Fatigue and Sleep Among Employees With Prospective Increase in Work Time Control

A 1-Year Observational Study With Objective Assessment

Tomohide Kubo, PhD, Masaya Takahashi, PhD, Xinxin Liu, PhD, Hiroki Ikeda, PhD, Fumiharu Togo, PhD, Akihito Shimazu, PhD, Katsutoshi Tanaka, PhD, Naoki Kamata, PhD, Yoshiko Kubo, MSc, and Junko Uesugi, BA

Objectives: This observational study aimed to determine how 1-year changes in work time control (WTC) have an impact upon objectively measured fatigue and sleep among employees. **Methods:** Thirty-nine employees were divided into two groups according to whether or not their WTC increased from baseline to 1 year later. Psychomotor vigilance task (PVT) and wrist actigraphy were used to objectively measure fatigue and sleep, respectively. Self-reported outcomes were also measured. **Results:** The increased WTC group showed gradual improvements in PVT performance and sleep quality over the course of the follow-up period compared with the not-increased WTC group. Between-group differences were statistically significant for PVT lapses and tended to be significant for PVT speed after 1 year. **Conclusions:** A progressive increase in WTC could play a crucial role in reducing fatigue and promoting sleep among employees.

Learning Objectives

- Become familiar with the emerging data on associations between work time control (WTC) and health outcomes.
- Summarize the new findings on the relationship between increased WTC and measures of fatigue and sleep.
- Discuss the study implications for programs to increase WTC as a means of enhancing workplace health, safety, and productivity.

As modern society has become more flexible and variable as a result of the development of information technology, our working-life has been dramatically changed so far. Although such changes have provided harmonization of work with life, possible risks of becoming a workaholic and other health disorders are suggested as well.[1] In other words, flexibility has a variety of forms that could affect our working life in both favorable and unfavorable manners. For example, use of smartphones and laptop computers outside the workplace has blurred the boundaries between work and nonwork, which relates to the problem of spatial flexibility. Variable work schedules (ie, employer-determined flexibility) seem to improve work productivity, but they reduce the regularity of work hours. Consequently, it is possible that employees adopting such schedules will have to work with variable or interrupted sleep schedules. Given that a regular lifestyle is associated with high-quality sleep,[2,3] employees who work a variable schedule may be at a higher risk of sleep problems.[4,5] In contrast, a flexible work schedule (ie, employee-determined flexibility) coupled with an increase in workers' perceived ability to control their working times (work time control; WTC), is reported to lead to positive health-related outcomes, including reduced fatigue, depression, and insomnia,[6] improved psychological health,[7] less frequent sickness absence,[8,9] and reduced risk of early retirement due to musculoskeletal disorders.[10]

However, working a flexible schedule appears to both positively and negatively affect health at work, suggesting that length of work hours may moderate the relationship between flexibility and health. Recent findings suggest that working long hours (more than 40 hours per week) with high levels of WTC is associated with sleep disturbances.[11] In contrast, a decreased risk of sleep disturbances was found for employees who have high levels of WTC but who do not work long hours. In other words, unfavorable influences occur if high levels of WTC lead employees to work long hours regardless of fatigue. Conversely, high levels of WTC may produce favorable influences on health-related outcomes when employees are allowed to stop working before becoming too fatigued.[12] Thus, it is possible that high levels of WTC are not always effective in helping employees improve their health.[4,5] Nevertheless, numerous studies support the relationship between low levels of WTC and adverse mental and physical health outcomes.[6–8]

Empirical data regarding the positive associations between WTC and worker health have been gathered, but it is unclear why these positive associations exist. One possible candidate to connect the two factors is sleep. Increased WTC levels could allow employees to take preventive strategies for recovery (eg, going home and going to bed early) before their fatigue levels become extreme. Consequently, their work-related stress levels would be reduced. In addition to sleep opportunity, previous findings have suggested the desirable influences associated with WTC, such as enhancing sleep quality.[6,13] Restorative sleep plays an essential role in creating a healthy and productive workplace.[14]

Most of the previous research assessed the effects of WTC using self-reported outcomes and cross-sectional designs.[12]

From the National Institute of Occupational Safety and Health (Drs Kubo, Takahashi, Liu, Ikeda), The University of Tokyo Graduate School of Education (Dr Togo), The University of Tokyo Graduate School of Medicine, Tokyo (Dr Shimazu), Graduate School of Medical Science, Kitasato University (Dr Tanaka), Department of Psychiatry, School of Medicine, Kitasato University, Sagamihara (Dr Kamata), School of Nursing, Faculty of Medicine, The Jikei University, Tokyo (Dr Kubo), and Occupational Health Center, Yokohama Branch, RIKEN (The Institute of Physical and Chemical Research), Yokohama, Japan (Uesugi).

The study was supported by the National Institute of Occupational Safety and Health, Japan (grant number; N-P22-01).

