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Predictability of seasonal mood fluctuations based on perceptions of weather conditions among residents in Iceland

The relationship between perceptions of weather conditions and seasonality

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Útdráttur

Rannsóknir hafa sýnt að veður hefur áhrif á lundarfar og atorku. Hins vegar hefur engin rannsókn skoðað áhrif veðurs á lundarfar í samhengi við árstíðabundnar lyndissveiflur (seasonality) og skammdegisþunglyndi á Íslandi. Tilgangur þessa verkefnis var að greina sambandið milli þess hvernig einstaklingar upplifa áhrif veðurs á líðan og atorku og árstíðabundinna lyndissveiflna á Íslandi. Í samræmi við fyrri rannsóknir var gert ráð fyrir því að skýjað og kalt veður auk sólskins myndi hafa sterkt samband við árstíðabundnar lyndissveiflur. Gögn úr EPiC SAD faraldsfræði rannsókninni, sem fengin voru með slembiúrtaki úr þjóðskrá (N=1977), voru greind með tvíkosta aðhvarfsgreiningu til að sjá hvort upplifanir einstaklinga á veðurfari, mældar með SPAQ spurningalistanum, gæti spáð fyrir um árstíðabundnar lyndissveiflur þátttakenda. Niðurstöður aðfhvarfsgreiningar gefa til kynna marktækt samband milli svara á spurningum um áhrif veðurfars á lundarfar og skiptingu þátttakenda í tvo hópa: hóp þeirra sem mælast með árstíðabundnar lyndissveiflur og þeirra sem gera það ekki (p<.001). Kalt veður (p<.001) og skammdegi (p<.001) voru einu marktæku spábreyturnar í módelinu en hlýtt veður, rigning, sólskin, þurrt veður, skýjað veður, hvassviðri og langur dagur voru ekki marktækar. Kalt veður og stuttur dagur eru veðurskilyrði sem tengjast vetrinum á Íslandi. Einnig hefur fundist samband milli kaldara veðurs og minni hreyfingar. Hreyfing yfir vetrartímann gæti mögulega dregið úr áhrifum einkenna af árstíðabundnum lyndissveiflum. Nánari greining leiddi einnig í ljós að yngri þátttakendur og konur í úrtakinu voru líklegri til að skora hærra á árstíðabundnum lyndissveiflum en karlmenn og þeir sem eldri eru. Rannsóknir gætu kannað hvort þessar breytur hafi samverkandi áhrif á sambandið í aðhvarfsgreiningar módelinu. Þessi rannsókn er fyrst til að skoða samband milli svara á veður undirkvarða SPAQ og árstíðabundinna sveiflna á Íslandi. Niðurstöður hennar undirstrika áhrif mismunandi upplifunar á veðri sérstaklega hjá einstaklingum í áhættu á skammdegisþunglyndi.

Lykilhugtök: Veðurfar, árstíðarbundnar lyndissveiflur, skammdegisþunglyndi, lundarfar, atorka.

Abstract

Previous research has revealed that weather influences mood and energy. However, thus far, no study explored the effects of weather on mood in relations to seasonality and seasonal affective disorder in Iceland. Main purpose of this thesis was to analyze the association between subjective perceptions of weather conditions and experiences of seasonal changes in well-being in Iceland. Based on prior research work it was hypothesized that cloudy, cold, and sunny weather will highly correlate with seasonality. Data from an epidemiological study, the EPiC SAD study, with a random sample from the national registry (N= 1977) was analyzed to test if subjective perceptions of weather, measured with the Seasonal Pattern Assessment Questionnaire (SPAQ), could predict seasonality group of participants. Results of a binary logistic regression indicated that there was a significant association between the SPAQ weather items and the classification into seasonality and non-seasonality group (p<.001). Cold weather (p<.001) and short day (p<.001) were significant predictors in the model whereas warm, rainy, sunny, dry, cloudy, and windy weather as well as long day were not significant. Moreover, cold weather and short day are weather conditions related to the winter in Iceland. Cold weather has also been related to less frequent physical activity. Thus, physical activity during winter could possibly assist in the reduction of seasonality symptoms. Further analysis revealed that younger participants and women in the sample were more likely to score high on seasonality than older participants and men. Future study could explore if those variables are moderators in the regression model. The present study is the first to focus on the relationship between the weather subscale of SPAQ and seasonality in Iceland. Results of the study highlight the important role in different weather perceptions especially in people at risk of seasonal affective disorder.

Keywords: Weather, seasonality, seasonal affective disorder, mood, energy.

I first want to think my supervisor Lada Zelinski for all her helpful comments and suggestions. I learned so much from her during the thesis process. Also, Viðar Ingason for teaching me to use R and evoking my interest in statistics. I also want to think Kalli and my family for patience and support.

Preface

Icelandic weather feels ever-changing. I believe that the weather experience is a part of the Icelandic self-image as it has been an important factor of survival in the country for centuries as well as being the main topic in daily conversations. A part of the Icelandic weather experience is the short day during winter and long day during summer. Timing of daylight is constantly changing. During the winters people seem to start longing for summers though the summers can turn out to be disappointing, cloudy, and cold. I have always been curious about the influence of the weather on people, and I feel lucky to be able to dig deeper into the myths of effects of the weather on mood in Iceland and see if there is some truth behind it.

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Introduction

Seasonal Affective Disorder

Seasonal Affective Disorder (SAD) was first described by Rosenthal et al. (1984) as a fluctuation of both mood and behavior that follows a pattern along with seasons. Symptoms are described as sadness, carbohydrate cravings, change in appetite and weight gain, less social involvement, and physical activity as well as hypersomnia, decreased energy or tiredness during the day (Rosenthal et al., 1984). According to DSM-5 SAD is classified under major depressive disorders as depression that follows seasonal patterns (American Psychiatric Association, 2022). SAD symptoms can affect people at all seasons but studies have revealed that winter seasonality is more common indicated for example by answers to a question on the Seasonal Pattern Assessment Questionnaire (SPAQ) that asks respondents which month of the year they feel worst (Kasper et al., 1989; Rosen et al., 1990). The SPAQ is a subjective self-rating tool used to screen for SAD and results in Global Seasonality Score (GSS) that ranges from 0-24 (Rosenthal et al., 1984) and based on Kasper criteria a score of 11 or higher indicates that a respondent might experience seasonality (Kasper et al., 1989). A clinical interview is then used for full diagnosis of SAD (Meester & Gordijn, 2016). Further information on SPAQ can be found in chapter 2.3.

