Associations between sleep and depressive symptoms
A cross-sectional study on working adults in Stockholm, Sweden

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<tr>
<td>DSM</td>
<td>Diagnostic and Statistical Manual of Mental Disorders</td>
</tr>
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<td>HAM-D</td>
<td>Hamilton Depression Rating Scale</td>
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<tr>
<td>ICD</td>
<td>International Statistical Classification of Diseases and Related Health Problems</td>
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<td>KSQ</td>
<td>Karolinska Sleep Questionnaire</td>
</tr>
<tr>
<td>MSF&lt;sub&gt;sc&lt;/sub&gt;</td>
<td>mid-sleep on free days corrected for oversleep due to the accumulated sleep debt over the week</td>
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<tr>
<td>MS&lt;sub&gt;W&lt;/sub&gt;/MS&lt;sub&gt;F&lt;/sub&gt;</td>
<td>mid-sleep on workdays and free days; the mid-point between sleep onset and sleep offset</td>
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<tr>
<td>SCL-CD</td>
<td>The Hopkins Symptoms Checklist- core depression</td>
</tr>
<tr>
<td>SD&lt;sub&gt;W&lt;/sub&gt;/SD&lt;sub&gt;F&lt;/sub&gt;</td>
<td>sleep duration on workdays and free days</td>
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<tr>
<td>SJL</td>
<td>social jetlag; the absolute difference in mid-sleep between workdays and free days</td>
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<td>WASO</td>
<td>waketime after sleep onset</td>
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<td>WHO</td>
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ABSTRACT

Background: Mental health disorders can be considered a public health problem and affect approximately one in ten people worldwide. It has profound negative effects on both the individual, the workplace and society. In the Swedish adult working population, diagnoses of mental health disorders is the most common reason for sick leaves among both men and women under the age of 50. Of these, depression and stress reactions are the primary diagnoses. Aim: To examine the relationship between sleep behaviour and depressive symptoms in a sample of working adults. Method: A cross-sectional design with data gathered through the use of actimetry, questionnaires and sleep diaries was employed. Analyses of correlation between sleep variables and depressive symptoms, analysis of variance to detect differences between groups and regression analyses to measure the predictive value of variables have been performed. Results: Depressive symptoms are positively associated with self-rated sleep measures. Self-rated sleepiness showed some explanatory value in predicting depressive symptoms but when adjusting for self-rated stress, sleepiness was no longer significant. Conclusion: Self-rated sleepiness only predicts depressive symptoms to a certain extent. Other factors such as self-rated stress seems to be a stronger indicator of depressive symptoms.

Keywords: sleep; depression; sleep disorders, circadian rhythm

SAMMANFATTNING


Nyckelord: sömn, depression, sömnrubbningar, dygnsrytm
BACKGROUND

Sleep is one of the most important processes of the human biology and an essential resource for all human beings (Roenneberg et al., 2015). Complex and multiple biological processes are involved in the sleep and wake pattern. The synchronization of the sleep and wake pattern to the 24-hour rotation of Earth is referred to as entrainment (Roenneberg, Kumar, & Merrow, 2007). The key biological process involved in sleep is the circadian rhythm, which is regulated by the light sensitive suprachiasmatic nuclei (SCN) in the brain. Along with other endogenous processes, the circadian rhythm either drives or modulates wakefulness and sleep (Albrecht, 2012). However, sleep is also determined by exogenous drivers, often made up of social structures such as school or work (Foster et al., 2013).

The effects of these endogenous processes are usually not considered in daily life as long as they are functioning well. The importance of alternating between activity and rest may first become evident when interruption does not occur or when it is insufficient (Roenneberg et al., 2015). Several studies have linked sleep disturbances to long-term sick-leave (Grossi et al., 2015; Åkerstedt, Kecklund, Alfredsson & Selen, 2007; Åkerstedt, Kecklund, & Selen, 2010). Poorly adjusted entrainment is often prevalent in individuals with depressive symptoms. In a study of work-related sleep disturbances, sickness absence and sleep disturbances were strongly associated. However, this association was substantially attenuated when controlling for depressive symptoms (Westerlund et al., 2008). Shift workers showing more difficulties recalibrating their circadian rhythm to their work-related sleep cycle were more prone to developing shift-work disorder, which also was associated with reported increases in symptoms of depression and anxiety (Kalmbach, Pillai, Cheng, Arnedt & Drake, 2015).

Mental health in the Swedish working population

Promoting mental health is one of the sustainable development goals set by the World Health Organization (WHO) as a target for 2030. According to WHO, depression and anxiety are the most prevalent mental disorders and estimated to affect nearly one in ten people worldwide. There is often an interrelationship between stress and depression, as well as between physical health and depression. Depression can lead to more stress, which in turn may worsen the depression. Physical diseases, such as cardiovascular disease are also associated with depression (WHO, 2010).

According to national guidelines for treatment of depression and anxiety, it is estimated that up to 25 per cent of Swedish women and 15 per cent of Swedish men will experience depression at least once in their lifetime. Many of those diagnosed with depression are people of working age and diagnoses within depression and anxiety are responsible for about 90 per cent of all sick leaves due to mental health disorders (Socialstyrelsen, 2010). Mental disorder is now the most common diagnosis for women on sick leave exceeding 14 days. As a cause for illness, mental disorders are most prevalent among men and women in the age span 30-49 years (Försäkringskassan, 2013).

In relation to factors in the work environment, mental health, as well as problems regarding sleep, are the most common problems reported by women. In a recent study, ten per cent of the interviewed women had experienced sleep related problems in the last 12 months. Mental problems like anxiety and depression were equally common. Fewer men reported problems regarding sleep and mental health, yet five per cent of men experienced these problems (Klevestedt, 2016).
The economic burden of depression is substantial both for the individual and for the society in terms of the indirect costs due to sick leave and early retirement. The total cost of depression in Sweden has been estimated to 3.5 billion euro (2005), which implies a two-fold increase in less than 10 years (Sobocki, Lekander, Borgström, Ström & Runeson, 2007). The most recent estimation of costs related to mental illness in Sweden is 7 billion euro (Oecd Economic, 2013). While the direct costs of disease have been relatively stable, the indirect costs for loss of productivity, retirement and mortality have increased rapidly. The majority of the costs are found in depressed women (Sobocki et al., 2007).

**Defining depression**

This thesis does not examine the association between sleep and clinical depression. When depressive symptoms are discussed it is rather a feeling of dejection that is observed. The Hopkins Symptoms Checklist- core depression (SCL-CD) used to measure depressive symptoms for this purpose include items concerning lack of interest and energy, guilt feelings and worrying. Other scales like the Hamilton Depression Scale (HAM-D) also include items on psychomotor retardation and sadness. All these are indicative of a depression but it is not a diagnosis; clinical depression can only be diagnosed by a physician.

Depression is clinically defined according to the international standard classification system Diagnostic and Statistical Manual of Mental Disorders (DSM) (Magnusson Hanson et al., 2013). For each disorder included in the DSM, a set of diagnostic criteria indicates symptoms that must be present, as well as for how long they have to be present. In addition, other symptoms, disorders and conditions are listed that first must be ruled out in order to qualify for the particular disorder (American Psychiatric Association [APA], 2017). However, not all listed symptoms are necessary for diagnosis, which means that persons diagnosed with a certain mental disorder share a large proportion of symptoms but the exact combination can vary (Magnusson Hanson et al., 2013).

**Defining sleep**

It is estimated that a little over 25 per cent of the adult Swedish population experience sleep problems and for nearly 10 per cent of the population the problems are severe (Statistics Sweden [SCB], 2014). Measures of work ability show that sick leave, diagnosed diseases and mental resources are negatively affected by insufficient sleep (Lian et al., 2015; Mokarami, Mortazavi, Asgari, Choobineh & Stallones, 2017). Research on sleep and mood disorders is extensive, pointing to a correlation between sleep and depressive symptoms. Several different measures of sleep behaviour and sleep quality have been suggested to be associated with depressive symptoms and other mental disorders.

