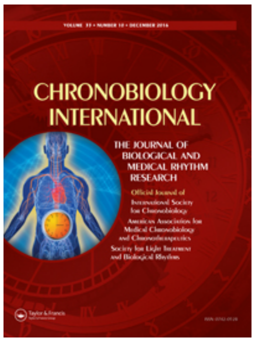

Chronobiology International
The Journal of Biological and Medical Rhythm Research

ISSN: 0742-0528 (Print) 1525-6073 (Online) Journal homepage: https://www.tandfonline.com/loi/icbi20

Individual differences in the sleep/wake cycle of Arctic flexitime workers

Daniela Wey, Johanna Garefelt, Frida M. Fischer, Claudia R. Moreno & Arne Lowden

To cite this article: Daniela Wey, Johanna Garefelt, Frida M. Fischer, Claudia R. Moreno & Arne Lowden (2016) Individual differences in the sleep/wake cycle of Arctic flexitime workers, Chronobiology International, 33:10, 1422-1432, DOI: 10.1080/07420528.2016.1227331

To link to this article: https://doi.org/10.1080/07420528.2016.1227331

Published online: 16 Sep 2016.

CHRONOBIOLOGY INTERNATIONAL
2016, VOL. 33, NO. 10, 1422–1432
http://dx.doi.org/10.1080/07420528.2016.1227331

ORIGINAL ARTICLE

Individual differences in the sleep/wake cycle of Arctic flexitime workers

Daniela Wey[a,b,c], Johanna Garefelt[a], Frida M. Fischer[b], Claudia R. Moreno[a,b], and Arne Lowden[a]

[a]Stress Research Institute, Stockholm University, Stockholm, Sweden; [b]School of Public Health, São Paulo University, São Paulo, Brazil; [c]Faculdades Metropolitanas Unidas, São Paulo, Brazil

ABSTRACT

Daytime workers tend to have shorter sleep duration and earlier sleep onset during work days than on days off. Large individual differences in sleep onset and sleep duration may be observed on work days, but work usually synchronizes sleep offset to a similar time. The present study describes individual differences in sleep behaviour of 48 daytime workers (25 men, aged 20–58 years) from an iron ore mine in Northern Sweden. The aim of the study was to determine whether differences in sleep patterns during work days were associated with the outcomes of sleepiness and sleep complaints. Cluster analysis was used to group workers into two categories of sleep onset and sleep duration. The "Late Sleep Onset" cluster comprised workers who slept 1.30 h later than the "Early Sleep Onset" cluster ($p < 0.0001$ for all weekdays). The "Long Sleep Duration" cluster slept 1.10 h longer than the "Short Sleep Duration" cluster ($p < 0.0002$ for work nights). The "Late Sleep Onset" cluster reported less refreshing sleep ($p < 0.01$) and had lower sufficient sleep scores ($p < 0.01$) than the "Early Sleep Onset" cluster. The "Short Sleep Duration" cluster also reported lower scores for sufficient sleep ($p < 0.04$) than the "Long Sleep Duration" cluster. For combined characteristics (phase and duration), workers with a late phase and short sleep duration reported greater sleep debt and sleepiness than workers with an early phase and short sleep duration ($p < 0.02$). Work schedule and commuting time modulate both sleep phase and sleep duration independently. Workers, classified as having an intermediate sleep phase preference, can organize their sleep time in order to minimize sleep debt and sleepiness symptoms. Individual differences in sleep phase and duration should be considered when promoting well-being at work even among groups with similar sleep needs. In order to minimize sleep debt and sleepiness symptoms, successful sleep behaviour could be promoted involving extend use of flexitime arrangement (i.e. later starting times) and reduce use of alarm clocks.

ARTICLE HISTORY
Received 26 January 2016
Revised 2 August 2016
Accepted 18 August 2016

KEYWORDS
Sleep duration; sleep phase; sleep debt; sleepiness; cluster analysis; work hours; daytime work

Introduction

Sleep is vital for maintaining physical and mental health, and to perform well at work. According to a recent literature review published by the National Sleep Foundation, a healthy adult's daily sleep should be 7–9 hours (Hirshkowitz et al., 2015). These data indicate a large inter-individual variation that could be mediated by numerous factors. According to previous studies in the literature, sleep duration has an endogenous characteristic (Aeschbach et al., 2003), but also has exogenous influences from socioeconomic factors (i.e. marital status, income, life style, work hours, and sleep in connection to work & leisure) (Boivin & Boudreau, 2014; Lallukka et al., 2012). This discussion has also to include time-of-day and circadian rhythm influences from natural light/dark cycles (environmental factors). This effect is exemplified by a study carried out in the Russian Arctic region showing that sleep patterns are modified by time of sunrise. The study showed shorter sleep duration and later sleep offset (diurnal preference) during equinoctial periods [October to December] compared to the period when days become longer [January to May] (Borisenkov, 2011). In a study with day workers in an Equatorial area (Moreno et al., 2015), we have found differences in sleep duration according to the availability of electricity at home: those without electricity at home used to sleep longer than those with electricity at home. This corroborates the relevance of being exposure to natural and artificial light on sleep duration. Finally, sleep time duration has been shown to be strongly influenced by sleep complaints (Cohen-Mansfield & Perach, 2012; Roepke & Duffy, 2010).

CONTACT Daniela Wey danicrono@gmail.com School of Public Health, São Paulo University, Av. Dr. Arnaldo, 715 – CEP: 01246-904, Brazil.

According to Mallon and collaborators (2014), difficulty initiating and/or maintaining sleep once or twice a week occurred in 24.6% of the Swedish adult population. Subjects with insomnia slept, on average, 5.8 hours on week nights, while normal sleepers slept approximately 7.0 hours. Individual differences in sleep duration among healthy individuals were observed: standard deviation values ranged from 20 minutes to 3 hours during the work days (Kalenkoski & Pabilonia, 2012; Moore et al., 2011).