Authors Kubo, Takahashi, Liu, Ikeda, Togo, Shimazu, Tanaka, Kamata, Kubo, and Uesugi have no relationships/conditions/circumstances that present potential conflict of interest.

The JOEM editorial board and planners have no financial interest related to this research.

Address correspondence to: Tomohide Kubo, PhD, National Institute of Occupational Safety and Health, Kawasaki, Japan, 6-21-1, Nagao, Tama-ku, Kawasaki 214-8585, Japan (e-mail: kubo@h.jniosh.johas.go.jp).

This 1-year follow-up study showed that a prospective increase in individual WTC levels relative to baseline yielded desirable influences upon objectively measured fatigue and sleep quality among employees.

Practical interventions to increase control over work times are recommended to enhance health, safety, and productivity at work.

DOI: 10.1097/JOM.0000000000000858

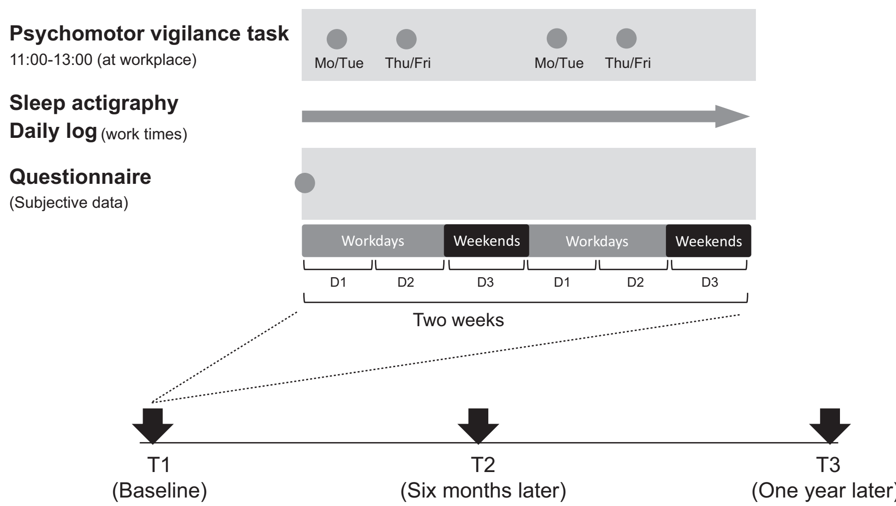

FIGURE 1. Study design. D1; First half of the workday, D2; Latter half of the workday, D3; Weekends.

Therefore, little is known about the effects of prospective changes (ie, increase, decrease, and no change) in WTC upon subsequent health consequences. Of the limited findings, an earlier study reported that an employee whose WTC increases between baseline and follow-up will likely show more favorable outcomes than an employee without an increased WTC level.[13] Nonetheless, to our best knowledge, evidence is still lacking regarding the associations between prospective increase in WTC levels and objective outcomes, such as neuro-behavioral function and actigraphic sleep. This study thus aimed to examine whether employees who increase their WTC levels (relative to baseline) after 1 year show objective improvements in fatigue and sleep compared with employees without increased WTC levels.

METHODS

Participants

Thirty-nine employees participated in this study [mean age 41.7 years, standard deviation (SD) 12.9; nine females]. One participant withdrew from the study due to a job requirement, and another participant was excluded from the data analysis due to missing WTC score data. Consequently, this study analyzed data from 37 participants (mean 41.9, SD 12.8; nine females). Of these, 32 participants (eight females) worked at a manufacturing industry, and five participants (one female) worked at a research institute. Their occupation categories were as follows: manager ($n = 15$), office worker ($n = 8$), researcher ($n = 8$), technician ($n = 4$), service worker ($n = 1$), and salesperson ($n = 1$). The institutional review board of the Japan National Institute of Occupational Safety and Health reviewed and approved the study protocol. All participants gave written informed consent and received payment for their participation.

Study Design

This observational study lasted for approximately 1 year and was carried out with three repeated measurements (Fig. 1). Those measurements covered periods of 2 weeks. Participants were required to conduct a psychomotor vigilance task (PVT), complete a questionnaire, provide a daily log of their working hours, and wear an actigraph. In each of 2 successive weeks, PVT was conducted during the employees' lunch break (11:00 to 13:00). In addition, participants were instructed to wear the actigraph throughout nighttime sleep and to record their working hours in the daily log before going to bed. During the test, participants were required to switch off their cell phones and take off their wristwatches so that they could concentrate on the test. They also practiced the PVT for a few minutes before each test period.

Measures

Psychomotor Vigilance Task

The PVT (PVT-192; Ambulatory Monitoring, Ardsley, New York), a sustained-attention reaction time (RT) task with a random inter-stimulus interval of 2 to 10 seconds, was used to objectively measure fatigue in this study. Lapses (response latency exceeding 500 ms) and speed (1/slowest 10% of RT $\times$ 1000) were counted during each 10-minute test.

