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The reduced Morningness–Eveningness Questionnaire: Psychometric properties and related factors in a young Swedish population

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ABSTRACT

During puberty, there is a delay in sleep patterns and the circadian clock, and the prevalence of sleep difficulties is high among young adults. Thus, it is important to be able to measure chronotype (CT) in this group, both in the clinic and for broader epidemiological studies, to better understand the sleep difficulties observed. The reduced version of one of the most widely used questionnaires to measure CT, the Horne & Östberg Morningness–Eveningness Questionnaire (MEQ), has been developed and validated in many languages. The aim of the present study was to investigate the reliability and validity of the Swedish reduced MEQ (rMEQ) and to investigate factors correlated with rMEQ scores in a random sample of young Swedish participants. We sent the rMEQ, sleep questions, demographic questions, the Insomnia Severity Index (ISI), the Epworth Sleepiness Scale, and the Hospital Anxiety and Depression Scale (HADS-A and HADS-D) to 1000 randomly selected individuals aged 16–26 years in Uppsala, Sweden (response rate = 68%). A parallel analysis of the rMEQ revealed a single factor solution. Inter-item correlations within the questionnaire were between 0.08 and 0.46. One of the rMEQ items displayed weak correlations with the other questions. Cronbach’s alpha of the rMEQ was 0.68. Low rMEQ scores (eveningness) were correlated with more frequent late bedtimes and difficulties getting up in the morning. Lower rMEQ scores were significantly related to male sex, no educational activity or work, nicotine use, younger age, and higher ISI and HADS-D scores. Even though the inter-item correlations of the rMEQ were very low to moderate, the rMEQ had a Cronbach’s alpha not far off from acceptable levels, and the strong correlations of the rMEQ scores with responses to the sleep questions indicated that the rMEQ had an adequate validity. To conclude, the rMEQ can be used to effectively estimate CT when a short questionnaire is required; however, caution should be taken when interpreting the results considering the reliability of the questionnaire.

Introduction

Circadian rhythms are endogenous 24-h oscillations that are primarily regulated by the anterior hypothalamic suprachiasmatic nucleus. This regulation is influenced by genetic factors and environmental factors such as light–dark cycles. Circadian rhythms coordinate our sleep–wake preferences, body temperature, hormonal secretion, food intake, and circulation (Weaver 2002; Young 2018). The preferred time of the day to be active or to sleep defines morningness–eveningness, which is also termed chronotype (CT). For example, morning-oriented individuals (morning types/“Larks”) go to bed early and reach their peak cognitive and physical performance in the early daytime hours, while evening-oriented individuals go to bed in the early hours of the morning and function best at later times in the day or the evening. There are also “neither” types who have a balanced circadian rhythm (Randler et al. 2016). There is a known delay of circadian rhythms during puberty, and eveningness CT is high in adolescence (Borisenkov et al. 2010; Hagenaier et al. 2009). Eveningness is associated with nicotine, alcohol and drug use, physical inactivity, sleep difficulties, and symptoms of depression and anxiety, whereas morningness is associated with healthy activities and higher conscientiousness (Adan 1994; Urban et al. 2011). CT is also linked to some sleep disorders such as delayed sleep–wake phase disorder (DSWPD) and advanced sleep–wake phase disorder (American Academy of Sleep Medicine 2014). It is of interest to measure CT in adolescents and young adults since sleep disturbances such as DSWPD and insomnia are common.
in this group. However, many of the CT questionnaires are lengthy. To have a short and easy way to measure CT would be beneficial especially for large population studies.

Several questionnaires have been designed to measure CT. The Morningness–Eveningness Questionnaire (MEQ) is one of the most widely used and accepted instruments to measure CT and is reported to be a useful tool for assessing CT in DSWPD (American Academy of Sleep Medicine 2014). The MEQ is considered as the gold standard measure of CT and has been translated into several languages. The Östberg Swedish language MEQ (Östberg 1973) was used as the basis when the English version was developed by Horne and Östberg in 1976 (Horne and Ostberg 1976). A number of large-scale studies with healthy subjects have reported MEQ to have a good reliability and validity in various countries (Di Milia et al. 2013; Lee et al. 2014; Roveda et al. 2017). The MEQ contains 19 items concerning sleep–wake times, and preferred times for physical and mental activities and subjective alertness, which are scored using a Likert-type response format. It has been suggested that cutoff scores of the MEQ are affected by age, sex, cultural variations, season of birth, and puberty (Adan and Natale 2002; Caci et al. 2009; Kim et al. 2002). A Swedish translation and reliability study of the MEQ by Ståleby and colleagues reported a high reliability of the scale in a healthy adult population (Ståleby et al. 2016).

