Paper:
Tucker, P., Albrecht, S., Keckund, G., Beckers, D. & Leineweber, C. (2016). Work time control, sleep & accident risk: A prospective cohort study. *Chronobiology International*, 1-11.
http://dx.doi.org/10.3109/07420528.2016.1167723

Accepted for publication in Chronobiology International 2/3/2016

http://www.tandfonline.com/toc/icbi20/current

Work Time Control, Sleep & Accident Risk: A Prospective Cohort Study

Philip Tucker*,[1, 2] Sophie Albrecht,[1] Göran Keckund,[1] Debby G.J. Beckers,[3] Constanze Leineweber. [1]

[1] Stress Research Institute, Stockholm University, Stockholm, Sweden

[2] Psychology Department, Swansea University, Swansea, United Kingdom

[3] Behavioural Science Institute, Radboud University, Nijmegen, Netherlands

* Corresponding author:

Dr. Philip Tucker, Psychology Department, Swansea University, Swansea SA2 8PP. Email p.t.tucker@swan.ac.uk. Telephone +44 (0) 1792 295894

Keywords: Work hours, work time control, sleep, accidents, injuries, longitudinal survey, mediation.

Running head: Work Time Control, Sleep & Accident Risk

Submitted for publication in the Chronobiology International special issue on Shiftwork and Working Time, 2016.

Abstract

We examined whether the beneficial impact of Work Time Control (WTC) on sleep leads to lower accident risk, using data from a nationally representative survey conducted in Sweden. Logistic regressions examined WTC in 2010 and 2012 as predictors of accidents occurring in the subsequent 2 years (N=4840 & 4337, respectively). Sleep disturbance and frequency of short sleeps in 2012 were examined as potential mediators of the associations between WTC in 2010 and subsequent accidents as reported in 2014 (N=3636). All analyses adjusted for age, sex, education, occupational category, weekly work hours, shiftwork status, job control and perceived accident risk at work. In both waves, overall WTC was inversely associated with accidents (p = .048 and p = .038, respectively). Analyses of the sub-dimensions of WTC indicated that Control over Daily Hours (CoDH; influence over start and finish times, and over length of shift) did not predict accidents in either wave, while Control over Time-off (CoT; influence over taking breaks, running private errands during work and taking paid leave) predicted fewer accidents in both waves (p = .013 and p = .010). Sleep disturbance in 2012 mediated associations between WTC / CoT in 2010 and accidents in 2014, although effects sizes were small ($effect_{WTC}$ = -.006, 95% confidence interval [CI] = -.018 – -.001; $effect_{CoT}$ = -.009, 95%CI = -.022 – -.001; unstandardized coefficients), with the indirect effects of sleep disturbance accounting for less than 5% of the total direct and indirect effects. Frequency of short sleeps was not a significant mediator. WTC reduces the risk of subsequently being involved in an accident, although sleep may not be a strong component of the mechanism underlying this association.

Introduction

Flexible working time arrangements are becoming increasingly common as organizations seek to satisfy employees' desires to combine work and private life, while maintaining high productivity and optimum staffing levels (Beckers et al., 2012). One way to increase flexibility is to increase work time control (WTC). This can be defined as an employee's possibilities of control over the duration, position, and distribution of his or her work time (Härmä, 2006). While there is moderately strong evidence that WTC promotes better work-life balance, the impact of WTC on outcomes such as health and job-related outcomes is less well established (Nijp et al., 2012). In particular, there is very little evidence regarding the possible link between WTC and safety.

A small number of studies have indicated that WTC may promote better sleep. For example, Salo et al. (2014) reported findings from a large-scale prospective cohort study in which they observed that less WTC was associated with greater sleep disturbances. Similarly, a longitudinal study examining changes in WTC over one year found that increases in WTC were accompanied by decreases in both insomnia symptoms and symptoms of depression (Takahashi et al., 2012).

The mechanisms underlying the link between WTC and sleep disturbance are not fully understood. One possibility is that WTC buffers the impact of stressors inside or outside the workplace (Nijp et al., 2012). Such a reduction in strain may promote more effective unwinding and hence improved sleep (Geurts & Sonnentag, 2006). Another suggestion is that WTC enables the individual to synchronise their work hours with their chronotype, by adjusting their work hours to fit with their circadian preferences e.g. morning vs. evening orientation (Baltes et al., 1999).

One of the most well established consequences of poor / restricted sleep is increased daytime fatigue and sleepiness, factors that are widely associated with increased accident risk (Uehli et al., 2014). This begs the question as to whether a lack of WTC - and the consequent impact on sleep disturbance - might lead to an increased risk of being involved in an accident. While this question has received little direct attention, a cross sectional study did find that higher levels of WTC were associated with fewer self-reported near misses in the preceding six months (Kubo et al., 2013). However, they found no main effect of WTC on sleep quality, suggesting that the association between WTC and accident risk was not mediated by the impact of WTC on sleep.

WTC can be seen as a recovery mechanism (Beckers et al., 2012) and hence it may reduce accident risk by facilitating recovery, rather than through its impact on sleep *per se*. Having WTC can mean that the worker is able to take a break, in order to replenish resources, when they are feeling tired or less alert; or that they can leave work for the day before they become too fatigued. Another reason why WTC may predict accident risk, other than through its influence on sleep, is that WTC is related to more general job control, a component of the Job-Demand-Control-Support (JDC-S) model (Theorell & Karasek, 1996). Some studies have identified job control as a predictor of lower accident risk (Kim et al., 2009; Nakata et al., 2006; Salminen et al., 2003), although others have failed to find an association after adjusting for confounding factors (Murata et al., 2000; Swaen et al., 2004). Job control may reduce risk through its effects on safety performance (Turner et al., 2012). One suggestion is that high job control allows employees to get involved in safety tasks that fall outside of their formal job descriptions, thereby enhancing the general safety of the work environment (Turner et al., 2005).

