TRENDS IN TIMING OF SLEEP IN THE GENERAL POPULATION OF NORWAY: 1980 TO 2000

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Summary. — The aim of the current study was to examine whether the timing of sleep have changed over the last two decades. As part of a general survey of activities throughout the 24-hr. cycle, collected in 1980, 1990, and 2000 by Statistics Norway, information on sleep timing was obtained for every 15-min. interval for 1 wk. All three samples were representative of Norwegians. The age span was from 16 to 74 years. Timing of sleep was significantly delayed in 2000 compared to 1990 and especially so in 1980, but with no change in total amount of sleep. From 1980 to 2000, there was an increasing discrepancy in sleep or wake timing between weekdays and weekends. The current analyses show that people sleep as much as before but do so at different times. The increased discrepancy between weekdays and weekends indicates that overall sleep habits are poorer now than previously.

According to the two-process theory, sleep is regulated both by a homeostatic (Process S) and a circadian (Process C) factor. The homeostatic factor reflects accumulation of sleep need which accumulates during wakefulness (Borbely, 1982). The strength of the homeostatic factor correlates positively with the amount of short-wave sleep (SWS) obtained following a wake period and negatively with sleep-onset latency (Bonnet, 2005). This is, for example, reflected in recovery sleep following sleep deprivation, which among others, is characterized by a large increase in slow-wave sleep (deep sleep) and a shortening of the sleep latency compared to baseline (Carskadon & Dement, 1979).

The circadian (circa = about, dies = day) factor influences sleep independently of the homeostatic factor (Borbely, 1982) and is governed by the suprachiasmatic nuclei (SCN) situated in the hypothalamus. These nuclei

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are regarded as the master clock of all bodily processes synchronizing the
different circadian bodily processes and functions (Gillette & Tischkau,
1999). For example, sleep usually is initiated when the core body temper-
ature starts dropping (normally in the evening) and normally ends ap-
proximately 2 hr. following its lowest point (nadir). The time for nadir of
the core body temperature rhythm for most people is early in the morning
(Brown & Czeisler, 1992).

Although the two above-mentioned factors are heavily rooted in bio-
logical and automatized processes, they are not isolated from behavioral
and societal factors. It is, for example, well-documented that poor sleep
habits often compromise quality of sleep in adolescents (LeBourgeois, Gi-
annotti, Cortesi, Wolfson, & Harsh, 2004). Several aspects of modern soci-
ety also seem to take a toll on sleep. Night work, which has increased dur-
ing the last decades, is associated with reduced sleep duration (Akerstedt,
2003). Use of modern tools and entertainment opportunities such as tele-
vision, mobile phones, internet and computer games is related to curtailed
sleep and is also associated with sleepiness (Van den Bulck, 2004, 2007).

Given this, there is concern about the potential detrimental effects of the
so-called 24-hour society on sleep (Ferrara & De Gennaro, 2001; Rajarat-
nam & Arendt, 2001; Bonnet, 2005). Recently, several studies of sleep-re-
lated trends have been carried out, and the majority of these suggest that
sleep is deteriorating. In a Swiss study following three birth cohorts (born
in 1974, 1979, and 1986) from 0 to 16 years of age, parental reports showed
that the children slept statistically significantly less in the 1990s than in
the 1970s. This change was mostly accounted for by later bedtimes in the
1990s (Iglowstein, Jenni, Molinari, & Largo, 2003). Similarly, in an Aus-
tralian study of self-reported sleep duration of adolescents, a statistically
significant reduction in sleep time from 1985 to 2004 was observed, mostly
associated with postponed bedtimes in 2004 (Dollman, Ridley, Olds, &
Lowe, 2007). In a trend study comprising students 11, 13, and 15 years old,
an increase from 12 to 20% in the prevalence of sleep-onset problems was
noted from 1983 to 2005 (Pallesen, Hetland, Sivertsen, Samdal, Torsheim,
& Nordhus, 2008). Data from the United States suggested that the number
of hours asleep in healthy adults (50–65 years old) has reduced from 8 or
9 hr. in 1959 to approximately 7 or 8 hr. in the mid-1980s (Bliwise, King,
Harris, & Haskell, 1992). In a study comprising college students, self-re-
ported sleep duration was reduced by 30 min. from 1978 to 1988 (Hicks,
Mistry, Lucero, Lee, & Pellegrini, 1989). Also, a recent reanalysis of all sur-
veys conducted in Finland from 1972 to 2005 showed a small (5.5 min.
per decade) decrease in sleep duration during the 33-year time interval
(Kronholm, Partonen, Laatikainen, Peltonen, Harma, Hublin, et al., 2008).

Thus, the overwhelming majority of studies on sleep-related trends
indicate that sleep has been curtailed during the last 50 years. Still, no study has investigated whether timing of sleep has changed over the years in the general population. To address this issue specifically, a study using existing data collected over two decades, from 1980 to 2000, in Norway was conducted. The aim was to assess whether the timing of sleep has changed over the last two decades and to compare data on this issue from 1980, 1990, and 2000.

