Dubious Bargain: Trading Sleep for Leno and Letterman

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Study Objectives: Sleeping less than 7 hours daily impairs alertness and is associated with increased obesity, morbidity, and mortality; yet up to 40% of US adults do so. Population data indicate work time is the primary activity reciprocally related to sleep time in the United States. Reducing work time and its economic benefits to increase sleep time may not be feasible for most of the population. We sought to identify waking activities under discretionary control and adjacent to the sleep period that would be a more feasible source for increasing sleep time.

Design/Participants: American Time Use Survey data from 21,475 respondents aged ≥ 15 years were pooled for the years 2003–2006 to explore activities in 2-hour periods prior to going to bed and past getting up on weekdays.

Interventions: N/A

Results: Long workers (≥ 8 hours) terminated bed time an average of 0.68 h earlier than short workers (< 8 hours, P < 0.0001) and 1.31 h earlier than respondents not working on the interview day (P < 0.001), but time of going to bed did not differ among groups (22:37 vs. 22:42 vs. 22:37, respectively, P = 0.385). Watching television was the primary activity people engaged in before going to bed, accounting for 55.6 min (46.3%) of the 2-h pre-bed period. In the morning, travel time and work time increased steadily toward the end of the post-awakening 2-h period, accounting for 14.8% and 12.3%, respectively.

Conclusions: Watching television may be an important social Zeitgeber for the time of going to bed. Watching less television in the evening and postponing work start time in the morning appear to be the candidate behavioral changes for achieving additional sleep. While the timing of work may not be flexible, giving up some TV viewing in the evening should be possible to reduce chronic sleep debt and promote adequate sleep in those who need it.

Keywords: Sleep, Television, Work, Zeitgeber, Mortality, Alertness

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CURRENT ESTIMATES INDICATE THAT 20%[1] TO 40%[2] OF THE ADULT US POPULATION SLEEP LESS ON WEEKDAY NIGHTS THAN THE 7 TO 8 HOURS THOUGHT TO be needed by the majority of people to maintain behavioral alertness and avoid sleepiness-related risks of errors and accidents.[3,4] The percentage of short sleepers may be even higher than self-report surveys suggest, because physiological sleep duration has been found to be as much as an hour or more below habitual sleep duration as reported in population studies.[5,6] The issue of how much sleep people are obtaining nightly and what factors influence the habitual duration of sleep are important because reduced sleep duration has frequently been associated with a higher prevalence of obesity,[7] morbidity, and mortality,[8,9] although it is unclear whether these relationships are causal. This report focuses on lifestyle factors associated with shorter sleep times, in an effort to identify waking activities under discretionary control that may be a source for increasing sleep time in those who need to do so.

Reduced sleep time in industrialized societies is primarily related to lifestyle. In a recent analysis of time use in the US, we found that work time was the primary activity that had a reciprocal relationship to sleep time.[10] It suggests that Americans perceive sleep as a flexible commodity that can be exchanged for waking activities considered more essential or of greater value. If this is the case, reducing work time and its economic benefits in order to increase sleep time may not be feasible for most of the population. This prompted us to ask whether waking activities under discretionary control and adjacent to the sleep period may be a better source for increasing sleep time.

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METHODS

The American Time Use Survey (ATUS) is a federally administered, continuous telephone survey sponsored by the Bureau of Labor Statistics and conducted by the U.S. Census Bureau.[11] ATUS covers all residents living in the 105 million households in the United States ≥ 15 years of age, with the exception of active military personnel and people residing in institutions such as nursing homes and prisons. People are interviewed once for 15-20 minutes about how they spent their time between 04:00 on the previous day and 04:00 on the interview day. ATUS was first conducted in 2003. Final annual response rates were 51.2% (2003), 53.1% (2004), 49.5% (2005), and 55.1% (2006).

For the present analysis, ATUS databases for the years 2003, 2004, 2005, and 2006 were merged. Only weekday interviews referring to the period Monday 04:00 until Friday 04:00, excluding holidays or days preceding a holiday, were included in the analysis, reducing the original sample size of 60,674 to 23,791.