The current study will prospectively examine whether higher levels of WTC are associated with lower risk of being involved in an accident. It also investigates whether WTC reduces accident risk through its indirect effects on sleep disturbance and sleep duration (see Figure 1). Given the possibility that associations with general job control may confound the link between WTC and accident risk, the analyses will include adjustments for job control. The analyses will also include adjustments for shiftwork, as accident risk is higher among shiftworkers (Wagstaff & Lie, 2011), while WTC is generally lower among shiftworkers (Ala-Mursula et al., 2005).

Measures of WTC (e.g. Ala-Mursula et al., 2005) are often based on relatively broad operationalizations of the concept, covering both the timing of work over the day and which days are worked. In line with previous findings (Ala-Mursula et al., 2005), our evidence (Albrecht et al., 2015) suggests that WTC can be broken down into two sub-dimensions, one that relates to control over the timing of work (i.e. start & finish times, as well as the length of the daily duty period; 'Control over Daily Hours' - CoDH) and another relating to taking time off (e.g. taking time out of the duty period for rest or other non-work activities, as well as taking days off; 'Control over Time-off' - CoT). Previous studies examining similar (but not identical) sub-dimensions of WTC have found that the sub-dimensions differentially predicted sickness absence (Ala-Mursula et al., 2005), work-family interference (Geurts et al., 2009), recovery from fatigue and sleep quality (Kubo et al., 2013).

The current study will include an examination of the two sub-dimensions of WTC identified by Albrecht et al. (2015) as predictors of sleep disturbance, short sleeps and accident risk. It is predicted that CoDH will be a stronger predictor of short sleeps than CoT. This is based on the premise that CoDH allows the individual to align the start (and possibly also the end) of their working day with their preferred times for sleeping (i.e. wake up times and going to bed) and thereby optimise the length of their sleep. From this it follows that CoDH would also be a stronger predictor than CoT of accident risk, through its indirect effect on short sleeps (a_2b_2 in Figure 1). However, the latter prediction would only hold true if there were an association between WTC and accident risk that was primarily mediated by sleep duration (and not sleep disturbance). If, on the other hand, there were an association between WTC and accident risk that was at least partially mediated by sleep disturbance (a_1b_1 in Figure 1), it is less clear which of the two sub-dimensions would be the more influential predictor of accident risk. This is because both CoDH and CoT could conceivably influence sleep disturbance (Takahashi et al., 2011). Hence, in the eventuality that sleep disturbance is identified as a mediator of an association between WTC and accident risk, then no prediction is made regarding the relative predictive strengths of the two sub-dimensions of WTC.

Method

Data was obtained from three waves (2010, 2012, 2014) of the Swedish Longitudinal Occupational Survey of Health (SLOSH). SLOSH is a nationally representative cohort survey, with a focus on the association between work organization, work environment and health. Since the start in 2006, follow-ups have been conducted every second year. All labour market sectors and occupations are represented, and the number of men and women is approximately equal. There are separate questionnaires for those who are in paid work and those who are not. In addition to questionnaire data, the database is linked to national registers, both prospectively and retrospectively for all respondents. The number of responses received in the 2010, 2012 and 2014 waves was 11525, 9880 & 20316 (response rates 56.4%, 56.8% & 52.6%) respectively. Ethical approval for SLOSH and the current study was obtained from the Regional Research Ethics Board in Stockholm.

Main variables

The measure of WTC (based on Ala-Mursula et al., 2005) comprised 6 items that assessed the perceived influence over: the length of the duty period; start and finish times of the duty period; which days to work; taking breaks at work; running private errands during work time; and scheduling vacation and other leave (the latter item being based on the combination of two separate items from the original scale). Level of control was rated on a 5-point Likert scale ranging from 1 (very little) to 5 (very much). Two sub-dimensions of WTC were calculated (based on Albrecht et al., 2015), namely Control over Time-off (CoT; the mean of the items 'influence over taking breaks', 'influence over scheduling leave' and 'influence over running private errands'. Cronbach's alpha = .76, & .77, for 2010 & 2012 respectively) and Control over Daily Hours (CoDH; the mean of the items 'influence over length of duty period' and 'influence over start and finish times'. r = .92 & .93). The item 'which days to work' was not included in either sub-dimension but was included in the overall WTC measure, calculated as the mean of the 6 items (Cronbach's alpha = .88 & .89).

The measure of sleep disturbance (Åkerstedt et al., 2002; Åkerstedt et al., 2008) was calculated as the mean of 4 items assessing the frequency of each of the following sleep symptoms experienced in the last three months: difficulty falling asleep, repeated awakenings with difficulty falling back to sleep, too early (final) awakening and interrupted / restless sleep. Possible responses ranged from 1 (Never) to 6 (Always / 5 times or more per week. Cronbach's alpha = .85). An additional item asked how often they experienced short sleep (<6 hours), with the same response format.

Accidents were measured by three items asking whether the respondent had had an accident in the last two years, either: at work; on the way to or from work; or during leisure time. For the purposes of the current analyses, a single dichotomous variable was calculated indicating whether or not the respondent had answered yes to any of these three items.

Covariates

Age (at the end of the year during which the questionnaire was completed) and gender were obtained from register data linked to questionnaire responses by means of the unique Swedish ten-digit personal identification numbers. Educational level was determined from register data indicating the respondents' highest level of education attained, with five categories ranging from 'maximum 9 years of compulsory schooling' to 'doctoral education'.

Occupational category was based on the respondents' self-reported job title, which was then classified according to the Swedish Standard Classification of Occupations (SSCO; Statistics Sweden, 2012). For the purposes of the current analyses, participants were classified in terms of either the first two digits of the classification code (26 categories) or the first digit (9 categories; see the description of the analyses, below, for further details).

Weekly work hours were assessed by a questionnaire item that asked how many paid hours the respondent worked, including overtime. Shiftwork status was determined by a questionnaire item asking respondents to choose from nine possible types of work schedules. For the purposes of the current analyses, respondents were classified as shiftworkers if they usually did: night work (approximately 18:00 – 06:00); shiftwork that either did, or did not, involve nightwork; or timetabled work (i.e. following a duty rota) that either did, or did not, involve nightwork. Respondents were classified as day workers if they usually did: only day work (approximately 06:00 – 18:00); or evening work (approximately 18:00 – 22:00).

