national Hospital Discharge Register.

Results: All the mental health symptoms, diagnoses and hospital treatments were more pronounced among Evening-types, especially when assessed by circadian type. Insufficient sleep mediated most but not all of the associations between eveningness and mental health.

Conclusions: Eveningness does not increase mental health risks only on symptom or diagnosis level, but also on hospital admission level. A higher prevalence of insufficient sleep among the Evening-types elevates the risk and severity for many of the mental health outcomes. Improving the sleep among Evening-types could help to improve their mental health prospective and ease the health care burden.

KEYWORDS

anxiety, bipolar disorder, depression, epidemiology, sleep disorders

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1 | INTRODUCTION

Chronotype describes individual differences in the timing of bodily functions and daily behavior (Czeisler & Gooley, 2007), with those falling more toward morning in this spectrum having a peak in their bodily functions and daily behavior timed earlier than those falling more toward evening (Duffy et al., 1999, 2001; Horne & Östberg, 1976). Growing evidence from epidemiological research has demonstrated that the individual chronotype is linked with mental health by eveningness predisposing to a range of symptoms and disorders (Au & Reece, 2017; Bauducco et al., 2020; Taylor & Hasler, 2018).

In our previous population-based studies representative of adults, we showed that eveningness increased the risk for depressive symptoms and disorders (Merikanto et al., 2013, 2015). However, it is important to examine whether the severity of mental health risk in Evening-types is manifested as hospital treatments due to mental disorders among those with Evening-chronotype, and whether insufficient sleep among the Evening-types is mediating the risk for mental disorders and its severity. Higher prevalence rates of sleep problems such as insomnia symptoms, insufficient sleep, and social jet lag among Evening-types (Merikanto & Partonen, 2020; Merikanto et al., 2012) most likely elevate the risk for mental disorders among Evening-types, because poor sleep and impaired mental health are associated reciprocally (Alvaro et al., 2013; Baglioni et al., 2011; Tsuno et al., 2005). Understanding these complex associations is necessary for preventive measures to ease the strain posed to health care system due to the chronotype associated mental health problems.

Here, our first aim was to study whether mental health related symptoms, diagnoses as well as hospital treatments were associated with chronotype in a population-based sample of 18,039 adults. Second aim was to examine how insufficient sleep was associated with mental health related symptoms, diagnoses, and hospital treatments. Our third aim was to examine whether insufficient sleep mediated the associations between chronotype and mental health.

2 | METHODS

2.1 | Participants

The analytic sample for this study was derived from combining three population-based health examination studies on adults living in Finland, including The National FINRISK 2007 Study, The National FINRISK 2012 Study, and The FinHealth 2017 Study. All these studies were conducted in five large geographical areas of the country and used random samples as stratified by the 10-year age-group from 25 to 74 years in 2007 and 2012 and from 18 to 99 years in 2017, as well as by the sex. A more detailed description of The National FINRISK 2007 and 2012 Studies is given in our previous reports (Merikanto & Partonen, 2020; Merikanto et al., 2015). The total of 18,039 participants (mean age in years = 52.1, $SD = 14.8$; 54% women), with data on the self-assessed circadian type and sleep-wake schedules as well as the register-based health care information on mental health, were included in this study.

The National FINRISK 2007 and 2012 Studies as well as The FinHealth 2017 Study were approved by the Coordinating Ethics Committee of the Hospital District of Helsinki and Uusimaa, Finland. The studies were conducted according to the accepted international ethical standards in accordance with the Declaration of Helsinki and its amendments. All the participants gave their written informed consent.

2.2 | Chronotype assessment

We assessed chronotype by using (1) the widely-used single item (MEQ_{i19}) of the original Morningness/Eveningness Questionnaire (MEQ) (Horne & Östberg, 1976) for the self-assessed behavioral trait of morningness-eveningness, and (2) the phase of entrainment as assessed with the habitual midpoint of sleep based on the self-reported sleep-wake schedule during weekend ($Sleep_{mid-wknd}$) as well as the sleep debt corrected midpoint of sleep ($Sleep_{mid-corr}$). Assessment of chronotype based on MEQ_{i19} is referred to here as circadian type in contrast to chronotype assessment based on habitual weekend midpoint of sleep. Circadian type was asked with the following question: "There are so-called "Morning-people" (early to rise, early to bed) and "Evening-people" (late to rise, late to bed). Which are you?" The response options were as follows: Definitely a "Morning" person (definite Morning-type scoring = 1), More a "Morning" than an "Evening" person (moderate Morning-type scoring = 2), More an "Evening" than a "Morning" person (moderate Evening-type scoring = 3), or Definitely an "Evening" person (definite Evening-type scoring = 4).