Sleep Actigraphy

Sleep was monitored by an actigraph (Micro-mini RR; Ambulatory Monitoring, Ardsley, New York) throughout the study. The actigraph was secured to the participant's nondominant wrist. The epoch length was set at 1-minute intervals. Total sleep time (TST), sleep efficiency (SE), wake-after-sleep onset (WASO), bed time, and wake time were analyzed.

Daily Log

Work times were self-recorded using the daily log at 30-minute intervals during the period of the study. Three parameters (the length of work, start time, and end time) were then assessed using the daily log. Furthermore, the means and standard deviations of each parameter were calculated to assess the average and variability of work times.

Questionnaire

The WTC scale[5,6,8,13] included the following five items: (i) length of the workday, (ii) starting and ending times of the workday, (iii) number of breaks during the workday, (iv) vacations and paid days off, and (v) unpaid leave. Participants reported the extent to which they could influence various aspects of their working time on a 5-point scale (1 = very little; 5 = very much).

The "Self-Diagnosis Checklist for Worker's Accumulated Fatigue" was used to assess the participants' subjective symptoms of accumulated fatigue.[15] The checklist asks respondents how often they have felt fatigue symptoms in the past month using 13 items on a 3-point scale (0 = rarely, 1 = sometimes, and 2 = often); one such item is "Feel no desire to do anything."

Work-life balance was assessed using four items on a 5-point scale (0 = never; 4 = always).[16] The scale consists of

TABLE 1. Results of Two-Way Mixed-Model ANCOVA—WTC Score, Diary-Based Working Times, Health-Related Outcomes

		T1		T2		T3		WTC			Time			WTC × T		
	WTC Group	Mean	SEM	Mean	SEM	Mean	SEM	*F*-ratio	df	*P*	*F*-ratio	df	*P*	*F*-ratio	df	*P*
Subjective data (Questionnaire)																
WTC score	Increased	12.89	1.44 *	14.99	1.40	15.24	1.45	0.414	(1, 22.7)	0.527	0.791	(2, 43.3)	0.460	4.924	(2, 38.1)	0.013*
	Not increased	16.87	1.41	15.72	1.31	13.71	1.32									
Accumulated fatigue	Increased	23.6	2.04	22.4	2.07	21.3	2.11	0.505	(1, 26.7)	0.484	1.848	(2, 47.8)	0.169	0.390	(2, 41.6)	0.680
	Not increased	20.9	2.11	21.3	1.95	19.7	1.96									
Work-self balance																
Positive effects	Increased	5.59	0.53	5.71	0.54	5.10	0.54	2.722	(1, 23.3)	0.112	3.948	(2, 43.4)	0.027*	0.970	(2, 39.8)	0.388
	Not increased	7.12	0.54	6.51	0.49	5.89	0.50									
Negative effects	Increased	5.80	0.44 *	6.60	0.45	6.81	0.45	0.345	(1, 24.6)	0.562	1.104	(2, 49.5)	0.339	2.439	(2, 44.9)	0.099
	Not increased	6.83	0.45	6.66	0.40	6.60	0.41									
Sleep quality (PSQI)	Increased	5.81	0.87	4.57	0.89	5.85	0.90	0.003	(1, 27.3)	0.955	1.661	(2, 47.3)	0.201	7.781	(2, 41.0)	0.001*
	Not increased	5.75	0.90	5.75	0.84	4.54	0.84									
Work times (Diary log)																
Time length (h)																
Average	Increased	10.08	0.33	9.80	0.34	9.86	0.37	0.075	(1, 26.6)	0.786	4.253	(2, 23.4)	0.027*	2.113	(2, 22.0)	0.145
	Not increased	10.40	0.33	10.07	0.29	9.58	0.31									
Variability (SD)	Increased	1.20	0.29	0.78	0.30	1.23	0.30	0.794	(1, 21.9)	0.383	2.634	(2, 48.1)	0.082	1.079	(2, 43.6)	0.349
	Not increased	1.63	0.29	1.24	0.26	1.21	0.27									
Start time (h)																
Average	Increased	8.71	0.14	8.57	0.09	8.62	0.17	0.107	(1, 23.5)	0.746	0.862	(2, 30.8)	0.432	0.465	(2, 30.1)	0.633
	Not increased	8.57	0.11	8.57	0.08	8.63	0.12									
Variability (SD)	Increased	0.31	0.18	0.36	0.18	0.30	0.18	0.020	(1, 26.0)	0.888	0.039	(2, 49.0)	0.961	0.058	(2, 47.4)	0.944
	Not increased	0.28	0.17	0.30	0.15	0.31	0.16									
End time (h)																
Average	Increased	18.9	0.34	18.4	0.39	18.5	0.36	0.001	(1, 26.8)	0.974	6.225	(2, 20.7)	0.008*	2.526	(2, 18.3)	0.108
	Not increased	19.0	0.36	18.7	0.35	18.2	0.32									
Variability (SD)	Increased	1.15	0.27	0.60	0.27	1.12	0.28	1.045	(1, 22.1)	0.318	3.062	(2, 48.0)	0.056	2.569	(2, 43.2)	0.088
	Not increased	1.48	0.27	1.25	0.24	1.07	0.25									