Prevalence of SAD was reported to range from 0%-9.7% based on a review by Magnusson (2000). Women usually score higher in the SPAQ and in general seem to be more affected by seasonality then men (Dam et al., 1998; Drew et al., 2021; Kasper et al., 1989; Lucht & Kasper, 1999; Rosen et al., 1990). In Sweden prevalence for women was found to be 1.5 times higher than in men (Chotai et al., 2004). In line with this, results from a study from Denmark revealed that participants with GSS of 11 or higher were 64% women and 36% men and that non-SAD women scored higher than men on the SPAQ (Dam et al., 1998). A study conducted in the Netherlands revealed similar results with women being 3.7 times more likely than men to have a GSS of 11 or higher (Merch et al., 1999b). Reason for this gender bias have been discussed. For example, Lucht and Kasper (1999) put forward some biological explanations stating that premenstrual syndrome related to serotonin dysfunctions and higher prevalence of thyroid disorder tend to follow seasonal patterns in women. One study also found rumination to be more predictive of SAD for women but not for men (Sigmon et al., 2009).

Seasonality affects people of all ages but studies have revealed that younger people are more likely to score 11 or higher on SPAQ and to suffer from SAD (Dam et al., 1998; Drew et al., 2021; Rosen et al., 1990). For instance, both older (Rosen et al., 1990) and more recent studies found seasonal patterns to be more common in younger participants with Fellinger et al. (2022) finding seasonality in younger patients suffering from major depressive disorder more common than in individuals being 55 years or older. Kasper et al. (1989) found that younger women were most likely to have high GSS score and that those scores declined with higher age.

The causes of SAD are debated but there are factors that seem to affect prevalence such as light availability, latitude, climate and disturbance of biological clock and circadian rhythm (Meesters & Gordijn, 2016). The hypothesis that winter SAD is associated with light availability is related to latitude and studies have found prevalence to be higher in northern latitudes where environmental light is lacking in winter (Rosen et al., 1990). In line with this, artificial light therapy seems to benefit persons suffering from SAD (Rosenthal et al., 1984). While common treatments during winter are most often light treatment, medication and psychotherapy can also be helpful (Meesters & Gordijn, 2016).

However, the latitude hypothesis has also been challenged and a review of the literature revealed mixed results stating that the associations between latitude and prevalence is most likely only a weak one (Merch et al., 1999a). Merch et al. (1999a) mentioned climate as one of possible factors influencing prevalence. Latitude is not the only variable influencing environmental light and it is called for to take climate factors into account when daylight during winter is considered (Magnusson., 2000). In relation to this, Sigmon et al. (2010) point to the lack of attention to weather as a variable in SAD studies as theories have focused on exposure to light during different seasons but especially in the northern latitude weather can both influence light availability and is a changing factor of seasons. The latitude hypothesis has been particularly challenged by epidemiologic studies conducted in Iceland as the country is located at a northern latitude but the prevalence of SAD is low compared to other Nordic countries (Magnusson et al., 2000; Magnusson & Stefánsson, 1993).

Seasonal Affective Disorder in Iceland

Seasonal variations of mood have been studied in Iceland (Höller et al., 2021; Magnusson & Stefánsson, 1993; Magnusson et al., 2000). Magnusson and Stefánsson (1993) used SPAQ to measure the prevalence of seasonality in Iceland with a random sample of 1000 Icelandic residents. The results showed a prevalence of 3.8% for SAD and 7.5% for subsyndromal SAD (S-SAD) in the sample (Magnusson & Stefánsson, 1993). In accordance with studies from other countries (Drew et al., 2021; Kasper et al., 1989; Rosen et al., 1990) prevalence was highest among women and in the younger generation (Magnusson & Stefánsson, 1993). Such a prevalence in a country at this latitude was considered low and raised further questions concerning seasonality patterns on the island. Another cross-sectional study looked at seasonality in Iceland with the Hospital Anxiety and Depression Questionnaire, an instrument that does not depend on retrospective recall of participants (Magnusson et al., 2000). The research did not find a significant difference in mean scores of anxiety and depression between seasons in the sample and the data did not reveal any gender differences in seasonality of anxiety and depression nor mean age differences (Magnusson et al., 2000). Based on these findings, the researchers hypothesize a genetic explanation for the low rate of SAD in the country (Magnusson et al., 2000).

To test the genetic factor hypothesis, Axelsson, Stefánsson et al. (2002) conducted a comparative study in 1993 with Icelandic descendants in Winnipeg in Canada and used non-Icelandic origin participants living in the same area as a comparative group. The results confirmed the hypothesis of an influence of a genetic factor in the SAD prevalence in the Icelandic population (Axelsson, Stefánsson et al., 2002). While the rate of Icelandic respondents with a score of 11 or higher on SPAQ was 4.8%, the rate in the non-Icelandic group was significantly higher at 9.1%. It must be noted that such a difference was not observed for S-SAD with the non-Icelandic group showing a 15.9% prevalence rate and the Icelandic group a 12.8% prevalence rate (Axelsson, Stefánsson et al., 2002). A previous study had found a prevalence in Icelandic descents in Canada to be 1.2% for SAD and 3.3% for S-SAD (Magnússon & Axelsson, 1993). Axelsson, Káradóttir and Karlsson (2002) further explored the genetic and latitude difference and found that two populations with Icelandic origin in Canada, living at different places but same latitude, had different prevalence rates of winter SAD (4.8% vs. 1.2%) indicating some other environmental factors influencing winter SAD than genetic ones or latitude.