However, the MEQ has been criticized for its length and that it contains items with varying number of possible choices (Di Milia et al. 2013). Furthermore, additional concerns about the underlying factor structure have led to the development of a reduced 5-item version (rMEQ). Using shorter scales can be advantageous for screening larger populations; shorter scales are also much easier for participants to fill in, which might increase compliance. Considering that adolescents may be more impatient than older adults, it is even more important to use assessment tools that are short and easy to apply.

The rMEQ was developed by Adan and Almirall (1991) and only includes items 1, 7, 10, 18, and 19 of the original MEQ (Adan and Almirall 1991). The briefness and psychometric properties of the rMEQ mean that it has been widely used and it has been evaluated in Hungary, France, Spain, America, Italy, the Kingdom of Saudi Arabia, China, Germany, Poland, India, Iraq, Iran, and Portugal (Adan and Almirall 1991; BaHammam et al. 2011; Biswas et al. 2014; Caci et al. 2009; Carciofo et al. 2012; Chelminski et al. 2000; Jankowski 2013; Loureiro and Garcia-Marques 2015; Natale et al. 2006; Rahafar et al. 2015; Randler 2013; Raoof et al. 2014; Urban et al. 2011). With adequate psychometric properties, the rMEQ has good convergent and construct validity with the MEQ and good test–retest reliability (Young 2018). Most of these previous studies found a one-factor structure and similar values for internal consistency. To our knowledge, the rMEQ has not yet been evaluated in Scandinavia. Furthermore, most previous studies have been conducted in samples where the subjects have had similar daytime commitments, e.g. samples of university students (BaHammam et al. 2011; Biswas et al. 2014; Caci et al. 2009; Chelminski et al. 2000; Jankowski 2013; Natale et al. 2006; Rahafar et al. 2015; Raoof et al. 2014), high-school students, or undergraduates (Loureiro and Garcia-Marques 2015). Only a few studies have investigated the rMEQ in groups with larger age spans and different occupations (Adan and Almirall 1991; Carciofo et al. 2012; Randler 2013).

Our primary aim was to test the psychometric properties of the Swedish version of the rMEQ, with a focus on factor structure, reliability and descriptive statistics in both the total sample and across subgroups (age, gender, occupation, tobacco use, alcohol consumption and drug use). To fairly validate the measurement of CT with the rMEQ, questions about sleep onset and difficulties rising in the morning were used. Additionally, as symptoms of depression, anxiety sleep difficulties and daytime sleepiness often are related to even- ingness CT (Alvaro et al. 2014; Au and Reece 2017; Taillard et al. 1999; Tutek et al. 2016), we wanted to investigate the relation between these symptoms with rMEQ to further understand its properties.

Materials and methods

Participants

Participants were 1000 individuals selected randomly from the Swedish Population Register in
Uppsala, Sweden, aged between 16 and 26 years (mean age = 21.8 years ± 3.1). Between October 2014 and May 2015, participants were sent a questionnaire about sleep and health by post. After two reminders, 671 participants (68%) responded. Responders received two cinema tickets as compensation. An advisory statement concerning human subjects was received from the Regional Ethical Board, Uppsala, Sweden.

**Measurement instruments**

Participants received a self-reported questionnaire that included demographic questions about age; sex; occupation; residential status; nicotine, alcohol, and drug use; and assessment questions regarding sleep patterns.

**The rMEQ**

Total scores of the 5-item rMEQ range from 4 to 26, whereby a higher score indicates a morningness CT. The same cutoff scores for determining CT groups were used as in Adan and Almirall (1991) (eveningness: < 12; neither: 12–17; morning: > 17). We did not translate the rMEQ since the MEQ is based on a Swedish MEQ (Ostberg 1973). Furthermore as one of the authors is from Sweden, we had the possibility to extract the rMEQ items from the Swedish version of the MEQ by Östberg. The questions are displayed in Table 1. The original scoring was used where the first four questions were scored 1–5 and question 5 was scored 0–6.

**Table 1.** Factor loadings of the rMEQ in an exploratory factor analysis with maximum likelihood extraction and direct oblimin rotation.