The usual daily sleep duration was self-reported in hours. The midpoint of sleep was calculated based on the self-reported bed-times and wake-up times, available separately for weekdays and weekends ($Sleep_{mid-wknd}$) in The FINRISK 2012 Study and The FinHealth 2017 Study. The midpoint of sleep on was determined by the half of the time passed in sleep since going to bed in local time (Roenneberg et al., 2003). We also calculated the corrected midpoint of sleep ($Sleep_{mid-corr}$) that accounts for the influence of sleep debt for those sleeping longer on weekends than on weekdays (Roenneberg et al., 2019). The sufficiency of sleep was assessed on the basis of the self-estimation of getting enough sleep either Nearly always, Often, or Rarely/never, where the answer Rarely/never indicated insufficient sleep.

2.3 | Self-reported information on mental health

The information on mental health was collected in The FINRISK 2007 and 2012 Studies as well as The FinHealth 2017 Study with the following five questions: (1) "Have you had during the past 12 months at least a 2-week continuous period when you have felt dispirited or depressed?" (No, or Yes); (2) "Have you had during the past 12 months at least a 2-week continuous period when you have lost interest in most of the things that normally feel good, such as hobbies or work?" (No, or Yes); (3) "Have you been diagnosed or

treated for depression by a medical doctor during the past year (12months)?" (No, or Yes); (4) "When is the last time you have used medication for depression?" (during the past week, 1–4 weeks ago, 1–12 months ago, Over a year ago, or Never); and (5) "When is the last time you have used tranquilizing medication?" (during the past week, 1–4 weeks ago, 1–12 months ago, Over a year ago, or Never). In addition, the familial background for depression was assessed with the following two questions: (1) "Has your father been diagnosed for depression?" (No, or Yes); and (2) "Has your mother been diagnosed for depression?" (No, or Yes).

2.4 | Health care information on mental health

The nationwide register-based health care information on treatments due to mood and stress-related disorders was derived from the National Care Register for Health Care (HILMO) for the years of 1996–2018. HILMO collects the information on patients, such as diagnoses and treatment, at any level of care, for example, inpatient care at health centers, hospitals, and other institutions providing inpatient care as well as data on outpatients care. Further information on the national Care Register for Health Care is found from the following webpage: <https://thl.fi/en/web/thlfi-en/statistics/information-on-statistics/register-descriptions/care-register-for-health-care>. HILMO uses the International Statistical Classification of Diseases and Related Health Problems (ICD) by World Health Organization (ICD-10 coding since 1996). The following ICD-10 codes were used in this study: F30–F39 Mood [affective] disorders; F31 Bipolar affective disorder; F32 Depressive episode; F34 Persistent mood [affective] disorders; F40–F48 Neurotic, stress-related and somatoform disorders; F41 Other anxiety disorders; and F43 Reaction to severe stress, and adjustment disorders (No treatment, or Treatments). The mental health diagnoses were conferred only by a medical doctor.

2.5 | Control variables

The age at the participation was calculated based on the year of birth given from the Population Information System of the national Population Register Centre. Information on the sex was received from the Population Information System of the national Population Register Centre. The effect of age and sex was taken into account for the statistical analyses, as there are age and sex related differences in sleep and chronotype in the Finnish adult population as reported previously (Merikanto & Partonen, 2020; Merikanto et al., 2012).

2.6 | Statistical analyses

First, we analyzed the differences in the mean age and the midpoint of sleep between the circadian types with one-way analysis of variance. χ^2 tests were used to study the differences in the distributions of the sex and insufficient sleep between the circadian types.

Second, we used generalized linear models (GZM), adjusted with age and sex, to analyze the associations of (1) MEQ_{19} , (2) $Sleep_{mid-wknd}$, (3) $Sleep_{mid-corr}$, and (4) insufficient sleep with the self-reported depressive symptoms, diagnosis and medication as well as health care information on hospital treatments. For the association of circadian type with mental health, the definite Morning-types were used as the reference category in GZMs. For the association of insufficient sleep with mental health, those reporting enough sleep nearly always were used as the reference category in GZMs. For these analyses, we used the IBM SPSS Statistics for Windows, version 25.0.