A more recent study on SAD in Iceland has focused on chronotype and age (Höller et al., 2021). In an Icelandic sample of 410 participants who filled out the SPAQ, an association between seasonality and evening chronotype as well as younger age was revealed. Moreover, EEG recordings and biomarkers (Höller, Jónsdóttir et al., 2022; Höller, Urbschat et al., 2022) and emotional bias (Theódórsdóttir & Höller, 2023) have been associated with seasonality.

The relationship between weather and mood

The relationship between weather as well as other meteorological variables and their effect on mood and energy have been studied using diverse methodologies and samples leading to mixed results (e.g. Kämpfer & Mutz, 2011; Keller et al., 2005; Molin et al., 1996; Sigmon et al., 2009). Some studies have found effects of weather variables on mood and emotions (O'Hare et al., 2016; Denissen et al., 2008; Kämpfer & Mutz, 2011). For instance, a cross sectional study using objective weather data found that rain had a negative impact on mood and increased depressive symptoms for older adults in Ireland, but sunny weather had the opposite effect (O´Hare et al., 2016). In another study in which daily weather information was used, some weather variables such as wind, sunlight and temperature had an effect on negative but not positive mood (Denissen et al., 2008). One study discovered that answers on questions about life satisfaction were influenced by the weather on the day filling out the questions (Kämpfer & Mutz, 2011). Participants that answered on a sunny day reported greater life satisfaction than participants that were interviewed when the weather was not as good (Kämpfer & Mutz, 2011). However, another, similar study found no relationship between sunny weather and reported life satisfaction (Schmiedeberg & Schröder, 2013). A study from Denmark that used a sample of patients with winter depression found a significant association between depression score (BDI) and temperature and amount of daylight exposure but not for cloudy or rainy weather (Molin et al., 1996). Weather in the morning was also found to be associated with energy and job satisfaction during the day (Venz & Pundt, 2021). The association between weather and mood has also been found to be influenced by personality (Spasova, 2011). Whereas people high in neuroticism seem to be more vulnerable to weather variables, people high in emotional stability appear to be more protected against negative emotional effects of weather (Spasova, 2011).

Another variable that influences the effect of weather on mood is time spend outside (Keller et al., 2005; Kööts et al., 2011). In three studies aimed to explore how weather affects mood and cognition authors found that higher temperature and barometric pressure had positive effects on mood and cognition but only during springtime and for those who spent time outside (Keller et al., 2005). Kööts et al. (2011) also took this outdoor aspect into account in their study and found that being outdoors influenced how the weather variables, temperature, and sunlight, affected mood in a sample of students and seniors in Estonia. Looking at weather at the time participants reported their mood and how age influenced the relationship they found in addition that sunlight showed some effect on positive mood, warmer temperature intensified mood, temperature together with sunlight seemed to reduce fatigue but only for the younger participants and that weather seems to have stronger effect on older people (Kööts et al., 2011). Their main conclusion was that the association between weather variables and emotions are trivial (Kööts et al., 2011).

The idea that weather influences emotions and mood has also been challenged by some other studies (Beecher et al., 2016; Huibers et al., 2010; Klimstra et al., 2011). Huibers et al. (2010) found seasonal variations in mood and depression, but no variation related to weather (temperature, sunshine and rainfall) in a Dutch sample that answered self-report questionnaire. Beecher et al. (2016) found no relations between weather variables and mental destress except for timing of sunlight. Klimstra et al. (2011) studied adolescents and their mothers' daily mood variation in relations to weather and found only a small association between weather and mood. The findings revealed that most people were not affected by weather variables but classified other participants as summer lovers, summer haters or rain haters and suggest that because of those opposing trends the association could be missed (Klimstra et al., 2011).

The relationship between weather and seasonality

Thus far only a small amount of research has focused on the relationship between seasonality and weather (Albert et al., 1991; Dam et al., 1998; Sigmon et al., 2009, Sigmon et al., 2010). Early research showed that individuals with SAD experienced cold weather to be as influential in their mood changes as the lack of light availability in the winter (Rosenthal et al., 1984). Some participants also reported being influenced by weather conditions during other seasons than winter (Rosenthal et al., 1984).

A somewhat more recent study exploring psychometric properties of SPAQ revealed that participants with SAD had more extreme scores on all the weather variables, except for cold-, hot- and dry weather items, then other participants (participants with depression, non-depressed patients, and control group) in the study (Merch et al., 2004). They also reported being more positively affected by weather variables related to summer and more negatively affected by weather variables related to winter (along with depressed patients) then participants in the other groups in terms of mood and energy (Merch et al., 2004). According to research conducted in Washington D.C. seasons appeared to have more influence on energy level then weather (humidity, rainy or sunny weather, temperature, and barometric pressure) in a sample of SAD patients (Albert et al., 1991). Most participants experienced the effects of daily weather on energy level during summer and researchers suggested it to be partly because they tend to spend more time outdoors (Albert et al., 1991).

Sigmon et al. (2009) explored the relationship between seasonality, rumination, weather condition and weather items of the SPAQ (i.e., sunny, cloudy, cold, hot weather) in order to see if these variables could predict seasonality. Subjective reports of impact of cold, cloudy, and sunny weather turned out to be significant predictors as well as photoperiod, temperature, rumination and depressed mood at the time of participation (Sigmon et al., 2009). Women reported being impacted by cloudy and sunny weather more than men whereas men were mainly impacted by cold weather and temperature (Sigmon et al., 2009). Overall, weather had stronger predictability for seasonality for women (Sigmon et al., 2009). Moreover, the reports of effects of different weather were similar for women and participants with high GSS scores who reported a stronger influence of cold, hot and sunny weather than male participants with low GSS scores (Sigmon et al., 2009).

