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Seasonal variations in mood and behavior associate with common chronic diseases and symptoms in a population-based study

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ABSTRACT

The purpose of this study was to assess how seasonality is associated with some of the most common non-communicable diseases (NCDs) in the general Finnish population. The global seasonality score (GSS) was used to measure the magnitude of seasonality in 4689 participants, in addition to which they reported the extent to which the seasonal variations in mood and behavior were experienced as a problem. Regression models and the odds ratios were adopted to analyze the associations adjusted for a range of covariates. Seventy percent of the participants had seasonal variations in sleep duration, social activity, mood, or energy level, and forty percent those in weight and appetite. Angina pectoris and depression were significantly associated with seasonality throughout the analysis. Hypertension, high cholesterol levels, diabetes, other (than rheumatoid) joint diseases and other (than depressive) psychological illnesses were significantly associated with experiencing a problem due to the seasonal variations, with an increase in the GSS, and with seasonal affective disorder and its subsyndromal form. The co-occurrence of the seasonal variations in mood and behavior with certain common NCDs warrants future research to have insights into the etiology and potentially shared pathways and mechanisms of action.

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1. Introduction

Seasonal variations in mood and behavior (seasonality) refers to depressive symptoms caused by seasonal changes (Rosenthal et al., 1984a). Seasonal affective disorder (SAD) was first recognized in Diagnostic Statistical Manual Revised Version (DSM-III-R) as a “seasonal pattern” in mood disorders (American Psychiatric Association Committee on Nomenclature and Statistics, 1987). It is characterized by predictable onset of major depression during fall or winter or during summer (Rosenthal et al., 1984a; Wehr et al., 1988). The prevalence of SAD is estimated 5% in the USA (Rohan et al., 2015), 2–3% in Canada (Levitt et al., 2000), and up to 10% in the northern latitudes (Byrne and Brainard, 2008). Epidemiological studies have showed that more than 90% of the general population have some seasonal influence on their mood, social activity, sleep, appetite, weight gain or energy level (Dam et al., 1998; Kasper et al., 1989; Oyane et al., 2008).

Earlier studies have found associations not only between seasonal variations and mood but also between seasonal variations and bulimia nervosa, depression, anxiety and other psychiatric illnesses (Gruber and Dilsaver, 1996; Magnusson, 1996; Oyane et al., 2008). Harmatz and colleagues demonstrated associations between seasonal variations and depression, anger, hostility and irritability, and anxiety (Harmatz et al., 2000). General anxiety disorder, panic disorder, obsessive compulsive disorder, tension anxiety and substance abuse are reportedly more prevalent during fall or winter than during spring or summer (Schlager et al., 1993; Harmatz et al., 2000; Kovalenko et al., 2000; de Graaf et al., 2005). The impacts of seasonal variations has also been studied in common non-communicable diseases (NCDs) such as diabetes, cardiovascular diseases (CVDs), cancer and rheumatic diseases (Hawley et al., 2001; Oyane et al., 2010; Ernst, 2012). Numerous studies have also reported seasonal variations within metabolic syndrome parameters like weight, serum cholesterol level, uric acid, blood pressure, and glucose (Yanovski et al., 2000; Ockene et al., 2004; Liang, 2007; Hayashi et al., 2008; Rintamäki et al., 2008; Alperovitch et al., 2009). Studies have repeatedly demonstrated higher

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morbidity and mortality of NCDs during winter than during summer (Kloner et al., 1999; Rumana et al., 2008). In European countries, mortality is 16% higher during winter than during summer (Healy, 2003). Moreover, NCDs impose the largest burden on human health globally. Its impact extends beyond ill health and mortality with large financial consequences. It accounted for 68% deaths (38 million) of world's 56 million deaths in 2012 (World Health Organization, 2014).