The measure of job control (Theorell et al., 1988) was calculated as the mean of six items assessing the extent to which: respondents had the possibility of learning things through their work; their job demanded a high level of skill or expertise; their work required ingenuity; they had to do the same thing repeatedly; they could influence how they did their work; and they could influence what they did at work. Possible responses ranged from 1 'Yes, often' to 4 'No, hardly ever / never' (Cronbach's alpha = .59 & .60 for 2010 & 2012 respectively).

Perceived injury risk at work was assessed by a questionnaire item asking whether the respondent was exposed to tangible risk of injury, e.g. from dangerous machines or elevated work positions. Possible responses ranged from 1 'Nearly all the time' to 6 'No, not at all'.

Analyses

Logistic regressions were conducted to examine WTC in 2010 and 2012 as predictors of accidents occurring in the subsequent 2 years (as reported in 2012 and 2014, respectively), adjusting for age, gender, education level, occupational classification (first two digits of the SSCO: 26 categories), weekly work hours, perceived injury risk, shiftworking status and job control. Separate analyses were conducted to examine overall WTC, CoDH and CoT as predictors, making a total of six regression analyses. The number of valid cases for the logistic regressions (excluding those who were not in gainful employment and those with missing data on the relevant measures) were N=4840 for the analyses of WTC in 2010 predicting accidents in in 2012; and N=4337 for the analyses of WTC in 2012 predicting accidents in in 2014.

Sleep disturbance and frequency of short sleeps in 2012 were examined as potential mediators of the association between WTC in 2010 and accident risk in 2014 using ordinary least squares path analysis (the PROCESS macro for SPSS; Hayes, 2013). Separate analyses were conducted to examine overall WTC, CoDH and CoT as predictors. The same covariates were used as in the logistic regressions, with one exception. In order to achieve sufficient variance within the data for the analysis to be run, it was necessary for the occupational classification variable to be based on the first digit of the SSCO (9 categories). The number of valid cases was N=3636.

Results

Descriptive statistics and associations between the main study variables are illustrated in Table 1. There were strong associations between the two sub-dimensions of WTC and between the two sleep variables. The majority of the remaining associations were significant but relatively weak.

TABLE 1 ABOUT HERE

Analyses of both WTC in 2010 and WTC in 2012 indicated that higher overall WTC was significantly associated with lower accident risk in the subsequent 2 years (P = .048 and P = .038, respectively; see Table 2). In the analyses of the sub-dimensions of WTC in relation to accident risk, the associations involving CoDH failed to reach significance in both waves (P = .165 and P = .241, respectively), while CoT was significantly associated with lower accident risk in both waves (P = .013 and P = .010).

TABLE 2 ABOUT HERE

A series of analyses were performed as supplements to the main regression analyses. The first was conducted in the light of additional analyses (see online supplement, Table 1) which indicated that shiftworkers tended to have relatively low WTC and were more likely to have been involved in an accident. Repeating the regression analyses while excluding shiftworkers (N=780 shiftworkers in 2010; N=649 shiftworkers in 2012) did not alter the pattern of results (see Table 2). Secondly, it was noted that there were quite high and significant correlations between WTC and job control ($r_{WTC\ 2010} = .38$, $P < .001$; $r_{CoDH\ 2010} = .36$, $P < .001$; $r_{CoT\ 2010} = .33$, $P < .001$; $r_{WTC\ 2012} = .37$, $P < .001$; $r_{CoDH\ 2012} = .37$, $P < .001$; $r_{CoT\ 2012} = .32$, $P < .001$). Given the conceptual overlap between these two predictors and the attendant risk of over-adjustment in the main analyses, additional analyses were conducted to examine the associations between WTC and accident risk without adjusting for job control; but this made little difference to the pattern of results (see online supplement, Table 2). Thirdly, the main analyses were repeated using accidents at work as the dependent variable, resulting in a similar pattern of results but with somewhat stronger associations (see online supplement, Table 3).

Mediation analysis indicated that overall WTC in 2010 indirectly influenced accident risk in 2014 through its effects on sleep disturbance in 2012. However there was no indirect influence of overall WTC on risk through an effect on short sleeps. As can be seen in Table 3 (upper panel) and Figure 1, those with higher

WTC in 2010 experienced less sleep disturbances in 2012 (a_1 = - .046) and those who experienced less sleep disturbances in 2012 were less likely to report in 2014 having had an accident in the previous two years (b_1 = .130). (Note that all regression coefficients reported for the mediation analyses are unstandardized). The bias-corrected bootstrap confidence interval for the indirect effect (a_1b_1 = -.006) based on 1000 bootstrap samples was entirely below zero (95%CI = -.018 – -.001). Conversely, the bias-corrected bootstrap confidence interval for the indirect effect of WTC in 2010 on accident risk in 2014 through its indirect effect on short sleeps (a_2b_2 = .000) included zero (95%CI = -.003 – .003). Despite finding that sleep disturbance acted as a mediator while short sleeps did not, there was no difference between the size of the two indirect effects, as indicated by a contrast test in which the bias corrected bootstrap confidence intervals included zero (95%CI = -.017 – .000). The analysis also indicated that WTC significantly influenced accident risk, independently of its effect on sleep disturbance (c' = -.215, p <.001).