**Chronotype**

Chronotype defines the synchronization of the sleep and wake cycle according to individual sleep preferences regarding timing of sleep and waking up, independently of work and social obligations. Chronotype can be assessed as the mid-point between sleep onset and sleep offset on days when waking up is not regulated by work and other obligations. It is assumed that, when uninterrupted, the biological clock will regulate sleep onset and offset in relation to the 24-hour clock. Length and timing of this synchronization vary across the population and is partly due to genetic factors. Thus, the variation within the population can span from extremely early to extremely late (Roenneberg et al., 2007). However, for the majority of any population,
the circadian rhythm, under free-running conditions, is somewhat longer than 24 hours (Roenneberg & Merrow, 2007).

Chronotype is associated with age and sex. Children and people over 60 years of age are generally the earliest chronotypes. In adolescence, chronotype is continuously delayed and men tend to be later chronotypes than women throughout adulthood. While women reach their maximum late chronotype at about 19.5 years, men, on average, delay their sleep until the age of 21 (Roenneberg & Merrow, 2007). From the age of around 20 to around 55, chronotype continuously becomes earlier in both sexes and at the age of 50, sex differences are no longer significant (Allebrandt et al., 2014; Roenneberg & Merrow, 2007).

A later chronotype has been identified as a risk factor for depression in several studies (Gaspar-Barba et al., 2009; Hidalgo et al., 2009; Hirata et al., 2007; Levandovski et al., 2011; Merikanto et al., 2013; Sheaves, Porcheret & Tsanas, 2015). Kitamura et al. (2010) show a highly significant positive correlation between incidence of depressive states and a later chronotype (OR=1.926), while an early chronotype significantly reduces the odds ratio for depressive states (OR=0.342), even after adjusting for possible confounders. The sleep parameters that did show an association with depressive states were daytime sleepiness, nocturnal awakening and poor subjective sleep quality. Although the association between chronotype and depression has been confirmed repeatedly, the causal direction remains uncertain (Kitamura et al., 2010).

Social jetlag

Social jetlag is a concept closely related to chronotype. It can be defined as the absolute difference in mid-sleep between workdays and free days and describes the weekly changes in sleep timing. The symptoms of social jetlag can be the same as those of a travel-induced jetlag. However, while the biological clock can entrain to new light-dark circumstances, social jetlag is often chronic throughout work life (Allebrandt et al., 2014; Foster et al., 2013).

In early chronotypes, who go to sleep and wake up more or less the same time both on workdays and on free days, social jetlag is minimal. However, the distribution of chronotypes in the general population is lightly skewed towards later chronotypes and therefore social structures such as work and school interfere with the sleep preferences of the majority of the population. Because of the conflict between later habits and the usually earlier commitments of work, later chronotypes show the largest difference in sleep timing between workdays and free days, which causes a considerable sleep debt on work days. This is compensated for by sleeping in on free days. Some early chronotypes also experience social jetlag to some extent. This is often due to social commitments at night, past their normal sleep time, with no possibility to postpone their biological wake up time (Wittmann, Dinich, Merrow & Roenneberg, 2006).

Levandovski et al. (2011) argue that social jetlag seems to be a stronger predictor of depressive mood than chronotype in itself. In an adult rural population, social jetlag correlated positively with both chronotype and depression. Depressive symptoms were significantly more common in those who experienced more than two hours of social jetlag. Associations between depression scores and social jetlag were significant in all chronotype categories although association between depression and chronotype was only significant for those with the lowest social jetlag. The age group 31-40 years showed the highest significance in the association between high depressive scores, a later chronotype and more severe social jetlag. Moreover, subjects with a
chronotype and a social jetlag greater than the population median were overrepresented in those with depressive symptoms.

Wittmann et al. (2006) found a positive correlation between social jetlag and depressed mood as well as a strong correlation between social jetlag and consumption of stimulants. Chronotypes with a mid-sleep on free days of 3 a.m. suffered the least social jetlag. Foster et al. (2013) discuss other emotional consequences of a lifestyle that demands one working against the circadian clock. Mood fluctuations, irritability and anger can also be related to social jetlag.

Other sleep measures and depressive symptoms

While chronotype and social jetlag are composite measures of sleep behaviour, extensive research has also been carried out on the possible associations between a wide variety of simple sleep measures and depressive symptoms. Among young Australians aged 12-35 years, sleep onset and sleep offset tended to occur later in those diagnosed with depression than in healthy controls. Wake time after sleep onset (WASO) was also significantly higher in the depression group compared to controls. Consequently, sleep efficiency was significantly lower (Robillard et al., 2015). A study of monozygotic twins, showed a significant association between both bedtime and sleep duration with depression scores. Moreover, late bedtime and short sleep duration was predictive of subsequent development of depression, even after controlling for bedtime regularity (Matamura et al., 2014).

Problem definition

Mental health disorders are some of the most commonly prevailing non-communicable diseases today and affect both individuals and society. The economic burden due to sick leave and early retirement is substantial. The prevalence of mental health disorders can be defined as a public health problem and the promotion of mental health is a target for the sustainable development goals set by WHO. Depression and anxiety stand out as particularly prevalent and constitute 90 per cent of sick leaves due to mental health disorders. Today, mental health disorder is the most common reason for sick leave exceeding 14 days among women in Sweden. Many report sleeping problems. The literature supports the association between sleep and depressive symptoms. Yet, there is still much to learn about how sleep and depressive symptoms relate, especially in an adult working population. It has also been debated which measures of sleep actually associate with depressive symptoms. It is of importance to further examine sleep characteristics and mental health in the working population to increase knowledge and possibly prevent depression associated with sleep related behaviour.

Aim and hypothesis

The aim of this thesis has been to examine the associations between sleep and depressive symptoms in a sample of working adults.

The hypothesis is:
Sleep behaviour is associated with depressive symptoms in working adults.
METHOD

Design

The study had a cross-sectional design, which is suitable for establishing variation within a population and associations between variables (Bryman, 2008). The data had previously been collected in the larger study Swedish Healthy Home, a collaboration between Stockholm University, Stress Research Institute and Lund University. The Swedish Healthy Home study is led by Prof. Thorbjörn Laike (Lund University) and Assoc. prof. Arne Lowden (Stress Research Institute and Stockholm University).

Study sample

The study sample consisted of Swedish adult men and women residing in Stockholm, Sweden. Subjects for the Swedish Healthy Home study were recruited through a newspaper advertisement in May and September 2016, with 71 and 40 subjects signing up respectively. A convenience sampling procedure was performed, where anyone who responded to the advertisement and met the inclusion criteria was welcome to participate. Subjects signed up online, which gave them access to a welcome letter with information about the study and their voluntary participation. This also gave respondents access to a questionnaire, which was to be filled out at the end of the study period. Loss of subjects mainly had to do with conflicting time schedules. The sample was chosen for this study because it consists of working adults, which was in line with the aim of this thesis.

Inclusion criteria for the Swedish Healthy Home study was full-time employment and aged 18 years or older. Exclusion criterion was medication used to improve sleep. Subjects in the Swedish Healthy Home study had flexible working hours where some of the respondents to some extent could dictate their own working hours while others had jobs where working hours varied over the week. For the purpose of this thesis, some days were excluded. This included days when respondents have reported i) working night shifts, ii) being sick or iii) staying home with sick children. The reason for excluding data from these days was the assumption that both night work and being sick/staying home with sick children notably affect sleep behaviour. Moreover, one Saturday was excluded for one respondent because of great deviation between subjectively and objectively reported wake-up time.

