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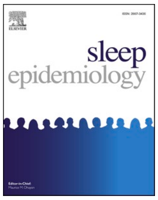

Association of working hours with accelerometer-based sleep duration and sleep quality on the following night among older employees

Saana Myllyntausta [a,*], Anna Pulakka [b,c], Jaana Pentti [d,e,f], Jussi Vahtera [d,e], Marianna Virtanen [g,h], Sari Stenholm [d,e]

[a] *Department of Psychology and Speech-Language Pathology, University of Turku, Turku FI-20014, Finland*
[b] *Research Unit of Population Health, Faculty of Medicine, University of Oulu, Oulu, Finland*
[c] *Population Health Unit, Finnish Institute for Health and Welfare, Helsinki, Finland*
[d] *Department of Public Health, University of Turku and Turku University Hospital, Turku, Finland*
[e] *Centre for Population Health Research, University of Turku and Turku University Hospital, Turku, Finland*
[f] *Clinicum, Faculty of Medicine, University of Helsinki, Helsinki, Finland*
[g] *School of Educational Sciences and Psychology, Psychology, University of Eastern Finland, Joensuu, Finland*
[h] *Division of Insurance Medicine, Karolinska Institutet, Stockholm, Sweden*

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ABSTRACT

This study examined the association between daily working hours and accelerometer-based sleep duration, sleep efficiency, and number of awakenings per hour of sleep on the following night among 800 older public sector employees in Finland (mean age 63 years in the first measurement they participated in, 87% women) with 4,818 measurement nights in total. Information on working hours was derived from daily logs and categorized into: 1) 6 h, 2) 7, hours 3) 8 h, 4) 9 h, and 5) 10 or more hours of work. The most common category (i.e. workdays with 8 h of work) was used as the reference category in the analyses. Nights followed by a workday and a free day were analyzed separately. No differences were observed in sleep duration between the reference group and the other working hour categories when the next day was a workday nor when the next day was a free day. After a 6-hour workday, sleep efficiency was on average 1.0 percentage points higher and there were on average 0.13 less awakenings per hour of sleep when compared with the reference category. When the next day was a free day, no differences in sleep quality were observed. Thus, no clear indication of a dose-response relationship between working hours and either duration or quality of sleep was found. Furthermore, future research should further examine the possibility that the association between working hours and sleep is somewhat different depending on whether the workday is followed by another workday or a free day.

1. Introduction

Many daily activities compete with the time available for sleeping, such as working and commuting, as well as leisure time activities, such as household chores, socializing, and electronic media use (e.g. the use of internet, social media, and television) [1–4]. According to 24-hour time use data, working has been shown to be the dominant wake-time activity for which sleep is traded off among short sleepers (< 6 h) [1]. Thus, working long hours decreases the time available for activities that enhance the recovery from work, including sleeping. Furthermore, after retirement when working hours are removed from the daily schedule, the average sleep duration has been shown to increase [5–7]. Approximately a third of the global workforce works long hours, for example more than 48 h per week [8]. These findings highlight the importance of examining the association of time used for work with sleep.

Previous research has consistently shown an association between long working hours and short sleep duration [9–15] as well as increased sleep duration when working hours are reduced [16]. In addition, long working hours have been shown to be associated with self-reported poor-quality sleep and sleep difficulties [9,13,17]. These findings raise concern, as both self-reported short sleep duration and impaired sleep quality are known to be associated with both morbidity [18–22] and mortality [23–25].

Abbreviations: CI, Confidence intervals; FIREA, The Finnish Retirement and Aging study; GEE, generalized estimating equations; OR, odds ratios.

[*] Corresponding author.

E-mail address: saana.myllyntausta@utu.fi (S. Myllyntausta).

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The previous studies on the association between working hours and sleep have mostly relied on self-reported sleep estimates (e.g. average sleep duration across a month) and do not often consider the variability of sleep throughout the workweek. For example, on weekends and other free days, employees have more time to rest than on workdays [1,26,27]. The few previous studies have provided mixed findings; one study among primary care physicians showed shorter sleep duration on both workdays and free days among those working overtime when compared with those not working overtime [13], and another study observed an association between long working hours and short sleep duration on both workdays and free days among men but only on workdays among women [10]. Thus, more information is needed on how long workdays are associated with sleep duration and quality of sleep throughout the workweek.