TABLE 3 AND FIGURE 1 ABOUT HERE

The mediation analyses of the two sub-dimensions of WTC produce somewhat contrasting findings. While there was a significant direct effect of CoDH in 2010 on accident risk in 2014 (c' = -.134, p =.004), CoDH was not significantly associated with either sleep disturbance or short sleeps in 2012 and neither sleep variable was shown to be a mediator of the association between CoDH and accident risk (see middle panel of Table 3 and Figure 1). However, the analysis of CoT produced similar findings to the analysis of overall WTC (see lower panel of

Table 3 and Figure 1). CoT in 2010 indirectly influenced accident risk in 2014 through its effects on sleep disturbance in 2012 (a_1 = - .073; b_1 = .126; c' = -.200, p = .001). The bias-corrected bootstrap confidence interval for the indirect effect of CoT in 2010 on accident risk in 2014 through its indirect effect on sleeps disturbance (a_1b_1 = -.009) was entirely below zero (95%CI = -.022 – -.001). Conversely, the bias-corrected bootstrap confidence interval for the indirect effect of CoT on accident risk through its indirect effect on short sleeps (a_2b_2 = -.001) included zero (95%CI = -.009 – .001). There was no difference between the sizes of the two indirect effects, as indicated by a contrast test in which the bias corrected bootstrap intervals included zero (95%CI = -.022 – .002).

The mediating effect of sleep disturbance was only marginally significant, as can be seen from the bootstrap confidence intervals given above which are close to zero. The statistical procedure used for conducting the mediation analysis (PROCESS) does not permit the calculation of effect sizes when the analysis involves covariates. Nevertheless, it is notable that, for example, in the analysis of overall WTC the indirect effect of sleep disturbance (a_1b_1) was less than 5% of the total direct and indirect effects (c' + $a_1b_1 + a_2b_2$).

Repeating the mediation analyses without adjusting for job control made no difference to the pattern of results obtained.

Discussion

Analyses of data from two separate waves of this prospective cohort study indicate that lower levels of overall WTC were predictive of being involved in an accident in the subsequent two years. When examining the two sub-dimensions of WTC using logistic regression analyses, CoT was identified as a significant predictor of accident risk, while CoDH was not. Mediation analysis suggested that sleep disturbance resulting from a lack of overall WTC (and CoT in particular) was partially responsible for these associations, although the sizes of the mediation effects were small.

While the results provide a degree of support for the hypothesis that WTC predicts accident risk, the hypothesised mechanism, via the impact of WTC on sleep, appears to be only weakly supported. Two possible mechanisms were suggested for a link between WTC and impaired sleep: firstly, the ameliorating effect that control has on strain and unwinding, leading to improved quality of sleep (e.g. ease of falling asleep); and secondly, the enhanced opportunity for adjusting work hours to suit one's personal preferences (e.g. delaying or advancing the start and end of the working day so as to afford a better match with one's chronotype). Arguably, the first mechanism focuses primarily on the impact that WTC has on the sleep disturbance, while the second focuses on its impact on sleep duration. In the current results, WTC was found to indirectly influence accident risk through its impact on sleep disturbance, but not through an effect on short sleeps (although admittedly the difference in size between the two indirect effects was marginal). Thus, to the extent that the results support either sleep variable as a mediator, the first mechanism is favoured by the current results, albeit weakly.

If sleep is not a substantial mediator of the relationship between WTC and accidents then the question remains as to what does underlie this association. Kubo et al. (2013) found that while WTC was negatively associated with near misses (a proxy for accident risk), it was not associated with sleep quality. However, WTC was positively associated with recovery from fatigue. This raises the possibility that WTC reduces accident risk through its effect on need for recovery (or factors that influence need for recovery), rather than sleep *per se*. This could help explain why, in the current study, CoT was a somewhat stronger predictor of accidents than CoDH. Taking time away from work reduces need for recovery (Sonnentag et al., 2010), even though there may be no direct impact on sleep (e.g. de Bloom et al., 2010). Thus, giving individuals greater control over when they take time off may reduce accident risk by helping them to manage their need for recovery, e.g. by taking a break or stopping work for the day when fatigue becomes too great (Beckers et al., 2012).

The finding that CoT was a stronger predictor of accidents than CoDH should be interpreted cautiously, as the difference in effect sizes was very small. The regression analysis examining CoDH as a predictor only just failed to reach significance, while the mediation analyses showed a significant direct association between CoDH and accident risk. Nevertheless, to the extent that there was a difference between the two sub-dimensions, the findings parallel those of a study that examined the links between WTC and work family interference (WFI; Geurts et al., 2009). While control over days off ('leave control') was associated with lower WFI, control over start and finish times ('flexitime)' was not. The authors suggested that, in accordance with the Effort–Recovery Model (Meijman et al., 1998), leave control allows employees to regulate their effort investment at work with their need for recovery. That said, they also noted that either sub-dimension could plausibly promote better recovery, citing the example of a tired worker who may decide to take a day-off or to leave the workplace earlier in order to promote recovery. Nevertheless, taking their findings together with the current results suggests that control over time / days off may be the stronger determinant of fatigue-related and recovery-related outcomes. Another possible reason why CoT was a stronger predictor of accidents is that it encompassed control over rest breaks, which are an important determinant of accident risk (Tucker et al., 2003).

It is possible that the association between WTC and accident risk was confounded e.g. by occupational factors. It is plausible that the sort of jobs that allow greater WTC tend to be ones that are less risky e.g. white-collar jobs. Additional analyses (see online supplement) indicated that shiftworkers, those with lower educational level (the latter being commonly seen as a proxy for socio-economic status) and those with lower job control tended to have relatively low WTC and were more likely to report having been in an accident. A number of variables were included as covariates in the current analyses in an attempt to eliminate such confounding. In addition, the logistic regression analyses were repeated excluding shift workers, but with little impact on the pattern of results. Nevertheless, we must concede that such checks cannot fully exclude the possibility of residual confounding. The inclusion of so many covariates into the analyses, including some that were closely related to WTC, both conceptually and empirically (e.g. job control), may have risked over-adjustment in the statistical models. This may be partly responsible for the small effect sizes observed, e.g. in the relationship between WTC and accident risk. That said, repeating the analyses while not adjusting for job control only slightly increased the strength of the observed associations (see online supplement, Table 2).

Another possible reason for small effect sizes is the two-year time intervals between measurements of the predictor and outcome variables. It is possible that these rather long intervals may have been suboptimal for identifying the associations between WTC, sleep and accident risk.