Sigmon et al. (2010) further looked at the subjective reports of weather effects (i.e., sunny, cloudy, cold, hot weather) on women in relation to SAD. They found a significant difference in reports of effect of weather on mood, between a SAD group, a group of women with nonseasonal depression and a control group (Sigmon et al., 2010). SAD women reported being more influenced by cold and cloudy weather and experienced worse mood and energy during those days than women in the control group (Sigmon et al., 2010). At the same time, women in the SAD group also experienced more energy and a better mood when the weather was warmer and sunny than controls (Sigmon et al., 2010). Overall, the result indicate that weather might play a role in seasonality for women with SAD (Sigmon et al., 2010).

However, the results of a prevalence study conducted in Denmark showed that both genders in a group of participants with a high GSS experienced more sensitivity to different weather variables compared to participants with a lower GSS scores (Dam et al., 1998). Instead, gender differences regarding weather variables were found with women showing stronger reaction to some of the weather variables such as negative effect of cloudy weather, better energy, and mood in a sunny and dry weather as well as on longer days (Dam et al., 1998).

Research question and hypothesis

Previous research has shown that weather can have an influence on variables such as mood and energy (Denissen et al., 2008; O´Hare et al., 2016; Venz & Pundt, 2021). However, the relationship between seasonality and weather has only been sparsely studied (Dam et al., 1998; Sigmon et al., 2009; Sigmon et al., 2010). Therefore, the main purpose of this thesis is to add to the scarce literature on the relationship between seasonality and weather perceptions. More specifically, it will be analyzed if perceptions of weather can predict seasonality. Based on previous work (Dam et al., 1998; Merch et al., 2004; Rosenthal., 1984; Sigmon et al., 2009; Sigmon et al., 2010) it is hypothesized that especially cloudy, cold, and sunny weather will be correlated highly with seasonality.

Methods

Ethics

The project makes use of data from a large ongoing, epidemiological study called EPiC SAD (Environmental, Physiological and Cognitive Risk Factors in Seasonal Affective Disorder) which aims to investigate the current prevalence of seasonality and Seasonal Affective Disorder (SAD) in Iceland. The study has been approved by the Icelandic bioethics committee (approval number: 22-058).

Recruitment

Data collection started in May 2022. A random sample of 15000 individuals residing in Iceland was obtained from the National Registry. The sample was representative for age (18-65 years), sex and residence.

Participants were recruited by Bachelor students at the department of Psychology at the University of Akureyri. The students contacted all participants of the random sample via phone call or through social media (Facebook or Instagram). If an individual agreed to participate in the study, they were asked to fill out an online survey that was sent to them by the researchers via email or text message. Participants filled out the survey using their own computers or other electronic devices. The survey was only in Icelandic language and participants did not get any payments or other benefits for participating in the study.

Questionnaires

The Seasonal Pattern Assessment Questionnaire (SPAQ; Rosenthal et al., 1984) was used in this study to measure possible seasonality symptoms of participants. It was developed to identify patterns of seasonality and to screen for SAD (Rosenthal et al., 1984). In the SPAQ participants answer items on a five-point-Likert scale according to how well statements concerning mood, energy level, appetite, weight, sleep length and social activity apply to the person and change along with seasons. The results are interpreted from a calculated total score called Global Seasonality Score (GSS) that can range from 0-24.

The items are scored from zero to four where a score of zero stands for no seasonal change and a score of four stands for extremely marked change. The Kasper criteria are commonly used to interpret the GSS score where a score of 11 or higher along with report of experiencing a moderate to disabling problems with seasonal changes will indicate that the respondent might suffer from seasonality (Kasper et al., 1989). Additionally, subsyndromal SAD (S-SAD), according to the criteria, refers to a syndrome that is milder than SAD and either indicated by a GSS score of eight or nine with seasonal problems, or a score of 10 or higher along with reports of minimal or no seasonal problem (Kasper et al., 1989).

A subscale of the SPAQ questionnaire is related to weather and consists of nine items concerning weather variables (i.e., cold, warm, rainy, sunny, dry, cloudy, windy, long day and short day). The items measure how participants experience different weather variables in relation to mood and energy. The answers are on a seven-point-Likert scale where one indicates that a person experiences being extremely low and unenergetic, four stands for no effects and seven indicates that the person experiences the weather having a very positive effect on mood and energy.

In addition, participants answered demographic questions concerning gender, age, occupation, education as well as contact information for the additional longitudinal part of the EPiC SAD study. However, in the present project only age and gender are considered. Participants also answered the Patients Health Questionnaire – 9 (PHQ-9; Kroenke et al., 2001) which measures how often they experienced certain depressive thoughts and feelings in the last two weeks. However, data from the PHQ-9 was not analyzed in the present study.

As the SPAQ is a popular instrument to assess seasonal mood variations, many studies have looked into its psychometric properties (Magnusson, 1996; Merch et al., 2004; Young et al., 2003). A validation of the questionnaire in Icelandic was made by Magnusson (1996) that supported the construct validity concerning SAD. The study revealed mixed results when it came to SPAQ‘s ability to identifying SAD cases (Magnusson, 1996). The researcher found good sensitivity (94%) and specificity (73%) when the questionnaire screened for SAD and S-SAD as a single variable labeled winter problem, however, it was inadequate in discriminating between the two (Magnusson, 1996). Also, other researchers tried to validate the SAD criteria by means of the questionnaire and while confirming a high specificity (94%), a rather low sensitivity (44%) was demonstrated (Mersch et al., 2004). Based on these findings, Mersch and colleagues (2004) concluded that the SPAQ should be used as a tool for screening but not for the diagnosis of SAD. A common criticism of SPAQ is its retrospective measurement method and biases that can follow from memory and recall (Neyyar & Cochrane, 1996).

For instance, one study compared the retrospective SPAQ with prospective questionnaires which are also intended to identify seasonality (Neyyar & Cochrane, 1996). The results indicated an overestimation of SAD cases by the retrospective method thereby threatening the reliability of results (Neyyar & Cochrane, 1996).

