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Transition to daylight saving time reduces sleep duration plus sleep efficiency of the deprived sleep

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Abstract

Daylight saving time (DST) is widely adopted. We explored the effects of transition to daylight saving time on sleep. With the use of wrist-worn accelerometers, we monitored the rest-activity cycles on a sample of 10 healthy adults for 10 days around the transition to summer time. Identical measurement protocols were carried out twice on the same individuals during the transitions in the years of 2003 and 2004, yielding data on 200 person-days for analysis. Both sleep duration and sleep efficiency were reduced after the transition both years. After the transition sleep time was shortened by 60.14 min ($P < 0.01$) and sleep efficiency was reduced by 10% ($P < 0.01$) on average. Transition to daylight saving time appears to compromise the process of sleep by decreasing both sleep duration and sleep efficiency.

Keywords: Actigraphy; Daylight saving time; Sleep

Daylight saving time (DST) is currently used in many countries in temperate regions worldwide. The rationale is to improve the match between the daylight hours and activity peaks of a population. Previous studies have focused on the effect on reaction and attention [4,5,7]. However, these data are conflicting and warrant further studies of the impact on well-being.

In a study of 65 subjects [11], a disruptive effect on the circadian rhythms was seen for 5 days after a transition from DST. Transition to DST may be even more disruptive to the circadian clockwork, since it may drive the individual into a later activity phase and subsequently to insomnia and changes in mood. In our recent study, we found that the transition to DST influences the fragmentation of the rest-activity cycle [10].

Accelerometer-based measurements (actigraphy) offer one of the best-known alternatives to polysomnography for identification of the sleep phase. Advantages of actigraphy include the relatively high accuracy, simplicity of use and low intrusiveness. Here, we show that a transition to DST has an effect on the duration and efficiency of sleep in healthy adults.

Ten healthy individuals, all free of psychotropic medication, participated in the study after giving a written informed consent. All subjects lived in Helsinki, Finland (60°12′N). None of them was a shift-worker nor crossed time zones during the study. All subjects used alarm clock regularly. Participants were asked to retain their normal plus regular daily schedule during the study. Identical measurement protocols were carried out twice on the same individuals, each using a personal and exclusive accelerometer throughout both study periods. The participants did not nap during the test period.

Since 2002, the European Union has fixed the last Sunday in March and the last Sunday in October as start and end dates. In 2003, DST was started on 30 March at 3 a.m. Rest-activity cycles were measured using wrist-worn accelerometers (Actiwatch-Plus®, Cambridge Neurotechnology Ltd., Cambridgeshire, UK) for a period of 10 days from 24 March to 3 April 2003. In 2004, DST was started on 28 March at 3 a.m. Rest-activity cycles were measured using wrist-worn accelerometers for a period of 10 days from 22 March to 1 April 2004. To sum up, we recorded and analyzed data on a total of 200 nights from 10 persons for this study.

The participants wore the units for all the time, except during short non-waterproof activities. The units were mounted in non-dominant arm and positioned using a standardized

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protocol, recording the intensity, amount and duration of movement in all directions over 0.05 g, with the sampling epoch of 30 s. The sampling frequency of the units was 32 Hz at maximum, the filters being set to 3–11 Hz.

To assess the preference to daily activity patterns, the participants filled in the Morningness–Eveningness Questionnaire [8]. This instrument includes 19 items estimating the preference to the timing of different activities and behaviors, whose sum yields the Morningness–Eveningness Score (MES), ranging from 16 to 86. The highest score indicates the definite preference to activities in the morning (Morningness), whereas the lowest one indicates the definite preference to activities in the evening (Eveningness). In addition, the participants were asked about the usual daily schedule and the estimate of how many hours of sleep they needed in order to feel refreshed. Each morning during the study period participants marked down the time of awakening that morning and the time of falling asleep the night before. The participants were assigned in subgroups by the preference for daily activity patterns (morning, intermediate or evening type), and by the preferred length of sleep (more than 8 h per night as long sleepers, 8 h or less per night as short sleepers). Sleep debt was calculated as the difference between the preferred and actual length of sleep per night.