Given the impact that WTC could be expected to have on sleep, fatigue and life outside work, it was anticipated that WTC would affect accident risk both within and outside work. Hence the main measure of accident risk in the current study incorporated accidents at work, on the way to or from work and during leisure time. However, while it was possible to control for a number of risk factors directly related to risk at work, it was not possible to control for risk factors directly associated with non-work activities. This may account for the results of the supplementary analyses (see online supplement, Table 3), in which associations between WTC and risk of an accident *at work* were found to be somewhat stronger than the associations between WTC and *general* accident risk (i.e. accidents that occurred either at work, on the way to / from work, or during leisure time). The difference between the two sets of findings may also indicate that, contrary to our initial expectations, WTC does not influence non-work accident risk as much as it influences risk of an accident at work.

Among the study's other limitations were that the main variables were all self-reported and were thus subject to potential bias or inaccuracy of recall. This may have been a particular issue with regard to the measure of accidents. Accidents may be forgotten or misremembered. Moreover the wording of the relevant question took no account of the severity of the incident or whether an injury was suffered. The measure of short sleeps was also rather crude and it is possible that a more precise measure of sleep duration would produce different results. More generally, the analyses were based primarily on self-report measures, which may be affected by common-method variance (Podsakoff et al., 2003), although it has been argued that mono-method correlations are often not higher than multi-method correlations (Spector, 2006).

The strengths of the study were that it was a prospective cohort study based on a large, broadly representative sample of the Swedish working population. It is the first study to demonstrate prospective associations between WTC and accident risk, tested in three separate analyses. A number of the key variables in the analyses were based on well-established and validated measures. Additionally, some of the variables were based on objective data obtained from national registers.

The current study leaves many questions unanswered regarding the link between WTC and accident risk. Firstly, the size of the current dataset limits the possibilities for more fine-grained analyses. Thus, for example, it remains to be determined whether the tentative relationship between WTC and accident risk is more pronounced in certain occupational groups or working conditions. Similarly, the possibility that WTC may have a stronger influence on occupational accidents than on accidents outside the workplace (as noted above) needs to be confirmed in a larger sample. Secondly, while we have speculated that WTC may influence accident risk through its impact on sleep or fatigue, it remains to be determined whether WTC is more strongly related to accidents that are primarily attributable to fatigue or sleep-loss (or any other particular type of accident). Such analyses would benefit from being based on accident records and investigations, rather than self-reports. Finally, given the relatively small effects observed in the current study, it remains to be determined whether the costs of increasing WTC would be outweighed by the benefits of what might only be a small reduction in accident risk. Such a consideration is especially important in situations where the decision to invest in one form hazard reduction (e.g. by introducing greater WTC) may be made at the expense of addressing other potentially higher-risk hazards.

In conclusion, the current study has demonstrated that having greater WTC may somewhat reduce the risk of subsequently being involved in an accident, albeit that the size of the effects appear to be relatively small. Disturbed sleep only marginally contributed to the prospective association between WTC and accident involvement, which indicates that sleep may not be a strong component of the mechanism underlying the association. Nevertheless, it seems that workers who have autonomy over when they can take time away from work may be better able to manage their fatigue and, as a consequence, may be at lower risk of having an accident.

Acknowledgements

We would like to thank all participants of SLOSH.

Funding Acknowledgements

This study was supported by the Swedish Research Council for Health, Working Life and Welfare (grant #2013-0448), the Swedish Research Council (grant #825-2013-1645) and NordForsk, the Nordic Programme on Health and Welfare.

Declaration of Conflicting Interests

The Authors declare that there are no conflicts of interest.

References

Ala-Mursula L, Vahtera J, Linna A, Pentti J, Kivimäki M. (2005). Employee worktime control moderates the effects of job strain and effort-reward imbalance on sickness absence: The 10-town study. Journal of Epidemiology and Community Health. 59:851-7. doi:10.1136/jech.2004.030924

Albrecht SC, Kecklund G, Tucker P, Leineweber C. (2015). Investigating the factorial structure and availability of work time control in a representative sample of the Swedish working population. Scandinavian Journal of Public Health. Advanced online publication, doi:10.1177/1403494815618854

Åkerstedt T, Ingre M, Broman JE, Kecklund G. (2008). Disturbed sleep in shift workers, day workers, and insomniacs. Chronobiology International. 25:333-48. doi:10.1080/07420520802113922

Åkerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. (2002). Sleep disturbances, work stress and work hours: A cross-sectional study. Journal of Psychosomatic Research. 53:741-748.

Baltes BB, Briggs TE, Huff JW, Wright JA, Neuman GA. (1999). Flexible and compressed workweek schedules: A meta-analysis of their effects on work-related criteria. Journal of Applied Psychology. 84:496.

Beckers DGJ, Kompier MAJ, Kecklund LG, Harma M. (2012). Worktime control: Theoretical conceptualization, current empirical knowledge, and research agenda [editorial]. Scandinavian Journal of Work, Environment & Health. 38:291-7.

de Bloom J, Geurts SA, Taris TW, Sonnentag S, de Weerth C, Kompier MA. (2010). Effects of vacation from work on health and well-being: Lots of fun, quickly gone. Work & Stress. 24:196-216.

Geurts SA, Beckers DG, Taris TW, Kompier MA, Smulders PG. (2009). Worktime demands and work-family interference: Does worktime control buffer the adverse effects of high demands? Journal of Business Ethics. 84:229-241. doi:10.1007/s10551-008-9699-y

Geurts SA, Sonnentag S. (2006). Recovery as an explanatory mechanism in the relation between acute stress reactions and chronic health impairment. Scandinavian Journal of Work, Environment & Health. 32:482-92.

Hayes AF. (2013). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. New York: Guilford Press.

Härmä M. (2006). Workhours in relation to work stress, recovery and health. Scandinavian Journal of Work, Environment & Health. 32:502-14

Kim HC, Min JY, Min KB, Park SG. (2009). Job strain and the risk for occupational injury in small- to medium-sized manufacturing enterprises: A prospective study of 1,209 korean employees. American Journal of Industrial Medicine. 52:322-30. doi:10.1002/ajim.20673

Kubo T, Takahashi M, Togo F, Liu X, Shimazu A, Tanaka K, Takaya M. (2013). Effects on employees of controlling working hours and working schedules. Occupational Medicine (Oxford, England). 63:148-51. doi:10.1093/occmed/kqs234

Meijman TF, Mulder G, Drenth PJD, Thierry H. (1998). Psychological aspects of workload. Handbook of Work and Organizational Psychology. Volume. 2.