Individual differences in sleep duration among healthy individuals were observed: standard deviation values ranged from 20 minutes to 3 hours during the work days (Kalenkoski & Pabilonia, 2012; Moore et al., 2011).

The preferred timing of sleep and wakefulness is often associated with diurnal type (or so-called diurnal preferences). Evening types usually go to bed later than morning types (Åkerstedt & Gillberg 1990; Torsvall & Åkerstedt, 1980). Studies of the relationship between sleep and work hours have revealed individual differences in sleep timing and sleepiness for subjects of the same age on similar work hour schedules (Horne, 2010, Kerkhof, 1985). Roepke and Duffy (2010) observed that evening types reported greater difficulty adjusting time of sleep to their work schedules, especially when early start times were required. It has also been shown that during a work week, sleep debt may accumulate and attempts are made to compensate this sleep loss during weekends (Roepke & Duffy, 2010), most commonly by extending sleep duration and delaying sleep onset (Basner et al., 2007; Binkley, 1993). Supplementary sleep episodes must be considered in this context, for example, napping seems more frequent among evening types who work in the morning than in morning types, whereas morning types who work at night usually nap more frequently than evening types (Torsvall & Åkerstedt, 1980).

As a consequence of this multifactorial influence on adult sleep duration and timing, individuals may develop chronic partial sleep deprivation, diseases and alterations in metabolic functions, as observed during normal aging (Cohen-Mansfield & Perach, 2012; Spiegel et al., 1999). In working life, while in transition from work days to days off, people may develop sleep deprivation, a phenomenon referred to as social jetlag, defined as chronic shift in sleep schedule on days off compared to work days (Wittmann et al., 2006).

In the present study, individual differences in sleep behaviour and possible health implications were investigated in a healthy group with similar socioeconomic background and very weak influences from daylight during the Arctic winter. The study group consisted of day workers at a mining company on a flexitime work schedule that allowed for personal preferences in sleep behaviour.

The study hypothesis was that late sleep onset and short sleep duration are associated with sleep disturbances. The aims of the present study were as follows: (i) to identify different profiles of sleep onset and sleep duration of daytime workers and cluster these according to similarities in sleep timing; and (ii) to investigate cluster differences for daily symptoms related to sleep complaints (sleepiness, sleep debt, sleep quality, sleep being refreshing or having slept enough, and difficulties waking up).

Methods

Participants

Arctic day- and shift-workers at an iron ore mine were initially asked by e-mail to fill out online questionnaires for both winter and summer reporting seasonal differences in sleep and mood. A group of 574 day-workers responded giving background information on demographics, sleep, work and health. The present study included a subgroup of 48 day-workers that had signed up in winter, through a second e-mail, to be part of an actigraph and diary study. Initially, 65 day-workers attended two scheduled meetings with the researchers and were eligible to enrol on the field study. Seven day-workers provided missing or incomplete data and ten workers had ongoing medical treatments (medication that could affect sleep) and were later dropped from the study. The study group resided in Kiruna, Sweden (67º 51’ N, 20º 13’ E). At this northern latitude, from 1 December to 31 January the light-dark cycle varies from 0.4 hours to 7.3 hours of daylight (light-dark cycle ratio ranges from 07:17 to 00:24). This period includes 27 polar days. Partly due to the inland Arctic climate, the daily mean hours of sunshine never exceeds one hour (<1 kWh/m^2 in global energy from solar radiation).

The study group worked Monday–Friday with two days off during weekends. Workers had a flexitime 8 h work schedule allowing them to start and end work according to personable preference. Of the workers, 36% worked as engineers and geologists, 34% were managers and coordinators, and 30% worked with human relations, development and control tasks. Eleven per cent felt they had not enough time to perform their work tasks and 9% reported often having to work very fast or hard (5%). Workers seldom (10%) lacked freedom of how to perform work tasks. Workers were informed collectively or individually about data collection for the study, including instructions on actigraphy use and diaries. Data were collected in December 2013. The study group included 25 men and 23 women, mean age 42 years (SD = 10 years), and range 20–58 years. Workers generally reported being satisfied with their work schedule (42% answering "fairly well" and 44% answered "very much"). Commuting time was, on average, 17 min (SD = 7 min), ranging from 5 to 30 min. The majority of workers used an alarm clock to wake up during work days (73%) and on days off (60%). The group reported no treatment for sleep problems or use of medication that could interfere with sleep.

The study was approved by the Regional Ethics Review Board, Stockholm, Sweden (protocol n° 2012/2145-31/3) in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments (Portaluppi et al., 2010). All procedures were carried out with adequate understanding and all workers provided written informed consent.

Instruments

The online questionnaire included questions on demographics (sex and age), work (commuting time, work schedule satisfaction) and health (sleep habits, use of alarm clock, diurnal type, health problems, and medication). The instrument employed to collect data on diurnal type was a validated short scale comprising seven questions (Torsvall & Åkerstedt, 1980). The answers are scored from 1 to 4 (1 point = extreme evening type; 1–2 points = evening type, 2–3 points = intermediate; 3–4 points = morning type, until 4 points = extreme morning type). The mean value referred classified the population as an intermediate preference. Data collection using diaries and actigraphs was performed according to a procedure starting on a Wednesday and finishing on the following Tuesday, yielding six consecutive nights of records, including two days off. The actigraph (Actiwatch 8, Cambridge-Neurotechnology, Cambridge, UK) was worn around the clock on the non-dominant wrist. Activity-rest data were exported to the Philips Respironics software (Respironics Actiware, version 5.71.0®), used for sleep analyses at a medium sensitivity. Analyses identified sleep onset (10 undisturbed epochs), sleep offset, sleep duration, wake duration after sleep onset (WASO), and sleep efficiency (ratio between sleep duration and time in bed). Calculations were made to obtain the variables: mid-sleep (sleep duration divided by two plus sleep onset), the difference between mid-sleep and work start time, sleep debt (difference between sleep duration and sleep need reported in background questionnaire).