Data represent estimated marginal mean and SEM. Covariates [gender, age, position (manager or others)], T1 = Baseline, T2 = 6 months later, T3 = 1 year later.
*$P < 0.05$.

questions regarding the negative and positive effects of work, such as "How often does your work schedule make it difficult for you to fulfil your personal interests?" (negative effects) and "How often do you feel full of energy after work, allowing you to enjoy your personal interests more?" (positive effects).

The Pittsburgh Sleep Quality Index (PSQI) was used to assess the participants' sleep quality.[17]

Data Analysis

All participants were divided into two groups on the basis of how their WTC scores changed from the baseline to the 1-year follow-up. The respondents were placed in the "WTC increased group" ($n = 13$), the "WTC decreased group" ($n = 18$)), and the "no change" group ($n = 6$), according to the changes in their WTC scores. However, the "WTC decreased" and "no change" groups were combined into a single "not increased group" ($n = 24$) to enhance the measure's statistical power. The data from the PVT and actigraphically measured sleep were averaged across the 2 weeks for each day (D1 = first half of the workday, D2 = latter half of the workday, and D3 = weekends) to enhance their reliability. Those data were analyzed using three-way [Group (WTC increased group, not increased group) × Time (T1, T2, and T3) × Day (D1, D2, and D3)] mixed-model analysis of covariance (ANCOVA). On the contrary, the data derived from the self-reported log and the questionnaire were analyzed using two-way (Group × Time) mixed-model ANCOVA. Covariates included gender, age, and position (manager or other). The multilevel model contained repeated measures for the same individual. For the analysis to be valid, we analyzed the data using compound symmetry, unstructured, and auto-regressive (1) approaches and chose the one for which the Akaike Information Criterion is a minimum. The Bonférroni test was used for planned comparisons. All statistical analyses were performed using SPSS 19.0 for Windows (SPSS Inc., Chicago, Illinois).

RESULTS

Changes in Work Time Control

Table 1 presents the prospective changes in WTC between the groups. A significant interaction between WTC and time was found ($F_{2,38.1} = 4.924$, $P = 0.013$), but the main effects of WTC and time were not significant. Planned comparisons revealed that a significantly higher level of WTC was observed in the not increased group than in the WTC increased group at T1 ($P < 0.05$).

Changes in PVT-Measured Fatigue

The effects of WTC on PVT performance are illustrated in Fig. 2. Significant three-way interactions were not observed in speed and lapses. In the analysis of speed, there was a significant interaction between WTC and time ($F_{2,158.0} = 3.665$, $P = 0.028$), but no significant difference was found for the lapses. The main effect of time was significant for the lapses ($F_{2,160.0} = 3.889$, $P = 0.022$). No significant main effects were found for the day. Planned comparisons showed that significantly fewer lapses were observed in the WTC increased group than in the not increased group ($P < 0.05$) at T3 on Day 2. A similar result was also found for speed ($P < 0.10$) on the same day.

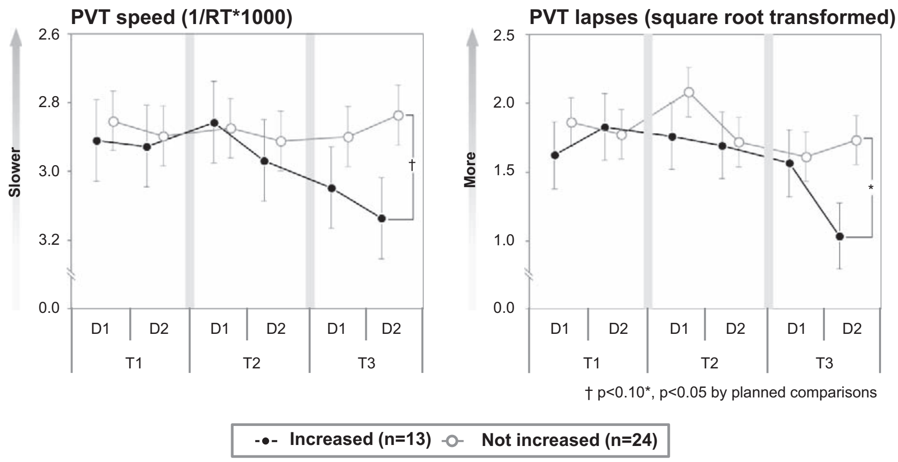

FIGURE 2. PVT performance and the 1-year changes in work time control. PVT speed (1/the slowest 10% of reaction time × 1000), PVT lapses (square root transform [SQR (Lapses)+SQR (Lapses+1)]). Data represent estimated marginal mean and SEM. Covariates [gender, age, position (manager or others)], T1 = Baseline, T2 = 6 months later, T3 = 1 year later, D1 = First half of the workday, D2 = Latter half of the workday.