Murata K, Kawakami N, Amari N. (2000). Does job stress affect injury due to labor accident in japanese male and female blue-collar workers? Industrial Health. 38:246-51.

Nakata A, Ikeda T, Takahashi M, Haratani T, Hojou M, Fujioka Y, . . . Araki S. (2006). Impact of psychosocial job stress on non-fatal occupational injuries in small and medium-sized manufacturing enterprises. American Journal of Industrial Medicine. 49:658-69. doi:10.1002/ajim.20338

Nijp HH, Beckers DG, Geurts SA, Tucker P, Kompier MA. (2012). Systematic review on the association between employee worktime control and work-non-work balance, health and well-being, and job-related outcomes. Scandinavian Journal of Work, Environment & Health. 38:299-313. doi:10.5271/sjweh.3307

Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. The Journal of Applied Psychology. 88:879-903. doi:10.1037/0021-9010.88.5.879

Salminen S, Kivimäki M, Elovainio M, Vahtera J. (2003). Stress factors predicting injuries of hospital personnel. American Journal of Industrial Medicine. 44:32-6. doi:10.1002/ajim.10235

Salo P, Ala-Mursula L, Rod NH, Tucker P, Pentti J, Kivimäki M, Vahtera J. (2014). Work time control and sleep disturbances: Prospective cohort study of finnish public sector employees. Sleep. 37:1217-25. doi:10.5665/sleep.3842

Sonnentag S, Kuttler I, Fritz C. (2010). Job stressors, emotional exhaustion, and need for recovery: A multi-source study on the benefits of psychological detachment. Journal of Vocational Behavior. 76:355-365.

Spector PE. (2006). Method variance in organizational research: truth or urban legend. Organizational Research Methods. 9:221-232.

Swaen GMH, Van Amelsvoort L, Bültmann U, Slangen JJM, Kant IJ. (2004). Psychosocial work characteristics as risk factors for being injured in an occupational accident. Journal of Occupational and Environmental Medicine. 46:521-527.

Statistics Sweden [SCB] (2012). Swedish standard classification of occupations (SSYK) in english. [Web page] Retrieved from www.scb.se on 2nd September, 2015.

Takahashi M, Iwasaki K, Sasaki T, Kubo T, Mori I, Otsuka Y. (2011). Worktime control-dependent reductions in fatigue, sleep problems, and depression. Applied Ergonomics. 42:244-50. doi:10.1016/j.apergo.2010.06.006

Takahashi M, Iwasaki K, Sasaki T, Kubo T, Mori I, Otsuka Y. (2012). Sleep, fatigue, recovery, and depression after change in work time control: A one-year follow-up study. Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine. 54:1078-85. doi:10.1097/JOM.0b013e31826230b7

Theorell T, Karasek RA. (1996). Current issues relating to psychosocial job strain and cardiovascular disease research. Journal of Occupational Health Psychology. 1:9-26.

Theorell T, Perski A, Åkerstedt T, Sigala F, Ahlberg-Hultén G, Svensson J, Eneroth P. (1988). Changes in job strain in relation to changes in physiological state: A longitudinal study. Scandinavian Journal of Work, Environment & Health. 189-196.

Tucker P, Folkard S, Macdonald I. (2003). Rest breaks and accident risk. The Lancet. 361:680.

Turner N, Chmiel N, Walls M. (2005). Railing for safety: Job demands, job control, and safety citizenship role definition. Journal of Occupational Health Psychology. 10:504-12. doi:10.1037/1076-8998.10.4.504

Turner N, Stride CB, Carter AJ, McCaughey D, Carroll AE. (2012). Job demands-control-support model and employee safety performance. Accident; Analysis and Prevention. 45:811-7. doi:10.1016/j.aap.2011.07.005

Uehli K, Mehta AJ, Miedinger D, Hug K, Schindler C, Holsboer-Trachsler E, . . . Künzli N. (2014). Sleep problems and work injuries: A systematic review and meta-analysis. Sleep Medicine Reviews. 18:61-73.

doi:10.1016/j.smrv.2013.01.004

Figure Legend

Figure 1. Predicted relationships between Work Time Control (WTC) [and its sub-dimensions Control over Daily Hours (CoDH) and Control over Time-off (CoT), Sleep disturbance, Short sleeps and Accident risk.