Workers filled in sleep diaries reporting sleep quality of the preceding night using the Karolinska Sleep Diary (KSD; Åkerstedt et al., 1994; Åkerstedt et al., 2014). The KSD questions collected sleep quality evaluations and were filled out in the morning and included: bedtime (h), time of awakening (h), sleep latency (h), sleep quality (how did you sleep?, very well 5 – very poorly 1), feeling refreshed after awakening (completely 5 – not at all 1), calm sleep (very calm 5 – very restless 1), did you get enough sleep? (definitely enough 5 – definitely too little 1), ease of waking up (very easy 5 – very difficult 1), and ease of falling asleep (very easy 5 – very difficult 1).

Sleepiness during the day was reported using the Karolinska Sleepiness Scale (KSS; Åkerstedt & Gillberg, 1990; Kaida et al., 2006). This scale ranges from 1 (very alert) to 9 (very sleepy, fighting sleep, an effort to keep awake). In the present study, workers provided KSS average ratings for six intervals during the day (time intervals: 6–8 h, 9–11 h, 12–14 h, 15–17 h, 18–20 h, and 21–23 h).

Data analyses

All statistical analyses were performed using Statistica 12 (StataSoft Inc©. 1984–2013). Four recorded work days were compared using one-way ANOVA. Sleep patterns and outcomes from diaries and questionnaire were compared during work days and days off by the *t*-test for dependent samples.

Individual differences in sleep onset and sleep duration were tested by cluster analyses. This procedure yielded cluster-*k*-means used as descriptive data to divide heterogeneous data into more homogeneous groups according to mean similarities (MacQueen, 1967). The total sample was then divided into "*k*" groups and the Euclidean distance from each member and groups' centres (or centroids) was calculated several times until the minimum distance between members and groups' centres was reached (Johnson & Wichern, 2007). Differences between groups were determined by ANOVA analyses. First, participants were described according to sleep time and sleep duration. Participants were then divided into two groups (using mean of six days including work days and days off) according to sleep onset (early and late groups); the same participants were divided into two other groups according to sleep duration (long and short groups). Second, sleep time and sleep duration information were pooled by combining clusters: "Early Sleep Onset" workers were subdivided into "Early-Short" (i.e. early sleep onset with short sleep duration) and "Early-Long" (i.e. early sleep onset with long sleep duration). As the same way, "Late Sleep Onset" workers were subdivided into "Late-Short" and "Late-Long". The clusters obtained on first and second analyses were compared according to outcome variables by the *t*-test for independent samples.

Results

The mean score for diurnal type preference of the workers was 2.21 points (95% CI: 2.08–2.34) classifying them as intermediate type. Data show a Gaussian distribution according to the Kolmogorov–Smirnov test ($d = 0.086$, $p > 0.20$). In fact, 59% were classified as intermediates, 37% as evening, and 4% as morning types. The majority of workers used the alarm clock to wake up during work days (73%) and on days off (60%). Working time started, on average, at 7:16 h (SD = 46 min; ranging from 05:45 h to 09:30 h), and ended at 16:03 h (SD = 79 min, ranging from 10:30 h to 22:00 h). On Fridays, work finished earlier, on average, at 15:28 h ($F[3,188] = 4.99$, $p < 0.003$).

Sleep characteristics and sleepiness for work days and days off

Sleep characteristics (from actigraph) and outcomes differed between work days and days off. During the four recorded work days, no significant differences were observed for sleep times or duration (onset: $F[3,188] = 1.10$, $p = 0.36$; offset: $F[3,188] = 0.27$, $p = 0.85$; sleep duration: $F[3,188] = 0.64$, $p = 0.59$). On days off, workers went to bed approximately one hour later and woke up around two hours later (Table 1). Thus, workers slept, on average, one hour longer on days off. Workers reported (in the questionnaire) needing 7.77 hours of sleep, on average. Questionnaire data from the initial group of day-workers from where the subgroup was drawn reported a sleep duration of 6.89 (SD = 0.9) hours on workdays and 8.75 (SD = 1.1) hours on days off and 50.2% agreed sleep in general was somewhat insufficient on

Table 1. Comparison of sleep parameters (actigraphy derived) for work days and days off (means [SEM]).

	Sleep variables	Work days	Days off	t	p-value
(A)	Sleep onset (h)	23.03 [0.12]	24.01 [0.15]	−9.21	p < 0.0001
	Sleep offset (h)	05.80 [0.06]	07.90 [0.15]	−12.21	p < 0.0001
	Sleep duration (h)	06.25 [0.10]	07.18 [0.13]	−5.90	p < 0.0001
	Sleep efficiency	90.2 [0.5]	89.5 [0.6]	1.56	p = 0.13
	WASO (min)	30 [2]	38 [17]	−4.06	p < 0.0002
(B)	Sleep debt (min)	95 [8]	70 [7]	2.17	p < 0.04
	Midsleep (h:min)	02:10 [5 min]	03:37 [85 min]	−245.99	p < 0.0001

[SE]; time (h) given in decimals; (A) actigraphy; (B) variables determined in "data analyses."

work days (12.3% on days off). Mid-sleep (calculated from actigraph) occurred later and sleep debt (sleep need – sleep duration) was lower for days off than work days; the duration of awakenings after sleep onset (WASO) was on average eight minutes longer on days off than on work days.

Sleepiness was significantly marked during work days as compared to days off during the time intervals 12:00–14:00 h ($p < 0.004$) and 15:00–17:00 h ($p < 0.05$, see Figure 1).

Significant differences were detected between work days and days off for diary parameters (Figure 2). During days off workers reported fewer difficulties waking up ($t = 3.12$, $p < 0.004$), were more refreshed after sleep ($t = -2.24$, $p < 0.03$) and predominantly reported having slept enough ($t = -4.42$, $p < 0.0001$). No significant differences were observed for subjective sleep quality.