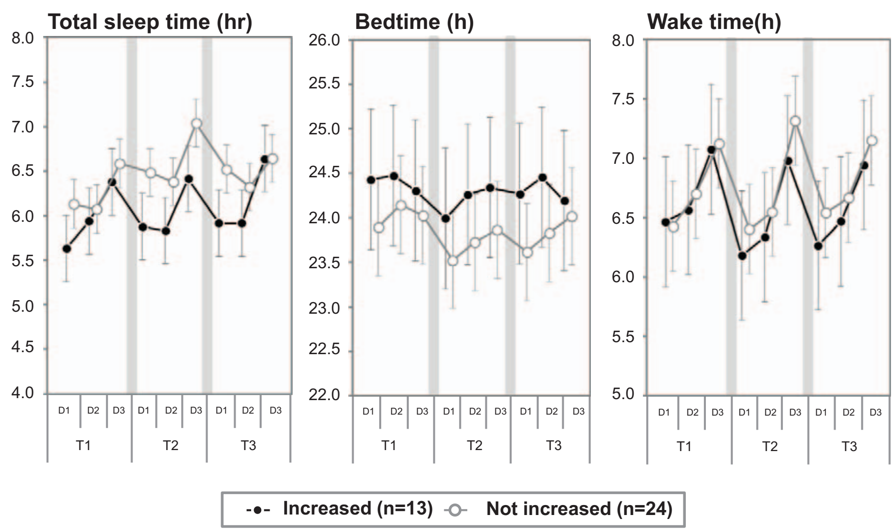

FIGURE 3. Actigraphically measured sleep quantity and the 1-year changes in work time control. Data represent estimated marginal mean and SEM. Covariates [gender, age, position (manager or others)], T1 = Baseline, T2 = 6 months later, T3 = 1 year later, D1 = First half of the workday, D2 = Latter half of the workday, D3 = Weekends.

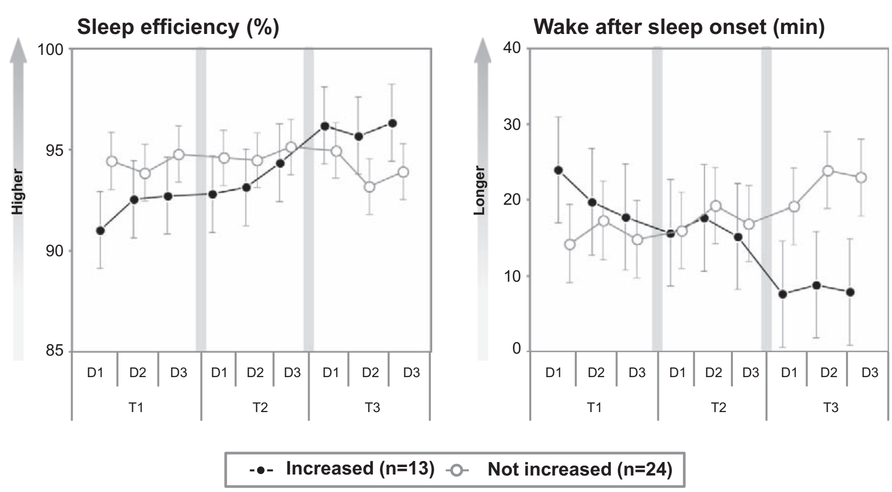

FIGURE 4. Actigraphically measured sleep quality and the 1-year changes in work time control. Data represent estimated marginal mean and SEM. Covariates [gender, age, position (manager or others)], T1 = Baseline, T2 = 6 months later, T3 = 1 year later, D1 = First half of the workday, D2 = Latter half of the workday, D3 = Weekends.

Changes in Actigraphically Measured Sleep

Figures 3 and 4 depict the effects of WTC on sleep parameters. Regarding sleep quantity (Fig. 3), no significant three-way interactions were observed for TST, bed time, and wake time. Similarly, there were no significant two-way interactions for those parameters. However, the main effects of the day showed a significant difference for TST and wake time ($F_{2,215.8} = 18.027$, $P < 0.001$; and $F_{2,267.0} = 38.862$, $P < 0.001$, respectively).

Sleep quality did not show significant three-way interactions for SE and WASO. Instead, two-way interactions between WTC and time were significant for SE and WASO ($F_{2,99.3} = 3.195$, $P = 0.045$; and $F_{2,102.1} = 4.192$, $P = 0.018$, respectively). SE and WASO appeared to improve more in the WTC increased group than in the not increased group during the T3 period. However, no significant differences between each day were found using the planned comparisons.