The use of accelerometers along with daily information on working hours allows a more detailed examination of the association and whether it is different on nights followed by workdays and nights followed by free days. By using accelerometers, the possible immediate effects of long working hours on the following night can be examined, and recall bias that are often associated with subjective sleep estimates can also be avoided. Of the two earlier accelerometer-based studies on this topic we are aware of, one found a strong, negative relationship between long working hours and sleep duration among nursing home employees [11]. The other one, an early experimental field study (n = 15), observed shorter total sleep time and earlier awakening times during an overtime week when compared with a workweek with normal hours [28]. However, these studies did not analyze the associations separately for workdays and free days. They also did not consider the possibility of variability of working hours throughout the workweek.

It would be important to study the association between working hours and sleep among older employees (i.e. employees aged over 55 years), as nightly sleep duration, sleep efficiency, and the ability to maintain sleep are known to decrease and nocturnal awakenings to increase with age [29–31]. Thus, findings ways to promote sufficient sleep is of high importance among older employees. Furthermore, findings on shorter sleep duration during the final working years when compared with retirement suggest that work has a major role in defining the amount of sleep older employees gain [5–7]. The participants in the previous studies on the association between working hours and sleep have mostly been on average young or middle-aged adults, and thus, more information is needed on this association among employees close to retirement age.

This study aimed to examine the association between daily working hours and accelerometer-based sleep duration and sleep quality (measured as sleep efficiency and number of awakenings per hour of sleep) of the following night among older public sector employees in Finland. The measurement nights were examined separately depending on whether the following day was a workday or a free day. We hypothesized that 1) long working hours are associated with shorter accelerometer-based sleep duration and poorer sleep quality on the following night and that 2) this association depends on whether the following day is a workday or a free day.

2. Methods

2.1. Participants and study design

This study uses data from the Finnish Retirement and Aging (FIREA) study [32]. The FIREA study is an ongoing, longitudinal cohort study of public sector employees close to their retirement age in Finland, established in 2013. The FIREA study target population included all public sector employees who had their statutory retirement date between 2014 and 2019 and who were working in one of the 27 municipalities in Southwest Finland, nine selected cities, or five hospital districts around Finland in 2012. We first contacted the eligible study population (N = 10,629) by sending them a questionnaire. All respondents who completed the first FIREA questionnaire while they were still working, who were Finnish-speaking, and had their estimated retirement date between 2016 and 2019 were then invited by mail to take part in an accelerometer sub-study (n = 2663). All 908 individuals (response rate 34%) who provided an informed consent to participate in the sub-study were sent an accelerometer. The participants were thereafter followed up annually with both questionnaires and accelerometer measurements during years 2014–2020 and each measurement of each participant was conducted at an approximately same time each year to avoid seasonal effects intervening with the results. The FIREA study cohort and the study protocols of the accelerometer sub-study have been described in detail elsewhere [6]. The FIREA study has been conducted in line with the Declaration of Helsinki and has been approved by the Ethics Committee of Hospital District of Southwest Finland.

For the current study, we included those accelerometer-measured nights from each participant that were conducted before retirement, included information on self-reported working hours on the preceding day and whether the following day was a workday or a free day, and did not include employees working night work (resulting $n = 810$ with 5070 measurement nights in total). Furthermore, we excluded those nights with less than 6 h of work on the previous day (n of excluded participants = 10 with 242 measurements nights in total), as these workdays were considered as atypical in terms of duration of an average workday. This resulted in a study sample of 800 participants who provided 4818 measurement nights in total of which 4279 were followed by a workday and 539 by a free day. On average, the participants provided data from 1.7 accelerometer measurements (standard deviation [SD] = 1.7, range 1 – 4 measurements).

2.2. Assessment of sleep with accelerometer

Two versions of a triaxial accelerometer by ActiGraph (Pensacola, FL, USA), namely wActiSleep-BT and wGT3X-BT, were used to measure movements during wakefulness and sleep. The devices were sent to the participants by mail. Participants were instructed to wear the device continuously on their non-dominant wrist 24-h/d for 7 days and nights and to remove the device only during sauna bathing to prevent it from overheating. While wearing the accelerometer, participants completed a daily log, in which they provided timing and information on their daily activities (e.g. bedtimes and waketimes). The participants returned the accelerometers and daily logs in postage-paid envelops after the measurement.