Studies have revealed good reliability of SPAQ (Magnusson et al., 1997; Merch et al., 2004; Young et al., 2003). Merch et al. (2004) found good internal consistency with a Cronbach's alpha of 0.85. The researchers also factor analyzed the weather subscale specifically (Cronbach's $\alpha = 0.56$) and demonstrated a three factor solution; one summer weather factor (hot, dry and sunny and long days) with Cronbach's $\alpha = 0.77$ and one winter weather factor (cold, cloudy, foggy and short days) with Cronbach's $\alpha = 0.69$ and a third factor consisting of two items: high pollen count and humid weather (Merch et al., 2004). Other researchers also displayed good internal consistency for the six items that constitute the Seasonality Score Index part of the questionnaire (Magnusson et al., 1997). Analysis have revealed good test-retest reliability of the scale with a two month interval between tests (Young et al., 2003). Moreover, results from item response theory reveal that the use of SPAQ over another seasonality measurement tool such as the Inventory for Seasonal Variation is recommended (Young et al., 2003). Nevertheless, it should be mentioned that other researchers made use of a longer interval between tests (i.e., five to eight years) and demonstrated the test-retest reliability of the SPAQ to be low (Raheja et al., 1996). However, there are no recent studies that have focused on psychometric properties of SPAQ.

Statistical analysis

The Jamovi version 2.3.18.0 and R studio version 1.4.1106 were used for data analysis. The GSS scores for each participant was calculated and the score was used to divide the participants into two groups. Participants who had GSS score of 11 or higher made up the seasonality group whereas participants with a score below 11 were classified into a non-seasonality (control) group. Binomial regression was used to explore the relationship between seasonality and subjective reports of how weather influences mood and energy with the aim to test if perceptions of weather predict seasonality of participants. Group (seasonality vs control) was used as a dependent variable. Different weather conditions were used as covariates: cold, warm, sunny, dry, windy, and cloudy weather and long- and short days.

To correct for multiple comparisons, resulting p-values will be interpreted at the Bonferroni corrected level of significance.

An independent t-test was used to test for significant between-group differences regarding age. A chi-square test was used to test for significant between-group differences regarding gender. Additionally a Spearman‘s rho correlation was calculated to explore the association between GSS score and the weather items.

Results

Descriptives

The sample in this project includes 1977 participants that had already participated in the registry study by the time we downloaded the data in February 2024. A total of 627 (31.9%) participants defined their gender as male and 1337 (68%) as female, one participant (0.1 %) defined as genderqueer, 12 people did not specify their gender and one participant was removed as he defined his gender as 65. Eight participants reported their age to be lower than 18 and needed to be removed and nineteen people did not report their age. Subsequently, the age of the participants ranged from 18-80 years with average age being *M* = 46.5 (*SD* = 12.3). The mean age of participants in the seasonality group was 41.6 (*SD* = 12.5) and in the non-seasonality group 47.9 (*SD* = 11.8). Additional information regarding mean age by gender and seasonality group can be found in Table 1.

Table 1

Mean age by gender and different seasonality groups

	Seasonality group			Non-seasonality group			Full sample		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Gender									
Female	342	41.2	12.4	989	47.2	11.9	1331	45.7	12.3
Male	92	42.9	12.8	529	49	11.7	621	48.1	12
Genderqueer	-	-	-	1	29	-	1	29	-

Note: *n* = number of participants, *M* = mean, *SD* = standard deviation.

According to the data 442 (22.4%) participants had a seasonality score of 11 or higher and were therefore classified according to Kasper criteria (1989) into the seasonality group and 1535 (77.6%) participants in the non-seasonality group. The median for GSS scores from all SPAQ items was 5 (*M* =6.33, *SD* = 5.32). In the seasonality group the median GSS scores was 14 (*M* = 14.5, *SD* = 3.02) and in the non-seasonality group the median GSS score was 3 (*M* = 3.99, *SD* = 3.03). Table 2 shows the mean scores and median from answers of the weather items of SPAQ divided by group.

Table 2

Median and mean scores of SPAQ weather items.

	Seasonality group				Non-seasonality group			
	n	*M*	*SD*	*Mdn*	*n*	*M*	*SD*	*Mdn*
Cold weather	439	2.83	1.24	3	1524	3.51	0.94	4
Warm weather	436	5.82	1.89	6	1515	5.55	1.19	6
Rainy weather	437	3.18	1.19	3	1508	3.5	0.91	3
Sunny weather	439	6.03	1.12	6	1515	5.78	1.18	6
Dry weather	437	4.98	1.19	5	1508	4.92	1.07	5
Cloudy weather	436	3.71	1.24	4	1506	3.98	0.87	4
Windy weather	437	2.76	1.19	3	1508	3.21	1.01	3
Long day	436	4.72	1.33	5	1510	4.61	1.38	4
Short day	437	2.26	1.29	2	1497	3.34	1.06	3

Note: 1=very low mood and energy, 2=moderately low mood and energy, 3=mildly mood and energy, 4=no effect, 5=mildly improved mood and energy, 6=moderately improved mood and energy, 7=much improved mood and energy.

A Spearman‘s correlation between GSS score and answers from the weather items showed a negative association between GSS score and short day (r_s = -.545, p<.001), cold weather (r_s = -.380, p<.001), rainy weather (r_s = -.248, p<.001), cloudy weather (r_s = -.178, p<.001) and windy weather (r_s = -.309, p<.001), and a positive association between GSS and warm weather (r_s = .214, p<.001), sunny weather (r_s = .216, p<.001), dry weather (r_s = .122, p<.001) and long day (r_s = .123, p<.001). Pearson´s correlation between age and GSS score was negative (r = -.279, p<.001).

Binomial logistic regression

In this project a binomial logistic regression was carried out to examine whether participants reports of being influenced by different weather conditions (i.e., cold-, warm-, rainy-, sunny-, dry-, windy- and cloudy weather as well as long- and short day) impact the likelihood of being classified into seasonality or non-seasonality group based on the GSS score. Assumptions concerning the logistic regression were checked and as the dependent variable is dichotomous, the data has independent observations, no continuous variables and no multicollinearity the data met assumptions for the logistic regression.