Work Times Measured by Daily Log

No significant interaction between WTC and time was found for time length, start time, and end time (Table 1). The main effects of time showed significant differences in the average time length ($F_{2,23.4} = 4.253$, $P = 0.027$) and the end time ($F_{2,20.7} = 6.225$, $P = 0.008$), suggesting shorter time length and earlier end time over time. With respect to the start time, no significant results were found. Planned comparisons showed that no significant differences between each day were found.

Subjective Data

Table 1 represents changes in accumulated fatigue, work-life balance, and sleep quality throughout the period of this study. With respect to accumulated fatigue, no significant results were observed. Regarding work-life balance, a significant main effect of time was observed for positive effects of work ($F_{2,43.4} = 3.948$, $P = 0.027$). In addition, planned comparisons showed a significant difference in the negative effects of work at T1 ($P < 0.05$). Self-reported sleep quality showed a significant interaction ($F_{2,41.0} = 7.781$, $P = 0.001$), but the planned comparisons found no significant differences between each day.

DISCUSSION

This study aimed to determine how changes in WTC were associated with objectively measured fatigue and sleep throughout the 1-year observation period. Employees with increased levels of WTC relative to the baseline showed a significantly better PVT performance and higher quality of sleep at the 1-year follow-up than their counterparts who did not experience an increase in WTC levels. However, the benefits did not extend to the quantity of sleep (Fig. 3). Moreover, significant favorable effects of increasing the individual WTC levels were not found in the self-reported data on work times and accumulated fatigue, work-life balance, and PSQI (Table 1). The present findings suggest that the prospective increases in individual WTC produced positive effects upon objectively measured fatigue and sleep quality among employees.

Progressive Changes in WTC Levels

As expected,[5,6,13,18–20] more favorable outcomes were observed for employees whose WTC levels increased compared with those employees whose WTC levels did not. This fact was supported by an objective assessment of fatigue and sleep. The current study thus presents new knowledge about the link between individual changes in WTC and worker health.

Of the limited available data, our previous longitudinal study, with 2382 day workers, conducted using the same WTC scale as this study, has provided important insights into the relationships between the dynamic changes in WTC levels and subjective health.[13] However, a high level of WTC was defined as using the baseline median score of 12 points in the previous study. On the contrary, this study dealt with individual WTC changes relative to the baseline. In light of the previous findings, both the WTC-increased and not increased groups in this study were categorized into a high level of WTC group in the previous study, as both the groups had WTC scores of at least 12 points (See WTC score on Table 1). Therefore, our data could reinforce evidence related to the better outcomes of pathways that prospectively increase in individual WTC levels play the significant role in health-related outcomes.

Recovery Mechanisms of WTC

Our results suggested beneficial effects, in terms of reducing fatigue and improving sleep quality, of increased WTC levels relative to the baseline after a 1-year follow-up. High levels of WTC have potential to protect off-work periods of time through appropriately controlling working hours, which is in turn likely to ensure the opportunity of sleep. One might thus have expected this study to find that increased WTC levels improved sleep outcomes. However, with respect to the quantity of sleep, no differences between the WTC-increased group and the not increased group were found (Fig. 3). Moreover, regarding the timing of going to bed and waking up, similar results were observed. Beside, against to our expectation, the association between increased WTC levels and reduced self-reported work times was not found (Table 1). Hence, in terms of how to spend participant's time, their time allocations of work, leisure, and sleep were the same for both groups during the period of this study. Nonetheless, our data showed a positive influence of increased WTC levels on SE and WASO, as measured by sleep actigraphy (Fig. 4).

An important question here is why recovery, as reflected in better outcomes, was achieved, despite there being no changes in daily work and sleep times. A potential explanation is related to the effects of WTC upon stress reduction. Namely, previous research suggested that having high levels of WTC played the role of buffer against mental stress, thereby improving the opportunities to balance the demands of work and private life.[10] Furthermore, it was implied that the beneficial effects could allow employees to plan their working times in a way that better suits their circadian type and their currently available psychological and physical resources. Thus, having high WTC levels may enhance their psychological readiness to cope with a problem when work-family conflicts, [21] such as childcare, and domestic demands occur. The plausibility could be partially supported by a recent intervention study.[22] Consequently, the effects would bring about positive cycles of stress reduction, restful sleep, and fatigue recovery. However, further investigations with larger samples are required to test the recovery cycle hypothesis.

Another possibility is associated with reduced workloads during working hours. The observed improvements in PVT performance could be explained if enhancing WTC levels served to promote control over breaks at work and days off (Fig. 2). Earlier studies reported the recuperative effects of rest behavior on PVT performance.[23–25] Given that the length of work times did not differ between the groups, it is likely that the day-to-day distribution of rest behaviors may change in association with increased WTC levels. However, further investigations with daily time budgets are required to examine the relationship between progressive changes in WTC levels and objectively measured outcomes.