Finally, we analyzed whether insufficient sleep mediated the association of circadian type with mental health. Here, we used the R mediation package (Tingley et al., 2014) in ordinal and probit regressions for the mediator and outcome models, respectively, employing the bootstrapping method with 1000 bootstrapping resamples with the bias-corrected confidence intervals (CI). All the regression analyses were adjusted for sex and age. For the mediation analysis, we used the R software version 4.0.3 for Windows.

3 | RESULTS

3.1 | Descriptive information on study sample by circadian type

As reported previously for the same population-based sample for ages 25–74 (Merikanto & Partonen, 2020), those with circadian type toward eveningness were on average younger and had later week-end and sleep debt corrected midpoints of sleep (Table 1). More Evening-types as compared to Morning-types had higher education and had an employment or were full-time students as compared to Morning-types who reported more than Evening-types being pensioned. Both extreme circadian types, the definite Evening- and Morning-types, had smaller average household size than moderate circadian types, although the difference was only by few decimals. However, definite Evening-types reported being single more often than definite Morning-types. To be noted, differences between the circadian types presented in Table 1 on marital status and employment in our data most likely arise from the age difference seen between circadian types, with pension, marriage or widowhood being more common among Morning-types who were on average older than Evening-types. Regarding sleep and health status, even though those with circadian type toward eveningness had longer daily sleep duration on average, they reported insufficient sleep and poor health status more often than Morning-types.

3.2 | Self-reported symptoms, diagnosis, and medication by circadian type

Eveningness was associated with the increased self-reported symptoms of depressed feelings and lost interest (Table 2). Eveningness was more frequently associated with depression and other mental

TABLE 1 Descriptive information on the sample and sleep differences by circadian type in the population-based study sample of Finnish adults

	Definite evening-type (N = 2686)	Moderate evening- type (N = 5652)	Moderate morning- type (N = 5830)	Definite morning- type (N = 3871)	p value
Age (mean in years, SD)	47.6 (15.3)	50.1 (15.1)	52.8 (14.4)	57.0 (13.2)	<.0001
Sex (%)					.25
Men	45.2	46.8	46.4	45.0	
Women	54.8	53.2	53.6	55.0	
Education level (%)					<.0001
Basic	15.1	17.0	22.9	31.3	
Secondary	50.0	52.6	53.6	49.7	
Higher	35.0	30.4	23.5	19.0	
Employment (%)					<.0001
Unemployed	6.2	5.6	5.2	5.4	
On employment support	1.1	0.9	0.7	0.7	
Pensioned	14.9	16.6	21.5	25.2	
Maternity/paternity leave	1.5	1.9	1.6	0.8	
Full-time student	4.1	3.0	2.3	1.3	
Independent entrepreneur	5.0	5.7	5.5	4.4	
Temporary employment	18.6	17.0	16.2	19.8	
Permanent employment	48.6	49.2	46.9	42.3	
Marital status (%)					<.0001
Married, cohabiting, registered relationship	64.1	72.2	74.0	71.9	
Single	21.6	14.5	11.7	9.8	
Separated or divorced	11.0	9.6	9.5	11.3	
Widowed	3.4	3.6	4.7	7.0	
Number of household members (mean, SD)	2.3 (1.3)	2.5 (1.4)	2.4 (1.3)	2.3 (1.2)	<.0001
Self-estimated health status (%)					<.0001
Excellent	17.1	18.3	16.6	15.8	
Quite good	41.4	44.3	45.2	42.8	
Average	31.2	30.2	31.1	33.4	
Quite bad	9.0	6.6	6.6	7.2	
Very bad	1.3	0.6	0.5	0.8	
Daily mean sleep duration (average in hh:mm, SD)	7:31 (1:25)	7:32 (1:17)	7:30 (1:15)	7:23 (1:22)	<.0001
Weekend midpoint of sleep (average in hh:mm, SD)	4:51 (1:15)	4:02 (0:54)	3:25 (1:33)	2:54 (1:33)	<.0001
Sleep debt corrected midpoint of sleep (average in hh:mm, SD)	4:36 (1:14)	3:48 (0:52)	3:14 (0:53)	2:45 (1:28)	<.0001
Insufficient sleep (%)					<.0001
Getting enough sleep nearly always	29.3	34.3	39.9	48.5	
Getting enough sleep often	44.4	49.5	47.9	39.4	
Getting enough sleep rarely/never	26.3	16.2	12.2	12.1	

disorders as being diagnosed by a medical doctor, and both definite Evening-types and moderate Evening-types had used antidepressant medication more frequently than definite Morning-types. Definite Evening-types had also used tranquilizing medication more frequently than definite Morning-types. Concerning the familial background of depression, both fathers as well as mothers of definite Evening-types had had depression more frequently as compared with definite Morning-types. Moderate evening-types had more frequently had mothers with a diagnosed depression as compared with definite Morning-types.