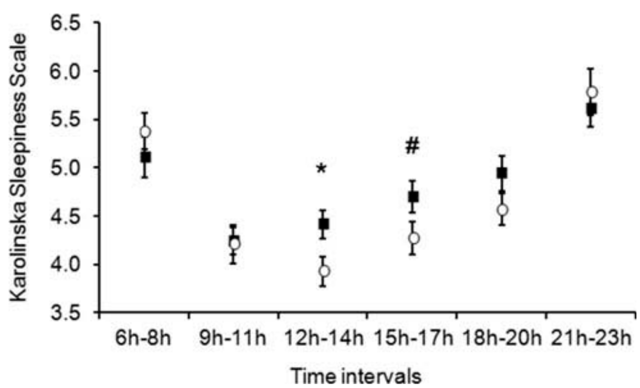

Figure 1. Daily intervals of subjective sleepiness scores (means and SEM bars) during work days (black squares) and days off (white circles). Significant differences: $^{*}p < 0.004$; $^{\#}p < 0.05$.

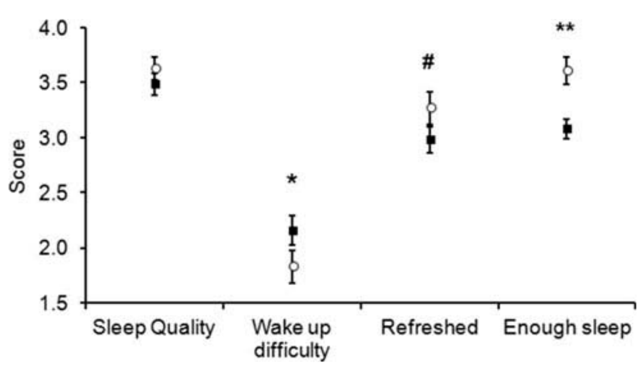

Figure 2. Sleep outcomes during work days (black squares) and days off (white circles). Significant differences = $^{*}p < 0.004$; $^{\#}p < 0.03$; $^{**}p < 0.0001$.

Groupings according to cluster analysis

Workers were clustered to observe differences in outcome variables for distinct sleep behaviour in sleep onset and sleep duration during weekdays. Two groups were formed according to sleep onset: "Late" and "Early". Workers were subsequently re-clustered into two sleep duration groups: "Long" and "Short". Figure 3 shows that the "Late Sleep Onset" group ($n = 21$) slept, on average, 1.30 h later than workers from the "Early Sleep Onset" group ($n = 27$). Figure 4 shows that "Long Sleep Duration" workers ($n = 32$) slept, on average, 1.10 h longer than "Short Sleep Duration" workers ($n = 16$).

Effects of grouping on outcome variables

Based on questionnaire data for the outcome variables, there was no difference between clusters in commuting time (Table 2). However, the mean score for diurnal preference was significantly lower in the "Early Sleep Onset" ($t = 2.04$, $p < 0.006$) since this group comprised 54% workers classified with eveningness and 42% with intermediate preference according to sleep phase preference. By contrast, the "Late Sleep Onset" group comprised mainly workers with intermediate sleep preference (80%) and showing a higher mean score for morningness. The characteristic of the "Late Sleep Onset" workers for actigraphy data were later sleep offset ($t = -5.30$, $p < 0.0001$) shorter sleep duration ($t = 4.15$, $p < 0.0002$) and later mid-sleep ($t = -7.83$, $p < 0.0001$). Diary data showed that "Late Sleep Onset" workers had shorter time between mid-sleep and start of work ($t = 2.92$, $p < 0.006$), was less refreshed from sleep ($t = 2.69$, $p < 0.01$), and more frequently did not sleep enough ($t = 2.79$, $p < 0.01$) compared to "Early Sleep Onset" workers.

The "Long Sleep Duration" group had a great sleep need than the "Short Sleep Duration" group ($t = 2.07$, $p < 0.05$) based on questionnaire data. Actigraphy data revealed that "Long Sleep Duration" group had an earlier sleep onset ($t = -5.29$, $p < 0.0001$) and earlier mid-sleep phase ($t = -3.13$, $p < 0.004$) and a longer interval between mid-sleep and work starting time ($t = 3.17$, $p < 0.003$) compared to the "Short Sleep Duration" group. Diary data showed that the "Long Sleep Duration" group also had a higher score for slept enough ($t = 2.14$, $p < 0.04$) than the "Short Sleep Duration" group.

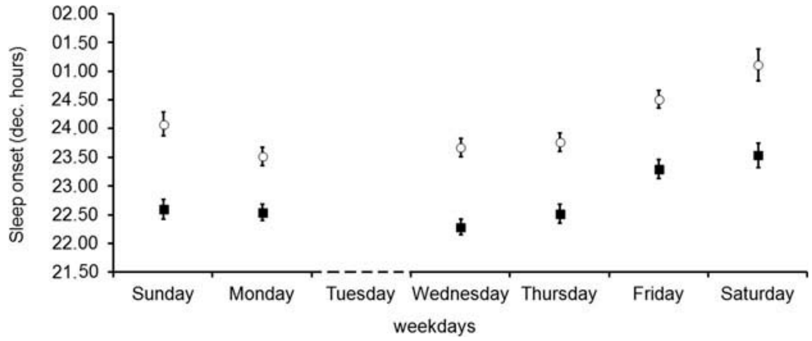

Figure 3. Sleep onset (means and SEM): "Late Sleep Onset" group (white circles) and "Early Sleep Onset" group (black squares). Both clusters showed significant differences (all $p < 0.0001$) for each weekday.