The data were extracted from the units and first analyzed with the software provided by the manufacturer (The Actiwatch Sleep Analysis 2001 software). Twelve variables were recorded including time in bed, assumed sleep, actual sleep time, actual wake time, sleep efficiency, sleep latency, number of minutes immobile, number of minutes moving, total activity score, mean activity score, mean score in active periods, and movement and fragmentation index. Assumed sleep equals to the duration of sleep (sleep start to sleep end), and sleep efficiency is the quotient of actual sleep time divided by time in bed. These variables were calculated for five nights before and four nights after the transition, thus omitting the transition night (Saturday to Sunday) from analysis. To exclude the effect of weekend (difference in bed times and sleep durations between the weekend and weekdays), we counted values for the three nights (Monday to Thursday) before and after transition only. Due to great intra- and inter-individual differences in sleep latency as calculated and provided by the software, we decided to exclude this variable from the analysis. Of the 12 recorded variables, four (assumed sleep, actual wake time, sleep efficiency, and movement and fragmentation index) were a priori decided to be focused on the analysis. Hence, the level of statistical significance was a priori set at $P < 0.01$.

Second, the significance of changes (before minus after values) in these variables was analyzed using two-tailed, paired samples t-test. These calculations were made using the SPSS for Windows, Release 11.5.1 (SPSS Inc., Chicago, Illinois, USA). Third, independent sample t-test was used to seek differences between subgroups (by the preference for daily activity patterns, and by the preferred length of sleep). Finally, separate general linear models were formulated in order to analyze the changes in the assumed sleep and sleep efficiency as dependent variables, with sex, age, the preference for daily activity patterns, the preferred length of sleep, and sleep debt as covariates.

Table 1
Values for the transition in 2003

Variable	Before		After	
	Mean	S.D.	Mean	S.D.
Time in bed (min)	480.50	39.92	474.88	45.49
Assumed sleep (min)	448.94	32.38	396.23	51.09
Actual sleep time (%)	90.74	4.35	89.74	3.82
Actual wake time (%)	9.26	4.35	10.26	3.82
Sleep efficiency (%)	85.00	6.67	74.80	6.50
Number of minutes immobile (%)	92.90	3.22	92.48	2.78
Number of minutes moving (%)	7.10	3.22	7.52	2.78
Total activity score	6964.16	4814.77	6951.58	4114.16
Mean activity score	7.70	5.17	8.88	5.09
Mean score in active periods	105.16	43.41	110.23	38.97
Movement and fragmentation index	23.07	12.11	22.76	11.20

Table 2
Values for the transition in 2004

Variable	Before		After	
	Mean	S.D.	Mean	S.D.
Time in bed (min)	489.40	36.55	461.98	45.35
Assumed sleep (min)	459.04	41.06	391.48	53.12
Actual sleep time (%)	98.02	25.55	89.87	4.55
Actual wake time (%)	9.41	4.50	10.14	4.55
Sleep efficiency (%)	85.44	6.59	75.63	6.36
Number of minutes immobile (%)	92.64	4.35	92.11	4.31
Number of minutes moving (%)	7.36	4.35	7.89	4.31
Total activity score	7047.32	4456.07	6842.20	4515.59
Mean activity score	7.56	4.63	8.52	5.45
Mean score in active periods	101.23	19.20	101.48	30.23
Movement and fragmentation index	22.61	16.77	24.67	16.83

Table 3
Change in values for Monday to Thursday nights each year

Variable	Change in 2003		Change in 2004	
	Mean	S.D.	Mean	S.D.
Time in bed (min)	12.67	30.17	22.87	42.33
Assumed sleep (min)	61.97	34.58	67.37	41.77
Actual sleep time (%)	1.65	1.99	13.42	39.66
Actual wake time (%)	−1.65	1.99	−1.04	2.60
Sleep efficiency (%)	11.29	4.13	11.29	4.98
Number of minutes immobile (%)	0.69	1.10	1.09	1.39
Number of minutes moving (%)	−0.69	1.10	−1.09	1.39
Total activity score	−233.90	2393.83	−191.60	3361.27
Mean activity score	−1.83	2.64	−1.39	3.41
Mean score in active periods	−8.83	26.15	2.63	24.11
Movement and fragmentation index	0.58	4.37	−3.14	4.47