3.3 | Hospital treatments due to mental disorders by circadian type

Definite Evening-types had had hospital treatments due to mental disorders more frequently as compared with other circadian types (Table 2). Definite Evening-types had higher risks for mood as well as neurotic, stress-related and somatoform disorders as compared with definite Morning-types. Of mood disorders, especially the risk for depressive episodes was higher for definite Evening-types than for definite Morning-types, but definite Evening-types had also higher risks for bipolar disorder and persistent mood disorders. Further, moderate Evening-types had a higher risk for persistent mood disorders as compared with definite Morning-types. Of neurotic, stress-related, and somatoform disorders, definite Evening-types had higher risks for other anxiety disorders, reactions to severe stress, and adjustment disorders as compared with definite Morning-types.

3.4 | Self-reported symptoms, diagnosis and medication by habitual sleep-wake rhythm

Later Sleep_{mid-wknd} and Sleep_{mid-corr} were associated with the increased self-reported symptoms of depressed feelings and lost interest, depression and other mental disorders as diagnosed by a medical doctor, and more frequent antidepressant and tranquilizing medication as compared with earlier midpoints of sleep (Table 3). Concerning the familial background of depression, those with later Sleep_{mid-wknd} and Sleep_{mid-corr} had more frequently fathers and mothers being diagnosed with depression.

Those who reported hardly ever getting enough sleep had self-reported depressive symptoms, both regarding depressed feelings and lost interest, depression and other mental disorders as diagnosed by a medical doctor, and antidepressant and tranquilizing medication more frequently than those who nearly always got enough sleep (Table 4). Concerning the familial background of depression, those who reported hardly ever getting enough sleep had fathers and mothers being diagnosed with depression more often as compared with those who nearly always got enough sleep. Of note, also those who often got enough sleep had depressive symptoms,

both regarding depressed feelings and lost interest, more frequently than those who nearly always got enough sleep.

3.5 | Hospital treatments due to mental disorders by habitual sleep-wake rhythm

As shown in Table 3, later Sleep_{mid-wknd} and Sleep_{mid-corr} were associated both with a higher risk for mood disorders in general, and of these with more depressive episodes and persistent mood disorders as compared to earlier midpoints of sleep. Later Sleep_{mid-wknd} and Sleep_{mid-corr} were associated with more neurotic, stress-related and somatoform disorders in general, and of these later Sleep_{mid-corr} was associated with more treatments due to other anxiety disorders as compared to earlier midpoints of sleep.

As shown in Table 4, those who reported hardly ever getting enough sleep had higher risks for mood disorders as well as neurotic, stress-related and somatoform disorders as compared to those who nearly always got enough sleep. Concerning mood disorders, not only the risk for depressive episodes but also the risk for persistent mood disorders was higher for those who reported hardly ever getting enough sleep, as compared to those who nearly always got enough sleep. Of neurotic, stress-related and somatoform disorders, those who reported hardly ever getting enough sleep had more treatments due to other anxiety disorders, reactions to severe stress and adjustment disorders as compared to those who nearly always got enough sleep. Of note again, those who reported often getting enough sleep had more treatments due to neurotic, stress-related and somatoform disorders in general as compared to those who nearly always got enough sleep.

3.6 | Mediating effect of insufficient sleep on the association of circadian type with mental health

Since the associations of mental health with circadian type were stronger than those with the midpoints of sleep, we wanted to analyze further, whether insufficient sleep mediated the association of circadian type with mental health. Table 5 shows the significant mediating effects of insufficient sleep on the association of circadian type with mental health. The indirect effect of insufficient sleep on the association of circadian type with depressive symptoms overrides the average direct association for which insufficient sleep is only controlled. Similar effects were found for hospital treatments due to mood disorders in general and due to depressive episodes in particular. The associations of circadian type with hospital treatments due to neurotic, stress-related and somatoform disorders, and of these hospital treatments due to other anxiety disorders, were indirectly mediated by insufficient sleep overriding the effect of average direct associations. In contrast, the association of circadian type with the self-reported diagnosis of depression was mediated by insufficient sleep, but the average direct effect of circadian type was stronger than the indirect effect of insufficient sleep.