<table>
<thead>
<tr>
<th>Question (Mean (SD))</th>
<th>Factor loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Considering only your own diurnal rhythm, at what time would you get up if you were entirely free to plan your day? 2.8 (0.9)</td>
<td>0.57</td>
</tr>
<tr>
<td>2. After the first half hour after having woken in the morning, how tired do you feel? 2.1 (0.8)</td>
<td>0.36</td>
</tr>
<tr>
<td>3. At what time in the evening do you feel tired and as a result in need of sleep? 3.2 (1.0)</td>
<td>0.50</td>
</tr>
<tr>
<td>4. At what time of the day do you think that you reach your “feeling best” peak? 3.0 (0.8)</td>
<td>0.56</td>
</tr>
<tr>
<td>5. One hears about morning and evening types of people. Which one of these types do you consider yourself to be? 2.2 (1.7)</td>
<td>0.82</td>
</tr>
</tbody>
</table>

SD = standard deviation.

**Sleep variables**

The sleep questions used to validate rMEQ were as follows: falling asleep time on most days of the week (scored from 1 to 5, where 1 was before 21:00 p.m. and 5 was later than 02:00 a.m.); the frequency per week of falling asleep at 01:00 a.m. or later (scored from 0 to 7 days/week); the frequency of being late for school or work because of difficulties waking up in the morning (scored from 1 to 5, where 1 was “never late” and 5 was “late almost every day of the week”); the most common sleep duration (scored from 1 to 5, where 1 was more than 9 h and 5 was less than 6 h); difficulties in falling asleep earlier if needed and in rising at 09:00 a.m. (scored from 1 to 5, where 1 was “not at all difficult” and 5 was “totally impossible”).

**The Insomnia Severity Index (ISI)**

The ISI is a 7-item scale that is scored using a 5-point Likert scale and is a standardized measure of sleep disturbance (Bastien et al. 2001). The ISI assesses the following seven domains of insomnia: severity of initial, middle, and late insomnia; sleep satisfaction; interference of insomnia with daytime functioning; noticeability of sleep problems by others; and distress about sleep difficulties. Total scores range from 0 to 28, whereby higher scores indicate more severe sleep difficulties.

**The Epworth Sleepiness Scale (ESS)**

The ESS is an 8-item symptom scale that is used to evaluate daytime sleepiness. Each item is scored on a 4-point Likert scale, and the total score ranges from 0 to 24. Higher scores indicate greater daytime sleepiness (Johns 1991).

**The Hospital Anxiety and Depression Scale (HADS)**

The HADS is used to evaluate symptoms of anxiety and depression (Zigmond and Snaith 1983). This scale consists of two subscales (anxiety, HADS-A; and depression, HADS-D), each of which has seven items that are scored on a 4-point Likert scale. Total scores range between 0 and 21, and higher scores indicate more severe symptoms of anxiety or depression.
**Statistical analysis**

Data analyses were performed using SPSS Statistics version 20.0. A parallel analysis was used to assess the factor structure of the rMEQ (O’Connor 2000), and Cronbach’s alpha was used to assess the internal consistency of the rMEQ. Composite reliability (i.e. the total amount of true score variance in relation to the total scale score variance) was calculated according to guidelines (Raykov 1997). Composite reliability above the 0.70 threshold has been suggested as acceptable (Hair et al. 1998). A one-way analysis of variance was used to identify significant differences in total rMEQ scores between subgroups that were determined according to age (16–19 years old versus 20–26 years old), sex (male versus female), alcohol intake (less than twice a week versus twice or more a week), drugs (tested versus never tested), nicotine (nicotine use versus no nicotine use), and occupational status (educational activity or work versus no educational activity or work). The number of participants in each subgroup is seen in Table 2. Since age is an interval variable, the correlation between age and rMEQ-score was also analyzed with Pearson correlation coefficient. The correlation between rMEQ-scores and the sleep variables, ESS scores, ISI scores, HADS-A scores, and HADS-D scores were also assessed using Pearson correlation coefficient. The strengths of the correlations were set according to those outlined by Cohen, whereby $r = 0.1–0.3$ was defined as a weak correlation, $r = 0.3–0.5$ a moderate correlation, and $r > 0.5$ a strong correlation (Cohen 1988).