Results of the binary logistic regression indicated that there was a significant association between the SPAQ weather items and the classification into seasonality and non-seasonality group ($X^2(9)=323$; $p< .001$). The model explained 24.3% (Nagelkerke $R^2 = 0.243$) of the variance in seasonality group and correctly predicted seasonality group for 81% of cases. 131 out of 418 were correctly classified with high seasonality by the model showing sensitivity of 31.3% but 1381 out of 1441 were correctly identified by the model as belonging to non-seasonality group with specificity of 95.8% with a cut value of 0.5. Following this, the nine individual predictors were examined for which a Bonferroni correction was applied resulting in a significance level of $\alpha = .006$ (.05/9). The results indicate that cold weather ($p<.001$) and short day ($p<.001$) were significant predictors in the model whereas warm weather, rainy weather, sunny weather, dry weather, cloudy weather and windy weather as well as long day were not significant. Exact p-values along with additional information can be found in Table 3.

Table 3

Binomial logistic regression analysis for the nine weather variables impact on the dependent variable seasonality group.

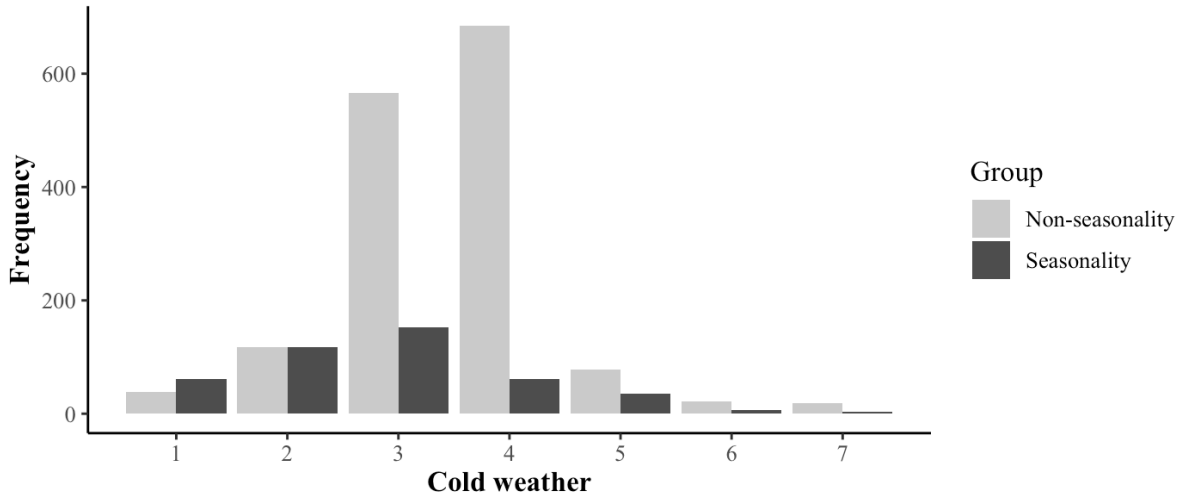
Weather variables	Estimate	*SE*	Odds ratio	95% CI		*p*
				LL	*UL*	
Intercept	2.440	.540	11.475	3.981	33.074	< .001
Cold weather	-.336	.071	.751	.622	.821	< .001
Warm weather	-.105	.080	.900	.770	1.052	.186
Rainy weather	-.013	.070	.987	.862	1.132	.856
Sunny weather	.044	.090	1.045	.882	1.236	.612
Dry weather	.008	.066	1.008	.885	1.148	.907
Cloudy weather	.012	.071	1.012	.881	1.162	.868
Windy weather	-.017	.067	.983	.862	1.121	.797
Long day	-.007	.040	.994	.918	1.075	.872
Short day	-.800	.070	.449	.391	.516	< .001

Note: SE = standard error, *LL* = Lower level, *UL* = Upper level, *p* = p-value.

Answers from the weather item short day had the strongest relationship with the probability of being classified in the seasonality group where an increase in one score on the Likert scale decreases the probability of being classified in the seasonality group by 55.1% (Odds ration 1-0.449). Also, answers from the cold weather item displays this relationship where an increase in one score on the Likert scale decreases the probability of being in the seasonality group by 28.5% (Odds ratio 1-0.715). Frequency distribution of scores on these items for each group can be seen in Figure 1 for cold weather and Figure 2 for short day.

Figure 1

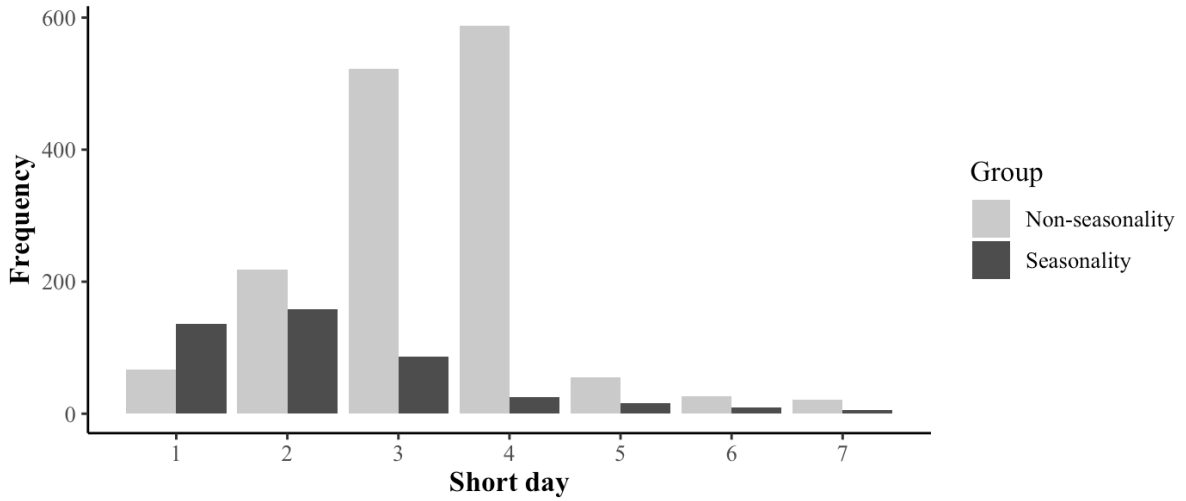
Histogram demonstrating frequency distribution of answers for the cold weather item.