TABLE 2 Self-reported mental health symptoms, diagnosis, medication, and Health Care information on mental health treatments in Finland from 1996 to 2018 based on ICD-10 coding by circadian type

	Definite evening-type (N = 2686)			Moderate evening-type (N = 5652)			Moderate morning-type (N = 5830)					
	B	95% CI Lower	Upper	p value	B	95% CI Lower	Upper	p value	B	95% CI Lower	Upper	p value
<i>Self-reported mental health symptoms, diagnosis and medication</i>												
Depressed during the last 12 months	0.12	0.10	0.14	<.0001	0.07	0.05	0.08	<.0001	0.02	0.002	0.03	.03
Lost interest during the last 12 months	0.10	0.08	0.12	<.0001	0.03	0.02	0.05	<.0001	0.008	-0.007	0.02	.29
Diagnosed depression	0.05	0.04	0.06	<0.0001	0.02	0.01	0.03	<.0001	0.008	-0.002	0.02	.11
Diagnosed other mental disorder	0.03	0.02	0.03	<.0001	0.008	0.002	0.01	.01	0.001	-0.006	0.007	.86
Antidepressant medication	-0.21	-0.26	-0.16	<.0001	-0.10	-0.15	-0.06	<.0001	-0.03	-0.07	0.01	.18
Tranquilizing medication	-0.11	-0.15	-0.06	<.0001	-0.02	-0.06	0.01	.22	0.03	-0.005	0.07	.09
Father's depression	0.02	0.01	0.04	.0003	0.007	-0.003	0.02	.18	-0.002	-0.01	0.009	.77
Mother's depression	0.02	0.004	0.03	.02	0.01	0.002	0.03	.02	0.004	-0.008	0.02	.53
<i>Treatments for mental and behavioral disorders</i>												
F30-F39 Mood [affective] disorders (Yes N = 712, No N = 17,327)	0.02	0.009	0.03	<.0001	0.006	-0.002	0.01	.16	-0.002	-0.01	0.006	.69
F31 Bipolar affective disorder (Yes N = 116, No N = 17,923)	0.004	0.0004	0.008	.03	-0.002	-0.006	0.001	.14	-0.002	-0.005	0.001	.21
F32 Depressive episode (Yes N = 545, No N = 17,494)	0.01	0.005	0.02	.002	0.004	-0.003	0.01	.21	-0.002	-0.009	0.005	.61
F34 Persistent mood [affective] disorders (Yes N = 44, No N = 17,995)	0.004	0.002	0.006	.001	0.003	0.001	0.005	.01	0.001	-0.001	0.003	.45
F40-F48 Neurotic, stress-related and somatoform disorders (Yes N = 432, No N = 17,607)	0.02	0.007	0.02	<.0001	0.005	-0.001	0.01	.10	0.001	-0.005	0.008	.68
F41 Other anxiety disorders (Yes N = 204, No N = 17,835)	0.008	0.003	0.01	.002	0.002	-0.002	0.006	.34	-0.0005	-0.005	0.004	.83
F43 Reaction to severe stress, and adjustment disorders (Yes N = 186, No N = 17,921)	0.007	0.002	0.01	.009	0.003	-0.001	0.007	.20	0.001	-0.003	0.005	.76

Note: General linear regression models adjusted with age and sex, and definite morning-types (N = 3871) are as the reference group.

4 | DISCUSSION

All the mental health related outcomes we studied here on 18,039 adults aged 18–99 years were more pronounced among those with the circadian type more toward eveningness. The subsample of 11,151 adults with data on the habitual sleep-wake behavior on weekends yielded similar results, indicating that symptoms, diagnoses and hospital treatments were more pronounced among those with later phases of entrainment.