**Results**

**Factor structure of the rMEQ**

The initial analyses of the factorability of the rMEQ resulted in a Kaiser–Meyer–Olkin measure of sampling adequacy index of 0.74 and a significant Bartlett Test of Sphericity ($\chi^2 = 584.31, p \leq 0.001$), which indicated that the data were suitable for factor analysis. The parallel analysis suggested a one-factor solution. A further exploration of this solution (explaining 45.2% of the variance) revealed four items with low communalities (i.e. <0.40; item 1: 0.32, item 2: 0.13, item 3: 0.25, and item 4: 0.31) and one item with adequate communality (item 5: 0.66). The factor loadings of the rMEQ are displayed in Table 1. Subgroup analyses demonstrated similar factorial findings for the following demographic parameters: age (teenagers and young adults separately), sex (women and men separately), and occupational status (persons with no educational activity or work and persons with an educational activity or work separately). These latter analyses are not presented in detail in this paper but can be sent to interested readers.

**Internal consistency of the rMEQ**

The internal consistency of the rMEQ was $\alpha = 0.68$. Cronbach’s alpha, analyzed from the total rMEQ, decreased slightly after removing items 1, 3, and 4 (the value of the alpha ranged between 0.61 and 0.63) and more substantially after removing item 5 ($\alpha = 0.55$). The inter-item correlations of the rMEQ

<table>
<thead>
<tr>
<th>Table 2. Descriptive statistics across subgroups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (%)</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
</tr>
<tr>
<td>16–19</td>
</tr>
<tr>
<td>20–26</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td><strong>Occupational status</strong></td>
</tr>
<tr>
<td>Educational activity or work</td>
</tr>
<tr>
<td>No educational activity or work</td>
</tr>
<tr>
<td><strong>Alcohol use</strong></td>
</tr>
<tr>
<td>Less than 2 times per week</td>
</tr>
<tr>
<td>2 times or more per week</td>
</tr>
<tr>
<td><strong>Nicotine use</strong></td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td><strong>Drug use</strong></td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

*p < .05. **p < .01.
were between 0.08 and 0.46. The composite reliability for the rMEQ items was acceptable at 0.71.

**Descriptive statistics for the rMEQ in the total sample and in subgroups**

In the total sample, the rMEQ scores were normally distributed (kurtosis: 0.03; skewness: −0.21). The mean rMEQ total score was 13.1 (SD = 3.5) and ranged from 4 to 24. The mean score for each of the five items are displayed in Table 1. According to the cutoff scores, we identified 118 (32.5%) evening types, 374 (55.7%) neither types, and 79 (11.7%) morning types.

We examined subgroup differences in rMEQ scores, according to age; sex; occupational status; and use of nicotine, alcohol, and drugs (see Table 2). The following participants scored significantly lower on the rMEQ: younger participants (16–19 years old) compared to young adults (BaHammam et al. 2011; Biswas et al. 2014; Carciofo et al. 2012; Jankowski 2013; Natale et al. 2006; Randler 2013; Raoof et al. 2014), male participants compared to female participants, participants with no educational activity or work compared to those with an educational activity or work, and those who used nicotine compared to those who did not use nicotine. Age had a positive correlation to rMEQ. When age was analyzed as an interval variable, it demonstrated a correlation with rMEQ ($r = 0.13, p < 0.01$), where lower age was correlated with lower scores on rMEQ.

**Validity of the rMEQ**

To examine the validity of the rMEQ, scores of the rMEQ and its five items were correlated with sleep onset timing, frequency of falling asleep at 1:00 a.m. or later, frequency of being late to school/work because of difficulties waking up in the morning, sleep duration, difficulties falling asleep earlier if needed, and difficulties rising at 09:00 a.m. (see Table 3). A negative correlation was observed between rMEQ score and the sleep variables. Whereas being more evening-oriented was correlated to late sleep onset timing, high frequency of falling asleep at 1:00 a.m. or later, shorter sleep duration, higher frequency of being late to work/school because of difficulties waking up in the morning, difficulties falling asleep earlier if needed, and difficulties rising at 9:00 a.m. There were similar results for the five rMEQ items when they were tested separately.

**Correlations between rMEQ and its items with ISI, ESS, HADS-A, and HADS-D**

The rMEQ and its items (except for item 3) were negatively correlated with ISI scores and HADS-D scores. Negative correlations were also demonstrated between two of the rMEQ items (Young 2018; Randler et al. 2016) and ESS scores and HADS-A scores. The results are displayed in Table 4.