**Method**

**Materials and Procedure**

Data were provided by Statistics Norway, which conducted surveys in 1980, 1990, and 2000, to have people describe at which times they did different activities such as leisure and work, as well as sleep, during a 24-hr. day. Each participant was visited in person by a study interviewer who explained in detail how to complete the activity diaries. The participants were also given a short pamphlet with this information. At various time intervals spanning across the seasons, participants completed an activity log for seven consecutive days, during which they indicated a specific activity for every 15-min. interval during the week. The response rates at the different time points were 65.4% (1980), 63.6% (1990), and 49.6% (2000), yielding sample sizes of \( n = 3,307 \), \( n = 3,097 \), and \( n = 3,211 \), respectively. All three samples were representative of the Norwegian population in terms of socioeconomic status, education, income, place of residence, and sex of respondents. Although the proportion of older adults in Norway increased from 1980 to 2000, the mean age was similar in the three studies used in the present paper, and also the sex and geographical distributions were comparable in the three studies. The age span was from 16 to 74 yr. Because many of these raw data were unavailable for the present analyses, the statistical calculations were limited to chi-squared analyses based on the proportion of participants reporting to be awake or sleeping at the different times of the night or day. For this reason, further exploration of possible age and sex differences could not be undertaken. All data were weighted for sample size, and separate analyses were conducted for weekdays (Monday to Thursday) and Saturdays. For the present study, focus was on the sleep-wake patterns.

Fridays and Sundays were disregarded in the current study given overlap between weekdays and weekend. IBM SPSS Statistics Version 19 for Mac (SPSS, Inc., Chicago, IL) was applied in the statistical analysis. Statistical significance was set at \( p < .05 \).

**Results**

Analyses yielded statistically significant changes in sleep timing from 1980 to 2000, as detailed in Fig. 1 and Table 1. For weekdays, statistically
significantly fewer participants reported to be sleeping from 21:30 to 01:30 in 1990 and 2000 than in 1980. Using 23:30 as an example, whereas 72% (95% CI = 70.9, 73.1) were sleeping at 23:30 in 1980, this proportion was reduced to 55% (95% CI = 53.7, 56.3) in 2000. Correspondingly, a larger proportion of the participants in 1990, and especially in 2000, reported to be sleeping in the hours from 05:30 to 12:00 than in 1980. In 1980, for example, 23% (95% CI = 22.0, 24.0) of the population were still sleeping at 07:30. This proportion had increased to 33% (95% CI = 31.8, 34.2) in 2000. This change was even more prominent on Saturdays. In 1980, 74% (95% CI = 72.9, 75.1) reported to be sleeping at midnight, while less than 43% (95% CI = 41.7,
**TABLE 1**

**Proportion of Participants Reporting to Be Asleep From 1980–2000 Stratified by Days of the Week**

<table>
<thead>
<tr>
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<td>81.0, 83.0</td>
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<td>61.0a</td>
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<td>63.0b</td>
<td>61.8, 64.2</td>
<td>68.0a</td>
<td>66.8, 69.2</td>
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<td>42.0a</td>
<td>40.8, 43.2</td>
<td>48.0a</td>
<td>46.7, 49.3</td>
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<td>27.0a</td>
<td>25.9, 28.1</td>
<td>33.0a</td>
<td>31.8, 34.2</td>
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<td>12.2, 13.8</td>
<td>17.0a</td>
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**Note.** — a, b, c = Different letters within the same line signify significant (p < .05) differences between the time points.
44.3) reported they were sleeping at this hour in 2000. However, there were no statistically significant changes in self-reported sleep duration among the three time points (in 1980: 7 hr. 49 min.; in 1990: 7 hr. 57 min.; and in 2000: 7 hr 51 min.).

Also, the difference between weekdays and Saturdays increased statistically significantly from 1980 to 2000. For example, the difference between weekdays and Saturdays in how many persons reported being asleep at midnight was 16% in 1980, compared to 31% in both 1990 and 2000 (Table 1). Similarly, in 1980 the difference between the proportion who were sleeping at 09:30 on weekdays versus Saturdays was 13%, compared with 18% in 1990 and 23% in 2000 (all ps < .001, Table 1).

Discussion

The present aim of these analyses was to examine whether the timing of sleep in the general population had changed over the last three decades. There is a clear pattern of a delayed bedtime in 2000 in comparison with both 1990 and, especially, 1980, with a corresponding delay in wake/rise times in the mornings. Also, timing of sleep was delayed in 1990 when compared with 1980. These differences were statistically significant for weekdays and especially for weekends. It was also found that the difference in sleep-wake timing between weekdays and Saturdays increased statistically significantly from 1980 to 2000. The total amount of sleep remained unchanged over the two decades. In sum, these observations indicate that people sleep as much as before but do so at different times.