Many factors might contribute to the increased mental health risks among Evening-types in a complex way. In line with previous studies indicating the increased sleep problems among Evening-types (Fabbian et al., 2016; Merikanto & Partonen, 2020; Merikanto et al., 2012), eveningness was associated with more insufficient sleep. Sleep problems are considered to be not only core symptoms but also predisposing factors in the development of mental disorders (Alvaro et al., 2013; Baglioni et al., 2011; Tsuno et al., 2005). Here, in the sample of 18,229 adults with the self-assessed sleep sufficiency, insufficient sleep increased the risk for all the mental health related outcomes, except that for hospital treatment due to bipolar disorder. However, the mediating effect of insufficient sleep on the association of eveningness with mental health was not significant regarding the mental health outcomes. Yet, for the associations which were mediated by insufficient sleep, in most cases the indirect effect of insufficient sleep overrode the direct effect of eveningness on poor mental health. Our findings show that insufficient sleep fully mediates the associations of eveningness with depressive symptoms and with hospital treatments due to depressive episodes and anxiety disorders, and that insufficient sleep partly mediates the association of eveningness with a diagnosed depression during the past 12 months. Recent studies with smaller samples of adults have demonstrated similar mediating effects of sleep, where poor sleep quality at least partly mediates the association of eveningness with depressive symptoms in healthy individuals (Horne et al., 2019; Van den Berg et al., 2018; Zhou et al., 2020) as well as in major-depressive disorder (Selvi et al., 2018) or bipolar disorder (Caruso et al., 2020). There are also few exceptions, where the mediating effect of sleep quality on depressive symptoms was not significant in young healthy adults (Lin et al., 2020; Üzer & Yücens, 2020).

According to our findings we report here, insufficient sleep does not mediate the association of eveningness with higher risks for use of antidepressant or tranquilizing medication, nor for hospital treatments due to bipolar disorder, persistent mood disorders, reactions to severe stress, or adjustment disorders. Therefore, there is some other, yet unidentified, underlying mechanism which plays a role here than the effect of poor sleep on the association of eveningness with poor mental health. The behavioral trait of eveningness and circadian disruption often go hand in hand among those with bipolar disorder (Melo et al., 2017), and social jet lag, indicating a mismatch between weekday and weekend phase entrainment, is

more common among Evening-types than in other types of circadian types (Merikanto & Partonen, 2020). It is therefore possible that a sleep-wake behavior that is not optimal regarding the circadian rhythms in physiological functions is a key risk factor for mental health problems among Evening-types.

Psychosocial factors might also have a role in the increased mental health risks among Evening-types. Increased psychosocial stress is associated with a higher risk for depression (Siegrist, 2008), and rumination which is a psychological risk factor for depression is more common among Evening-types (Antypa et al., 2017). In the body, stress related circuits are connected to the circadian system but can also override the habitual sleep-wake schedules to maintain alertness for instance by suppressing melatonin secretion and thus disturbing sleep (Malhi & Kuiper, 2013). Psychosocial factors which contribute to increased rumination might influence mental health among Evening-types as well. Deteriorated mood and increased anxiety might also at least partly explain why risky alcohol consumption is more prominent among Evening-types (Merikanto et al., 2015, 2017; Prat & Adan, 2011) but elevated alcohol consumption among Evening-types could also promote mental health problems (Wittmann et al., 2010).

Family background might also influence the liability of Evening-types for poor mental health. Our findings herein indicated that the circadian type toward eveningness as well as later phase entrainment were associated with one or both parents being diagnosed for depression. Further, those who reported more insufficient sleep had parents more frequently being diagnosed for depression. Parental depression is a well-established risk factor for development of depression and other mental health problems in the offspring (Eckshtain et al., 2019; Hosman et al., 2009; Weissman et al., 2016), where the potential influence of familial depression can either be psychological or genetic (Hosman et al., 2009). Parental depression has a negative effect on parenting skills and the cognitive development of the child (Eckshtain et al., 2019), whereas major depressive disorder (Guffanti et al., 2016) and bipolar disorder (McGuffin et al., 2003) are highly heritable and the offspring of depressed parents have a higher genetic predisposition for mental disorders. The circadian type also has rather high heritability estimates of 44%–57% (Barclay et al., 2014; Koskenvuo et al., 2007; Vink et al., 2001). There might in addition be a heightened genetic liability for mood disorders among Evening-types as compared to other chronotypes, since certain variants of the core circadian clock genes which associate with eveningness have been shown to associate with poor mental health as well (Mendoza & Vanotti, 2019).

Our findings on the increased risks of symptoms, diagnoses and hospital treatments due to mental disorders among Evening-types as well as among those reporting insufficient sleep are concerning, as the prevalence rates of both eveningness and insufficient sleep appear to increase in a population (Merikanto & Partonen, 2020). Measures to ensure a better prospective among Evening-types, such as those lowering the risk of insufficient sleep or circadian misalignment, are thus needed.