The etiology of SAD is not certain, but several hypotheses has been presented (Roeklein and Rohan, 2005). Several lines of evidence suggests common etiological factors in many disorder found to co-occur in SAD through indications of common pathophysiological mechanisms, common treatment response and common genetic liabilities (Partonen and Magnusson, 2001). For example, it has been suggested that SAD is caused by vitamin D deficiency (Berk et al., 2007; Gloth, Alam, and Hollis, 1999). This hypothesis is supported by the findings that vitamin D supplementation improves SAD (Lansdowne and Provost, 1998; Gloth et al., 1999). Vitamin D deficiency is also found to be associated with an increased risk for several NCDs such as osteoporosis, cancer, diabetes, autoimmune disorders, hypertension, atherosclerosis, muscle weakness, chronic obstructive pulmonary disease (COPD), vascular disease events in type 2 diabetes, cardiovascular diseases (CVDs), and renal failure (Forman et al., 2007; Holick, 2007; Donaldson and Wedzicha, 2014). Certain neurotransmitters have been implicated in SAD etiology; for example serotonergic system dysregulation has shown to play important role in the regulation of mood, appetite and sleep (Partonen and Lönngqvist, 1998). Further, photon hypothesis in SAD has been proposed, according to which the changing photoperiod during winter has drastic impact on the circadian rhythms and entrainment causing SAD. Low levels of outdoor light exposure during winter months might cause inadequate resetting of the circadian clock, which presumably is also linked to chronic diseases (Laposky et al., 2008). Accordingly, evening types felt better in the summer while morning types in the winter, due to long and short photoperiods within these seasons (Natale et al., 2005).

In summary, understanding the role of hormones and circadian systems biology may bring a new perspective on the influence of SAD on the course and outcomes of NCDs. It could help in designing more appropriate treatment regimes.

In the present study, we examined the relationship between seasonality and some of the most common NCDs (hypertension, high cholesterol, cardiac insufficiency, angina pectoris, diabetes, cancer, bronchial asthma, chronic obstructive pulmonary disease, gallstones, rheumatoid arthritis, other joint disease, degenerative arthritis, depression, other psychological illnesses, renal failure, and proteinuria). To elucidate this association, we measured the degree of seasonality among Finnish participants suffering from NCDs. In Finland (60–69°N), the seasonal temperature and day-light fluctuations are intense, and thus the Finnish population is a good subject for to study seasonality. The current study is part of a larger national FINRISK health examination survey, carried out at every-five-year intervals since 1972 in Finland.

2. Methods

2.1. Participants

Random samples of Finns, aged 25–74 years, were invited to the National FINRISK Study 2012 from five large geographical areas in Finland. The sample was derived from the population information system of the national population register center. Total participants (n=6424) answered and attended to the health examinations of the study. Participants (n=4800) responded to each

item of the seasonal variations in sleep duration, social activity, mood, weight, appetite, and energy level (the maximum n=4852 reported the seasonal variation in sleep duration). Participants (n=4777) reported their experience on the seasonal variations as a problem and produced the global seasonality score (n=4770). Finally, a total of 4689 participants reported both their experience and scored on the GSS (see Table 2).

2.2. Covariates

The surveys included a self-administered questionnaire (mainly including questions on socioeconomic factors, medical history, health behavior, and psychosocial factors), physical examination and laboratory measures. Socioeconomic covariates were age as continuous variable, sex as male or female, marital status as living together with somebody (either married, cohabitating or registered partnership) or alone (either single, separated or divorce, widow), education as low (less than four years of high school), medium (either high school only or 1–3 years post high school) or high (4 or more years post high school) level, region as living in North Karelia and Kuopio, North Savo, Turku and Loimaa, Helsinki and Vantaa, or Oulu. Lifestyle covariates were smoking as smokers (either smoked daily or occasionally) or non-smokers (smoked not at all), alcohol consumption as alcohol intake (at least once or more than once a month) or no alcohol intake (no alcohol consumption at all) and exercise as regular exercise (at least 3–4 h per week or several times a week) or no-exercise. The participants were asked if the doctor has diagnosed or treated them in the past 12 months for the following NCDs: hypertension, high cholesterol, cardiac insufficiency, angina pectoris, diabetes, cancer, bronchial asthma, COPD, gallstone, rheumatoid arthritis, other joint diseases, degenerative arthritis of the back, depression, other psychological illnesses, renal failure, and proteinuria.

2.3. Global seasonality score

Seasonality was measured in this study by a modified self-rating Global Seasonality Score (GSS), a central subscale of the Seasonal Pattern Assessment Questionnaire (SPAQ) (Rosenthal et al., 1984b). The GSS investigates the seasonal variations in sleep duration, social activity, mood, weight, appetite, and energy level. Each item is a Likert-like scale scored as 0 (no variation) to 3 (marked variation), yielding the total sum score from 0 to 18. The higher the GSS is, the higher the degree of seasonality is. In addition, the item about the experience on the seasonal variations as a problem is scored from 0 (no problem) to 4 (severe problem). In the current study, SAD refers to 8–18 points on the GSS and 3–4 points on the experienced problem; sub-syndromal SAD (S-SAD) refers to 8–18 points on the GSS and 2 points on the experienced problem, or 6–7 points on the GSS and 2–5 points on the experienced problem; and normal seasonality refers to the remaining. The GSS has been shown to have an acceptable reliability and validity in epidemiological studies (Thompson et al., 1988; Magnusson, 1996).