Responses are codified using the ATUS activity classification system, a 3-tiered system, with 17 major (first-tier) categories, each having 2 additional levels (tiers) of detail (see ATUS Activity Lexicon at http://www.bls.gov/tus/ or the appendix of Basner et al.[10]). Categories 01.01.01 ("sleeping"), 01.01.02 ("sleeplessness"), and 01.01.99 ("sleeping not elsewhere classified") were combined as "time in bed" for the analyses, because people usually either tried to sleep or actually slept. ATUS "activity files" list, for each respondent, type and duration of all activities performed

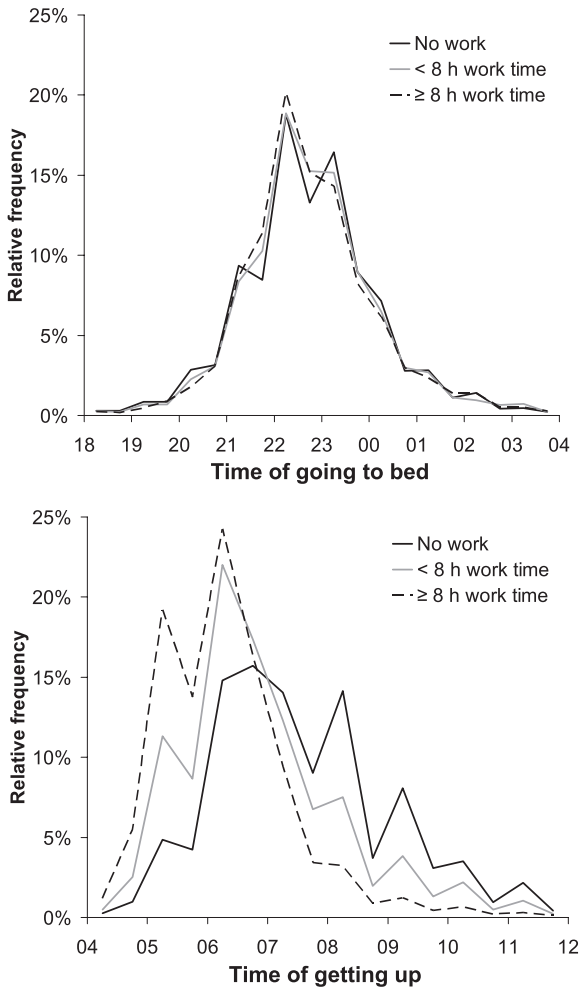

Figure 1—Panels A and B show distributions of time of going to bed (A) and time of getting up (B) for respondents who did not work (black lines, N = 9770), who worked less than 8 h (gray lines, N = 5589), and for those who worked 8 h or more (broken black lines, N = 6,116).

between 04:00 on the day before the interview day and 04:00 on the interview day. These files were used to identify waking activities in the 2 hours prior going to bed in the evening and in the 2 hours after getting up in the morning. The beginning of the first time in bed period initiated between 18:00 and 04:00 and followed by ≥ 2 continuous hours in bed was defined as time of going to bed. This could be identified in 23,165 respondents (97.4%). The beginning of the first wake period initiated after 04:00 and before 12:00 and followed by ≥ 2 hours of continuous wakefulness was defined as time of getting up, which could be identified in 21,792 respondents (91.6%). In 21,475 subjects (90.3%) both the time of going to bed and the time of getting up could be identified.

Three hundred seventeen different waking activities were identified prior to going to bed and 350 after getting up. Activities were merged or analyzed on 1st- or 2nd-tier level either if the level of detail seemed too high or if the prevalence of the activity in the 2 h pre- or post-bed was too low. For example, it did not seem sensible to differentiate watching TV with and without religious content (tiers 12.03.03 and 12.03.04), especially as the prevalence of watching TV with religious content was low. Activities coded as "Travel Related to Work" (ATUS code 18.05) were defined as commute time, a subgroup of the "Traveling" activity (ATUS code 18).