TABLE 3 Self-reported mental health symptoms, diagnosis, medication and Health Care information on mental health treatments in Finland from 1996 to 2018 based on ICD-10 coding by midpoint of sleep

	Midpoint of sleep on weekends (N = 11 151)			Sleep debt corrected midpoint of sleep (N = 11 151)				
	B	95% CI Lower	Upper	p value	B	95% CI Lower	Upper	p value
<i>Self-reported mental health symptoms, diagnosis, and medication</i>								
Depressed during the last 12 months	0.00001	0.000008	0.000011	<.0001	0.00001	0.000008	0.00001	<.0001
Lost interest during the last 12 months	0.000008	0.000006	0.000009	<.0001	0.000008	0.000006	0.000009	<.0001
Diagnosed depression	0.000004	0.000003	0.000005	<.0001	0.000004	0.000003	0.000005	<.0001
Diagnosed other mental disorder	0.000003	0.000002	0.000004	<.0001	0.000003	0.000002	0.000004	<.0001
Antidepressant medication	-0.00002	-0.00002	-0.00001	<.0001	-0.00002	-0.00002	-0.00001	<.0001
Tranquilizing medication	-0.00001	-0.00002	-0.000009	<.0001	-0.00001	-0.00002	-0.00001	<.0001
Father's depression	0.00002	5.8 × 10 ⁻⁷	0.000003	.003	0.000002	5.8 × 10 ⁻⁷	0.000003	.003
Mother's depression	0.000003	6.9 × 10 ⁻⁷	0.000001	.001	0.000003	9.3 × 10 ⁻⁷	0.000004	.001
<i>Treatments for mental and behavioral disorders</i>								
F30-F39 Mood [affective] disorders (Yes N = 504, No N = 10,647)	0.000002	9.8 × 10 ⁻⁷	0.000003	<.0001	0.000002	0.000001	0.000003	<.0001
F31 Bipolar affective disorder (Yes N = 75, No N = 11,076)	2.1 × 10 ⁻⁷	-1.2 × 10 ⁻⁷	5.3 × 10 ⁻⁷	.21	3.4 × 10 ⁻⁷	6.1 × 10 ⁻⁹	6.9 × 10 ⁻⁷	.05
F32 Depressive episode (Yes N = 393, No N = 10,758)	0.000001	2.9 × 10 ⁻⁷	0.000002	.006	0.000001	7.1 × 10 ⁻⁷	0.000002	.0002
F34 Persistent mood [affective] disorders (Yes N = 37, No N = 11,114)	5.0 × 10 ⁻⁷	2.7 × 10 ⁻⁷	7.2 × 10 ⁻⁷	<.0001	2.5 × 10 ⁻⁷	6.1 × 10 ⁻⁹	4.9 × 10 ⁻⁷	.04
F40-F48 Neurotic, stress-related and somatoform disorders (Yes N = 355, No N = 10,796)	7.9 × 10 ⁻⁷	9.2 × 10 ⁻⁸	0.000001	.03	0.000001	3.0 × 10 ⁻⁷	0.000002	.006
F41 Other anxiety disorders (Yes N = 165, No N = 10,986)	4.6 × 10 ⁻⁷	-1.7 × 10 ⁻⁸	9.4 × 10 ⁻⁷	.06	5.6 × 10 ⁻⁷	3.8 × 10 ⁻⁸	0.000001	.04
F43 Reaction to severe stress, and adjustment disorders (Yes N = 156, No N = 10,995)	3.7 × 10 ⁻⁷	-9.0 × 10 ⁻⁸	8.4 × 10 ⁻⁷	.11	4.7 × 10 ⁻⁷	-2.4 × 10 ⁻⁸	9.7 × 10 ⁻⁹	.06

Note: General linear regression models adjusted with age and sex.

TABLE 4 Self-reported mental health symptoms, diagnosis, medication and Health Care information on mental health treatments in Finland from 1996 to 2018 based on ICD-10 coding by insufficient sleep