Attrition

The sample consisted of 74 respondents. Attrition after the data was finalized occurred because some respondents did not have enough days with sleep data in order to calculate means, indexes and composite sleep measures. Respondents with more than four sick days (n=3) were excluded because valid measures for workdays and/or free days were missing and valid questionnaires were also missing for these subjects. Further, one respondent only working night shifts (n=1) was excluded. Night shift workers entail markedly different sleep behaviours than day workers and chronotype is calculated differently for this type of worker (The Worldwide experimental Platform [The WeP], 2017). Moreover, objective measures of sleep during the week of change to Winter Daylight Saving Time were excluded (n=4) since this would give measures of sleep that are not comparable with other respondents. The total remaining sample consisted of 66 subjects.
Sample characteristics

Women constituted the majority of the sample (81%). Mean age for all respondents were 46.2 years (CI 95% 43.4-49). Mean age differed somewhat between men and women with a higher mean age for women (46.6 years, CI 95% 43.4-49.7) while mean age for men was 44.5 years (CI 95% 37.9-51.0). Thus, there was also a greater variation in age among male respondents. Overall, age ranged from 25 to 67 years. Age and sex distribution is displayed in Figure 2. The majority of the respondents worked Monday through Friday with weekends off but some of the respondents had other work schedules. Data showed that 96.5% of Saturdays and Sundays were reported as free days. Of weekdays, 98% were reported as workdays.

Data collection

Data were collected with the use of actimeters, questionnaires and sleep diaries.

Actimetry

Objective sleep data were measured with the use of actimeters (Actiwatch, Philips Respironics). Actimeters have been suggested as the choice of preference when the goal is to gain information about the daily patterns of wake and sleep (Roenneberg et al., 2015). The actimeter is a device worn on the wrist, which records activity, rest and light exposure. It was only taken off in order to avoid contact with water, e.g. during shower. Participants were required to wear the device during a 7-day period including two days off work. Data from the actimeter was imported into a software (Philips Actiware 6.0.9, Philips Respironics) from which various statistics could be produced. Data collection occurred continuously over the year from May 2016 to Feb 2017 with two primary periods during late spring and winter. Figure 3 graphically displays the different measurement periods.
Questionnaire

At the end of the actimetry period, respondents filled out a questionnaire online. The questionnaire included items regarding demographic characteristics (sex, age, length, weight), daylight exposure during winter, job satisfaction, sleep, use of electronic devices such as smartphones, tablets and computers in the evening, physical activity, stress, depressive symptoms, physical illness, caffeine consumption and use of nicotine. Of the variables measured in the questionnaire, the scales measuring sleep, depressive symptoms and stress were of most interest for this study (Appendix 1).

Sleep

Sleep quality was assessed through the Karolinska Sleep Questionnaire (KSQ) included in the questionnaire. The KSQ has been developed to retrospectively assess sleep habits and sleepiness in adults and has been widely used in Scandinavian populations (Westerlund, Lagerros, Kecklund, Axelsson & Åkerstedt, 2014). Four dimensions of sleep are measured: sleep quality, non-restorative sleep, sleepiness and sleep apnea. Sleep quality and non-restorative sleep can be combined to an index of insomnia. An index for sleep apnea has also been suggested (Nordin, Åkerstedt & Nordin, 2013). The KSQ has been validated in a representative Swedish sample with regard to dimensionality, internal consistency and construct and criterion validity. All dimensions showed good internal consistency (Chronbach’s $\alpha$.71-.87 for the different subscales across age groups and gender). Construct validity was found to be satisfactory. Indexes for the dimensions “insomnia” and “sleep apnea” also showed good criterion validity and internal consistency (Nordin et al., 2013).

The original KSQ includes 18 questions, while the version used in the questionnaire has 12 questions; four on sleep quality, two on non-restorative sleep, three on daytime sleepiness, two on sleep apnea and one on nightmares. The question on nightmares was excluded in the analysis, following the suggestion by Nordin et al. (2013). Sleep quality questions concern problems falling asleep, repeated awakenings, too early final awakening and disturbed sleep. Non-restorative sleep regards problems waking up and not feeling well-rested upon awakening. Daytime sleepiness includes questions on involuntary sleep episodes during the day and sleep apnea concerns snoring and breathing cessation problems. All items are measured on a six-point scale ranging from “never” to “always” (five or more times a week).
Depressive symptoms
Depressive symptoms were measured with a brief subscale (SCL-6) from the Hopkins Symptom Checklist (SCL-90). The six items in the subscale measure intensity for six symptoms during the past three months. Items include “feeling blue/sad”, “no interest in things”, “low in energy”, “worrying too much”, “blaming yourself” and “everything is an effort”. Response alternatives range from 0 (not at all) to 4 (extremely) with a maximum total of 24 (Magnusson Hansson et al., 2013). In the questionnaire, the scale ranged between 1 (not at all) and 5 (very much).

SCL-6 corresponds to the six-item Hamilton Depression Scale (HAM-D6), which has previously been validated by psychiatrists as well as item response theory models as a quick and accurate tool to measure depression (Magnusson Hansson et al., 2013). In a validation study, SCL-6 was found to have a Loevinger coefficient of .70, which is well above the level of acceptance. The Loevinger coefficient is a measure of homogeneity, indicating that items in the scale measure the same, underlying concept. Thus, it implies that the total score is a sufficient statistic for measuring depression severity. Moreover, it was found to have an α coefficient of 0.92 and to correlate relatively strongly with sleep and self-rated health (Magnusson Hanson et al., 2013).

Stress
The stress scale used in this thesis is a three-item newly developed scale (Stress Research Institute), why no reference to its validity and reliability is yet available. The items include measures of days when “feeling ‘excited’ all the time”, “feeling lots of pressure, on the verge of what I can handle” and “feeling stressed all the time”. Response alternatives consist of four levels ranging from “not at all” to “almost all the time”, which gives a minimum score of three and a maximum score of 12 points.

Sleep diary
In addition to wearing the actimeter, respondents filled out a sleep diary each day during the 7-day period. The diary included items regarding sleep, work, intake of sweets and caffeine, sleepiness, light exposure, work, energy and mood among other things. For the purpose of this thesis, the only item of interest in the diary was whether the respondent reported days as workdays or free days.

Procedure
Swedish Healthy Home has been approved by an ethics committee (Regionala etikprövningsnämnden Stockholm: 2016/729-31/4). All respondents were assigned an id number for the actimetry measurement period and another id number for the questionnaire. These id numbers could then be linked to each other.

Self-rated depressive symptoms, sleep and stress
An index score of depression was calculated by summing up the individual scores for each item in the SCL-6. In the case of missing values, the score for that item was based on the mean score of the existing observations (Magnusson Hansson et al., 2013). Depressive symptoms were then categorised into three groups: no depressive symptoms, mild depressive symptoms and more severe depressive symptoms. These groups were based on suggested cut-off points (Stress...
Research Institute; Magnusson Hansson et al., 2013). Therefore the cut-offs were set to ≤15 points for no depressive symptoms, 15-21 points for mild depressive symptoms and 22-30 points for more severe depressive symptoms. A cut-off of 15 for mild depressive symptoms has been used for the same scale (A. Lowden, associate professor, March 2017). For "probable major depression", an optimal cut-point of ≥17 on the SCL-6 has been suggested (Magnusson Hansson et al., 2013). However, in their version scores range from 0-4 with a maximum score of 24. The scoring of SCL-6 in the questionnaire ranged from 6-30 points, why the equivalent in this case would be 21.25 points.

Means across each item of the KSQ dimensions sleep quality, non-restorative sleep, sleepiness and sleep apnea were computed. Index of insomnia was calculated in accordance with recommended dichotomization (Nordin et al., 2013). Thus, questions were dichotomized between response options 4 (often; 1–2 times per week) and 5 (most of the times; 3–4 times per week). The final dichotomization was the result of summing up responses again and dichotomizing between 0 (no symptoms) and 1 (one or more symptoms). This reflects experiencing at least one symptom of insomnia more than three times per week. The same procedure was carried out for the sleep apnea index. Since items on stress refer to a newly developed scale, no cut-point has been suggested. Therefore, the resulting index was treated as ordinal data only indicating severity of stress in relation to the sample.