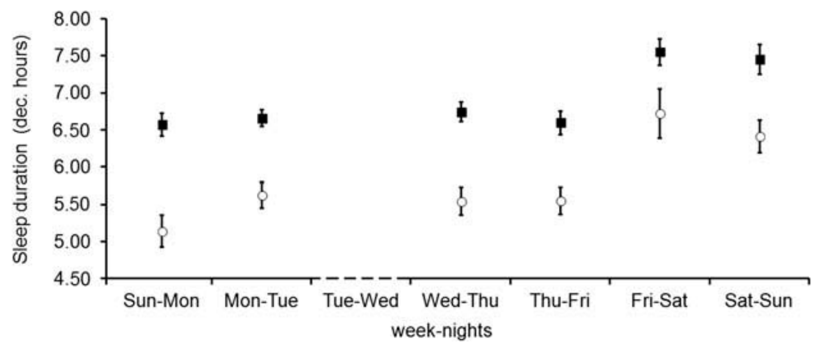

Figure 4. Sleep duration (means and SEM): "Long Sleep Duration" (black squares) and "Short Sleep Duration" (white circles). The clusters showed significant differences on work days ($p < 0.0002$). Others significant differences: Friday night to Saturday morning ($p < 0.02$); Saturday night to Sunday morning ($p < 0.003$).

Table 2. Group comparison of sleep onset (late/early) and sleep duration (long/short) and outcome variables (mean [SEM]). Variables from questionnaire (A), actigraphy (B), diary (C), actigraphy and diary (D), actigraphy and questionnaire (E).

		Onset		Duration	
	Variables	Late (n = 21)	Early (n = 27)	Long (n = 32)	Short (n = 16)
A	Commuting time (min)	15 [2]	18 [1]	17 [1]	16 [2]
	Diurnal preferences score	2.4 [0.1]**	2.0 [0.1]	2.2 [0.1]	2.3 [0.1]
	Sleep need (h)	7.53 [0.15]	7.95 h [0.18]	7.95 [0.15]*	7.04 [0.18]
B	Sleep onset (h)	24.01 [0.13]***	22.78 [0.10]	22.98 [0.10]***	24.12 [0.18]
	Sleep offset (h)	6.85 [0.07]***	6.02 [0.08]	6.48 [0.08]	6.5 [0.13]
	Sleep duration (h)	6.18 [0.12]***	6.83 [0.08]	6.92 [0.05]***	5.82 [0.07]
	Mid-sleep (hh:min)	03:12 [05 min]***	02:13 [05 min]	02:27 [05 min]**	03:02 [10 min]
	Sleep Efficiency (%)	89.6 [0.7]	90.3 [0.7]	90.6 [0.7]	88.8% [0.8]
	WASO (min)	31.0 [2.8]	33.7 [2.7]	32.1 [2.4]	33.4 [3.3]
C	Sleep Quality	3.5 [0.1]	3.5 [0.1]	3.6 [0.1]	3.4 [0.1]
	Difficulty to wake up	2.2 [0.2]	1.9 [0.2]	2.1 [0.2]	2.0 [0.2]
	Refresh sleep	2.8 [0.2]**	3.3. [0.1]	3.2 [0.1]	2.9 [0.2]
	Enough sleep	3.0 [0.1]**	3.5 [0.1]	3.4 [0.1]*	3.0 [0.2]
D	Mid sleep – Start Work (h)	4.85 [0.10]**	5.28 [0.08]	5.25 [0.08]**	4.77 [0.13]
E	Sleep debt (min)	81 [10]	72 [10]	67 [09]	94 min [10]

[SE]; time (h) given in decimals; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

Combined clusters

In a further step, the two sleep parameters, timing and duration, were used in four comparisons. The combined phase-duration groups were compared on outcome variables (Table 3, *t*-test for independent samples). The groups were homogeneous for age, reported sleep need, sleep quality, difficulty waking up, refreshing sleep, enough sleep, sleep efficiency and WASO. When comparing "Short

Table 3. Combined phase-duration sleep groups and outcome variables. Mean and *p*-values.

	Mean			
Comparison 1 (later onset)	short-**late**(n = 12)	long-**late**(n = 9)	T-test	p-value
Sleep onset (h)	24.45	23.63	−3,80	p < 0.002
Sleep debt (min)	103	53	−2,80	p < 0.02
Commuting (min)	13	19	2.22	p < 0.05
Comparison 2 (early onset)	*short-**early**(n = 4)*	*long-**early**(n = 23)*		
Commuting (min)	26	16	−2,95	p < 0.007
Comparison 3 (short duration)	***short**-late (n = 12)*	***short**-early (n = 4)*		
Sleep duration (min)	5.72	6.12	−2,37	*p* < 0.04
Mid-sleep (hh:min)	03:19	02:11	4.33	*p* < 0.0007
Commuting (min)	13	26	−4,60	*p* < 0.0005
Sleepiness	5.5	4.3	3.66	*p* < 0.003
Comparison 4 (long duration)	***long**-late (n = 9)*	***long**-early (n = 23)*		
Sleep offset (h)	7.02	6.28	−4,63	*p* < 0.0005
Mid-sleep (hh:min)	03:03	02:13	−4,98	*p* < 0.0005

Time (h) given in decimals.

Sleep Duration" versus "Long Sleep Duration" while maintaining late sleep onset (comparison 1), the "Long Sleep Duration" group went to bed earlier, had less sleep debt but spent longer commuting. For the "Early Sleep Onset" groups combined with either short or long sleep duration (comparison 2), those with short sleep duration spent longer commuting than long sleepers. Regarding the "Short Sleep Duration" with early or late sleep onset (comparison 3), the early onset group spent longer commuting, slept more hours and had earlier mid-sleep than late onset group; these workers also reported greater sleepiness. Finally (comparison 4), workers with "Long Sleep Duration" and early sleep onset showed earlier sleep offset and earlier mid-sleep than "Long Sleep Duration" with late sleep onset.