Figure 1. Tucker et al. Top

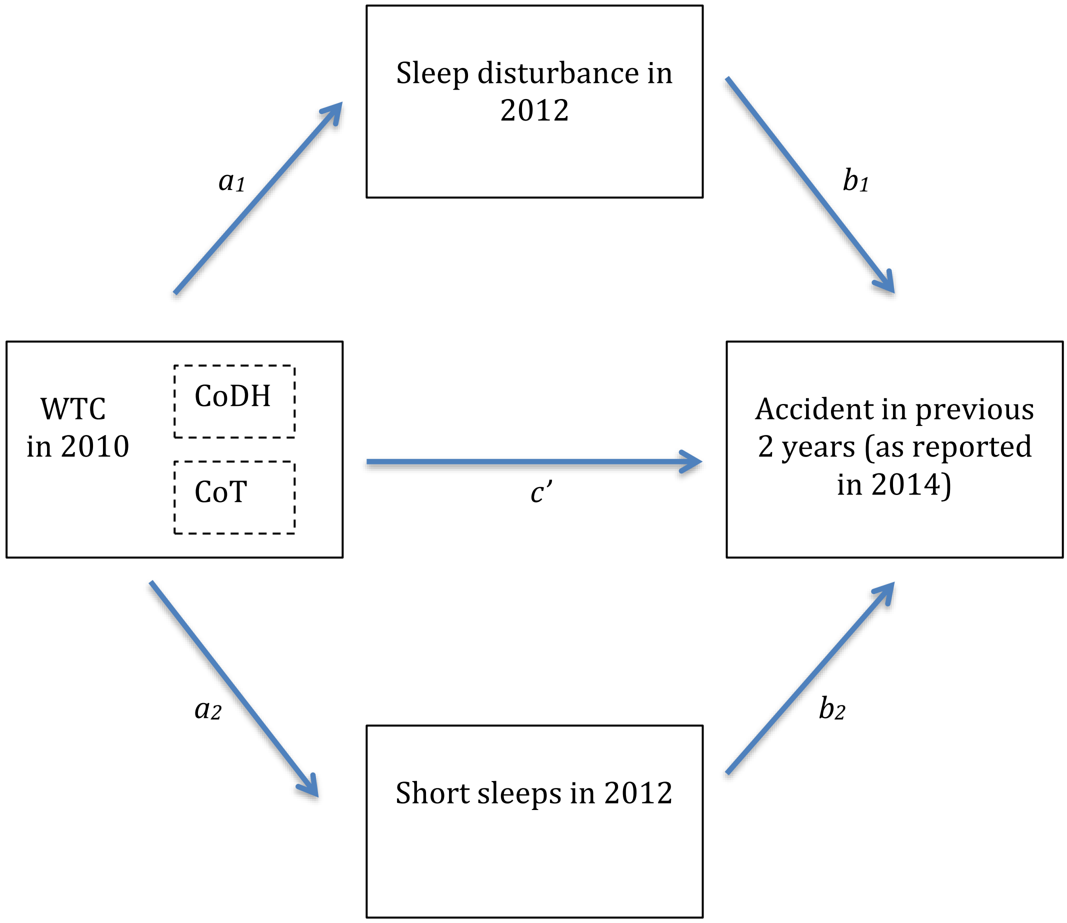

Table 1: Descriptive statistics (means, standard deviations, distributions and frequencies) and correlat

variables for each of the three analyses.

		Range of possible scores	Mean / %	SD / N	*1*	*2*	*3*	*4*
1	WTC 2010	1-5	2.88	1.03		.90**	.91**	-.09**
2	CoDH 2010	1-5	2.79	1.34			.69**	-.08**
3	CoT 2010	1-5	3.13	1.01				-.09**
4	Accidents 2012		12.8%	N=603				
					5	*6*	*7*	*8*
5	WTC 2012	1-5	2.88	1.02		.91**	.91**	-.09**
6	CoDH 2012	1-5	2.80	1.31			.70**	-.08**
7	CoT 2012	1-5	3.13	1.00				-.09**
8	Accidents 2014		12.2%	N=443				

Notes: * = < .05; **= < .01. WTC = Work Time Control; CoDH = Control over Daily Hours; CoT = Control

Table 1 (*continued*)

					9	10	11	12	13
9	WTC 2010	1-5	2.9	1		.90**	.91**	-.08**	-.04*
10	CoDH 2010	1-5	2.8	1			.68**	-.04*	-.02
11	CoT 2010	1-5	3.14	1.01				-.11**	-.05**
12	Sleep disturbance 2012	1-6	2.62	1.05					.54**
13	Short sleeps 2012	1-6	2.81	1.31					
14	Accidents 2014		12.0%	N=429					

Notes: * = < .05; **= < .01. WTC = Work Time Control; CoDH = Control over Daily Hours; CoT = Control

Table 2: Logistic regression analyses examining Work Time Control and its two sub-scales as predictors of subsequent accident risk. Odds Ratios (OR) and 95% Confidence Intervals (CI)

	Accident risk in subsequent 2 years			
	Including shiftworkers		Excluding shiftworkers	
	OR	95%CI	OR	95%CI
WTC 2010	0.90*	0.80-1.00	0.87*	0.77-0.98
CoDH 2010	0.94	0.87-1.02	0.93	0.85-1.02
CoT 2010	0.87*	0.78-0.97	0.83**	0.74-0.94
WTC 2012	0.88*	0.78-0.99	0.88*	0.77-1.00
CoDH 2012	0.95	0.87-1.04	0.97	0.88-1.07
CoT 2012	0.86*	0.76-0.96	0.84*	0.74-0.96

Notes: * = $p < .05$; ** = $p < .01$. WTC = Work Time Control; CoDH = Control over Daily Hours; CoT = Control over Time-off. All analyses adjusted for age, sex, education, occupational category, weekly work hours, shiftwork status, job control and perceived accident risk at work.

Table 3a. Unstandardized regression coefficients, standard errors and model summary information for

and short sleeps as mediators of the association between WTC and accident risk.

	Consequent							
	M$_1$ (Sleep disturbance)				M$_2$ (Short sleep)			
Antecedent		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*
X (WTC)	a_1	-.046	.020	.019	a_2	.001	.025	.969
M$_1$ (Sleep disturb)		-	-	-		-	-	-
M$_2$ (Short sleep)		-	-	-		-	-	-
Constant	iM_1	2.206	.218	<.001	iM_2	3.912	.274	<.001
		R^2 = .039				R^2 = .032		
		F(16,3619) = 9.1326, p < .001				F(16,3619) = 7.4611, p = < .001		

Note: Analysis adjusted for age, sex, education, occupational category, weekly work hours, shiftwork st

accident risk at work.

Table 3b. Unstandardized regression coefficients, standard errors and model summary information for

and short sleeps as mediators of the association between CoS and accident risk.

		Consequent						
		M_1 (Sleep disturbance)				M_2 (Short sleep)		
Antecedent		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*
X (CoS)	a_1	.002	.015	.898	a_2	.023	.019	.218
M_1 (Sleep disturb)		-	-	-		-	-	-
M_2 (Short sleep)		-	-	-		-	-	-
Constant	iM_1	2.158	.218	<.001	iM_2	3.915	.273	<.001
		$R^2 = .037$				$R^2 = .032$		
		$F(16,3618) = 8.777$, $p < .001$				$F(16,3618) = 7.560$, $p = < .001$		

Note: Analysis adjusted for age, sex, education, occupational category, weekly work hours, shiftwork st

accident risk at work.