**Objective sleep measures**

The actimeters produce activity and light exposure data, which can be displayed as activity and light exposure graphs for each subject and each recorded day or as descriptive statistics. Subjects were coded with an individual number related to their entry into the study, number on the actimeter and number of daisymeter, which was an advice subjects wore as part of the Swedish Healthy Home study. Activity graphs were examined in order to observe possibly faulty measurements as well as to get acquainted to the actigraphy. The start days were compared to the start days according to diaries in order to examine concordance so that workdays and free days could be coded correctly. From the actigraphy, descriptive statistics on various sleep measures were produced and exported into an Excel file for further elaboration in order to retrieve the independent variables of interest.

Note that time will consistently be expressed as a continuous variable and not as the actual time of day/night. Hours are presented from 1.00 and up. Therefore, a sleep onset one hour after midnight will be expressed as 25.00. Minutes are dealt with as centesimals of an hour, which for the time 1.15 am will be expressed as 25.25.

**Dichotomization of variables**

Workdays and free days were coded separately, with workdays as reference. Actimetry measures of sleep were compared to reported workdays in the sleep diary. For most of the respondents, free days coincided with weekends so as a rule of thumb, Monday through Friday were coded as workdays and Saturday through Sunday were coded as free days. However, exceptions were made when activity measures and reported work did not seem to correlate or when the reported data from the diary was incomplete or inconsistent. In these cases, days were coded as follows:

- In cases where respondents reported work from 10 am or later on Saturdays and Sundays, these days were still considered free days. Weekend days with reported work
from 10 am or earlier and working a full shift (minimum 6 hours) were considered work
days.

- When the diary was not filled out properly, Saturdays and Sundays were coded as free
days. Days that seemed to greatly deviate from the normal were excluded
   because such a great deviation could indicate some measurement error (e.g. sleeping 14 hours on a
   work night when sleeping only 7-8 hours on the other work nights).
- Weekdays reported as free days have in some cases been considered workdays after the
   assumption that even if the respondent is free from work that day, weekdays usually
   carry with them other commitments that urges the respondent to get up at an earlier time
   than on weekends.
- Public holidays with no reported work have been considered free days.

Other dichotomized variables are (reference value in parenthesis): sex (female), insomnia (no),
sleep apnea (no) and time of year (winter). Time of year was dichotomized so that October to
March were labeled winter and May to September were labeled summer. This corresponds to
average hours of sunlight being less than or more than 100 per month.

_Computation of independent variables from the actimeter_

For the purpose of this thesis, several independent variables had to be calculated. Sleep duration
was computed as means across measured sleep periods for each person. Mid-sleep denotes the
mid-point between sleep onset and sleep offset. This was computed as means across measured
sleep periods based on the mid-point of sleep duration. Sleep duration and mid-sleep were
computed separately for workdays and free days.

Chronotype is defined as the mid-sleep time on free days (MS_F), that is, when there is no work
or social obligations on the day of awakening. Work-free days are measured because of the
assumption that sleep behaviour is strongly influenced by the circadian clock when there is no
use of an alarm clock in order to wake up (Roenneberg et al., 2004; Roenneberg et al., 2015).
To adjust for the sleep debt that most individuals accumulate during the workweek, a sleep
corrected measure of chronotype is used. The algorithm for the corrected MS_F (MSF_sc),
described more in detail in Roenneberg at al. (2004), is as follows:

\[
MSF_{sc} = MS_F - 0.5 \times (SD_F - (5 \times SD_w + 2 \times SD_F)/7)
\]

SD_F denotes sleep duration on free days and SD_w denotes sleep duration on workdays. From
the actimetry measured sleep onset and offset, MS_F, SD_F and SD_w as well as mid-sleep on
workdays (MS_w) were computed as the means for each measured period. With the use of these
means, chronotype was then calculated for each respondent.

Social jetlag (SJL) is a measure of the accumulated sleep debt and the discrepancy between the
internal and the external timing system. This measure relates the mid-sleep on workdays to the
mid-sleep on free days and the absolute difference between these two is called social jetlag
(Roenneberg et al., 2015). Except for extremely early chronotypes, most people accumulate a
sleep debt on workdays, which they compensate for by sleeping in on free days. This sleep debt
systematically depends on chronotype, resulting in the later the MS_F, the larger the accumulated
sleep debt. The computation for SJL is as follows:

\[
SJL = MS_F - MS_w
\]
Ethical considerations

According to the World Medical Association (WMA) Declaration of Helsinki, research on humans should be in accordance with good scientific praxis and the researcher should be conversant with the scientific literature regarding the purpose and research question of the study. Moreover, knowledge may be based on laboratory or animal experiments (World Medical Association, 2017). In the first phase of Swedish Healthy Home, experiments on mice were conducted, where circadian rhythms were disrupted. This showed a negative effect on measured health related variables. Present study, however, was not experimental in its design. Study subjects monitored the technical devices themselves during the 7-day period and could at any time choose to take it off. They reported self-rated measures on a number of variables, without any interference by the researchers.

Personal records were handled in accordance with the Swedish Data Protection Act. As stated in the information pamphlet received at the entry of the study, subjects had the right to find out what personal information is held on record on them (Bryman, 2008).

Analysis

Stata version 14.2 (StataCorp, College Station, Texas) was used to carry out the statistical analyses. For a description of sample characteristics, means with confidence intervals, medians with interquartile ranges and proportions were estimated. For test of normality, Shapiro Wilk W test was computed for all ordinal and continuous variables.

A correlation matrix was produced using Pearson’s correlation coefficient. For significant correlations including ordinal or non-normally distributed variables, additional tests of correlations were carried out using Spearman’s rank correlation. To assess significant differences between groups according to depressive symptoms cut-off points, oneway ANOVA was performed. For analyses including variables that could be interpreted as ordinal Kruskal Wallis rank test was carried out in order to confirm or reject significance.

Multiple linear regression was carried out to determine the predictive value of measured sleep variables. To further examine the potential non-normality of dependent and predictive variables, Kernel density plots and boxplots were graphed. Non-normally distributed variables were transformed in order to achieve normality. Standardized residuals and leverages were computed and examined both statistically and graphically. The most influential observations were detected using Cook’s d. Residuals were then checked for normality using Kernel density plot and Shapiro Wilks W test. Tests of heteroscedasticity were performed with White’s test and Breusch-Pagan test and by graphically plotting the residuals versus the predicted values. Multicollinearity was checked using the Stata command "vif". Linearity of predictive variables was checked with the Stata command "acprplot". An \( \alpha \) level of .05 was used to denote statistical significance for all statistical analyses.
RESULT

All continuous sleep variables from the actimetry except SDw were normally distributed, as were the averaged mean of sleep quality based on the KSQ. Sleepiness and sleep apnea measured with the KSQ were as expected non-normally distributed. A few variables almost reached significance in terms of non-normality. These were SJL (p = 0.059), bedtime on free days (p = 0.085) and MSw (p = 0.086) from the actimetry and non-restorative sleep (p = 0.051) from the KSQ. 56.4 per cent of the total showed no depressive symptoms given the cut-offs used in this sample. 12.7 per cent showed mild depressive symptoms and another 18.2 per cent showed more severe depressive symptoms. Sample characteristics are presented in Table 1.

Table 1. Sample characteristics.