There are several aspects of modern society which may help to explain this change in timing of sleep. From an historical perspective, the introduction of artificial lighting in the 19th century resulted in a restructuring of work times which increasingly has detached people from the regular 24-hr. cycle of light. Although no changes in actual sleep duration from 1980 to 2000 were found in the current study, it has been suggested that people sleep less now than in previous centuries (Foster & Wulff, 2005). In terms of changes in working hours, examination of data from the United States Department of Labor (2005) shows there were twice as many workers on flexible and shift schedules in 2001 than in 1985. Today, more than 20% of the working-age population spends at least part of their work hours outside the 7 a.m. to 7 p.m. interval (Kreitzman, 1999). In comparable statistics from the UK, the proportion of workers who say they work night shifts "most of the time" or "usually" rose from 13 to 15% between 1993 and 2003 (The Parliamentary Office of Science and Technology, 2005). A shift in work schedules, in which more work hours were pushed forward, may lead to a correspondingly delayed bedtime. The introduction of modern work schedules in the 1970s reduced the working
week from 40+ hr. to 36 to 38 hr. per week, which consequently has increased time available for leisure activities (Wedderburn, 1996). The subsequent increase in use of videogames, 24-hr. television, Internet, etc., may explain why an increasingly larger proportion now appear to stay up later at night. In Norway, for example, only a single TV channel was widely available for the general population until the beginning of the 1990s, with limited hours of broadcast ending at what used to be considered “normal bedtime.” Similarly, cell phones, video-game consoles, and the Internet did not become publicly available in Norwegian households until the mid- and late 1990s. These factors in combination may have delayed bedtime and contributed to stretching the timing of sleep from those of previous decades.

Whereas considerable research has focused on the consequences of sleep restriction, specifically with regard to daytime functioning (Dinges, Rogers, & Baynard, 2005), recent studies have also found evidence of changes in both immune (Balachandran, Ewing, Murray, Lebeau, & Mullington, 2002) and endocrine functioning (Spiegel, Leproult, & Van Cauter, 1999) due to sleep restriction, and sleep loss may also disrupt the circadian timing system. Although present data analyses showed no change in actual sleep time, the change in sleep timing may be detrimental, especially considering the increasing difference between weekdays and weekends from 1980 to 2000. This increased instability of sleep schedules may lead to less stable circadian rhythms, as Burgess and Eastman (2004) reported on an individual level, delaying bedtime was significantly associated with phase delay of the circadian rhythms. Similarly, late wake time has delayed the human dim-light melatonin rhythm (Burgess & Eastman, 2006), demonstrating that, when the timing of sleep/wake-rhythm is shifted, there is a closely corresponding shift in the human circadian-clock phase. Although the consequences of such changes in the circadian system remain unclear, the circadian system is known to coordinate a range of endogenous behavioral and physiological systems, mainly due to the daily exposure to the 24-hr. light-to-dark cycle (Rogers & Dinges, 2008). Furthermore, long-term disruption of the circadian rhythms has been linked to adverse health consequences in animals, particularly in the development or exacerbation of cardiovascular disease (Martino, Oudit, Herzenberg, Tata, Koletar, Kabir, et al., 2008). Suppression of melatonin production is also associated with disrupted circadian rhythm and there are indications that this may increase the risk of developing cancer in both humans and animals (Straif, Baan, Grosse, Secretan, El Ghissassi, Bouvard, et al., 2007).

A consistent weekday/weekend sleep schedule is reported to be important for people across age groups. In children, for example, sleep irregularities from weekdays to weekends have been shown to predict poor
adjustment in preschool (Bates, Viken, Alexander, Beyers, & Stockton, 2002), and is associated with increased risk for internalizing symptoms (Pesonen, Raikkonen, Paavonen, Heinonen, Koms, Lahti, et al., 2010). In adolescents, sleep differences on school versus nonschool nights have been linked with symptoms of anxiety, depression, and fatigue (Fuligni & Hardway, 2006). It is likely that a delayed “sleep window” may affect people’s exposure to physical activity and dietary environments, irrespective of age. For example, those who get up early might have more available time and thus be more likely to engage in physical activities in the morning and eat healthy breakfasts, compared to persons who have a more delayed sleep-wake rhythm.

There are some methodological limitations to the study that should be noted. Some of the original data files were lost during a transfer from Statistics Norway (which conducted the survey) to the Norwegian Social Science Data Services (NSD), which is the largest archive for research data in Norway, where all the aggregated data used in this study were kept. As a consequence, the dataset does not provide individual-level data that would have allowed us to address possible individual correlates of change in sleep patterns, hereunder potential age and sex differences. This would have been interesting with regards to recent time-trends studies showing increasing sleep-onset problems from 1983 to 2005 in adolescents (Pallesen, et al., 2008). The information on sleep and wake time was registered through completed sleep diaries and should reflect actual behavior and not be affected by, e.g., changes in perceived suitable bed-times or other issues.

REFERENCES


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