The raw accelerometer data were downloaded and converted into 60 s epochs using the manufacturer's ActiLife software (version 6.13; ActiGraph, Pensacola, FL, USA). We used the Cole-Kripke algorithm [33] to define each epoch as sleep or wake and the algorithm by ActiGraph [34] to detect sleep periods. We took multiple steps to handle and clean the accelerometer data and the sleep periods before the statistical analyses; for example, we restricted the analyses on the main sleep period (i.e. the night), combined sleep periods that were divided into two or more sleep periods by the algorithm, and removed non-wear times the algorithm defined as sleep using the daily logs as a reference. A more detailed description of the procedures has been provided elsewhere [6]. We derived sleep variables separately for workday nights (i.e. nights that were followed by workdays) and free day nights (i.e. nights that were followed by free days). These sleep variables included sleep duration (i.e. total minutes of sleep between sleep onset and awakening time according to the algorithm), sleep efficiency (i.e. the percentage of sleep duration from the time spent in bed during the night), and the number of awakenings per hour of sleep.

2.3. Assessment of working hours

Information on working hours was derived from the daily logs, where the participants reported whether the measurement day in question was a workday or a free day and at what time they began and ended their workday. Daily working hours were defined as the duration from the beginning of the workday to the end of the workday in hours.

Working hours were analyzed as a categorical variable with five categories of working hours/ workday: 1) 6 h (i.e. workdays with 6–6.9 h of work), 2) 7 h (i.e. workdays with 7–7.9 h of work), 3) 8 h (i.e. workdays with 8–8.9 h of work), 4) 9 h (i.e. workdays with 9–9.9 h of work), and 5) 10 h or more (i.e. workdays with 10–10.9 h of work).

2.4. Assessment of covariates

We obtained information on participants' sex, date of birth, and occupational title from the pension insurance institute for the public sector (Keva Public Sector Pensions). We used occupational title at the time of the survey to define participants' occupational status [35], which was dichotomized into non-manual occupation (which included both upper-grade and lower-grade non-manual occupations) and service and manual occupations.

In addition, information on participants' working hour schedules was derived from the questionnaires completed closest to the time of each accelerometer measurement. The participants were categorized based on whether they did shift work (including shift work with or without night shifts, regular night work, and other irregular work) or not. Finally, the date of each measurement night was used to derive information on which season (spring, summer, fall, or winter) the measurement occurred.

2.5. Statistical analyses

We conducted all statistical analyses using the SAS Statistical Package version 9.4 (SAS Institute Inc., Cary, North Carolina). Characteristics of the participants in their first measurement are reported as frequencies and percentages for categorical variables and as mean and standard deviation for age.

We analyzed each measurement night as its own statistical unit. Nights followed by a workday and nights followed by a free day were analyzed separately. First, we analyzed the association between working hours and sleep parameters on the following night, by examining the average levels of sleep duration, sleep efficiency, and the number of awakenings per hour of sleep in each category of working hours using linear regression analyses with generalized estimating equations (GEE) while adjusting for age, sex, occupational status, and the season of the accelerometer measurement. As each participant contributed several measurement nights, we used GEE models as they control for intra-individual correlation between measurements. The average levels of the sleep parameters are reported as mean estimates and their 95% confidence intervals (CI) by working hour categories. We also conducted pairwise comparisons between the reference group, that is workdays of 8 h of work, and all other working hour categories and report the results as mean differences and their 95% CIs. This group was chosen as the reference group as it was observed to be the most common working hour category on the examined workdays.

Finally, we repeated the main analyses excluding those with shift work or no information on their working hour schedules from the analyses (n included = 594). These participants provided information on 3278 measurement nights in total of which 2973 were followed by a workday and 305 by a free day.

3. Results

In Table 1, a detailed description of the participants ($n = 800$) based on the first measurement they participated in is provided. On average, the participants were 62.7 years old (SD = 1.1) and majority of them were women (87%) and in non-manual occupations (69%). Of the 4818 examined workdays, 6% were workdays with 6 h of work, 28% were workdays with 7 h of work, 52% workdays with 8 h of work, 10% were workdays with 9 h of work, and 5% were workdays with 10 h or more work.