Weights (variable TU06FWGT) provided by the Census Bureau were used to calculate representative estimates correcting for oversampling of some demographic groups, oversampling of weekend days, and differing response rates across demographic groups and days of the week. Standard errors were calculated with the replicate variance method described in detail in chapter 7 of the ATUS User's Guide.[11]

A median split was performed on those respondents who worked on the day before the interview day, differentiating subjects who did not work (N = 9,770) or worked < 8 h (N = 5,589) from those who worked ≥ 8 h (N = 6,116). Kruskal-Wallis tests (SPSS 14.0, SPSS Inc.) were used to investigate differences in time of going to bed, time of getting up, and time spent watching TV between groups. In case of a significant ($P < 0.05$) Kruskal-Wallis test indicating differences between groups, Mann-Whitney U-tests were performed post hoc.

In a special analysis, time of going to bed was compared between respondents living in U.S. States with Eastern or Pacific Standard Time (EST/PST) and those living in States with Central or Mountain Standard Time (CST/MST). U.S. states were identified with the ATUS variable GESTFIPS. Idaho, Kentucky, South Dakota, and Tennessee include 2 different time zones, none of them dominating a greater part of the state, and, like Alaska and Hawaii, these states were thus excluded from the analysis.

RESULTS

Respondents who worked ≥ 8 h (i.e., long workers) spent on average 7 h 32 min in bed, while those who worked < 8 hours (i.e., short workers) spent on average 8 h 07 min in bed, and those who did not work on the interview day spent on average 8 h 50 min in bed (Table 1). Therefore, time in bed and work time were reciprocally related, corroborating our earlier findings.[10] This difference in time in bed was due to long workers terminating bed time an average of 40 min earlier than short workers (6:09 vs. 6:49, $P < 0.0001$, Figure 1B) and 78 min earlier than respondents not working on the interview day (6:09 vs. 7:27, $P < 0.0001$), but not due to differences in time of going to bed (22:37 vs. 22:42 vs. 22:37, respectively, $P = 0.385$, Figure 1A). Respondents living in EST and PST time zones went to bed on average 9 minutes later than respondents living in CST and MST time zones (22:42 vs. 22:33, $P < 0.0001$).

Of the 317 activities identified in the 2-h pre-bed period, watching television (TV) was the primary activity people engaged in before going to bed, accounting for 55.6 min (46.3%) of the 2-h pre-bed period (Table 2 and Figure 2A). A total of 68.1% of respondents watched at least some TV in the 2 h pre-bed; watching TV peaked 36 min prior to respondents' individual bed times, when more than half of respondents (51.1%) watched TV. In 38.2% of respondents, watching TV was the last waking activity before going to bed. Another 7%, after turning off the TV, first visited the bathroom and then went to bed. Prior to bed time, long workers watched an average of 2.6 min less TV than short workers (50.7 vs. 53.3 min, $P = 0.0002$) and 10.5 min less than respondents not working (50.7 vs. 61.1 min, $P < 0.0001$). Time in bed and the amount of TV watched in the 2 h pre-bed were uncorrelated (Spearman rho 0.08, $P < 0.001$).

