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Original Article

Sleep timing, chronotype, mood, and behavior at an Arctic latitude (69°N)

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ABSTRACT

Objective: Daylight is an important zeitgeber for entraining the circadian rhythm to a 24 h clock cycle, especially within the Polar circle, which has long Polar nights several months each year. Phase delays in sleep timing may occur, but the mean shift is normally small. However, the individual variation in phase shifts is large, implicating moderating factors. Here we examined the role of several self-regulatory variables (mood and fatigue, behavioral habits, and psychological self-regulation) as moderators of seasonality in sleep timing and chronotype.
Methods: A sample of 162 young adults (76% females; mean age: females 23.4 years, males 24.3 years) participated in a prospective study across three seasons (September, December, March) in Tromsø/Norway at 69°39′N. Sleep diary and sleep/health-related questionnaire data were collected at each time-point.
Results: Sleep timing and chronotype were delayed during the dark period (December) compared with brighter photoperiods (September and March). Comparable effects were observed for insomnia, fatigue, mood (depression and anxiety), subjective health complaints, physical activity, and school-related stress. Most importantly, depression and fatigue moderated the degree of seasonal shifting in sleep timing, whereas the other self-regulation indicators did not (ie eating habits, physical activity, and psychological self-regulation).
Conclusion: Seasonality in sleep timing and chronotype was confirmed, and it seems that depressive symptoms during the dark period exacerbate phase-shifting problems for people living in sub-Arctic regions.

1. Introduction

People living in sub-Arctic regions may experience more seasonal variations in sleep patterns and problems [1] than people living closer to the Equator [2]. Chronotype also seems more delayed in people living at higher latitudes [3,4], but seasonal variations in chronotype are less well studied. A single cross-sectional study is available; however, it indicates a small magnitude for chronotype changes [5]. The hypothesized explanation is that one of the two processes regulating sleep – the endogenous sleep circadian factor [6] – becomes more easily desynchronized with the 24 h clock during the winter months when sunlight is absent. The other factor – the internal homeostat – exponentially increases sleep pressure the longer a person is awake, but is not affected by seasons.

The circadian factor is a biologically governed process and several clock genes responsible for the rhythmicity have been identified [7]. Since the circadian clock follows a mean 24.18 h rhythm [8], an ever-increasing mismatch between the environmental and the circadian rhythm is in operation. The circadian clock hence needs to be reset or advanced each day to stay synchronized with the daily spin of the Earth. A morning dose of bright daylight is the most potent zeitgeber (time-giver) for entraining and preventing the circadian clock from free-running [9,10]. When light relayed from the retina hits the suprachiasmatic nuclei in the hypothalamus, the production of melatonin in the pineal gland is suppressed [11]. During the evening, melatonin secretion again increases and induces drowsiness [12], accompanied by reduced alertness, reduction in body temperature, and decreased cardiovascular output [13].

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Since melatonin is important for sleep–wake cycles [14] and is influenced by light, seasonal differences in daylight exposure should influence circadian rhythms and sleep timing. Studies conducted under extreme conditions at base camps in Antarctica confirm that desynchrony is common among inhabitants during winter [15,16]. As the sub-Arctic people are not exposed to bright sunlight during winter, a delay in chronotype is expected [3,10]. However, not all individuals seem to develop large phase shifts, suggesting that additional processes must be involved. The present study examined whether several behavioral or psychological self-regulatory factors played a moderating role of seasonal shifts in sleep timing.

The city of Tromsø (69°39′N) represents a natural habitat for studying regularity in sleep timing and chronotype, as the sun is absent between mid-November and mid-January. Tromsø has a population of about 70,000 and is the largest city in the world at this latitude. Tromsø is comparable to other western cities with regard to modern facilities and living standards. It has a university hospital and a university campus housing about 10,000 students. Mean temperatures range between 11 °C and −4 °C due to the Gulf Stream. Although the sun is absent, it does not become pitch black even at winter solstice. The sky is still deep blue at midday, but the intensity is dim and of short duration (∼3 h).

The typical complaint during the winter months is increased sleeplessness and fatigue. In the population-based cross-sectional 'Tromsø study' ($N = 12{,}984$), increased insomnia problems [1] and phase shifts [17] have been reported more often during winter than during summer. 'Winter insomnia' also seems more prevalent among women [18]. These sleep problems may be alleviated by bright light therapy [19,20], or short wavelength (460–480 nm) blue light [21]. In the Tromsø study using a retrospective recall of bed times and wake times, chronotype was less affected by season, delaying by ∼10 min [5]. In a prospective study using sleep diary recordings across two seasons ($N = 200 + 150$, 7 days, ∼2450 recordings) [2], the phase delay from summer to winter was ∼20 min. The prospective design thus seems to detect larger phase shifts, and in the present study we extended the repeated measures design by adding a third season to examine this further.