2.4. Statistical analysis

The data was analyzed using appropriate statistical methods with IBM SPSS Statistics 21 software. Group differences were measured, and the statistical significance was tested. Chi-square test was used to measure the distribution between SAD, S-SAD and socio-demographic factors. Bivariate and multiple regression models with NCDs as dependent variables and the seasonality items as independent explanatory variables were generated, after controlling for the background covariates (age, gender, education, civil status, alcohol consumption, physical activity, smoking, and

area of residence). No self-reported seasonal variation, no problem, and normal seasonality were used as the reference categories in these analyses.

2.5. Ethics

The data collection was conducted according to the guidelines of the Declaration of Helsinki and international ethical standards. The Ethics Committee of the Hospital District of Helsinki and Uusimaa (HUS) approved the research protocols. All the participants gave a written informed consent.

3. Results

The mean age of the participants (3041 males and 3383 females) was 51 years (ranged from 24 to 74 years). 20–25% participants had CVD risk factors. 15–20% had joint diseases and degenerative arthritis. 7–8% had bronchial asthma, diabetes and depression. 3% had psychological illness, cardiac insufficiency and angina pectoris. 1–2% had gallstones, proteinuria, cancer, rheumatoid arthritis, and COPD, and < 1% had renal failure 7% of the participants living alone, 10% of ever smokers, 20% of those who consumed alcohol, and 5% of those who did not exercise at all had SAD symptoms (see Table 1). Some statistically significant group

differences in gender, age group, marital status, and physical activity were observed in SAD. There were no statistically significant group differences in SAD for region, education level, smoking or alcohol intake (see Table 1). 70% of the participants had the seasonal variations in sleep duration, social activity, mood and energy level, and 40% those in weight, and appetite. The total GSS sum in this sample ranged from 0 to 18 points (mean=5.11, SD=3.29), 23% of them had SAD symptoms (6% for SAD and 17% for S-SAD), and 32.5% of them experienced problem due to the seasonal variations.

3.1. Cardiovascular disease and risk factors

Cardiovascular diseases (CVDs) and their risk factors were significantly associated with the seasonal variation in appetite and the experienced problem due to seasonality (see Table 2).

Angina pectoris was significantly associated with each measure of the seasonality, including the seasonal variations in sleep duration (OR=1.937, $p < .05$), social activity (OR=2.476, $p < .01$), mood (OR=2.427, $p < .01$), weight (OR=1.993, $p < .01$), appetite (OR=2.119, $p < .01$), and energy level (OR=2.331, $p < .05$). Hypertension was significantly associated with the increased odds for the seasonal variations in sleep duration (OR=1.265, $p < .05$), weight (OR=1.38, $p < .01$), and appetite (OR=1.358, $p < .01$). Cardiac insufficiency was significantly associated with the

Table 1
Background characteristics by SAD, S-SAD and no SAD.

Background variables	SAD n(%)	S-SAD n(%)	No SAD n(%)	Total n(%)	Test
Age-group					
25–34 years	54(1.2)	149(3.2)	458(9.8)	661(14.1)	$\chi^2 = 69.13$, $df = 8$, $p < 0.001$
35–44	58(1.2)	149(3.2)	597(12.7)	804(17.1)	
45–54	77(1.6)	172(3.7)	705(15)	954(20.3)	
55–64	73(1.6)	172(3.7)	705(15)	954(20.3)	
> 65 years	42(0.9)	145(3.1)	1006(21.5)	1193(25.4)	
Gender					
Male	83(1.8)	285(6.1)	1759(37.5)	2127(45.4)	$\chi^2 = 92.76$, $df = 2$, $p < 0.001$
Female	221(4.7)	520(11.1)	1821(38.8)	2562(54.6)	
Marital status^a					
Together	186(4)	571(12.2)	2682(57.3)	3439(73.5)	$\chi^2 = 30.53$, $df = 2$, $p < 0.001$
Alone	118(2.5)	233(5)	892(19.1)	1243(26.5)	
Education^b					
Medium	94(2)	251(5.4)	1184(25.6)	1529(33.1)	$\chi^2 = 9.28$, $df = 4$, $p < 0.05$
High	109(2.4)	305(6.6)	1153(24.9)	1567(33.9)	
Low	96(2.1)	246(5.3)	1188(25.7)	1530(33.1)	
Region					
North Karelia and Kuopio	75(1.6)	174(3.7)	765(16.3)	1014(21.6)	$\chi^2 = 10.99$, $df = 8$, $p = 0.202$
North Savo	54(1.2)	155(3.3)	753(16.1)	753(16.1)	
Turku and Loimaa	65(1.4)	164(3.5)	662(14.1)	891(19)	
Helsinki and Vantaa	57(1.2)	157(3.3)	627(13.4)	841(17.9)	
Oulu and Lapland	53(1.1)	155(3.3)	773(16.5)	981(20.9)	
Smoking^c					
Smokers	78(3.3)	172(7.2)	672(28)	922(38.5)	$\chi^2 = 7.25$, $df = 2$, $p < 0.05$
Non-smokers	85(3.5)	262(10.9)	1127(47)	1574(61.5)	
Alcohol use^d					
Alcohol use	263(5.6)	707(15.1)	3134(67)	4104(87.7)	$\chi^2 = .443$, $df = 2$, $p = 0.802$
No alcohol use	41(0.9)	97(2.1)	438(9.4)	576(12.3)	
Physical activity^e					
Regular exercise	216(4.6)	631(13.5)	2906(62.1)	3753(80.2)	$\chi^2 = 19.22$, $df = 2$, $p < 0.001$
No exercise	87(1.9)	171(3.7)	667(14.3)	925(19.8)	