**Discussion**

The Swedish version of the rMEQ seems to have acceptable psychometric properties regarding validity; however, the internal consistency was only satisfactory and the percentage of explained variance was relatively low. Across the subgroups male gender, younger age (teenagers), no work or educational activity, and nicotine use were associated with eveningness CT.

<table>
<thead>
<tr>
<th>Table 3. Correlations between rMEQ scores and questions assessing sleep onset, sleep duration, and rising in the morning.</th>
</tr>
</thead>
<tbody>
<tr>
<td>rMEQ: total</td>
</tr>
<tr>
<td>Sleep onset timing</td>
</tr>
<tr>
<td>Frequency of falling asleep at 1:00 a.m. or later</td>
</tr>
<tr>
<td>Sleep duration</td>
</tr>
<tr>
<td>Frequency of being late to school/work because of difficulties waking up in the morning</td>
</tr>
<tr>
<td>Difficulties falling asleep earlier if needed</td>
</tr>
<tr>
<td>Difficulties rising at 09:00 a.m.</td>
</tr>
</tbody>
</table>

*p < 0.05. **p < 0.01.
Moreover, a correlation was observed between lower rMEQ scores and higher severity of sleep difficulties and depressive symptoms.

**Psychometric properties of the rMEQ**

In the present study, the reliability and validity of the Swedish version of the rMEQ was evaluated in a random sample of adolescents and young adults. The rMEQ displayed a one-factor structure and could thus be regarded as unidimensional. This finding was stable even when dividing data into different subgroups depending on sociodemographic data. This is consistent with most research on the rMEQ (Jankowski 2013; Rahafar et al. 2015; Randler 2013). Our understanding of the usefulness of the rMEQ could benefit from using confirmatory factor analysis and item response theory analysis in future research.

The Swedish rMEQ had a satisfactory but not optimal reliability. The Cronbach’s alpha was somewhat lower (0.68) than the usually accepted level of 0.70. Other evaluations of the rMEQ have found a Cronbach’s alpha between 0.69 and 0.78 (Caci et al. 2009; Jankowski 2013). In one Hungarian sample, Cronbach’s alpha was even lower at 0.56 (Urban et al. 2011). In that study, the mean age of participants was younger (15.3 years) than in the present study (21.8 years), and the rMEQ had an additional question (morning fatigue/freshness on free days). Low Cronbach’s alpha values can be caused by a small sample size, a small number of items, the administration of data-collecting tools, or poor inter-relations between items. However, we had an acceptable sample size of 671 participants; thus, the consistency of the questionnaire with only five items might contribute to the low Cronbach’s alpha. In the present study, we do not know how motivated the responders were when they filled out the questionnaire and we do not know if the responders filled out the entire questionnaire at once or did a bit every now and then. We tried to limit the amount of questions but there is always a risk that questionnaires appear too lengthy. Furthermore, our sample included a randomly selected group of young adults and adolescents, compared to samples including only college or university students or youngsters in secondary school, which are more often observed in other studies of the rMEQ. This might have affected both the Cronbach’s alpha and the inter-item correlations. A weak correlation was observed between items 2 and 3, and item 2 (which measures tiredness when waking up) had a weak correlation with total rMEQ-scores and with each of the items of the rMEQ separately. The finding of a lower inter-item value for item 2 is in accordance with the findings of other studies (Loureiro and Garcia-Marques 2015; Randler 2013) Morning tiredness is related to CT preference; however, feeling tired in the morning might not only be caused by a late CT, but could also be the result of other health or social problems that disturb sleep. Furthermore, the question might be better adapted to a group with similar morning commitments since the question never addresses at what time the respondent actually wakes up in the morning.

In the present study, the distribution of the total rMEQ scores in the sample were neither > eveningness > morningness CT. This is in accordance with earlier studies conducted in healthy young adults and adolescents (BaHammam et al. 2011; Chelminski et al. 2000; Natalee et al. 2006). However, some other studies found an order of neither > morningness > eveningness CT (Loureiro and Garcia-Marques 2015; Raoof et al. 2014; Urban et al. 2011). These three studies were conducted in Hungary, the Middle East, and Portugal. It is known that latitude can influence CT distribution, whereby the CT of individuals living in northern Europe tends to be more eveningness-oriented compared to those living in Central Europe (Borisenkov et al. 2010). Furthermore, our results can be explained by