Table 3c. Unstandardized regression coefficients, standard errors and model summary information for
and short sleeps as mediators of the association between CoT and accident risk.

		Consequent						
		M_1 (Sleep disturbance)				M_2 (Short sleep)		
Antecedent		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*
X (CoT)	a_1	-.073	.019	<.001	a_2	-.024	.024	.313
M_1 (Sleep disturb)		-	-	-		-	-	-
M_2 (Short sleep)		-	-	-		-	-	-
Constant	iM_1	2.275	.220	<.001	iM_2	3.930	.276	<.001
		$R^2 = .041$				$R^2 = .032$		
		$F(16,3612) = 9.607$, $p < .001$				$F(16,3612) = 7.485$, $p = < .001$		

Note: Analysis adjusted for age, sex, education, occupational category, weekly work hours, shiftwork st
accident risk at work.

Online supplementary material. Table 1: Relationships between predictors at baseline and accident ris

	Accident 2012				
	Yes		No		
	Mean	SD	Mean	SD	M
WTC	2.64	1.01	2.91	1.03	
CoDH	2.50	1.32	2.83	1.33	
CoT	2.89	0.99	3.16	1.01	
Sleep disturbance *					
Short sleep *					
Age	49.32	9.56	49.49	9.23	5
Weekly work hours	2.49	1.12	2.47	1.07	
Perceived risk	5.12	1.46	5.59	1.01	
Job control	2.96	0.51	3.02	0.48	

	%	N	%	N	
Occupational category					
Legislators and senior officials	0	0	100.00	8	
Corporate managers	7.50	20	92.50	247	
Managers of small enterprises	8.80	5	91.20	52	
Physical, mathematical and engineering science professionals	9.10	22	90.90	220	
Life science and health professionals	17.40	34	82.60	161	1
Teaching professionals	11.40	30	88.60	234	1
Other professionals	7.40	34	92.60	423	
Physical and engineering science associate professionals	12.10	32	87.90	233	1
Life science and health associate professionals	15.30	40	84.70	222	1
Teaching associate professionals	17.40	29	82.60	138	1
Other associate professionals	7.70	42	92.30	503	
Office clerks	8.20	29	91.80	326	1

Customer services clerks	6.70	4	93.30	56	
Personal and protective services workers	18.70	116	81.30	505	1
Models, salespersons and demonstrators	8.00	8	92.00	92	
Skilled agricultural and fishery workers	21.40	9	78.60	33	1
Extraction and building trades workers	20.70	43	79.30	165	1
Metal, machinery and related trades workers	20.60	28	79.40	108	1
Precision, handicraft, craft printing and related trades workers	11.10	2	88.90	16	2
Other craft and related trades workers	33.30	5	66.70	10	
Stationary-plant and related operators	16.70	9	83.30	45	
Machine operators and assemblers	19.50	29	80.50	120	2
Drivers and mobile-plant operators	17.80	23	82.20	106	1
Sales and services elementary occupations	7.90	7	92.10	82	1
Agricultural, fishery and related labourers	50.00	1	50.00	1	1
Labourers in mining, construction, manufacturing and transport	9.50	2	90.50	19	

Shiftwork status					
Shift worker	18.40	141	81.60	627	1
Day worker	11.70	462	88.30	3498	1
Education					
≤ 9 yrs of school	13.40	47	86.60	305	1
High school	14.60	305	85.40	1785	1
University < 3yrs	9.20	31	90.80	307	1
University ≥3 yrs	11.40	214	88.60	1656	1
Research education	7.70	6	92.30	72	
Gender					
Male	13.20	266	86.80	1753	1
Female	12.40	337	87.60	2372	1

Notes: * values are given for sleep disturbance and short sleeps measured in 2012. WTC = Work Time

Daily Hours; CoT = Control over Time-off.

Online supplementary material .Table 2: Logistic regression analyses examining Work Time Control predictors of subsequent accident risk, excluding job control as a covariate. Odds Ratios (OR) and 95%

	Accident risk in subsequent 2 years			
	Including shiftworkers		Excluding shiftworkers	
	OR	95%CI	OR	95%CI
WTC 2010	0.88*	0.79-0.97	0.84*	0.75-0.94
CoDH 2010	0.93	0.86-1.01	0.91*	0.83-1.00
CoT 2010	0.86**	0.78-0.95	0.82***	0.73-0.91
WTC 2012	0.87*	0.77-0.99	0.87*	0.77-0.98
CoDH 2012	0.93	0.86-1.02	0.96	0.87-1.05
CoT 2012	0.85**	0.76-0.95	0.84**	0.74-0.95

Notes: * = $p < .05$; ** = $p < .01$. WTC = Work Time Control; CoDH = Control over Daily Hours; CoT = Cont

adjusted for age, sex, education, occupational category, weekly work hours, shiftwork status and perce

Online supplementary material .Table 3: Logistic regression analyses examining Work Time Control predictors of subsequent accident risk *at work*. Odds Ratios (OR) and 95% Confidence Intervals (CI)

	Accident risk in subsequent 2 years			
	Including shiftworkers		Excluding shiftworkers	
	OR	95%CI	OR	95%CI
WTC 2010	0.81**	0.70-0.94	0.76**	0.65-0.90
CoDH 2010	0.86**	0.77-0.96	0.83**	0.74-0.94
CoT 2010	0.81**	0.78-0.97	0.75**	0.64-0.89
WTC 2012	0.82*	0.70-0.96	0.81*	0.67-0.96
CoDH 2012	0.87*	0.77-0.98	0.88	0.77-1.00
CoT 2012	0.85*	0.73-0.99	0.82*	0.69-0.98

Notes: * = $p < .05$; ** = $p < .01$. WTC = Work Time Control; CoDH = Control over Daily Hours; CoT = Cont adjusted for age, sex, education, occupational category, weekly work hours, shiftwork status, job contro work.