In addition to those mentioned above, it is important to address the question of what factors were contributing to prospective changes in employee WTC levels in this study. An earlier study investigated the associations between some potential factors (eg, employment, occupation, weekly work hours, and material status) and increased WTC levels at 1-year follow-up, but it has remained unclear.[13] On the contrary, the latest intervention study with the training of managers in family supportive supervision suggested favorable influences of increased family-supportive supervision and employee control over work time upon sleep quantity and quality.[22] Hence, one of the more powerful contributors to enhance WTC levels may be related with organizational factors, especially manager's support. Hence, an intervention to create a supportive workplace for work-family conflicts could benefit the enrichment of employee WTC levels, thereby facilitating sleep and recovery. Of course, the current study cannot address the causal links of prospectively increase in WTC levels and the improvements observed on health-related outcomes. That is why other external factors (eg, change in management policy) may have resulted in improvements of both WTC and health. Therefore, measuring environmental factors in addition to individual factors is required to examine the assumption in future research.

Workplace Implications

In the present study, employees who increased WTC levels at 1-year follow-up had 40.3% fewer transformed lapses (increased group 1.036, not increased group 1.734) and 10.6% faster reciprocal RTs (increased group 3.14, not increased group 2.84) at T3 on Day 2 on PVT performance than employees without increasing WTC levels (see Fig. 2). These improvements are close to the results of interventions to enhance alertness at work. For example, an alertness management program for flight crew members yielded 41.9% fewer transformed lapses (intervention 2.19, control 3.77) and 24.1% faster reciprocal RTs (intervention 2.53, control 3.14) during a trip schedule.[26] Brief morning exposure to bright light produced 28.7% improvements on PVT-transformed lapses during the break period of day shift among shift-working nurses (bright light 1.96, control 2.75).[27] In addition, a 40-minute nap during night shifts showed 24% fewer transformed lapses (napping 3.13, control 4.12) and 15% faster reciprocal RTs (napping 2.45, control 2.13) at 7:30 AM among physicians and nurses working 12-hour night shifts.[28] Based upon the findings above, the prospectively increasing employee WTC levels can be taken as effective in improving alertness during work hours. Higher alertness is translated into increases in safety and productivity. In addition, the latest finding suggested the benefit of WTC on reduced accident risk.[29] Hence, our present data support practical interventions of increasing control over work times, for example, software-based self-rostering systems,[30] to promote fatigue recovery, thereby creating healthy, safe, and productive workplaces.

Strengths and Limitations

The primary strength of this study is that it was based on objectively measured data to assess the benefits of WTC with prospective study design. Meanwhile, some limitations of this study should be noted. First, further research with a larger sample size is necessary to reinforce our findings because the relatively small sample size limits the generalizability of our findings. Second, our data suggested positive cycles of higher WTC levels, better quality of sleep, and lower fatigue. However, more research, specifically an interventional study,[22,31,32] is needed to test the hypothesis that sleep can mediate between WTC and fatigue at work. Third, the WTC increased group was regarded as employees who increased their WTC score at follow-up relative to a baseline. This study did not concern absolute WTC levels. Therefore, more research is needed to examine which method of characterizing the WTC score is best when detecting the influence of WTC changes. Finally, previous studies (including the findings of this study) have suggested the importance of WTC on employees' health, but examining the associations between the enrichment of WTC levels and actual work productivity (eg, employee income and company profit) would provide valuable insights.

CONCLUSIONS

In this study, prospective increases in control over work times are associated with better quality of sleep and lower levels of fatigue, as shown by objective assessments. Hence, the primary findings of this study suggest that a progressive increase in WTC could play a crucial role in reducing fatigue and promoting sleep among employees.