<table>
<thead>
<tr>
<th></th>
<th>rMEQ: total</th>
<th>rMEQ: item 1</th>
<th>rMEQ: item 2</th>
<th>rMEQ: item 3</th>
<th>rMEQ: item 4</th>
<th>rMEQ: item 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISI</td>
<td>−0.30**</td>
<td>−0.18**</td>
<td>−0.41**</td>
<td>−0.07</td>
<td>−0.20**</td>
<td>−0.21**</td>
</tr>
<tr>
<td>ESS</td>
<td>−0.06</td>
<td>−0.05</td>
<td>−0.20**</td>
<td>0.06</td>
<td>−0.08</td>
<td>−0.01</td>
</tr>
<tr>
<td>HADS – Anxiety</td>
<td>−0.05</td>
<td>−0.01</td>
<td>−0.28**</td>
<td>0.10*</td>
<td>−0.02</td>
<td>−0.03</td>
</tr>
<tr>
<td>HADS – Depression</td>
<td>−0.25**</td>
<td>−0.14**</td>
<td>−0.31**</td>
<td>−0.06</td>
<td>−0.16**</td>
<td>−0.19**</td>
</tr>
</tbody>
</table>

ESS = Epworth Sleepiness Scale, HADS = Hospital Anxiety and Depression Scale, ISI = Insomnia Severity Index. *p < 0.05, **p < 0.01.
several other factors such as differences in time for sunrise, different climate, and cultural differences. There is evidence that the circadian clock synchronizes to sunrise where earlier time for sunrise leads to earlier awakenings (Randler 2008) and that morning CT are more common in countries with warmer climate (Tonetti et al. 2012). Additionally, cultural differences are important for the distribution of CT. The study from Sudan where time for morning prayers was suggested as a reason for the high prevalence of morningness CT is a typical example of the importance of cultural differences (BaHammam et al. 2011).

In line with several other studies (Randler 2013; Randler et al. 2016; Urban et al. 2011), we found that male participants had a significantly higher eveningness preference according to rMEQ than female participants. Night activities such as computer gaming and non-favorable sleep habits such as nicotine, alcohol, and drug use are often more common among young men (Kuhn 2015; Willoughby 2018) and might cause the increased eveningness CT in this group. However, there are also studies that have failed to find sex differences for total rMEQ scores (Caci et al. 2009; Jankowski 2013; Loureiro and Garcia-Marques 2015; Raoof et al. 2014).

Furthermore, absence of educational or work activities was associated with eveningness in the present study. This might be due to several reasons; both unemployment and sick leave can lead to socioeconomic deprivation and can result in sleep problems (Paine et al. 2014), and there is an increased incidence of psychiatric disorders in those with eveningness CT (Au and Reece 2017; Reid et al. 2012), which can make ongoing employment difficult. Additionally, there is no pressing need to wake up at a certain time when one is unemployed.

It is known that the midpoint of sleep becomes increasingly later from 10 years of age until about 20 years of age, after which people tend toward earlier CTs again (Roenneberg et al. 2004). This phenomenon is in accordance with our finding that significantly lower rMEQ scores (eveningness) were related to the teenage group compared to the young adults. This result is further supported by Randler et al. (2017) who found that

the turning point toward morningness is 15.7 years in girls and 17.2 years in boys (Hagenauer et al. 2009).

The finding that nicotine use was associated with eveningness CT was expected since nicotine and other psychostimulants can influence sleep, shortened sleep duration, prolonged sleep latency, and lighter sleep (McNamara et al. 2014; Zhang et al. 2006). Eveningness orientation measured with rMEQ has also previously been associated with nicotine use (Adan 1994). Surprisingly, there were no significant correlation between eveningness and alcohol consumption. Other studies have found a correlation between increased alcohol use and eveningness CT both in adolescents and in adults (Adan 1994; Prat and Adan 2011; Urban et al. 2011). In the present study, we cannot interpret if any of the participants had a hazardous alcohol use or if there were any hangover symptoms caused by alcohol use disorder, since there was only one dichotomized question about weekly alcohol consumption. Furthermore, persons with delayed sleep patterns and late CT are not a homogenous group considering substance use, as have been observed in a study on DSPD (Danielsson et al. 2016).