Table 1
Background characteristics of the participants ($n = 800$) in their first measurement and descriptive characteristics of the accelerometer measurements.

Characteristics	n/M	%/SD
Age, years	62.7	1.1
Sex		
Men	107	13
Women	693	87
Occupational status		
Nonmanual	549	69
Service and manual	245	31
Shift work		
No	572	79
Yes	150	21
Season of the accelerometer measurement		
Spring	1368	28
Summer	750	16
Fall	1428	30
Winter	1272	26
Number of measurement nights per participant		
1	31	4
2	56	7
3	97	12
4	159	20
5	45	6
6	58	7
7	94	12
8	140	18
9	36	5
10 or more	84	11
Average measurement nights per participant	6.0	3.3
Average measurement nights followed by a workday per participant	5.3	3.1
Average measurement nights followed by a free day per participant	0.7	0.9

Sleep parameters were first examined in terms of categories of working hours of the previous day. Mean estimates and their 95% CIs for sleep duration are shown in Fig. 1 by previous day's working hour categories separately for nights followed by a workday and nights followed by a free day and adjusted for age, sex, occupational status, and the season of the accelerometer measurement. No differences were observed in sleep duration between workdays of 8 h of work and the other working hour categories when the next day was a workday (Fig. 1a) nor when the next day was a free day (Fig. 1b).

As seen in Fig. 2a, when the next day was a workday, sleep efficiency was on average higher after workdays with 6 h of work when compared with workdays of 8 h of work (mean difference 1.0 percentage points, 95% CI 0.3 – 1.7), but no other differences were observed. When the next day was a free day (Fig. 2b), no differences in sleep efficiency were observed between workdays of 8 h of work and the other working hour categories.

As seen in Fig. 3a, the number of awakenings per hour of sleep was smaller after workdays of 6 h when compared with workdays of 8 h of work (mean difference −0.13, 95% CI −0.25 – −0.01) when adjusted for age, sex, occupational status, and the season of the accelerometer measurement when the next day was a workday. No other differences were observed when the next day was a workday and no statistically significant differences were observed when the next day was free day (Fig. 3b).

Finally, we repeated the main analyses among participants who did not do shift work. The results of these analyses are reported in supplementary materials (Figures S1–S3). The findings of the sensitivity analysis were highly similar as those in the main analyses. The only difference to the findings of the main analyses was the finding that the number of awakenings per hour of sleep (Fig. S3b) was smaller after workdays of 10 h or more when compared with workdays of 8 h of work (mean difference −0.56, 95% CI −0.98 – −0.15) when adjusted for age, sex, occupational status, and the season of the accelerometer