Note: 1 = *extremely lower mood and energy effect*, 2 = *markedly lower mood and energy effect*, 3 = *slightly lower mood and energy effect*, 4 = *no effects*, 5 = *slightly positive effect on mood and energy,* 6 = *markedly positive effect on mood and energy and* 7 = *a very positive effect on mood and energy.*

Figure 2

Histogram demonstrating frequency distribution of answers for the short day item.



Note: 1 = *extremely lower mood and unenergetic effect*, 2 = *markedly lower mood and unenergetic effect*, 3 = *slightly lower mood and unenergetic effect*, 4 = *no effects*, 5 = *slightly positive effect on mood and energy,* 6 = *markedly positive effect on mood and energy, and* 7 = *a very positive effect on mood and energy.*

Analysis of demographic variables

In order to see if age was associated with different seasonality group an independent t-test was conducted. There was a statistically significant difference in age between the groups (t (1956) = 9.68, $p < .001$) with participants in the seasonality group being younger (M = 41.6) than participants in the non-seasonality group (M = 47.9).

To check for association between gender and seasonality group a chi-square test of independence was performed. One assumption was not met as the frequencies of observations was not sufficiently large because only one participant defined as genderqueer. Therefore, this participant was filtered out in the analysis. Results revealed a statistically significant association between gender (male and female) and seasonality groups (X^2 (1) = 29.7, $p< .001$). According to the results women seem to be more likely to be classified in the seasonality group than men (see also Table 4). The odds ratio was 2 indicating that the odds of female being in the seasonality group are two times greater than that of male participants.

Table 4

Crosstab for Chi-square results for association between gender and seasonality groups

	Seasonality group		Non-seasonality group	
	Observed	Expected	Observed	Expected
Male	93	140	534	487
Female	345	298	992	1039
Total	1526	1526	438	438

Discussions

Perceptions of weather and seasonality

The main objective of this project was to analyze if subjective perceptions of weather conditions could predict seasonality in Iceland. It was expected that cloudy weather, cold weather and sunny weather would correlate highly with seasonality in accordance with results from previous studies (Dam et al., 1998; Merch et al., 2004; Rosenthal., 1984; Sigmon et al., 2009; Sigmon et al., 2010). The present results only support part of the hypothesis. Even though the model as whole was statistically significant, interestingly, only perception of cold weather and short day were significant individual predictors of seasonality group according to our data.

The hypothesis of an association between perception of cold weather and seasonality in Iceland was supported. The relationship between cold weather and seasonality has been suggested by previous studies (Rosenthal et al., 1984; Sigmon et al., 2009) and between temperature on mood in others (Denissen et al., 2008; Keller et al., 2005; Kööts et al., 2011). However, it should be noted when interpreting results that those studies have much smaller sample sizes and use different methodologies and statistical procedures.

There could be many reasons for finding association between effects of cold weather and seasonality. One possible explanation of the impact of cold weather on mood and energy in Iceland could be related to physical activity. Cold weather has been related to less frequent physical activity (Tucker & Gilliand, 2006) and more physical activity with less depressive symptoms (Pedersen & Saltin, 2015; Hrafnkelsdottir et al., 2018). Physical exercise was found to be as effective in reducing depressive symptoms as light therapy for women with winter SAD (Pinchasov et al., 2000). Moreover, women with SAD have been found to exercise less than women without depression, especially during winter months and they report stronger effects from cold weather (Sigmon et al., 2010). It is possible that during winter when weather is colder people generally engage in less exercise and activity and those high in seasonality could be especially affected by that lack of exercise leading to greater depressive symptoms. The importance of considering these weather effects in treatments for depression for example through behavioral therapies and interventions that focus on physical activity have been pointed out by some researchers (Sigmon et al., 2010; Tucker & Gilliand, 2006). Exposure to nature could also be considered in this respect.

A review of the literature that looked into nature exposure in association to health outcomes reported that spending time in the nature improved affective states and reduced anxiety, rumination tendencies and depression (Jimenez et al., 2021). People living in urban areas in Iceland still live in proximity of the nature. However, during dark and cold winters as people tend to spend more time indoors it is possible that they reduce time spend in the nature therefore encouraging people to spend more time in nature should be considered.

Another interesting finding was that short day was a significant predictor in the model which was not hypothesized. This supports evidence from previous studies that photoperiod and cold weather contribute to GSS score (Sigmon et al., 2009). Merch (2004) found extreme scores on the short day item along with few other weather items of SPAQ for participants with SAD. Similarly, another study found that influence of photoperiod on mood revealed greater differences between participants than other variables related to weather, though not in the context of seasonality (Denissen et al., 2008). A relationship between daylight (and temperature) and depression score (as measured by the Beck's depression inventory) of people with winter depression has also been reported (Molin et al., 1996). Again, it should be noted when comparing studies that they differ in sample sizes and methodologies from this particular study.

The fact that short day was related to seasonality in the model, but not long day should not be surprising, after all it is the most noticeable environmental change during winter in Iceland along with the cold weather. Winter SAD in Iceland is more common than summer SAD and in fact summer SAD seems almost non-existent (Magnússon & Stefánsson, 1993). This seems to be a common pattern in the northern hemisphere, a higher prevalence of winter SAD and lower prevalence of summer SAD is considered to be caused by lack of daylight in winter determined by latitude (Rosen et al., 1990) though research have found mixed results on the matter (Magnusson, 2000). The fact that short day was a significant predictor in this model supports the latitude hypothesis that previous studies in Iceland have refuted (Axelsson, Stefánsson et al., 2002; Magnússon & Stefánsson, 1993; Magnusson et al., 2000). Those studies also found lower prevalence in the country (Magnússon & Stefánsson, 1993). These present results that short day is associated with seasonality along with findings from recent studies that indicate higher prevalence rate especially for younger people (Höller et al., 2021) might give reason to reconsider the latitude hypothesis in relation to seasonality in Iceland.