Abbreviations: SAD=seasonal affective disorder; S-SAD=subsyndromal SAD; df =degrees of freedom; p =probability.

^a Together (either married, cohabitating or registered partnership); alone (either single, separated or divorce, widow).

^b Medium (either high school only or 1–3 years post High school) or High (4 or more years post high school) level, low (less than four years of high school).

^c Smokers (either smoked daily or occasionally); non-smokers(smoked not at all).

^d Alcohol intake (at least once or more than once a month; no alcohol (no alcohol consumption at all or quit using alcohol)).

^e Regular exercise (at least 3–4 h per week or several times a week); no-exercise.

Table 2

Regression analysis outcomes for diagnosed non-communicable diseases and seasonality by each item of the global seasonality score (GSS), the seasonal variations experienced as a problem, GSS, seasonal affective disorder (SAD) and subsyndromal-SAD.^a

Disease	GSS items						Problem (n=4777)	GSS (n=4770)	GSS and problem (n=4689)	
	Sleep length (n=4852) OR(95% CI)p	Social activity (n=4827) OR(9% CI)p	Mood (n=4832) OR(95% CI)p	Weight (n=4825) OR(95% CI)p	Appetite (n=4837) OR(95% CI)p	Energy level (n=4832) OR(95% CI)p	OR(95% CI)p	B(SE)p	SAD (n=304) OR(95% CI)	S-SAD (n=805) OR(95% CI)
Hypertension	1.265(1.0–1.5)*	1.137(0.91–1.42)	1.062(0.85–1.32)	1.38(1.13–1.70)**	1.358(1.10–1.66)**	1.180(0.93–1.48)	1.510(1.21–1.87)****	1.072(0.016)****	2.390(1.60–3.55)****	1.548(1.18–2.025)***
High cholesterol levels	1.003(0.80–1.25)	1.178(0.93–1.48)	1.032(0.82–1.29)	0.883(0.71–1.08)	1.229(0.99–1.51)*	1.054(0.83–1.33)	1.423(1.14–1.77)**	1.031(0.016)*	1.955(1.30–2.93)***	1.525(1.16–2.00)**
Cardiac insufficiency	1.039(0.62–1.71)	0.986(0.59–1.62)	1.612(0.92–2.80)	1.670(1.04–2.68)*	1.616(1.0–2.60)*	1.398(0.81–2.41)	1.695(1.04–2.75)*	1.065(0.036)	1.759(0.66–4.68)	2.195(1.23–3.91)**
Angina pectoris	1.937(1.07–3.47)*	2.476(1.34–4.56)**	2.427(1.30–4.53)**	1.993(1.21–3.25)**	2.119(1.30–3.44)**	2.331(1.22–4.43)**	2.221(1.36–3.60)***	1.134(0.035)****	2.664(1.15–6.16)*	2.363(1.31–4.25)**
Diabetes	0.966(0.68–1.35)	1.002(0.71–1.41)	1.200(0.84–1.70)	1.323(0.96–1.82)	1.510(1.09–2.08)**	1.158(0.80–1.65)	1.509(1.07–2.11)*	1.066(0.024)**	2.788(1.56–4.96)****	1.791(1.18–2.71)**
Cancer	1.150(0.61–2.14)	0.969(0.53–1.77)	1.502(0.78–2.88)	0.525(0.28–.95)*	.492(0.25–.94)*	1.629(0.81–3.25)	1.168(0.64–2.13)	1.007(0.044)	2.358(0.85–6.47)	0.944(0.40–2.17)
Bronchial asthma	1.153(0.80–1.65)	1.581(1.07–2.33)*	1.376(0.93–2.01)	1.562(1.14–2.13)**	1.196(0.87–1.63)	1.181(0.80–1.72)	1.468(1.07–2.00)*	1.060(0.023)**	1.938(1.17–3.20)*	1.398(0.95–2.04)