<table>
<thead>
<tr>
<th>Demographic variable</th>
<th>No depressive symptoms</th>
<th>Mild depressive symptoms</th>
<th>More severe depressive symptoms</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean</td>
<td>45.02</td>
<td>48.7</td>
<td>47.4</td>
<td>46.19</td>
</tr>
<tr>
<td>MSf</td>
<td>28.05 (27.70-28.4)</td>
<td>28.16 (27.52-28.81)</td>
<td>28.43 (27.73-29.14)</td>
<td>28.14 (27.9-28.38)</td>
</tr>
<tr>
<td>SDw</td>
<td>7.26 (6.97-7.55)</td>
<td>7.47 (6.93-8.02)</td>
<td>7.37 (6.39-8.36)</td>
<td>7.28 (7.04-7.52)</td>
</tr>
<tr>
<td>SDF</td>
<td>8.22 (7.80-8.63)</td>
<td>8.44 (7.57-9.32)</td>
<td>8.40 (7.33-9.47)</td>
<td>8.26 (7.95-8.57)</td>
</tr>
<tr>
<td>MSFSc</td>
<td>27.71 (27.36-28.06)</td>
<td>27.82 (27.32-28.32)</td>
<td>28.07 (27.38-28.76)</td>
<td>27.79 (27.55-28.03)</td>
</tr>
<tr>
<td>SJL</td>
<td>1.33 (1.03-1.62)</td>
<td>1.33 (1.81-1.85)</td>
<td>1.04 (0.81-1.39)</td>
<td>1.23 (1.04-1.43)</td>
</tr>
<tr>
<td>Bedtime, free</td>
<td>23.12 (22.91-23.34)</td>
<td>23.11 (22.56-23.67)</td>
<td>23.71 (22.83-24.58)</td>
<td>23.28 (23.06-23.49)</td>
</tr>
<tr>
<td>Bedtime, work</td>
<td>23.97 (23.57-24.36)</td>
<td>23.87 (23.32-24.42)</td>
<td>23.84 (22.88-24.80)</td>
<td>23.94 (23.65-24.23)</td>
</tr>
<tr>
<td>Waketime, work</td>
<td>30.39 (30.08-30.69)</td>
<td>30.61 (30.22-30.01)</td>
<td>31.08 (30.44-31.73)</td>
<td>30.57 (30.35-30.78)</td>
</tr>
<tr>
<td>Waketime, free</td>
<td>32.21 (31.77-32.65)</td>
<td>32.35 (31.29-33.41)</td>
<td>32.63 (31.88-33.39)</td>
<td>32.29 (31.99-32.59)</td>
</tr>
<tr>
<td>Effectivity %</td>
<td>90.77 (89.69-91.84)</td>
<td>90.71 (86.84-94.62)</td>
<td>91.19 (88.14-94.24)</td>
<td>90.88 (89.99-91.77)</td>
</tr>
<tr>
<td>WASO</td>
<td>33.06 (29.11-37.01)</td>
<td>35.63 (21.43-49.83)</td>
<td>35.62 (19.27-51.97)</td>
<td>33.54 (29.76-37.32)</td>
</tr>
</tbody>
</table>

| Sleep quality (1-5)   | 2.25 (1.75-3.25)       | 2.25 (3.0-4.5)           | 3.62 (2.25-4.0)                 | 2.88 (2.0-3.5) |
| Non-restorative sleep (1-5) | 2.0 (1.5-2.5) | 3.00 (1.5-3.5) | 3.5 (3.0-4.25) | 2.0 (1.5-3.0) |
| Sleepiness (1-5)      | 1.67 (1.33-2.33)       | 2.17 (1.33-2.67)         | 2.17 (1.67-4.0)                 | 1.67 (1.33-2.33) |
| Sleep apnea (1-5)     | 1.0 (1.0-2.0)          | 1.5 (1.0-2.0)            | 1.5 (1.0-2.5)                   | 1.0 (1.0-1.5) |
| Stress (3-12)         | 5.0 (4.0-6.0)          | 6.0 (5.0-7.0)            | 9.0 (8.0-10.0)                  | 5.5 (4.0-7.0) |
| Depressive symptoms (6-30) | 10.0 (8.0-13.0) | 18.5 (18.0-20.0) | 27.5 (25.0-28.0) | 13.0 (9.0-19.0) |

Actigraphy measures: MSw: mid-sleep workdays MSf: mid-sleep free days SDw: sleep duration workdays SDF: sleep duration free days MSFS: mid-sleep free days corrected for oversleep SJL: social jetlag WASO: waketime after sleep onset. All other sleep variables are self-rated measures from the KSQ. Depressive symptoms derived from the SCL-6.

Associations between sleep and depressive symptoms

The correlation matrix based on Pearson’s correlation coefficient (r) showed significant associations between a majority of actimetry sleep measures. Obviously, there were strong
correlations between SJL and MSF_{sc} and the respective sleep measures which these two are based on. Moreover, there was also a strong positive correlation between SJL and MSF_{sc} (r 0.59, p .00), which showed that these two are indeed closely associated. Surprisingly, none of the actimetry measured sleep variables were significantly associated with depressive symptoms nor with stress. Neither were age or sex associated with depressive symptoms. Age did not show significant associations with any sleep variables except waketime on free days (r -0.29, p .036). Sex, on the other hand, was negatively associated with sleep effectivity (r -0.2, p .032), non-restorative sleep (-0.34, p .001) and insomnia (r -0.25, p .042), indicating that men tended to have poorer sleep effectivity but women suffered more from problems with non-restorative sleep and insomnia. Stress was positively associated with non-restorative sleep (r 0.39, p .002), insomnia (r 0.45, p .00) and sleepiness (r 0.37, p .003).

Significant correlation coefficients (r) are summarized in Table 2 with the respective p-values in parenthesis. All correlations including ordinal variables were still valid when assessed with non-parametric tests (depressive symptoms and sleep variables, rho .00-.007; stress and depressive symptoms rho .00).

Table 2. Significant associations between sleep and depressive symptoms.

<table>
<thead>
<tr>
<th>Depressive symptoms r (p)</th>
<th>Non-restorative sleep 0.49 (.00)</th>
<th>Insomnia 0.48 (.00)</th>
<th>Sleepiness 0.47 (.00)</th>
<th>Stress 0.69 (.00)</th>
<th>Sleep quality 0.32 (.014)</th>
<th>Winter/summer -0.36 (.009)</th>
</tr>
</thead>
</table>

As shown above, time of year (wintertime or summertime) when the data were collected was highly significant for the depressive index score, indicating that winter depression, or at least more depressive feelings during wintertime, was prevalent in the sample. Moreover, while there was a correlation between reported depressive symptoms and time of year, no sleep variables were significantly associated with time of year. Only waketime on free days showed a very moderate positive association with time of year, with a tendency to be earlier during the months with more daylight (r 0.24, p .87).

Since the only sleep variables that showed significant associations with depressive symptoms were the combined measures from the KSQ, further correlation analyses were conducted by examining the associations between depressive symptoms and each independent item in the scale. The result from this analysis is presented below with rho coefficient and p –values (in parenthesis).

Table 3. Associations between depressive symptoms and items from the KSQ.

<table>
<thead>
<tr>
<th>Difficulties falling asleep 0.36 (.006)</th>
<th>Repeated awakenings 0.3 (.024)</th>
<th>Disturbed/restless sleep 0.31 (.02)</th>
<th>Difficulties waking up 0.27 (.038)</th>
<th>Not well-rested on awakening 0.42 (.001)</th>
<th>Involuntary dozing of during leisure time 0.29 (.03)</th>
<th>Need to fight sleep to stay awake 0.53 (.00)</th>
</tr>
</thead>
</table>

Depressive symptoms rho (p) 0.36 (.006) 0.3 (.024) 0.31 (.02) 0.27 (.038) 0.42 (.001) 0.29 (.03) 0.53 (.00)
All but four of the included items were positively associated with depressive symptoms. Stress was also positively associated with some of the items: difficulties waking up \((\rho = 0.29, p = 0.029)\), not well-rested on awakening \((\rho = 0.27, p = 0.045)\) and need to fight sleep to stay awake \((\rho = 0.47, p = 0.00)\). Neither depressive symptoms nor stress were associated with breathing cessation during sleep, heavy snoring or involuntary dozing off at work.