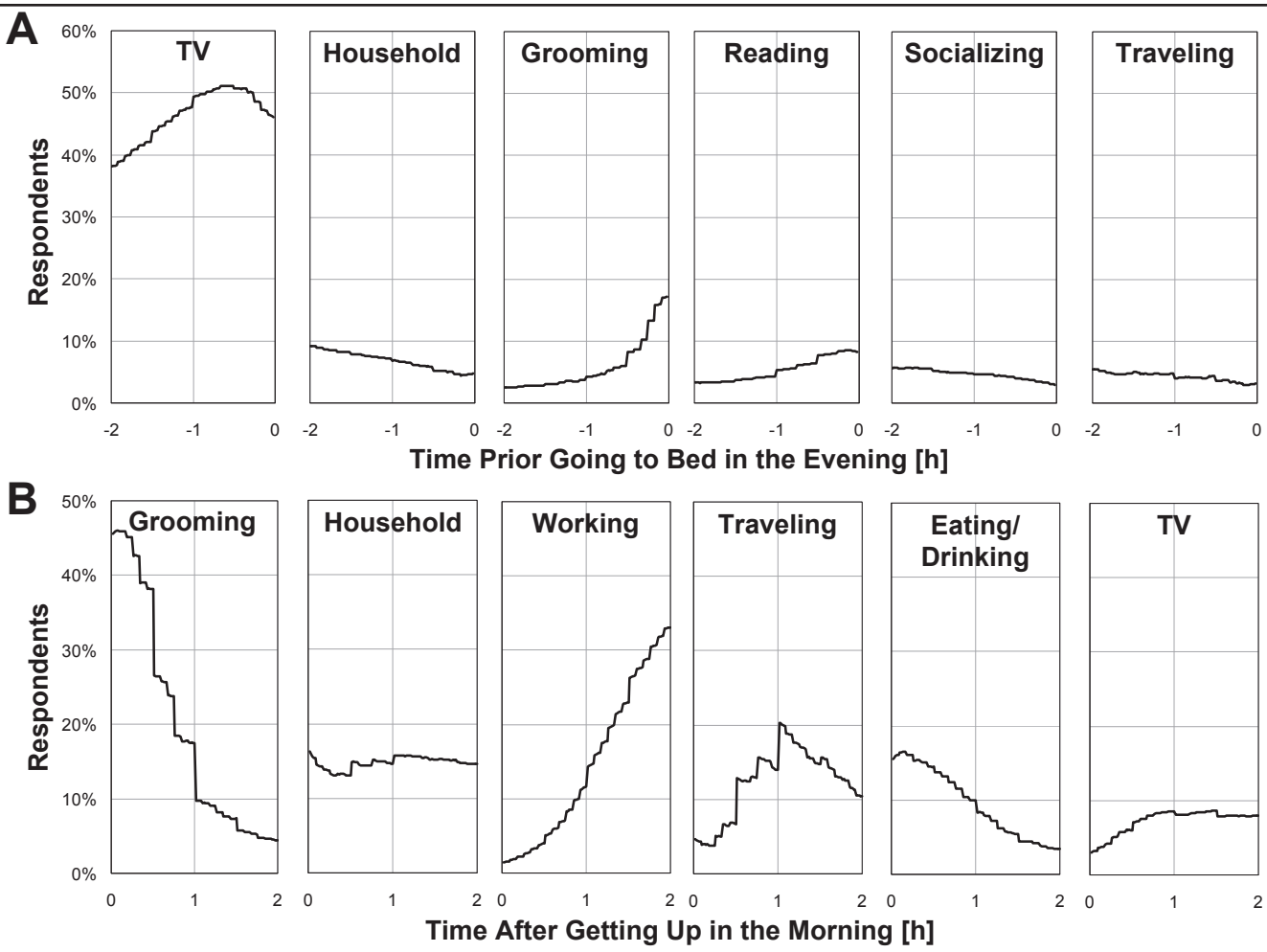

Figure 2—Panels A and B show the time course of the 6 most common waking activities in 2-h periods prior to going to bed (−2h to time of going to bed in panel A) and after getting up (time of getting up to +2h in panel B).

All other activities individually contributed little to the pre-bedtime period (Figure 2A). The behavior in the 2 h pre-bed of respondents living in EST/PST time zones did not differ from that of respondents living in CST/MST time zones. Each of the 10 most frequent evening activities listed in Table 2 differed by less than 2 min between EST/PST and CST/MST time zones. Respondents in EST/PST time zones watched on average 1.3 min more TV pre-bed than respondents living in CST/MST time zones ($P = 0.044$).

In the morning, grooming was the dominant activity (20.2%). Travel time and especially work time increased steadily towards the end of the post-awakening 2 h period, accounting for 14.7 min (12.3%) and 17.7 min (14.8%), respectively (Table 2 and Figure 2B). Commute time accounted for 7.5 min of the post-awakening 2-h period, making up 50.9% of total travel time. In those respondents who worked, travel time and commute time accounted for 19.5 min (16.3%) and 13.6 min (11.3%) of the post-awakening 2-h period, respectively. In those who worked, commute time constituted 69.7% of total travel time.

DISCUSSION

This analysis used 2003-2006 ATUS data from 21,475 respondents to investigate how a representative sample of Americans aged 15 years or older reported spending the 2-h periods before going to bed in the evening and after waking up in the morning. We hypothesized that activities spent in the 2 hours adjacent to the sleep period are the best candidates for being exchanged for more sleep time. We were also interested in whether and how the behavior of long workers, who were shown to exchange sleep time for more work time,[10] differed from that of short workers in the 2-h periods before and after bedtime.