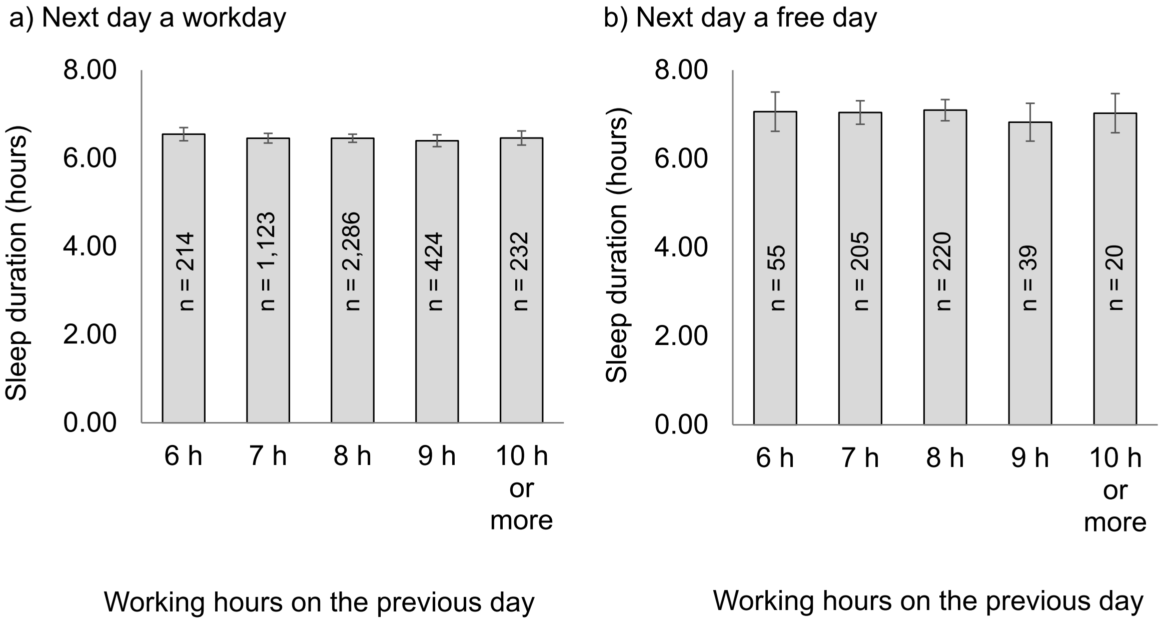

Fig. 1. – Mean estimates for sleep duration and their 95% confidence intervals by working hours on the previous day when a) the next day is a workday and when b) the next day is a free day. Adjusted for age, gender, occupational status, and the season of the accelerometer measurement.

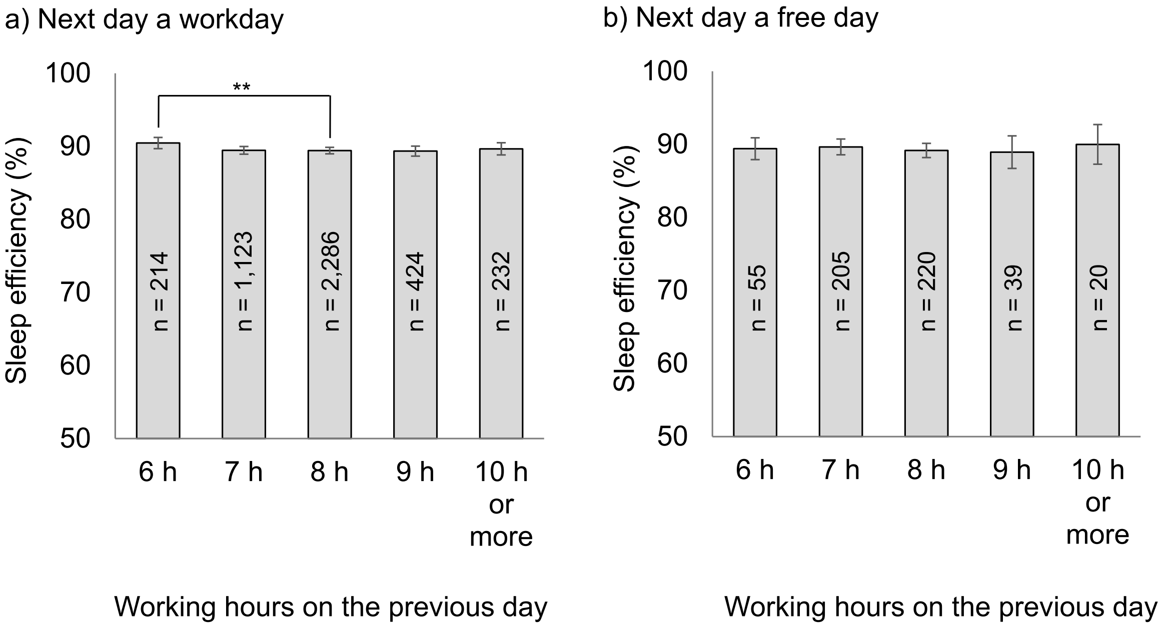

Fig. 2. – Mean estimates for sleep efficiency and their 95% confidence intervals by working hours on the previous day when a) the next day is a workday and when b) the next day is a free day. Adjusted for age, gender, occupational status, and the season of the accelerometer measurement. $^{**}p < 0.01$.

measurement when the next day was a free day. However, it should be noted that there were only eight observations of 10 h or more work when the next day was a free day in this sensitivity analysis.