COPD	0.916(0.48–1.73)	1.352(0.69–2.64)	1.852(0.88–3.87)	2.448(1.29–4.63)**	1.557(0.84–2.88)	1.860(0.86–3.99)	1.773(0.94–3.33)	1.046(0.046)	2.868(0.97–8.43)*	1.315(0.54–3.15)
Gallstones	1.099(0.34–3.52)	1.897(0.51–6.94)	3.036(0.67–13.73)	1.881(0.66–5.35)	1.854(0.65–5.21)	5.436(0.70–42.10)	4.953(1.65–14.80)**	1.231(0.067)**	15.98(4.67–54.65)****	1.348(0.26–6.75)
Rheumatoid arthritis	1.216(0.63–2.34)	0.644(0.35–1.17)	0.641(0.35–1.17)	1.143(0.63–2.04)	0.644(0.35–1.18)	0.729(0.39–1.35)	0.763(0.40–1.44)	0.955(0.045)	1.611(0.64–4.03)	0.448(0.15–1.27)
Other joint diseases	1.286(0.96–1.70)	1.006(0.76–1.32)	1.350(1.01–1.79)*	1.590(1.24–2.03)****	1.398(1.09–1.79)**	1.242(0.92–1.66)	1.752(1.35–2.26)****	1.082(0.019)****	2.018(1.27–3.19)**	1.668(1.22–2.27)***
Degenerative arthritis	1.218(0.96–1.54)	1.221(0.96–1.54)	1.480(1.15–1.89)**	1.265(1.02–1.55)*	1.156(0.93–1.42)	1.357(1.05–1.74)*	1.255(1.00–1.56)*	1.079(0.016)****	1.770(1.20–2.59)**	1.092(0.82–1.44)
Depression	1.616(1.10–2.37)**	2.186(1.42–3.36)****	3.941(2.32–6.69)****	1.813(1.32–2.47)****	2.238(1.62–3.08)****	3.121(1.90–5.12)****	4.851(3.48–6.76)****	1.228(0.023)****	8.733(5.74–13.27)****	2.566(1.75–3.75)****
Other psychological illnesses	0.941(0.53–1.65)	0.948(0.52–1.71)	1.599(0.81–3.12)	1.565(0.94–2.59)	1.503(0.89–2.51)	1.311(0.68–2.50)	3.859(2.21–6.71)****	1.103(0.036)**	6.629(3.40–12.91)****	2.990(1.60–5.55)***
Renal failure	2.613(0.56–12.15)	2.465(0.52–11.54)	1.475(0.39–5.49)	0.911(0.28–2.94)	0.961(0.30–3.04)	1.269(0.33–4.74)	2.131(0.69–6.56)	1.194(0.086)*	5.623(1.29–24.42)*	0.688(0.08–5.73)
Proteinuria	3.955(0.91–17.16)	0.835(0.32–2.12)	1.849(0.61–5.60)	1.572(0.64–3.81)	2.092(0.86–5.05)	7.794(0.99–56.69)*	2.280(0.96–5.41)	1.151(0.063)*	4.477(1.34–14.86)*	1.526(0.47–4.86)

Abbreviations: OR=odds ratio; CI=confidence interval; SE=standard error; COPD=chronic obstructive pulmonary disease.

^a Covariates included age, sex, marital status, education, region, smoking, alcohol intake, and physical activity. Significance: p=* < 0.05, ** < 0.01, *** < 0.001, **** < 0.0001.

increased odds for the seasonal variations in weight and appetite, the experienced problem (OR=1.695, $p < .05$), and S-SAD (OR=2.195, $p < .01$). Furthermore, other CVD risk factors were significantly associated with the GSS, the experienced problem, SAD, and S-SAD.

3.2. Diabetes

Diabetes was significantly associated with the increased seasonal variation in appetite (OR=1.510, $p < .01$), as well as with the experienced problem (OR=1.509, $p < .05$), GSS (B=1.066, $p < .01$), SAD (OR=2.788, $p < .0001$), and S-SAD (OR=1.791, $p < .01$).