Watching TV was the dominant activity in the 2-h pre-bed period, while the 2-h post-awakening period was dominated by grooming, household activities, work, and travel time. Time in bed for long workers was significantly shorter than for short workers and for respondents not working on the interview day, corroborating our earlier findings.[10] This difference in time in bed was due to long workers terminating bed time earlier, but not to differences in time of going to bed. Compared to short workers and respondents not working, long workers watched an average of only 2.6 min and 10.5 min less TV prior to bed, respectively. The fact that they averaged 50.7 min of TV viewing before bed suggests that they could exchange more of this discretionary TV time for sleep time, and reduce the 40 min to 78 min time in bed gap between themselves and those who worked less and slept more. This temporal exchange of behavioral activity should be feasible relative to circadian tim-

Table 1—Differences in Mean Time of Going to Bed, Time of Getting Up, Mid Time in Bed, Time in Bed, Time Watching Television, Age, and Percent Female Among Respondents Working ≥ 8 Hours, < 8 Hours, and Not Working on the Interview Day

	Work time category			Statistical tests (P values)			
	No work	< 8 h work	≥ 8 h work	K-W Test*	No vs < 8 h	No vs ≥ 8 h	< 8 h vs ≥ 8 h
	N = 9,770	N = 5,589	N = 6,116				
Time of going to bed [hh:mm]	22:37 (0:01)	22:42 (0:02)	22:37 (0:01)	0.3847			
Time of getting up [hh:mm]	7:27 (0:01)	6:49 (0:02)	6:09 (0:01)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Mid time in bed [hh:mm]	3:02 (0:01)	2:46 (0:01)	2:23 (0:01)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Time in bed [h]	8.84 (0.02)	8.13 (0.03)	7.54 (0.01)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Watching Television [min]	61.1 (0.6)	53.3 (0.7)	50.7 (0.7)	< 0.0001	< 0.0001	< 0.0001	0.0002
Age [years]	48.2 (0.2)	40.2 (0.2)	41.4 (0.2)	< 0.0001	< 0.0001	< 0.0001	0.1190
Female [%]	60.9 (0.5)	55.0 (0.8)	38.4 (0.6)	< 0.0001**	< 0.0001**	< 0.0001**	< 0.0001**

Mid time in bed is calculated as the midpoint between time of going to bed and time of getting up. Standard errors are given in parenthesis.
*P values for K-W Test: Kruskal-Wallis Test, **Pearson Chi-Square tests

ing, since earlier awakening in the morning promotes an earlier phase relationship of sleep timing.[12]

The finding that pre-bed TV and time in bed were uncorrelated stresses the fact that watching TV in the evening is a very common behavior in both short and long sleepers. This was shown in our previous ATUS analysis, where time spent watching TV was only moderately increased in very short sleepers (< 5.5 h) and very long sleepers (> 9.5 h), and practically unchanged in all other sleep time categories compared to reference (7.5 to 8.5 h).[10] In this study, respondents working long hours spent on average 1.3 h less in bed than those not working on the interview day, but they only watched 10.4 min less TV in the 2 h pre-bed than the latter.

An estimated 105.7 million people watched television during prime time in the 2005/2006 season (According to Nielsen Media Research[13], prime time is defined as 8 pm - 11 pm [Mon – Sat] and 7 pm – 11 pm [Sun]. The 2005-2006 TV season started on August 29, 2005 and ended on August 27, 2006). There are an estimated 312 million television sets in the USA, and 111.4 million U.S. domiciles have at least 1 television set.[13] Since cable and dish satellite have become available, viewers have an average of 96.5 channels available to them 24 hours a day (data from 2005). The highest percentage of Americans watches television in the evenings between the hours of 20:00 and 23:00.

It surprised us to find that work status (no work, short workers, long workers) had no effect on time of going to bed, even though the three groups differed from each other relative to time in bed, mid time in bed, and time out of bed. It is entirely possible that by getting up earlier in the morning without advancing time of going to bed in the evening, some long workers could accumulate a sleep debt[14] through partial sleep deprivation during the workweek. This behavior was recently referred to as "social jetlag" by Rönneberg and colleagues.[17] The only way to reduce sleep debt and its neurobehavioral consequences[3] is by increasing sleep time on weekends and days off,[10] although it is unknown precisely what duration of sleep and number of days of additional sleep are needed on non-work days to liquidate varying degrees of sleep debt.