Very few studies have investigated the validity of the rMEQ in relation to other measures of circadian rhythm or sleep patterns. However, the rMEQ has been compared to the Composite Scale of Morningness (Caci et al. 2009) and external validity has been tested with actigraphy monitoring (Natale et al. 2006). Both these studies presented results pointing toward a sound validity of the rMEQ. In the present study, five questions about sleep onset and difficulties rising were used to validate the measurement of CT with the rMEQ. The strong correlations observed between lower rMEQ scores (eveningness) and later sleep times, difficulties rising in the morning, often arriving late to work/school, and difficulties in falling asleep earlier if needed indicate that the rMEQ has a good validity. Future studies could also use sleep diaries, melatonin sampling, or core body temperature measurements for validation of rMEQ. Furthermore, to analyze rMEQ with a confirmatory factor analysis could be of interest to evaluate the factorial validity.
Correlations of rMEQ with depressive and anxiety symptoms, sleep difficulties, and daytime sleepiness

A correlation between “eveningness” and more depressive symptomatology and sleep difficulties was observed in the present study; this finding is in accordance with previous studies (Au and Reece 2017; Hirata et al. 2009; Simor et al. 2014; Tutek et al. 2016). There is growing evidence that depression and circadian disturbances are closely related and may even have a common etiology and common genetic factors (Bielen et al. 2015; Merikanto et al. 2013). Furthermore, short sleep durations can increase the vulnerability to depression (Toomey et al. 2014). That said, depressive symptoms might result in less daylight because of reduced physical and social activity which in turn leads to poorer sleep. Furthermore, sleep disturbances and morning tiredness can be symptoms of depression, but can also be a co-occurring phenomenon of a sleep disorder (American Academy of Sleep Medicine 2014).

There was no significant relationship between CT and anxiety in the present study. Similar results have been observed both in adolescents and in young adults (Pasch et al. 2010; Selvi et al. 2012; Taylor et al. 2011). Furthermore, eveningness CT has not been observed as a risk factor for any anxiety disorder (Antypa et al. 2016). Contradictorily, there are some studies that have observed an association between anxiety and eveningness (Alvaro et al. 2014; Lemoine et al. 2013; Pabst et al. 2009; Passos et al. 2017). These studies have, however, investigated specific groups, for example, only young girls, insomnia patients, or psychiatric patients. In the present study, we used a random sample from the population which might explain our results.

Daytime sleepiness was not significantly related to total rMEQ scores. Relationships between eveningness and higher daytime sleepiness have been reported (Taillard et al. 1999; Tutek et al. 2016). The difference between our own results and those of the previous studies may be explained by the fact that their samples were conducted in adults (the age ranged between 18–43 and 17–80 years, respectively) compared to our study (16–26 years). Swedish universities and high schools do not always have mandatory presence in whole class lectures, and there are possibilities to choose evening courses for many students. Therefore, younger adults and adolescents may have the opportunity to compensate late bedtimes with adequate sleep in the morning. Adults, on the other hand, generally have more obligations to be awake early in the morning and thus risk to experience inadequate sleep and more daytime sleepiness as a result for adults with an eveningness CT.

Limitations

The present study relied on self-reported measures, which might result in response biases. We were not able to determine any somatic or psychiatric diagnosis or potential treatments precisely, and these factors could affect sleep. Furthermore, we did not specifically ask the respondents about their understanding of the questions. To use a think-aloud method might be interesting in future studies of rMEQ. Since this study is cross-sectional, we could not examine test–retest reliability. Choosing a sample with adolescents and young adults was useful since sleep disturbances and delayed sleep–wake patterns and circadian rhythms are more common in this age-group. However, choosing a specific age group may have influenced the evaluation of the psychometric properties of the rMEQ. We therefore suggest that future studies of the Swedish rMEQ examine validity and test–retest reliability in a large population and in different age groups.

Conclusion

To our knowledge, this was the first study to assess the psychometric properties of the Swedish rMEQ. The main finding was that the Swedish version of the rMEQ had a one-factor structure and the rMEQ score was well correlated to other questions about sleep–wake patterns. However, the explained variance was relatively low, and the internal consistency was only satisfactory. Eveningness was related to lower age, male sex, nicotine use, sleep difficulties, and depressive symptoms. Finally, these results partly question the usefulness of the rMEQ, because of its reliability. Nevertheless, due to the fair validity observed in this study, we suggest that the rMEQ could be preferred to measure CT in large epidemiological studies or as an initial screening in
preventive or treatment studies, especially when there is a need to reduce the length of the questionnaire.

Declaration of Interest

This was not an industry-supported study. There are no conflicts of interest to declare for any of the authors.

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