3.3. Cancer

Cancer was significantly associated with the decreased odds for the seasonal variations in weight (OR=.525, $p < .05$) and appetite (OR=.492, $p < .05$), but it was not associated with the experienced problem, GSS, SAD, or S-SAD.

3.4. Chronic respiratory diseases

Bronchial asthma was significantly associated with the seasonal variations in social activity (OR=1.581, $p < .05$) and weight (OR=1.562, $p < .01$), the experienced problem (OR=1.468, $p < .05$), GSS (B=1.060, $p < .01$), and SAD (OR=1.938, $p < .05$). On the other hand, chronic obstructive pulmonary disease was significantly associated with the seasonal variation in weight (OR=2.448, $p < .01$), and SAD (OR=2.868, $p < .05$).

3.5. Gallstones

Gallstones were significantly associated with the increased odds for the experienced problem (OR=4.953, $p < .01$), GSS (B=1.231, $p < .01$), and SAD (OR=15.98, $p < .0001$). Of interest, gallstones had the highest odds of all the NCDs for the seasonal variation in energy level (OR=5.436), but however this association was not significant.

3.6. Depression and other psychological illnesses

Depression was significantly associated with each measure of seasonality, including the seasonal variations in sleep duration (OR=1.616, $p < .01$), social activity (OR=2.186, $p < .0001$), mood (OR=3.941, $p < .0001$), weight (OR=1.813, $p < .0001$), appetite (OR=2.238, $p < .0001$), and energy level (OR=3.121, $p < .0001$). Both depression and other psychological illnesses were associated with the experienced problem, GSS, SAD, and S-SAD.

3.7. Muscular skeleton diseases

Other joint diseases were significantly associated with the increased odds for seasonal variations in mood (OR=1.350, $p < .05$), weight (OR=1.590, $p < .0001$), and appetite (OR=1.398, $p < .01$). Degenerative arthritis was significantly associated with the increased odds of seasonal variations in mood (OR=1.480, $p < .01$), weight (OR=1.265, $p < .05$), and energy level (OR=1.357, $p < .05$), the experienced problem (OR=1.255, $p < .05$), GSS (B=1.079, $p < .0001$), and SAD (OR=1.770, $p < .01$). Other joint diseases were significantly associated with the experienced problem (OR=1.752, $p < .0001$), GSS (B=1.082, $p < .0001$), SAD (OR=2.018, $p < .01$), and S-SAD (OR=1.668, $p < .001$). Here, it is of note that rheumatoid arthritis did not show any significant association with seasonality.

3.8. Renal failure and proteinuria

Renal failure was not significantly associated with any of the GSS items, the experienced problem, or S-SAD. However, it was associated with GSS (B=1.194, $p < .05$), and SAD (OR=5.623, $p < .05$), similar to proteinuria. Proteinuria was in addition significantly associated with the increased odds for the seasonal variation in energy level (OR=7.794, $p < .05$).

4. Discussion

To our knowledge, this is the first study to assess the association between SAD and most common NCDs in a large population based cohort. Four major NCDs including CVDs, cancers, respiratory diseases and diabetes responsible for 82% of NCD deaths (World Health Organization, 2014) and twelve other NCDs are discussed for the association. According to our results, the prevalence of SAD in the Finnish general population is 23% reported SAD symptoms (including SAD and S-SAD); this finding coincides with the prevalence observed in other populations of up to 10% in the northern latitudes (Byrne and Brainard, 2008), and 15% for S-SAD. Most of the earlier prevalence studies have used SPAQ to determine SAD as in the present study. Our findings suggest that depression and angina pectoris were significantly associated with seasonality throughout. Further, hypertension, high cholesterol, diabetes, other joint diseases, and other psychological illnesses were significantly associated with the experiencing problem due to seasonal variations, increase in the GSS, with SAD and S-SAD.

4.1. Cardiovascular disease risk factors

CVDs are the first leading cause of global mortality, accounting for 46.2% (17.5 million) of NCD deaths (World Health Organization, 2014). Earlier studies have reported for example higher morbidity, mortality and hospitalization rates of CVDs during winter than during summer months (Baune et al., 2012; Fiksenzer et al., 2014; Kloner et al., 1999; Rumana et al., 2008). Comorbidity in 15–31% is reported for depression in CVDs (Mayou et al., 2000; Schleifer et al., 1989; Whyte and Mulsant, 2002). In a previous study, SAD was positively associated with many health risk factors elevating the risk of CVDs (Øyane et al., 2010). SAD was associated with psychological distress which was associated with unhealthy behaviors increasing the risk of CVDs (Lavie and Milani, 2006). Likewise in the current study, 23–27% with CVD risk factors had SAD. The risk factors were significantly associated with the increased odds of seasonal variations in appetite, and experiencing problem due to seasonal variations. Further, hypertension, high cholesterol, and angina pectoris significantly increased the odds for SAD and S-SAD.