4. Discussion

In this study, we extended previous knowledge on the association between daily working hours and sleep by measuring both sleep duration and quality with accelerometers and by examining the association separately for nights preceding workdays and free days. Although some differences based on previous day's working hours were observed in the sleep quality measures, we did not find indication of a clear dose-response relationship between working hours and either duration or quality of sleep. Furthermore, when the workdays were followed by a free day, no differences in neither sleep duration nor quality were observed between the working hour groups. Thus, as hypothesized, the findings on the association between working hours and sleep where somewhat different depending on whether the next day was a workday or a free day. This is understandable, as the opportunities to sleep and recover from work are better on free days and in that way, working hours on the previous day may not have as high an impact on sleep as on workdays.

Short sleep duration was raised as one of the most concerning occupational health problems related to long working hours in a recent meta-analysis [36]. In a previous study, an almost 5-minute decrease per night was observed in accelerometer-measured sleep duration with

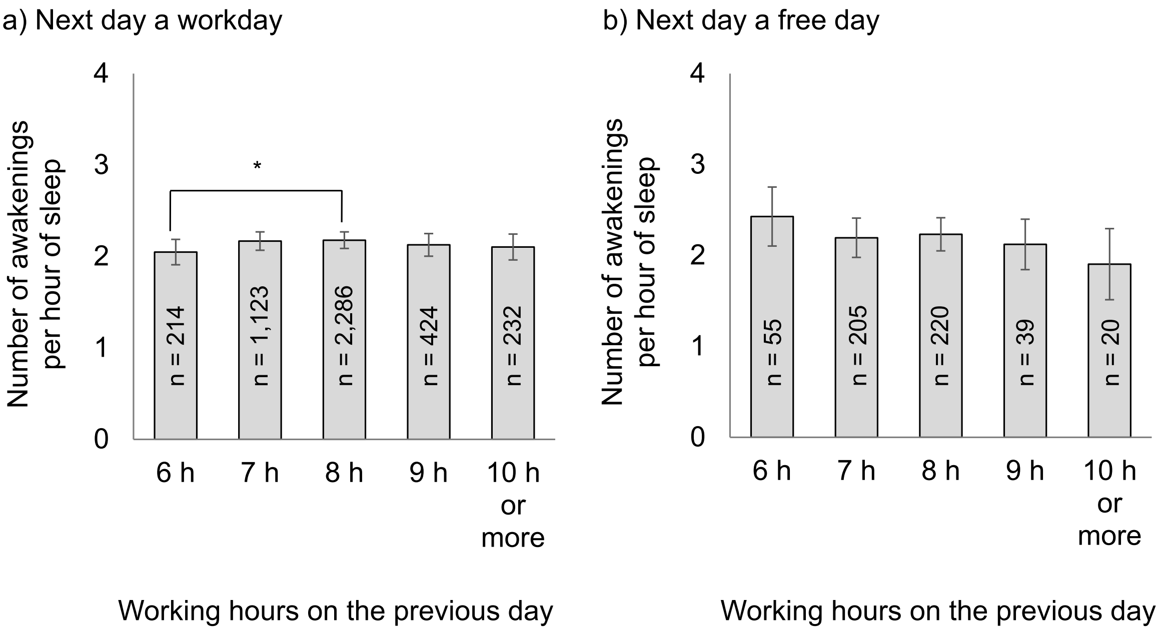

Fig. 3. – Mean estimates for number of awakenings per hour of sleep and their 95% confidence intervals by working hours on the previous day when a) the next day is a workday and when b) the next day is a free day. Adjusted for age, gender, occupational status, and the season of the accelerometer measurement. *$p < 0.05$.

every 10 h of work per week among nursing home employees in the United States [11]. In that study, the participants were somewhat younger (on average 37.6 years old) than in our study and daily sleep duration was averaged throughout the measurement week. That study did not, thus, separate between workdays and free days. Contradictory to the previous findings and our hypothesis, we did not observe any differences in sleep duration between the working hour categories. Although working long hours could generally be thought to decrease the time available for sleeping, we did not observe an immediate association between long working hours and short sleep duration in our data. Whether this finding is due to there not actually being an immediate effect of long working hours on sleep duration on the following night or due to limited statistical power to observe such effects requires for further research.