In order to further examine the extent to which relationships between sleep and depressive symptoms varied between groups, respondents were grouped according to depressive symptoms status. In this analysis, compared to the correlation matrix, sleep quality \((p = 0.065)\) lost its significance and MS\(_w\) became significant, being progressively delayed with depressive status. A non-parametric analysis of association between sleep quality and depressive symptoms group actually revealed a significant association \((\chi^2 = 7.483, df = 2, p = 0.024)\). However, sleepiness lost significance using this method \((\chi^2 = 3.259, df = 2, p = 0.196)\). A look at the ANOVA table revealed that the means for sleep quality were the same in the group with mild depressive symptoms and more severe depressive symptoms. The same was true for time of year \((\text{winter/summer})\) which almost reached significance \((p = 0.54)\).

**Table 4.** Significant differences in means across groups based on depressive symptoms.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-restorative sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>21.301</td>
<td>2</td>
<td>10.65</td>
<td>8.44</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>69.393</td>
<td>55</td>
<td>1.262</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>90.693</td>
<td>57</td>
<td>1.591</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insomnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>3.903</td>
<td>2</td>
<td>1.951</td>
<td>10.28</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>10.442</td>
<td>55</td>
<td>.1899</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14.345</td>
<td>57</td>
<td>.252</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleepiness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>6.264</td>
<td>2</td>
<td>3.138</td>
<td>3.85</td>
<td>.027</td>
</tr>
<tr>
<td>Within groups</td>
<td>44.727</td>
<td>55</td>
<td>.8132</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50.99</td>
<td>57</td>
<td>.895</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS(_w)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>3.19</td>
<td>2</td>
<td>1.595</td>
<td>3.99</td>
<td>.026</td>
</tr>
<tr>
<td>Within groups</td>
<td>18.007</td>
<td>45</td>
<td>.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>21.197</td>
<td>47</td>
<td>.451</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>129.26</td>
<td>2</td>
<td>64.63</td>
<td>26.46</td>
<td>.00</td>
</tr>
<tr>
<td>Within groups</td>
<td>134.34</td>
<td>55</td>
<td>2.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>263.60</td>
<td>57</td>
<td>4.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter/Summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>1.282</td>
<td>2</td>
<td>.64</td>
<td>3.09</td>
<td>.054</td>
</tr>
<tr>
<td>Within groups</td>
<td>10.16</td>
<td>49</td>
<td>.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11.442</td>
<td>51</td>
<td>.22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MS\(_w\): mid-sleep on work days. All other sleep variables are self-rated measures from the KSQ.

**Associations adjusted for demographic and other sleep variables**

Normality tests showed that sleepiness, stress and depressive symptoms all were non-normally distributed. These variables showed positive skewness and box plots revealed outliers in the variables sleepiness and stress. The most appropriate transformations were: stress: log \((\chi^2 = 1.94, p = 0.379)\), sleepiness: 1/square root \((\chi^2 = 2.03, p = 0.362)\), depression: inverse \((\chi^2 = 4.0, p = 0.132)\). Three potential outliers were detected when examining the residuals and two observations showed a greater impact due to leverage. When computing the overall influence of the single variables,
three variables were found, of which one was identical with one found inspecting both the residuals and the leverages separately. Checking the residuals, they were non-significant \( (p \ .997) \). White’s test revealed the possibility of heteroscedasticity \( (p .004) \) while Breusch-Pagan did not \( (.211) \). Plotting the residuals versus the fitted line did not show that the problem of heteroscedasticity was severe, since there was no clear pattern in the distribution. Multicollinearity was very low in the final model. None of the predictive variables showed any significant non-linearity.

Several regression models were tested. The predictive value of the sleep variables was controlled against age, sex, time of year and stress as well as against other sleep variables. Sex and age were non-significant so these were removed. The model with the best fit is presented in Table 5. Results are presented with the unstandardized coefficient \( (B) \) and its standard error, the standardized coefficient \( (\beta) \), t-value and p-value. Note that for some variables, the transformed versions have been used and the coefficient and t-value for these have been changed from positive to negative and vice versa where needed in order to reflect their actual influence. The explanatory value for this model was satisfactory \( (F_{3,48} 14.07, p .00, R^2 .47, adjusted R^2 .43) \) but still suggesting that other variables not controlled for exert a large impact on the outcome. It should also be noted that this model does include the influential variables detected. When removing these from the model, sleepiness and time of year were no longer significant, although time of year could be assumed to still exert a moderate effect \( (.068) \). The explanatory value of this model was \( F_{3,46} 13, p .00, R^2 .46, adjusted R^2 .42 \), showing that removing these observations did not significantly change the explanatory value and stress was the only variable with a predictive significance. It should also be noted that all of the models are based on the transformed values, which is only necessary in order for the t-values to be significant. Re-running the analysis of the model below using the untransformed variables increased the significance of the model but also changed sleepiness to not being significant \( (F_{3,48}, p .00, R^2 .57, adjusted R^2 .54) \) with stress \( (p .00) \), sleepiness \( (p .074) \) and time of year \( (p .006) \).

Table 5. Predictive value of KSQ derived sleepiness on depressive symptoms outcome and controlled for stress and time of year.

<table>
<thead>
<tr>
<th>Depressive symptoms</th>
<th>( B )</th>
<th>( SE\ B )</th>
<th>( B )</th>
<th>( t )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleepiness</td>
<td>.076</td>
<td>.028</td>
<td>.297</td>
<td>2.65</td>
<td>.011</td>
</tr>
<tr>
<td>Stress</td>
<td>.042</td>
<td>.011</td>
<td>.415</td>
<td>3.72</td>
<td>.001</td>
</tr>
<tr>
<td>Time of year</td>
<td>.022</td>
<td>.008</td>
<td>.281</td>
<td>2.64</td>
<td>.011</td>
</tr>
</tbody>
</table>

\( B \): unstandardized coefficient \( SE\ B \): standard error of the unstandardized coefficient \( \beta \): standardized coefficient \( t \): t-value \( p \): p-value

Removing stress from the model and including non-restorative sleep instead also produced a model with a satisfactory explanatory value \( (F_{3,48} 11.09, p .00, R^2 .41, adjusted R^2 .37) \) indicating that sleepiness and stress are indeed interrelated. All predictive variables in this model were significant (sleepiness \( p .00 \), non-restorative sleep \( p .01 \) and time of year \( p .02 \)). However, removing time of year had a larger impact on the explanatory value of every model tested. In the model including sleepiness and non-restorative sleep, excluding time of year
resulted in these variables still being highly significant but in a model with a less satisfactory fit ($F_{2.55} = 10.82, p .00, R^2 .28, \text{adjusted } R^2 .26$).

Controlling sleepiness for other sleep variables in a separate model only including sleep did not reveal any significant influence of other sleep variables. In a model with sleepiness, non-restorative sleep and sleep quality ($F_{3.54} = 8.60, p .00, R^2 .32, \text{adjusted } R^2 .29$) only sleepiness was significant in predicting depressive symptoms ($p .00$). Removing sleepiness from the model ($F_{2.55} = 7.40, p .00, R^2 .21, \text{adjusted } R^2 .18$) changed non-restorative sleep to being significant ($p .015$) but not sleep quality. Concluding the regression analyses, it seems like self-rated sleep measures to some extent can predict depressive symptoms. However, only self-rated sleepiness can be said to be significant when controlled for other non-sleep related factors. Finally, when stress was included in the models, none of the sleep measures were significant in predicting depressive symptoms.
DISCUSSION

Analyses of objectively measured sleep variables as well as self-rated sleep show some associations with self-rated depressive symptoms. Opposite to the prevailing literature, no associations were found between actimetry measured sleep variables and depressive symptoms. Neither did age nor sex show any significant associations to depressive symptoms in the studied sample. Even though some associations between sleep variables and depressive symptoms were found, most sleep variables lost significance when controlled for other variables and demographic data. The final model showed that sleepiness, time of year and self-rated stress were the variables that best predicted depressive symptoms outcome.