4.2. Diabetes

Diabetes is the fourth leading cause of death, accounting for 7% (1.5 million) of NCD deaths (World Health Organization, 2014), and its prevalence is projected to increase to 4.3 million by 2030 (Shaw et al., 2010). Diabetes doubles the odds for depression, and 11–15% comorbidity is reported for depression in diabetes (Anderson et al., 2001). Comorbidity results in a higher rate of adverse outcomes. For example, diabetic patient with depression have do not adherence to diet and report frequent treatment relapses (Ciechanowski et al., 2000; Lin et al., 2004). SAD is significantly associated with poorer glucose control and increased reporting of diabetic symptoms (Eaton et al., 1996; Mueller et al., 1969). Metabolic syndrome was associated with the seasonal variation in weight in a national study in Finland (Rintamäki et al., 2008). Elevated uric

acid levels which are also found in type 2 diabetes tend to increase the risk for uric acid stones through increasing insulin resistance (Massy et al., 2005). Further, carbohydrate craving, emotional and external eating in SAD (Kräuchi et al., 1997) and eating disorder in diabetes are the distinct features of both conditions (American Diabetes Association, 2004; Ismail, 2008). Hence, previous studies proposes the link between type 2 diabetes and SAD (Ernst, 2012). In line with previous study, in the current study, 22% with diabetes had SAD and it was significantly associated with the increased seasonal variation in appetite, experiencing problem due to seasonal variations, increase in the GSS, with SAD and S-SAD.

4.3. Cancer

Cancers are the second leading cause of death, accounting for 21.7% (8.2 million) of NCDs death (World Health Organization, 2014). The prevalence of depression is high in cancer, varying between 30% and 40% (Mitchell et al., 2011). Depression in cancer reduces participation in medical care, and prolongs duration of hospitalization (Prieto et al., 2002). Psychological distress, in cancer is linked with circadian and endocrine disruption (Cash et al., 2015). Disruption of the biological rhythms is reported to impair immune system and degrades health in cancer as in SAD (Mate et al., 2014). However, not many studies have examined the direct association of cancer and SAD, but the available evidence suggests the link with depression. As in the current study, 24% with cancer had SAD and it was associated with the increased odds for seasonal variations in weight and appetite.

4.4. Chronic respiratory diseases

Chronic respiratory diseases are the third leading cause of death, accounting for 10.7% (4 million) of NCD deaths (World Health Organization, 2014). Asthma affects > 300 million people worldwide (Masoli et al., 2004), and COPD will be the fourth leading cause of death by 2015. Evidence has shown that asthma doubles the risk of developing depressive symptoms, as compared with no asthma (Rosenkranz and Davidson, 2009). Comorbidity of 20–40% is reported for depression in COPD (Schane et al., 2008; Schnell et al., 2012). Patients with COPD have abnormal circadian rhythms, as is reflected by the everyday changes in respiratory symptoms and lung function (Sundar et al., 2014), the abnormalities in circadian rhythms is also common in SAD. Studies have reported increased rates of emergency room visits and hospitalization, mostly at night and in the early morning hours in COPD (Barnes, 1985; Tsai et al., 2007). This frequent disruption in the sleep-wake cycles could exaggerate the SAD symptoms in COPD. In line with the previous studies, 24–31% with chronic respiratory diseases had SAD in the current study. Bronchial asthma was significantly associated with the seasonal variations in social activity, weight, for the increase in the GSS, and SAD. COPD was significantly associated with the seasonal variations in weight and with SAD.

4.5. Gallstones

In the current study, 36% with gallstones had SAD. Gallstones significantly increased the odds for experiencing problem due to seasonal variations, for the increase in the GSS and SAD. However, there are no prior studies, which have assessed the association of seasonality with gallstones.

4.6. Depression and other psychological illnesses

Depression is the leading cause of disability worldwide, affecting about 121 million people (World Health Organization,

2008). WHO predicts that it will be the second most common global burden of disease by the year 2020. Of patients with SAD, 33–44% develop non-seasonal symptoms (Magnusson and Partonen, 2005). SAD is associated with many health risk behaviors, an increased medical symptom burden, functional impairment, more medical costs, poor adherence, and the increased risk of morbidity and mortality in patients with chronic medical disorders (Katon, 2011). In line with the earlier evidence, the association of seasonality with depression as well as that between seasonality and other psychological illnesses was found in the current study.