Sleepiness throughout the day differed between combined clusters (Figure 5). During early hours (6h–11h), including start of work, short sleep groups were sleepier. During the middle of the day, the early/long sleep group remained alert whereas towards the afternoon and evening there were no group differences in perceived sleepiness. During days off 35 workers were awake before 8:00 h (reporting KSS) and 45 workers awoke before 11:00 h. Late Sleep Onset (black or white circles in Figure 5) were more sleepy at 06:00–08:00 h ($t = -2.61$, $p < 0.02$) and at 12:00–14:00 h ($t = -2.12$, $p < 0.04$) than Early Sleep Onset (black or white squares). "Short Sleep Duration" (black symbols) reported greater sleepiness during the intervals: 09:00–11:00 h ($t = -2.25$, $p < 0.03$) and 12:00–14:00 h ($t = -2.10$, $p < 0.05$) than "Long Sleep Duration" (white symbols). At the end of the day, all groups had a similar sleepiness pattern.

Discussion

Despite the extreme geographical location of the sample of Arctic day-workers studied, their sleep behaviour was comparable to other populations (Binkley et al., 1990; Soehner et al., 2011; Valdez

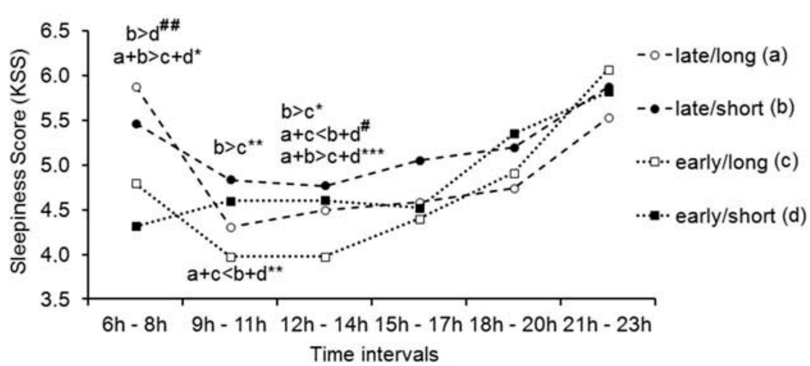

Figure 5. Intervals of sleepiness during the day in combined clusters (a-d). Elevated sleepiness for groups marked in figure (*p < 0.02; **p < 0.03; ***p < 0.04; #p<0.05; ##p<0.003).

et al., 1996). The fact that our groups were assessed during dark conditions increases the likelihood that workers were studied during similar controlled daylight conditions that reduce the impact of circadian daylight strength as an exogenous factor affecting sleep/wake behaviour. Also, the sample was restricted to in-door workers where these groups do not differ greatly from other working groups in the Scandinavian winter, receiving less than 30h of sunlight in December, commuting in darkness between work and home. Thus, the results can probably be generalized to larger populations in Western societies with weak daylight influences.

The aim of this study was to describe individual differences in timing and duration of sleep, representing the main parameters for identifying sleep behaviours. Knowledge of this behaviour could be used in health promotion. Several studies aiming to promote workers' health and well-being have demonstrated the influence of work scheduling and sleep timing (Léger et al., 2014; Levandovski et al., 2011; Monk et al., 2004; Soehner et al., 2011; Wittmann et al., 2006). Since workers in the current sample exhibited stable sleep behaviours over time, it was reasonable to use a cluster analysis approach to divide day-workers into groups and also associate their behaviour to psychosocial factors, sleepiness and perceived sleep need during the week. Although workers had regular working hours, we found distinct individual behaviours of sleep onset, sleep duration and profiles of sleepiness. Two different sleep behaviours were identified, the first being timing of sleep onset with a difference of more than one hour between groups, and another related to sleep duration, which differed by approximately one hour between groups.

Both work days and days off were included in the cluster analysis because analyses including only work days or only days off would have multiplied the grouping numbers. The flexibility to decide the sleep onset and sleep duration by the individuals in the sample justified not dividing between work days and days off and also allowed carry over effects and general sleep behaviours to be investigated. Since both work days and days off were considered in the study, it was possible to study carry over effects and circadian adaptation. For example, levels of sleepiness were significantly lower during days off than on work days. One likely reason for this was that workers commonly exhibited longer sleep durations and delayed sleep onset on days off. Such transitions from days with imposed schedules to free activities on days off could act as a temporal challenge to circadian oscillators and induce social jetlag (Valdez et al., 1996; Wittmann et al., 2006).

Social jetlag may also reflect reactions to work demands, as greater difficulties waking up were observed during days off. On days off, workers also reported feeling more refreshed from sleep and "had higher scores for enough sleep". Thus, the statistical difference observed in difficulties waking up, refreshing sleep and enough sleep between work days and days off may be due to a temporal challenge imposed by differences in daily routine combined with work demands.

Short and long sleepers differed in reported sleep need: unsurprisingly, long sleepers needed more sleep hours than short sleepers. The present results support the idea proposed by Horne (2011) that sleep in adults normally ranges from, approximately, 6–9 h per day. Short sleepers may not be affected by sleep debt as much as long sleepers due to a genetic determination of sleep duration and also a phenotypically derived ability to adapt to social demands (Aeschbach et al., 2003; Horne, 2011; Webb, 1979).

We expected workers with later sleep onset and restriction of sleep time to report more sleep complaints. This was partially true for some variables: workers with later sleep onset perceived sleep as neither refreshing nor providing full recovery after a night's rest. Workers with shorter sleep duration reported they did not sleep enough.