Discussion of results

Various sleep measures showed significant associations with depressive symptoms. As recently has been reported, problems regarding sleep and mental health are the most common problems related to factors in the work environment among women in Sweden (Klevestedt, 2016). It could therefore be hypothesized that gender would be associated with depressive symptoms. This association was not found but may be due to women being heavily overrepresented in the sample.

In accordance with earlier findings (Grossi et al., 2015; Kitamura et al., 2010; Plante, Finn, Hagen, Mignot & Peppard, 2016), daytime sleepiness showed a positive correlation with depressive symptoms. In fact, in this study, it was the only sleep variable of significance when controlled for other factors. Type of population studied may contribute to the partial discrepancy between results in this study and earlier findings. For example, as opposed to the study by Matamura et al. (2014), results in this thesis show no association between sleep duration and depressive symptoms. However, caution should be called for when comparing these results since the study by Matamura was carried out on adolescents in a different social and cultural context and sleep duration was not calculated separately for school days and free days.

The composite sleep measures indicating chronotype and social jetlag were strongly correlated. Interestingly, this study found no evidence to support these sleep measures’ association with depressive symptoms, even though extensive earlier research has pointed to a positive correlation (Hidalgo et al., 2009; Levandovski et al., 2011). Objective sleep measures were only significant in terms of mid-sleep on workdays when comparing groups. Mid-sleep on workdays tended to become progressively later with increased depressive symptoms, possibly suggesting a later chronotype and/or greater social jetlag for the groups showing depressive symptoms. The sleep measures constituting chronotype were also analysed separately in order to find any meaningful correlations but none were detected. For social jetlag, none of the included variables showed any correlation to depressive symptoms. In fact, none of the objectively derived measures of sleep showed any significant associations with depressive symptoms. This was somewhat surprising since the literature suggests otherwise. However, the paradox of finding significant associations between depressive symptoms and self-rated sleep measures but not with objective measures has recently been reported in a larger study (Plante et al., 2016).

The finding of significant associations with self-rated measures and not with objective measures is also interesting in the regard that it suggests that the subjective experience may be of greater importance than the actual objective data. As a comparison, the objectively derived sleep
variable “WASO”, which indicates disturbed and restless sleep, showed no significance in any of the analyses, while the KSQ item “disturbed/restless sleep” was independently significant in association with depressive symptoms as well as included in the combined variable “sleep quality”.

Possible effects of choice of data treatment methods and statistical analyses on the outcome

It is possible that more associations would have been found if other measures of sleep had been included in the analysis. For example, some studies suggest that a greater variability in sleep timing is associated with depressive symptoms (Matamura et al., 2014; Robillard et al., 2015). It is also possible that dividing the sample into groups based on chronotype would have revealed associations with depressive symptoms, as was the case in the study by Gaspar-Barba et al. (2009). A third way to deal with the data could have been to divide sleep duration into categories since there are studies that show associations both with short and long sleep duration (> 9 hrs) and depressive symptoms (Borisenkov et al., 2015; Grossi et al., 2015; Kalmbach, Arndt, Swanson, Rapier & Ciesla, 2016). Finally, other methods of analysing the data could possibly have been more appropriate. In the case of variance between group means it was concluded in hindsight that a parametric or non-parametric test comparing only two groups probably would have been a better choice, since significant associations somewhat may have been lost comparing three groups when two of them displayed the same mean on several variables.

The effect of non-sleep variables on the outcome

Self-rated daytime sleepiness was the single most influential sleep variable predicting the depressive symptoms outcome. However, it did not significantly change the explanatory value of the model omitting sleepiness when controlled for self-rated stress. Stress and sleepiness were associated, as was stress with depressive symptoms. Further analyses could examine the possibly moderating or mediating effect of sleepiness on the association between stress and depressive symptoms. Although this thesis does not focus on the possible association of depressive problems with work related factors, the studied sample consists only of full-time employees. In the sleep diary used for the Swedish Healthy Home study it was possible for the respondents to leave comments on their sleep behaviour during the week measured with actimetry. Some of the comments to why respondents experienced disturbed sleep include: “at a conference, much to think about”, “worries about work”, “job stress”, “working late”, “thoughts about work” and “stressed about work”. This may be a warning sign and should not be neglected.

Somewhat unexpectedly, time of year showed a very strong significant association with depressive symptoms, indicating that seasonal depressive symptoms may be prevalent in this sample. Although outside the scope of this particular study, the association between time of year and depressive symptoms in a working population should be further examined. In this study, participants joined the study at two major times of the year: spring and autumn/winter. This was dichotomized as winter/summer based on the average hours of sunlight during a month being more or less than 100 hours. This also coincides with the change from summertime to wintertime and vice versa. Borisenkov et al. (2015) have found significant differences in sleep behaviour between individuals categorised as with or without winter depression. However, that study was carried out on adolescents and focused on somewhat different sleep measures and did not report on the possible association with self-rated sleepiness. Instead, winter depression was associated with a later bedtime, shorter sleep duration and more
pronounced sleep inertia. This study also showed gender differences in sleep behaviour and depressive mood. Winter depression was more prevalent in women compared to men.

As a concluding remark on the results, it is important to acknowledge that this study was carried out on a small sample as opposed to many other studies related to chronotype and social jetlag. The demographic specificities may also be of great importance for the outcome. For this sample, one can assume that work may influence sleep in so that the respondents to a greater extent have to regulate their sleep according to working hours and demands. Therefore, they may display a more “normal” sleeping pattern than otherwise would have been the case. Studying a sample including or only consisting of persons partly or fully on sick leave might have produced other results.

**Discussion of method**

*Internal and external validity*

The cross-sectional design is suitable for establishing variation within a population and associations between variables, however it will not determine any causality. This makes the internal validity weak, since causal inferences are difficult (but not always impossible) to draw from the material in a cross-sectional study and preferably are generated in experimental designs. In the cross-sectional design lies that variables are collected more or less simultaneously, which is why it is not possible in most cases to say that the independent variable with certainty precedes the dependent variable (Bryman, 2008).

This multi-source cross-sectional design gathered data from the respondents in several ways: through the use of actimetry, sleep diaries and questionnaires. In a cross-sectional design like the one in this study, time is considered to have random effects producing only variance within the studied sample. Moreover, time is not considered to introduce bias in this type of study (Liu, 2008). In this study, data were collected from each respondent during a restricted time period. However, it became evident that time actually did exert a significant effect on the results. Excluding time from the final analysis would have lowered the predictive value of the model. Additionally, since the questionnaire asked respondents to rate their mood during the past three months it may be that the actual time of distribution influenced the outcome on the depressive symptoms scale. Thus, it may be that individuals experiencing seasonal mood fluctuations could report lesser symptoms of depression if they took part in the study e.g. in fall or vice versa if they took part in late winter or early spring (responding to the items considering a time period of three months up to the time of taking part in the study). This is not necessarily problematic but rather an interesting fact that should be considered in the analyses.

Regarding external validity, estimation bias and non-response bias will be discussed further. The study builds on a convenience sampling procedure, which may introduce bias. The problem with this kind of sampling is that it is impossible to generalize the findings, since there is no way to know if the sample is representative of all adults in full-time day jobs with flexible starting hours. First of all, women were overrepresented in the sample. Secondly, it may be that other factors such as age distribution is not representative. Regarding income, living situation and other demographic data, information about these was not gathered in this study. In this case, the very fact that subjects saw the advertisement in the newspaper and also responded to it may be related to a factor that differs them from the rest of the population (for example, commuting to work instead of taking the car). However, convenience sampling has the advantage of involving less preparation than a probability sampling and it also involves less difficulties and
costs. A study based on convenience sampling can provide a basis for future research and links to existing findings can be observed (Bryman, 2008). The results may also contribute to a better understanding of the associations, as well as give an indication of possible causal relationships to examine in future studies. It could also be of interest to draw another sample and conduct the same study in order to see if the results change due to the possible sample error (Stec, 2008).