We found higher sleep efficiency and lower number of awakenings per sleep hours when workday was slightly shorter (i.e. 6 h of work) than the average (i.e. 8 of work), when the next day was a workday. These findings indicate sleep quality to be somewhat better with shorter working hours when compared to more moderate working hours. Overall, sleep efficiency was quite high and the number of awakenings were low in our study. Given that the differences in sleep quality observed between the working hour groups were small (albeit statistically significant), the practical relevance of these differences might be quite minimal. No other differences in sleep quality between the working hour groups were found, which is in contrast to some of the previous studies on sleep quality showing poorer self-reported sleep quality with longer working hours and overtime [9,13,17]. Although accelerometers have been deemed a valid measurement tool for assessing sleep efficiency on a population level with the algorithms used in the current study, the sensitivity of the accelerometers is poor in identifying wake episodes [37,38]. Thus, accelerometers may not be sensitive enough for detecting the sleep difficulties associated with long working hours, which might explain the discrepancy with the previous findings.

As we hypothesized, there were some differences in the association between long working hours and sleep depending on whether the next day was a workday or a free day. The association between shorter working hours and better sleep quality was observed when the next day was a workday, but not when the next day was a free day. Similar findings have been observed previously in terms of short self-reported sleep duration among women, whereas among men, long working hours were associated with short sleep duration on both workdays and free days [10]. As the majority (87%) of the participants in our study population were women (corresponding to the sex distribution of the public sector employees in Finland) more research is needed to examine this association among male employees and whether there are sex differences in this association. Furthermore, the amount of measurement nights followed by a free day per participant in comparison to measurement nights followed by a workday was low in our study, which may have limited the statistical power to observe differences in the sleep measures on the nights followed by a free day. Thus, more accelerometer-based research is needed to examine the possibility that the association between working hours and sleep is different depending on whether the workday is followed by another workday or a free day.

Our study has a number of significant strengths, including a reasonably large sample of older employees from a range of public sector occupations. A major strength of the study are the daily accelerometer measurements of sleep by which the possible evaluation biases associated with self-reported sleep were avoided. In addition, the detailed information of daily working hours allowed us to examine nights followed by workdays and free days separately. This is important as the association between working hours and sleep seems to be somewhat different depending on whether the next day is a workday or a free day. Furthermore, we used the most common working hour category (work days with 8 h of work) as the reference category for clarity and easier interpretation of the results, as has been previously recommended [39]. Finally, we repeated the analyses among participants who did not do any shift work, as shift work is known to disturb sleep, and observed similar findings as in the main analyses. The importance of considering the possible influence of shift work when examining the association between long working hours and health has been pointed out previously [39].

There are also some limitations that need to be acknowledged when interpreting the findings of this study. Firstly, due to the observational nature of the study, it is not possible to draw any conclusions regarding causality between working hours and sleep. Secondly, although the use of daily reports of working hours may reduce possible memory bias, there may be variation in what the participants themselves define as working hours. For example, there may be differences between the participants in whether they define time used for lunch, coffee breaks, and reading emails at home as working hours or not. Additionally, we were not able to control for other working time dimensions, such high work tempo, that have been association with poor sleep [40]. Long working hours may coexist with high work stress, and we did not have information on how much work stress the participants experienced on the measurement days so that we could have examined whether the observed associations are attributable to high work stress rather than working hours per se. Finally, of the examined nights, only 5% were related to long workdays (≥10 h). This low prevalence may have limited the statistical power in our analyses.

In conclusion, this study is one of the first to examine the association of daily working hours on accelerometer-based sleep throughout the workweek. No clear indication of a dose-response relationship between daily working hours and either duration or quality of sleep was found. The association between working hours and sleep was somewhat different on the nights that were followed by a workday and on the nights that were followed by a free day, which indicates the need for further research that considers the variability of sleep throughout the week when examining the association between working hours and sleep. Promoting good sleep health is especially important among older employees, because sleep quantity and quality tend to decrease with advancing age. Sleep health of older employees may be promoted, for example, through health promotion programs and interventions at the workplace [41,42] and through behavioral interventions for the individual employees, such as cognitive behavioral therapy for insomnia [43].

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Sari Stenholm has received research grants from the Academy of Finland, Ministry of Education and Culture, and the Finnish Work Environment Fund; Marianna Virtanen has received a research grant from the Finnish Work Environment Fund; Jussi Vahtera has received a research grant from the Academy of Finland; and Anna Pulakka was supported by the European Commission through Horizon 2020.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sleepe.2023.100060.

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