4.7. Muscular skeleton diseases

Some studies have demonstrated the association of seasonality with rheumatic disease (Hawley et al., 2001). In the current study, 18–27% with muscular skeleton diseases had SAD. We did not find any significant association of seasonality with rheumatic arthritis. Other joint diseases and degenerative arthritis were significantly associated with experiencing problem due to seasonal variations; increase in the GSS, and with SAD.

4.8. Renal failure and proteinuria

Uric acid is commonly elevated in chronic kidney diseases (Johnson et al., 2013). High uric acid levels have also been associated with metabolic syndrome (Kawamoto et al., 2006), which is found associated with seasonality (Rintamäki et al., 2008). However, no study has assessed the direct association of proteinuria and renal failure with SAD. According to our novel findings, 33–35% with renal failure and proteinuria had SAD. Proteinuria was significantly associated with seasonal variations in energy level. Proteinuria and renal failure significantly increased the GSS, and SAD.

4.9. General discussion

SAD is often undiagnosed, due to non-recognition of potential seasonal pattern in a patient who presents with other disorders (BMJ Best Practice, 2012). So far, only a limited number of studies have examined the association between SAD and chronic diseases (de Winter et al., 2015; Purebl et al., 2006). Those having one of eight medical disorders had a 41% increase in the risk of having a range of psychiatric disorders such as anxiety and mood disorders or substance abuse (Wells et al., 1988). In line with the previous studies in the current study, the risk of SAD was significant in 81% of diseases (13 out of 16), S-SAD was significant in 50% of diseases (8 out of 16), 68% of diseases for experiencing problem due to seasonal variations (11 out of 16), and 75% of diseases for the increase in the GSS (12 out of 16).

It is reported that the symptoms, intensity, and mortality of many human diseases conditions and syndromes exhibits circadian rhythms (Smolensky et al., 2014). The circadian rhythms disruption impairs the immune system and consequently degrades health also in SAD (Mate et al., 2014). Sher and colleagues suggested that SAD could suppress the immune system during winter, thus increasing the risk of having NCDs (Sher, 2001). Further, SAD increases psychological distresses, which are associated with unhealthy behaviors, supporting the links between the NCDs and SAD.

The major strength of this study is that it is based on a big dataset, due to which the results of this study are fairly generalizable and the potential risk of selection bias is reduced. The diseases reported in the study were based on the subjective responses of the participants, but were clinically verified with the previous diagnosis assessed by a medical doctor. Our analysis is not without limitations that must be considered for interpretation

of the results. A limitation is the non-control of morningness–eveningness orientation of the participants which may impact the findings, since the chronotype has been related to SAD and the risk of developing some of the NCDs analyzed (Adan et al., 2012). Hence, the results need to be interpreted cautiously. To address this issue, the association of the chronotype and NCDs will be assessed in further investigation. Second, the study design is cross-sectional, and therefore causation between NCDs and SAD cannot be inferred with the significant associations observed. Hence, in future, prospective longitudinal studies need to be done. Third, recall biases might exist, as the responses were based on the self-report. However, the structured questionnaires and validated screening tools were used to minimize such biases. Finally, the novel findings of the present study should be cautiously interpreted due to a small number of the cases for some of the diseases under analysis.

In conclusion, our data demonstrates the association of SAD and most common NCDs in the general Finnish population. The contribution of this article is the establishment of association between seasonality and NCDs at large. This finding suggests a potential importance of screening of NCDs in the patients with SAD symptoms and vice versa. This might become standard health watch for NCDs in SAD. Screening is necessary to provide comprehensive care for NCDs for people with SAD particularly for angina pectoris and depression. To conclude, early diagnosis prompt treatment of patients with SAD co-occurring with other NCDs requires careful attention, as better understanding of seasonality will ease the clinical diagnosis and management of these chronic diseases. Depression and NCDs such as CVDs are the two largest public health problem, but depressed patients with CVDs were likely to be clinically recognized as being depressed than those who have depression but no CVDs (Jiang et al., 2002). Hence, their appropriate prevention and treatment is an enormous public health challenge. However, despite the growing interest in this area, the available evidence is limited. Further, till date no research has addressed whether the treatment of depression or SAD in patients with chronic diseases will improve its prognosis. Future studies should focus on this. As circadian typology is an emerging predictor of health and longevity, further study should also focus on understanding its effect on chronobiological intervention outcomes in common chronic diseases.

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