	Enough sleep rarely or hardly ever (N = 2881)			Enough sleep often (N = 8389)			p value	p value
	B	95% CI Lower	Upper	B	95% CI Lower	Upper		
<i>Self-reported mental health symptoms, diagnosis and medication</i>								
Depressed during the last 12 months	0.22	0.21	0.24	0.06	0.04	0.07	<.0001	<.0001
Lost interest during the last 12 months	0.21	0.19	0.22	0.05	0.03	0.06	<.0001	<.0001
Diagnosed depression	0.06	0.05	0.07	0.006	-0.002	0.01	<.0001	.15
Diagnosed other mental disorder	0.01	0.005	0.02	-0.00003	-0.005	0.005	.001	.99
Antidepressant medication	-0.15	-0.20	-0.11	-0.007	-0.04	0.03	<.0001	.68
Tranquilizing medication	-0.14	-0.18	-0.10	0.001	-0.03	0.03	<.0001	.92
Father's depression	0.02	0.01	0.04	0.008	-0.0004	0.02	<.0001	.06
Mother's depression	0.02	0.003	0.03	0.003	-0.007	0.01	.02	.60
<i>Treatments for mental and behavioral disorders</i>								
F30-F39 Mood [affective] disorders (Yes N = 771, No N = 17,458)	0.03	0.03	0.04	0.003	-0.003	0.01	<.0001	.32
F31 Bipolar affective disorder (Yes N = 117, No N = 18,112)	0.001	-0.003	0.004	-0.0004	-0.003	0.002	.64	.77
F32 Depressive episode (Yes N = 596, No N = 17,633)	0.03	0.02	0.04	0.003	-0.003	0.008	<.0001	.35
F34 Persistent mood [affective] disorders (Yes N = 54, No N = 18,175)	0.004	0.001	0.006	-0.0002	-0.002	0.002	.002	.84
F40-F48 Neurotic, stress-related and somatoform disorders (Yes N = 486, No N = 17,743)	0.03	0.02	0.03	0.006	0.001	0.01	<.0001	.02
F41 Other anxiety disorders (Yes N = 234, No N = 17,995)	0.01	0.007	0.02	0.003	-0.0002	0.007	<.0001	.06
F43 Reaction to severe stress, and adjustment disorders (Yes N = 210, No N = 18,019)	0.01	0.007	0.02	0.002	-0.001	0.005	<.0001	.26

Note: General linear regression models adjusted with age and sex, and those reporting enough sleep nearly always (N = 6959) are as the reference group.

TABLE 5 Statistically significant mediating effects of insufficient sleep on the association between circadian type and mental health

	Indirect effect			Direct effect		
	Estimate	95% CI Lower	Upper	Estimate	95% CI Lower	Upper
<i>Self-reported mental health symptoms, diagnosis, and medication</i>						
Depressed during the last 12 months	0.005	0.001	0.001	0.01	-0.006	0.03
Lost interest during the last 12 months	0.003	0.001	0.01	-0.0006	-0.02	0.02
Diagnosed depression	0.0007	0.0002	0.001	0.01	0.001	0.02
<i>Treatments for mental and behavioral disorders</i>						
F30–F39 Mood [affective] disorders	0.0004	0.0001	0.001	0.001	-0.006	0.01
F32 Depressive episode	0.0004	0.0001	0.001	0.0003	-0.006	0.01
F40–F48 Neurotic, stress-related and somatoform disorders	0.00002	0.000008	0.001	0.0001	-0.0005	0.01
F41 Other anxiety disorders	0.00001	0.000002	0.001	0.00003	-0.0004	0.001

Note: Indirect effect indicates the average causal mediation effects when the influence of circadian type on mental health goes through the mediator, insufficient sleep. Direct effect indicates the average direct association between circadian type and mental health when insufficient sleep is included in the model. Total effect indicates the influence of both indirect and direct effect on the association between circadian type and mental health.

4.1 | Limitations and strengths

Strengths of our study include the recruitment of the participants from random samples representative of the general adult population, the relatively big sample size and the assessment of chronotype and mental health readouts using diverse, subjective, and objective data. A notable strength of this study is the data derived from the national Care Register for Health Care providing us nationwide register-based health care information on treatments due to mood and stress-related disorders besides from questionnaire-based data on symptoms and diagnosis. Our study has also limitations. A limitation is that the assessment of chronotype, albeit with two different methods, was based only on the self-reported data. Another limitation is that the questionnaire-based data was cross-sectional and does not allow us to examine possible confounder effects on the association of chronotype and mental health longitudinally.

5 | CONCLUSIONS

Our findings indicate that there are increased mental health risks among Evening-types not only on symptom or diagnosis level, but also being evidenced as mental disorders requiring hospital treatment. Insufficient sleep heightened the risk for these outcomes, and either fully or partly mediated the association between circadian type and many of the mental health outcomes. For other mental health outcomes, such as use of medication or treatments due to bipolar disorder, persistent mood disorders or reactions to severe stress, there are still undefined underlying mechanisms at play explaining the increased mental health risk among Evening-types. These still undefined underlying mechanisms, which contribute to the increased mental health risk among Evening-types need further analysis, identification and mechanistic studies, and subsequently data-based interventions to alleviate the risk.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Finnish Institute for Health and Welfare. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the Finnish Institute for Health and Welfare with permission.

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