Previous studies have reported individual differences in sleep timing preferences and regularity of sleep timing during the week (Foster & Wulff, 2005; Horne & Östberg, 1977; Soehner et al., 2011; Taillard et al., 1999). Morning types exhibited less variability in bedtime and sleep duration than evening types (Roepke & Duffy, 2010). According to Taillard and collaborators, unstable sleep time was observed in 48% of morning types, compared to 59% of intermediate types and 72% of evening types (Taillard et al., 1999). Based on the current study, even though the majority of the subjects had an "intermediate" sleep phase preference, differences in sleep patterns within this group were still observed. Workers classified as "Early Sleep Onset" had lower scores (indicating greater eveningness in the diurnal type scale) for diurnal preference than "Late Sleep Onset" workers. This contradictory result can be explained by the fact that most of the workers were classified as "intermediate" diurnal type on the questionnaire which used desired sleep time, while clusters were formed based on real-life data from actigraphy – derived sleep timing.

The sleepiness profiles were as expected. Sleepiness is an evolutionary signal to detect physiological and cognitive indicators of sleep debt and can be essential to survival, as well as hunger and thirst (Horne & Burley, 2010). Daily sleepiness scores of the workers showed higher values in the morning and close to bedtime, as described in previous studies (Åkerstedt & Gillberg, 1990; Teixeira et al., 2007).

It is important to emphasize that the studied day-workers slept, on average, 6–7 hours per day, and reported 8 hours of sleep need. Despite this, the analyses of individual differences highlighted that workers with later sleep onset and shorter duration had more complaints of sleep debt (around 100 min) and sleepiness. Sleep debt may be associated with a stressful life (Anderson & Horne, 2008; Horne, 2011), and not all shorter sleepers suffer from this. However, we must take into consideration that people with later bedtimes may have fewer sleep hours due to imposed work times, resulting in sleep debt. During work days, the sleep debt accumulates and is more evident in evening types than in morning types (Roepke & Duffy, 2010).

It is likely that the flexible work hours for some day-workers were not truly flexible but influenced by the mining culture tradition of having early starts for morning work, especially since the fixed morning shift for shiftworkers started early (06.00 h). These cultural influences might be negative for some of the studied clusters, especially late onset clusters, whose greater need for sleep could increase the risk of sleep debt. This could partly explain why sleep duration was dramatically shorter than the reported sleep need. Also, the high prevalence of not having enough sleep and a high level of sleepiness upon waking in the "Late Sleep Onset/Long Sleep Duration" group might have been due to more "forced" setting of alarm clocks. Possible advice to day-workers needing to reduce sleep debt and sleepiness would be to go to bed earlier. However, if greater emphasis is given to sleep need, diurnal preferences and endogenous circadian signals then a healthier strategy might be to reduce the influence of the cultural early start and instead promote flexibility, later start of work and the non-use of alarm clocks. However, changing sleep behaviours of workers is challenging and warrants further investigation.

A limitation of this study is the low number of measured days. Although only a few nights of study may sometimes seem sufficient (Acebo et al., 1999; Chontong et al., 2016), fewer days reduce study validity and the possibility of detecting mid-sleep characteristics and discrepancies between work days and days off, data that could be of interest not least for describing social jetlag outcomes.

The studied workers seemed to have a moderate degree of high demands at work but also a high level of control. It is quite possible that work stress may be related to sleep problems and/or sleep behaviours. In the recruitment process the workers were suggested to sign up for a "normal" study week that did not contain stressful events including travels, scheduled over-time work etc. However, future studies could be benefited by also detecting work demands at each day of study.

Another limitation of the current study was the number of clusters formed was limited to the sample size. More explanatory factors could also have been analysed in larger samples to reflect sleep behaviour. Future studies evaluating the sleep/wake cycle should consider daily routines and demographics, besides sleep time preferences.

Conclusions

The present study revealed distinct sleep behaviours and subjective sleepiness outcomes of Arctic daytime workers enrolled in the same flexible work schedule. Workers changed their sleep onset and sleep duration according to recovery needs and social demands during days off. Early sleep onset workers reported more refreshing sleep and had higher scores for enough sleep than workers with late sleep onset. Long sleep duration workers reported having slept enough but reported a need for longer sleep. Workers with late sleep onset and short sleep duration reported greater sleepiness than the early sleep onset and short sleep group.

These results highlight the differences in sleep patterns for workers with similar work hours in terms of sleep timing and sleep duration characteristics. Sleep timing and sleep duration should be taken into account when planning interventions among groups of workers.

Acknowledgements

We would like to acknowledge funding from Capes/Stint [grant number 004/12; 021/14]; FAPESP [grant number 2014/01514-0; and Swedish Research Council for Health, Working Life and Welfare [grant number 2011-0488].

Declaration of interest

The authors declare no conflicts of interests. The authors are responsible for the content and writing of this article.

References

Acebo C, Sadeh A, Seifer R, Tzischinsky O, Wolfson AR, Hafer A, Carskadon MA. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: How many nights are necessary for reliable measures? Sleep. 22:95–103.

Aeschbach D, Sher L, Postolache TT, Matthews JR, Jackson MA, Wehr TA. (2003). A longer biological night in long sleepers than in short sleepers. J Clin Endocrinol Metab. 88:26–30.

Åkerstedt T, Axelsson J, Lekander M, Orsini N, Kecklund G. (2014). Do sleep, stress, and illness explain daily variations in fatigue? A prospective study. J Psychosom Res. 76:280–5.

Åkerstedt T, Gillberg M. (1990). Subjective and objective sleepiness in the active individual. Int J Neurosci. 52:29–37.

Åkerstedt T, Hume K, Minors D, Waterhouse J. (1994). The subjective meaning of good sleep, an intraindividual approach using the Karolinska Sleep Diary. Percept Mot Skills. 79:287–96.

Anderson C, Horne JA. (2008). Do we really want more sleep? A population based study evaluating the strength of desire for more sleep. Sleep Med. 9:184–7.

Basner M, Fomberstein KM, Razavi FM, Banks S; William JH, Rosa RR, Dinges DF. (2007). American time use survey: Sleep time and its relationship to waking activities. Sleep. 30:1085–95.