While the human circadian clock is programmed biologically to entrain to the solar photoperiod,[16] our data suggest that nighttime television has potent control over the behavioral timing of sleep onset for millions of Americans—watching TV was the last waking activity of 45.1% of the respondents before grooming or going to bed, and 68.1% of respondents watched at least some TV in the 2 hours before bedtime. Thus, television viewing was by far and away the dominant pre-sleep activity. When considered with equally potent control over wake times by alarm clocks, these two social Zeitgebers—television and alarm clocks—are bracketing sleep time for millions of people, but especially for those who work long hours. Because TV and alarm clock timing fluctuate relative to work hours, commute time, and day of week, they may further exacerbate social jetlag[17] for most Americans.

The hypothesis of television viewing as the primary external social Zeitgeber for bedtime is corroborated by the fact that respondents living in EST and PST time zones went to bed significantly later than respondents living in CST and MST time zones (22:42 vs. 22:33, P < 0.0001). This finding replicates results by Silva et al., who were able to show with data from the Sleep Heart Health Study that total sleep time of subjects living in CST/MST time zones exceeded that of subjects living in EST/PST time zones by 15 min (P = 0.010).[5] Many prime time and late night shows are broadcast one hour later in EST/PST time zones than CST/MST time zones. Using 2003 and 2004 ATUS data, Hamermesh et al.[15] showed that respondents in CST/MST time zones were 6.4 percentage points less likely to be watching TV between 23:00 and 23:15 than the 17% of respondents who watched TV at that time in EST/PST time zones. Compared to this cue of early television start times, the effects of sunset (1 percentage point less TV for a 1-hour advance in sunset) and time zone (1.8 percentage points less TV for a 1-hour shift westward in time zone) were much less pronounced, corroborating the importance of TV as a more influential Zeitgeber than sunset time and time zones differences.

The data from our study suggest that regardless whether or not one works for pay, or among those who work, whether or not the hours are long, television viewing before bedtime is remarkably common, temporally synchronizing, and the major contributor to the decision when to initiate of the nocturnal sleep period.

This suggests that evening television viewing is a prime behavior to target to ensure that large segments of the working population obtaining adequate sleep. But would voluntary restriction of TV viewing time in the evening result in more sleep?

Only one small interventional study by Asaoka and colleagues[18] has attempted to test this hypothesis. They found that restricting television time to only 30 min per day advanced bed time and increased total sleep time significantly in university students, while no effects were observed in elderly people. However, giving up much of the evening prime time viewing may be impractical for many people. A more feasible approach might involve shifting the timing of prime time television programs. According to the results of Hamermesh and colleagues,[15] sleep time may be increased on the population level by advancing prime time TV by one hour in EST/PST time zones, and thus aligning it more with the photoperiod. This would allow people to watch the programs they like while still getting to bed as much as 1 hour earlier.

We also found that in the morning, travel time (including commute time) and work time increased steadily towards the end of the post-awakening 2-h period. Therefore, additional sleep time might also be obtained by postponing the start of the work or living closer to work, if the additional time is not used to further postpone bedtime in the evening. A recent study by Danner et al. was able to demonstrate that a 1-hour delay in high-school start times increased sleep duration and decreased extended sleep on weekends.[19] Average crash rates for teen drivers in the study county in the 2 years after the change in school start time dropped 16.5%, compared with the 2 years prior to the change, whereas teen crash rates for the rest of the state increased 7.8% over the same time period.

Limitations

Most of the limitations of ATUS that were discussed in detail in Basner et al.[10] also apply to this study. The overall response rate of 52.1% is relatively low, which may be partly explained by response fatigue, as ATUS respondents were drawn from households that completed their eighth and final month interviews for the Current Population Survey (CPS). The extent to which non-response influences the representativeness of the sample is discussed in greater detail in Abraham et al.[20]