REFERENCES

1. Arlinghaus A, Nachreiner F. Health effects of supplemental work from home in the European Union. *Chronobiol Int*. 2014;31:1100–1107.
2. Monk TH, Reynolds III CF, Buysse DJ, DeGrazia JM, Kupfer DJ. The relationship between lifestyle regularity and subjective sleep quality. *Chronobiol Int*. 2003;20:97–107.
3. Kubo T, Takahashi M, Tachi N, et al. Characterizing recovery of sleep after four successive night shifts. *Ind Health*. 2009;47:527–532.
4. Costa G, Åkerstedt T, Nachreiner F, et al. Flexible working hours, health, and well-being in Europe: some considerations from a SALTSA project. *Chronobiol Int*. 2004;21:831–844.
5. Kubo T, Takahashi M, Togo F, et al. Effects on employees of controlling working hours and working schedules. *Occup Med (Lond)*. 2013;63:148–151.
6. Takahashi M, Iwasaki K, Sasaki T, et al. Worktime control-dependent reductions in fatigue, sleep problems, and depression. *Appl Ergon*. 2011; 42:244–250.
7. Ala-Mursula L, Vahtera J, Kivimaki M, Kevin MV, Pentti J. Employee control over working times: associations with subjective health and sickness absences. *J Epidemiol Community Health*. 2002;56:272–278.
8. Ala-Mursula L, Vahtera J, Linna A, Pentti J, Kivimaki M. Employee work-time control moderates the effects of job strain and effort-reward imbalance on sickness absence: the 10-town study. *J Epidemiol Community Health*. 2005;59:851–857.
9. Nätti J, Oinas T, Anttila T. Time pressure, working time control and long-term sickness absence. *Occup Environ Med*. 2015;72:265–270.
10. Vahtera J, Laine S, Virtanen M, et al. Employee control over working times and risk of cause-specific disability pension: the Finnish Public Sector Study. *Occup Environ Med*. 2010;67:479–485.
11. Salo P, Ala-Mursula L, Rod NH, et al. Work time control and sleep disturbances: prospective cohort study of Finnish public sector employees. *Sleep*. 2014;37:1217–1225.
12. Nijp HH, Beckers DG, Geurts SA, Tucker P, Kompier MA. Systematic review on the association between employee worktime control and work-non-work balance, health and well-being, and job-related outcomes. *Scand J Work Environ Health*. 2012;38:299–313.
13. Takahashi M, Iwasaki K, Sasaki T, et al. Sleep, fatigue, recovery, and depression after change in work time control: a one-year follow-up study. *J Occup Environ Med*. 2012;54:1078–1085.
14. Takahashi M. Prioritizing sleep for healthy work schedules. *J Physiol Anthropol*. 2012;31:6.
15. Japan Ministry of Health Labour and Welfare. The Self-Diagnosis Checklist for Workers' Accumulated Fatigue, 2004. Available at: http://www.jniosh.go.jp/icpro/jicosh-old/english/topics/AccumulatedFatigueCheckList.html. Accessed March 30, 2016.
16. Demerouti E, Shimazu A, Bakker AB, Shimada K, Kawakami N. Work-self balance: a longitudinal study on the effects of job demands and resources on personal functioning in Japanese working parents. *Work Stress*. 2013; 27:223–243.
17. Buysse DJ, Reynolds 3rd CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28:193–213.
18. Costa G, Sartori S, Åkerstedt T. Influence of flexibility and variability of working hours on health and well-being. *Chronobiol Int*. 2006;23:1125–1137.
19. Tucker P, Bejerot E, Kecklund G, Aronsson G, Akerstedt T. The impact of work time control on physicians' sleep and well-being. *Appl Ergon*. 2015; 47:109–116.
20. Härmä M. Workhours in relation to work stress, recovery and health. *Scand J Work Environ Health*. 2006;32:502–514.
21. Geurts S, Bakker D, Taris T, Kompier M, Smulders P. Worktime demands and work-family interference: does worktime control buffer the adverse effects of high demands? *J Bus Ethics*. 2008;84:229–241.
22. Olson R, Crain T, Bodner T, et al. A workplace intervention improves sleep: results from the randomized controlled Work, Family, and Health Study. *Sleep Health*. 2015;1:55–65.

23. Sato T, Kubo T, Ebara T, et al. Brief hourly exercise during night work can help maintain workers' performance. *Ind Health*. 2010;48: 470–477.
24. Van Dongen HP, Belenky G, Vila BJ. The efficacy of a restart break for recycling with optimal performance depends critically on circadian timing. *Sleep*. 2011;34:917–929.
25. Kubo T, Takahashi M, Sato T, et al. Weekend sleep intervention for workers with habitually short sleep periods. *Scand J Work Environ Health*. 2011; 37:418–426.
26. Rosekind M, Gregory K, Mallis M. Alertness management in aviation operations: enhancing performance and sleep. *Aviat Space Environ Med*. 2006;77:1256–1265.
27. Takana K, Takahashi M, Tanaka M, et al. Brief morning exposure to bright light improves subjective symptoms and performance in nurses with rapidly rotating shifts. *J Occup Health*. 2011;53:258–266.
28. Smith-Coggins R, Howard S, Mac D, et al. Improving alertness and performance in emergency department physicians and nurses: the use of planned naps. *Ann Emerg Med*. 2006;48:596–604.
29. Tucker P, Albrecht S, Kecklund G, et al. Work time control, sleep & accident risk: a prospective cohort study. *Chronobiol Int*. 2016;33:619–629.
30. Ingre M, Åkerstedt T, Ekstedt M, Kecklund G. Periodic self-rostering in shift work: correspondence between objective work hours, work hour preferences (personal fit), and work schedule satisfaction. *Scand J Work Environ Health*. 2012;38:327–336.
31. Hansen AM, Nabe-Nielsen K, Albertsen K, et al. Self-rostering and psychosocial work factors: a mixed methods intervention study. *Appl Ergon*. 2015;47:203–210.
32. Viitasalo K, Kuosma E, Laitinen J, Härmä M. Effects of shift rotation and the flexibility of a shift system on daytime alertness and cardiovascular risk factors. *Scand J Work Environ Health*. 2008;34:198–205.