Somewhat surprisingly, none of the objectively gathered sleep data were associated with depressive symptoms, while several of the self-rated data were. Moreover, only a few of the objectively measured sleep variables were associated with the self-reported variables, while the interrelationship between objective data and self-rated data respectively was high. Although unlikely, it cannot be completely ruled out that systematic bias of a survey estimate has been introduced (Stec, 2008).

Data treatment and analytical methods

One factor that can be discussed in relation to this thesis is the choice of statistical methods and how data are treated. For correlations, parametric analyses were performed but in cases where variables were strictly ordinal or could be regarded as either ordinal or ratio, comparative analyses were carried out with non-parametric tests. It is appealing to use parametric tests as these usually detect significant differences more easily.

Further, it could also be discussed whether the most appropriate cut-offs were used in in the analysis of variance. Groups based on other cut-offs may have resulted in the change from significant to non-significant and vice versa. In this thesis, a proposed cut-off for mild depression was used as well as a validated cut-off for more severe depressive symptoms. In this particular sample this resulted in a larger group of more severely depressed respondents than with mild depressive symptoms. A dichotomized variable of depressive symptoms might have shown significant differences between groups regarding sleep quality and time of year. Time of year appeared to have a large impact on the outcome in the following regression analysis.

Based on the common rule of thumb for regression analysis, which states that there should be at least 20 observations per variable, the sample used in this analysis has to be considered to be very small. Therefore, the results should be treated with caution. However, necessary assumptions for performing a regression analysis were met. Regarding the results of the regression analysis, the model with the best fit included three possibly strongly influential observations due to residuals and leverage. Removing these observations changed the results and left only stress as a significant predictive factor. The reason for keeping these observations in the final model is that in a given population some people may demonstrate extreme values. Taking a closer look at these observations they did not seem to significantly deviate from the rest of the sample in any way that implicated the presence of an error in the data, so it was determined to keep them in the model but being cautious about the interpretation due to their influence on the results.

Validity and reliability of instruments

The construct validity of the collection process can be considered strong. Two of the scales in the questionnaire have shown more than acceptable reliability. The internal consistency for the subscales in the KSQ ranged from $\alpha .71$ to $.87$ in a normative Swedish study evaluating the psychometric properties of this scale (Nordin et al., 2013). For the SCL-CD$_6$, an $\alpha$ of .92 has been confirmed (Magnusson Hanson et al., 2013). The scale measuring stress is newly
developed and validation studies and reliability measures are therefore not yet available. However, the indexed stress variable was strongly correlated to the depression index from the KSQ.

Item nonresponse has occurred with some respondents failing to respond to one or several of the survey questions. For item nonresponse on scales, a mean was estimated based on the responses of the other items. This was not considered a problem since only one respondent had failed to respond to one item. On the other hand, a few respondents failed to respond to the entire scale or questionnaire, resulting in a smaller analysed sample than the initial one. Regarding actimetry, a few cases were excluded and some others had only questionnaire data and no actimetry data. No analysis of attrition was performed but it is unlikely that the actimetry data should be missing in any systematic way since this more has to do with technical issues (e.g. the device not working properly) or that the data had not yet been imported into the software. Since the data used in this thesis comes from an on-going collection of data, the latter may also be applied to the nonresponse of questionnaires.

**Strengths and weaknesses**

This study has several strengths as well as weaknesses. One great advantage of using a cross-sectional design is that it is highly efficient in testing associations. This study also included several variables measuring the same underlying concept, using different types of data as well as constructed in different ways. Although not representative, this study can still form a basis for future research. The biggest limitation regarding cross-sectional designs is that it is not possible to suggest any causal relationship, unless an experiment is embedded within the design (Liu, 2008). For example, to more thoroughly examine the possible influence of time on these kinds of results longitudinal data are required.

**Clinical implications and future research**

For clinical purposes it is of importance to raise the awareness of early depressive symptoms and adjoining behaviours. Depression also has large costs both for the individual and the society in terms of economic loss. For the individual it has an extensive emotional effect, which severely may reduce life quality. However, studying associations involving humans and illness may raise several ethical issues. Randomized experimental studies, which are considered to render a stronger evidence base than cross-sectional designs, may be problematic in this case since experimenting with people’s health would be unethical. Longitudinal studies following cohorts over time is an alternative but involves larger costs and are also more time-consuming.

A few interesting findings in this study would be worth following up. For example, the association between time of year and depressive symptoms and the possible factors causing this association should be further investigated. It was beyond the scope of this study to analyse light exposure in the sample although this might have resulted in interesting findings. Some research on the influence of light exposure on depressive symptoms is available. Older studies of patients in mental institutions show some associations between light exposure and depression. Beauchemin & Hays (1996) showed in a retrospective study of patients treated for depression that natural morning light exposure was associated with shorter hospital stays. Patients in rooms with windows towards east, which therefore received a higher dose of morning light, had shorter hospital stays than patients in rooms facing the opposite direction. The study was replicated with similar results, with the main difference that the association was only seen during Italian summer and fall (Benedetti, Colombo, Barbini, Campori, & Smeraldi, 2001).
Associations between natural light exposure and depression have also been observed in Arctic workers. In this sample, a reduction of one hour of daylight on working days significantly increased scores on depression scale (Marqueze et al., 2015).

Future research should further investigate these possible associations in representative samples of working adults under conditions that apply to the general Swedish working population. A better understanding of how light exposure, sleep and depressive symptoms may be interrelated can have implications for improving physical work environments. It can also be relevant knowledge when planning and building new dwelling houses and living environments, especially in metropolitan areas, since city dwellers demonstrate a larger proportion of late chronotypes. A possible explanation might less exposure to outdoor natural light for inhabitants of large cities (Roenneberg et al., 2007; Roenneberg & Merrow, 2007)

**Conclusion**

In line with earlier research, sleep and depressive symptoms seem to be associated to some extent. Even though working full-time probably exerts a restrictive effect on sleep behaviour, associations were still evident. Only self-rated measures of sleep were associated with depressive symptoms in this sample, which raises questions about which aspects of sleep actually can be said to be associated with depressive symptoms and why. Self-rated sleep measures could predict depressive symptoms to some extent but when controlled for other factors only sleepiness was significant. When stress was added to the model none of the sleep measures were significant in predicting depressive symptoms. This puts forward a discussion about the measurements in themselves and the possibly shared underlying concept measured by self-rated sleep and stress.
REFERENCES


APPENDIX 1. Scales and items.

KSQ items

Have you suffered from any of the following sleep disturbances during the past three months? (never/rarely [a few times]/sometimes [a few times/month]/often [1-2 times/week]/most of the time [3-4 times/week]/always [5 or more times/week]

1. Difficulties falling asleep.
2. Repeated awakenings with difficulties falling asleep again.
3. Premature (final) awakening.
4. Disturbed/restless sleep.
5. Not well-rested upon awakening.
6. Involuntary dozing off during work.
7. Involuntary dozing off during leisure time.
8. Need to fight sleep to stay awake.
9. Heavy snoring.
10. Breathing cessation during sleep.

SCL-6 items

How much have you suffered from the following during the past three months? (not at all/a little/moderately/quite a lot/very much)

1. Low in energy.
4. Worrying too much.
5. No interest in things.
6. Everything feels like an effort.

Stress items

Mark the response that comes closest how you have felt during the past three months. (not at all/sometimes/quite often/almost all the time)

1. I have days when I feel excited all the time.
2. I have days when I feel very pressured, on the verge of what I can handle.
3. I have days when I feel stressed all the time.