The individual variation in delay is, however, very large (±90 min, 68% confidence interval) [2]. Individuals may accumulate a considerable amount of sleep debt during work days and develop 'social jetlag' (ie mismatch between circadian and social rhythms). Thus, it is necessary to examine to what extent various hypothesized self-regulatory behaviors may account for the large variations in sleep timing when bright morning light is absent.

1.1. Self-regulation and sleep

In the absence of sunlight during winter, self-regulation skills may help in offsetting delays in sleep timing and other sleep problems. Self-regulation is considered a vital aspect of many mental health problems or disturbances [22]. Direct measures of self-regulation are, however, not readily available due to its extensive scope and multifaceted nature. Self-regulation closely resembles concepts such as willfulness, self-control, motivation, inhibition, executive control, and impulse control, to mention a few. An underlying common factor is the ability to plan, guide, and monitor one's behavior flexibly, to sustain task performance, and to maintain a certain degree of regularity [22].

Seasonal shifts in sleep are accompanied by moderate to strong seasonal changes in fatigue, of which physical fatigue seems more influenced than mental fatigue [2]. Fatigue is also negatively correlated with physical activity and regularity [23], and may therefore act as a moderator of sleep timing. Negative mood and depression symptoms, especially, show a similar albeit weaker pattern [1,2,15,24,25]. Depressed mood should not be confused with 'winter depression' or, more specifically, seasonal affective disorder [26,27]. Nevertheless, symptoms of depression and anxiety represent important indications of dysregulation in mood and cognitions [28], and are related to poorer sleep quality [29].

Self-regulation and motivation may also regulate sleep behaviors. The ability to plan ahead and control one's impulses is important for good mental health and general adaptability [30–32]. According to the regulatory focus theory of Higgins [33], behavior may be motivated for two reasons: to prevent negative health outcomes and/or to promote desired goals (like better sleep). Regulatory focus and sleep have not been previously examined, but, based on how regulatory focus generally predicts motivation [34] and is related to consumption of healthy food [35], it may be associated with better self-regulation of sleep patterns as well.

Eating habits and frequency in physical activity also indicate self-regulation, as both represent behavioral indications of regularity. Unhealthy or unstable eating habits have been connected with a delay in chronotype [36] and with poorer sleep, as instability in meals is associated with more frequent headaches [37], which impact negatively on sleep. Phase shifts influenced by daytime physical activity have little empirical support, but may be expected to influence sleep timing similarly.

1.2. Hypotheses

(1) Based on sleep diary data, sleep timing (sleep onset and wake times) and chronotype are hypothesized to covary with seasons, displaying significant phase delays during the dark period (December) compared to brighter photoperiods (September and March).
(2) Insomnia, depression, fatigue, and anxiety will show a similar seasonal pattern as described in hypothesis 1.
(3) The strength of the correlation between season and sleep timing/chronotype (hypothesis 1) will be modified by indices of self-regulation, ie individuals characterized by better self-regulation will demonstrate less phase delay during the dark period relative to individuals demonstrating poorer self-regulation.

2. Methods

2.1. Participants

The participants ($N = 162$) consisted of a convenience sample recruited during lectures at the University of Tromsø in Norway in December 2011 ($n = 94$; 70/24 females/males) and in March 2012 ($n = 68$; 54/14 females/males). The difference in mean age of females (mean, 23.4; standard deviation, 5.0; range, 19–48) and of males (24.3; 5.4; 19–46) was not significant. Females were over-represented (76%) compared with the number enrolled at the University in 2012 (60%) [38]. The participation (response rate) from wave 1 to wave 3 fell as follows: 162 (100%), 148 (92%), and 138 (85%), respectively. Participants were thus reordered according to seasons: September (T1, $N = 138$, 77% females), December (T2, $N = 148$, 76% females) and March (T3, $N = 150$, 78% females). Among the 162 students, 58 studied medicine and odontology (36%), 46 studied psychology (28%), and the remaining 58 students (36%) followed courses within social sciences, economy, or leadership.

The study was approved by the regional ethical committee for medical and health research (case ID: 2011/743/REK Nord), and conformed to international ethical standards [39].

2.2. Study design

The study used a within-subjects, quasi-experimental design assessing sleep and questionnaire data across three seasons