Binkley S. (1993). Individual phase, and weekly variations in daily cycles of wrist activity in freeliving humans. Physiol Behav. 53:205–7.

Binkley S, Tome MB, Crawford D, Mosher K. (1990). Human daily rhythms measured for one year. Physiol Behav. 48:293–8.

Boivin DB, Boudreau P. (2014). Impacts of shift work on sleep and circadian rhythms. Pathol Biol (Paris). 62:292–301.

Borisenkov MF. The pattern of entrainment of the human sleep-wake rhythm by the natural photoperiod in the north. (2011). Chronobiol Int. 28:921–9.

Chontong S, Saetung S, Reutrakul S. (2016). Higher sleep variability is associated with poorer glycaemic control in patients with type 1 diabetes. J Sleep Res. 23:1–7

Cohen-Mansfield J, Perach R. (2012). Sleep duration, nap habits, and mortality in older persons. Sleep. 35:1003–9.

Foster RG, Wulff K. (2005). The rhythm of rest and excess. Nat Rev Neurosci. 6:407–14.

Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, et al. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. Sleep Health. 1:40–3.

Horne JA. (2010). Sleepiness as a need for sleep: When is enough, enough? Neurosci Biobehav Rev. 34:108–18.

Horne JA. (2011). The end of sleep: 'Sleep debt' versus biological adaptation of human sleep to waking needs. Biol Psychol. 87:1–14.

Horne JA, Burley CV. (2010) We know when we are sleepy: Subjective versus objective measurements of moderate sleepiness in healthy adults. Biol Psychol. 83:266–8.

Horne JA, Östberg O. (1977). Individual differences in human circadian rhythms. Biol Psychol. 5:179–190.

Johnson RA, Wichern DW. (2007). Applied multivariate statistical analysis. Harlow, UK: Pearson Education Ltd.

Kaida K, Takahashi M, Akerstedt T, Nakata A, Otsuka Y, Haratani T, Fukasawa K. (2006). Validation of the Karolinska sleepiness scale against performance and EEG variables. Clin Neurophysiol. 117:1574–81.

Kalenkoski CM, Pabilonia SW. (2012). Time to work or time to play: The effect of student employment on homework, sleep, and screen time. Labour Econ. 19:211–21.

Kerkhof GA. (1985). Inter-individual differences in the human circadian system: A review. Biol Physiol. 20:83–112.

Lallukka T, Sares-Jäske L, Kronholm E, Sääksjärvi K, Lundqvist A, Partonen T, Rahkonen O, Paul Knekt P. (2012) Sociodemographic and socioeconomic differences in sleep duration and insomnia-related symptoms in Finnish adults.BMC Public Health. 12:1–22

Léger D, Beck F, Richard J-B, Sauvet F, Faraut B. (2014). The risks of sleeping "Too Much". Survey of a national representative sample of 24671 adults (INPES Health Barometer). PLoS ONE. 9: e106950.

Levandovski R, Dantas G, Fernandes LC, Caumo W, Torres I, Roenneberg T, Hidalgo MP, Allebrandt KV. (2011). Depression scores associate with chronotype and social jetlag in a rural population. Chronobiol Int. 28:771–8.

MacQueen JB. (1967). Some methods for clustering and analysis of multivariate observations. Proc. 5th Berkeley Symp. on Math. Statist. Prob. 01. University of California Press, Berkeley.

Mallon L, Broman JE, Akerstedt T, Hetta J. (2014). Insomnia in Sweden: A population-based survey. Sleep Disord. 2014:7. doi:10.1155/2014/843126. Epub 2014 May 12.

Monk TH, Buysse DJ, Potts JM, DeGrazia JM, Kupfer DJ. (2004). Morningness-eveningness and lifestyle regularity. Chronobiol Int. 21:435–43.

Moore M, Kirchner HL, Drotar D, Johnson N, Rosen C, Redline S. (2011). Correlates of adolescent sleep time and variability in sleep time: The role of individual and health related characteristics. Sleep Med. 12:239–45.

Moreno C, Vasconcelos S, Marqueze EC, Lowden A, Middleton B, Fischer F, Louzada F, Skene D. (2015). Sleep patterns in Amazon rubber tappers with and without electric light at home. Scientific Reports 5:14074. doi:10.1038/srep14074.

Portaluppi F, Smolensky MH, Touitou Y. (2010). Ethics and methods for biological rhythm research on animals and human beings. Chronobiol Int. 27:1911–29.

Roepke SE, Duffy JF. (2010). Differential impact of chronotype on weekday and weekend sleep timing and duration. Nat Sci Sleep. September 1:213–20.

Soehner AM, Kennedy KS, Monk TH. (2011). Circadian preference and sleep-wake regularity: Associations with self-report sleep parameters in daytime-working adults. Chronobiol Int. 28:802–9.

Spiegel K, Leproult R, Van Cauter E. (1999). Impact of sleep debt on metabolic and endocrine function. Lancet. 354:1435–9.

Taillard J, Philip P, Bioulac B. (1999). Morningness/eveningness and the need for sleep. J Sleep Res. 8:291–5.

Teixeira LR, Lowden A, Turte SL, Nagai R, Moreno CRC, Latorre MRDO, Valente D, Fischer FM. (2007). Sleep and sleepiness among working and non-working high school evening students. Chronobiol Int. 24:99–113.

Torsvall L, Åkerstedt T. (1980). A diurnal type scale. Construction, consistency and validation in shift work. Scand J Work Environ Health. 6:283–90.

Valdez P, Ramirez C, Garcia A. (1996). Delaying and extending sleep during weekends: Sleep recovery or circadian effects? Chronobiol Int. 13:191–8.

Webb WB. (1979). Are short and long sleepers different? Psychol Rep. 44:259–64.

Wittmann M, Dinich J, Roenneberg T. (2006). Social jet-lag: Sleep, well-being and stimulus consumption of different chronotypes. Chronobiol Int. 23:497–509.