This study did not demonstrate significant associations between the weather variables cloudy weather and sunny weather with seasonality and that part of the hypothesis is therefore rejected.

This contradicts results from some previous studies that have looked at relations between weather variables in relations to seasonality (Dam et al., 1998; Sigmon et al., 2009; Sigmon et al., 2010). Sigmon et al. (2009) found cloudy and sunny weather to be related to seasonality, but effects were stronger for women. Another study found that in comparison to a control group, women with SAD experienced negative effects on mood and energy from cloudy weather but positive effects when weather was sunny (Sigmon et al., 2010). However, Dam et al. (1998) reported that compared to men in a non-SAD group, women in the group were more negatively affected by cloudy weather and positively by sunny weather. Some studies have only explored the relationship between weather variables and mood without looking at relations to seasonality. Those studies found associations between sunny weather and depressive symptoms (O'Hare et al., 2016), life satisfaction (Käpfer & Mutz, 2011) and between sunlight and positive affect (Kööts et al., 2011).

This inconsistency with our results and previous work is a little surprising. One possible explanation is that it might be due to a gender difference. As mentioned above previous significant findings were only conformed for women (Dam et al., 1998; Sigmon et al., 2010). Thus, those variables (i.e., sunny weather and cloudy weather) might be significant predictors for women only and therefore we failed to get significant results because we did not analyze the effects for gender separately. Another possible explanation for lack of strong relationship of seasonality to those weather variables is that sunny and cloudy weather are common weather conditions in both summer and winter in Iceland so a lack of association to seasonality could be due to the Icelandic sample. It should also be kept in mind that this does not mean that those weather variables do not influence how we feel but only that they are not related to GSS score or seasonal changes of wellbeing.

Age, gender and seasonality group

In terms of age and its relations to seasonality results corroborate with findings from previous work. It revealed a significant difference of mean age between the two different seasonality groups indicating that participants in the seasonality group were younger than participants in the non-seasonality group. This is consistent with some previous studies on seasonality supporting that younger people are more affected by seasonal changes (e.g Chotai et al., 2004; Dam et al., 1998; Drew et al., 2021; Fellinger et al., 2022; Höller et al., 2021).

Concerning gender differences, the study also supports evidence from previous research (e.g., Chotai et al., 2004; Dam et al., 1998; Kasper et al., 1989; Lucht & Kasper et al., 1999). Our study showed that women are two times more likely than men to be classified in the seasonality group. This is not surprising because previous research has consistently reported that women are more affected by seasonality than men. In fact, studies have revealed that younger women seem to be most affected by seasonality (Merch et al., 1999b; Kasper et al., 1989).

Limitations and future research

There are some limitations to this project. There is a possible omitted-variable bias in the regression model. According to findings it seems that women and younger age are associated with higher GSS score and those variables should preferably be included in the binary regression model in order to confirm results. The statistical effect we found in the model should be further explored by adding age and gender into the model in order to see if same weather variables stay significant as predictors in the model. Age and gender could turn out to be moderator variables in the association of seasonality and perceptions of weather conditions. The significant predictors in the model, cold weather and short day, are very descriptive for winter weather in Iceland where winter SAD is more common. However, additional research is needed to better understand the influence of gender and age on perceptions of different weather variables in relations to seasonality.

There are some aforementioned weaknesses in the retrospective method of SPAQ that are related to memory and recall (Neyyar & Cochrane, 1996) that has been addressed in some studies by looking at daily weather and mood (Albert et al., 1991; Denissen et al., 2008). In that respect it is possible that the timing and current weather could affect answers when people report their mood, and it would therefore be interesting to see what daily collected data would reveal in an Icelandic sample. However, the SPAQ is an easy to use, firmly established instrument and studies have revealed good psychometric properties of the scale (Magnusson et al., 1997; Merch et al., 2004; Young et al., 2003).

It should be kept in mind when interpreting results from this project that seasonality groups are based on GSS score of participants from answering the SPAQ. SPAQ is only a screening tool and since no clinical interviews were conducted with all participants, we can only divide them in groups according to their probable risk of SAD and not based on a confirmed diagnosis.

Also, in this study participants were only divided in two seasonality groups and sub-SAD group was omitted. It would be interesting to further explore how weather influences mood and energy for that third group as well as SAD patients.

Generalizability of this study is limited. The questionnaire was only sent out in Icelandic language that means that most participants are Icelandic residents. Therefore, we can assume that the weather items are only answered with Icelandic weather in mind. This is what makes it difficult to generalize from different studies concerning weather as they are conducted in different climates and latitude.

Conclusion

The purpose of the current study was to explore the relationship between perceptions of weather conditions and seasonality. The study has identified cold weather and short day as significant predictors of seasonality whereas other weather variables do not seem to be highly correlated with seasonality groups of participants. These finding suggest that weather variables associated with winter are related to seasonality in Iceland and could indicate that winter seasonality is more prevalent than summer seasonality in the sample. During winter the cold and dark environmental variables can impact mood and energy that should be kept in mind when treating winter depression for example when it comes to physical activity and encouraging people to go out into the nature during all seasons. Further analysis revealed age and gender differences where women and younger people were more likely to be classified into the seasonality groups than men and those who are older. A further study could include such demographic variables in the model to see if they moderate the relationship. Despite some limitations, this study is the first to investigate the effect of weather conditions on mood and its relations to seasonality in Iceland. The study thereby adds to the understanding of the important role of different weather perceptions in people at risk of seasonal affective disorder.

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