Subjectively assessed sleep time usually overestimates physiologically measured sleep duration.[5,6] However, even if compared to self-reported sleep times in other population-based studies, average ATUS sleep times were on average longer:[1,2,21] If compared to the National Sleep Foundation's (NSF) 2005 Sleep in America poll,[2] average ATUS nighttime bed times in our sample (8 h 17 min) exceeded average NSF weekday sleep times (6 h 48 min) by 89 min (+21.7%). Given that the "sleep" category for ATUS included a wide range of terms that may not involve physiological sleep (e.g., falling asleep, dozing off, napping, getting up, waking up), it is certain that ATUS sleep times are overestimates of actual physiological sleep obtained by respondents per 24 hours, which is why we preferred to use the term *time in bed* instead of *sleep tim*e throughout the manuscript. Defining *sleeplessness* (ATUS category 01.01.02) as wake instead of sleep would not have changed this overestimation substantially, as the category sleeplessness accounted for less than 1% of the ATUS sleep time category. Additionally, based on our definitions of time of going to bed and time of getting up, intermittent periods of wakefulness within the night were counted as sleep. This also may have contributed to the longer estimated sleep period durations obtained in this study compared to other population-based studies.[1,2,21] However, it is unlikely that the overestimation of sleep time substantially biases our findings on waking activities in the 2-h periods before going to bed and after getting up.

We also acknowledge the possibility that many long workers are naturally shorter sleepers, in which case obtaining additional sleep by going to bed earlier may not be of benefit to them. Alternatively, they may be exchanging sleep time for work time but be individuals who are somewhat resilient to the effects of chronic sleep restriction (e.g., there is now evidence that some people are more resistant to the effects of a night of total sleep deprivation than others[22-27]). These possibilities highlight the dearth of information on the relationship of habitual sleep duration to neurobehavioral vulnerability to sleep restriction. Until population data are available on objective sleep duration and neurobehavioral vulnerability to sleep restriction, it will not be possible to know how important it is to recommend people to

Table 2—Top Ten Activities in the 2-h Period Prior Bedtime in the Evening and in the 2-h Period Past Bedtime in the Morning

Category	ATUS Code*	Activity [min] ± 95% CL	Activity [%]
EVENING			
Television	12.03.03 & 12.03.04	55.6 ± 0.7	46.3
Household activities	02	8.2 ± 0.3	6.8
Personal care w/o sleep (grooming)	01	7.8 ± 0.2	6.5
Reading for personal interest	12.03.12	6.4 ± 0.3	5.3
Socializing & communicating	12.01&12.02	5.6 ± 0.3	4.7
Traveling	18	5.1 ± 0.2	4.3
Caring for household and non-household members	03 & 04	4.9 ± 0.2	4.1
Eating and drinking	11	4.7 ± 0.2	3.9
Work	05	4.5 ± 0.3	3.7
Relaxing, thinking	12.03.01	2.4 ± 0.2	2.0
MORNING			
Personal care w/o sleep (grooming)	01	24.2 ± 0.4	20.2
Household activities	02	17.8 ± 0.5	14.8
Work	05	17.7 ± 0.5	14.7
Traveling	18	14.7 ± 0.3	12.3
Eating and drinking	11	11.5 ± 0.3	9.6
Television	12.03.03 & 12.03.04	8.7 ± 0.4	7.2
Caring for household and non-household members	03 & 04	6.4 ± 0.2	5.3
Education	06	3.7 ± 0.3	3.1
Reading for personal interest	12.03.12	3.5 ± 0.2	2.9
Sports, exercise, recreation	13	2.6 ± 0.2	2.2

ATUS: American Time Use Survey; CL: confidence limit; *ATUS Codes are defined in the ATUS Activity Lexicon (see http://www.bls.gov/tus/ or the appendix of Basner et al.[10])

turn off the television and go to bed earlier, or record their favorite shows and watch them earlier in the evening.

Finally, we note that advancing television viewing in the evening may not benefit night owls. Social jetlag is very pronounced in late phase chronotypes, as these individuals may have to get up early due to social demands without being able to advance their circadian controlled sleep onset.[17] Hence, in late chronotypes watching less TV in the evening may not result in increased sleep time.

Conclusions

In conclusion, time use surveys of Americans over 14 years of age suggest that the discretionary time use trade that would most likely increase sleep time in long workers is an exchange of evening television time for an earlier bedtime. This could be accomplished while still working the longer hours many Americans find necessary.

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