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Working hours, sleep duration and the risk of acute coronary heart disease: A case–control study of middle-aged men in Taiwan

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ABSTRACT

Background: This study aimed to examine whether long working hours and short sleep duration were associated with an increased risk of acute myocardial infarction (AMI) or severe coronary heart diseases (SCHD), independent of established psychosocial work-related factors.
Methods: A case–control study was conducted. Cases were 322 men, aged <60 years and economically active, who were admitted to hospital with a first diagnosed AMI or SCHD during 2008–2011, of whom 134 were confirmed AMI and the other 188 were angiography-confirmed SCHD. Controls were 644 men who were drawn from a national survey and were matched to the cases on age, education and area of residence. Odds ratios of total CHD and confirmed AMI in relation to average weekly working hours and daily hours of sleep were calculated.
Results: Men with average working hours longer than 60 h/week were found to have significantly increased risks for total CHD (OR = 2.2) as compared to those with weekly working hours in 40–48 h, and those with daily hours of sleep fewer than 6 h were found to have increased risks for CHD (OR = 3.0) as compared to those with sleeping hours in 6–9 h. Restriction to confirmed AMI yielded a greater risk and these associations remained consistent with adjustment of smoking status, body mass index and psychosocial work factors including job demands, job control, workplace justice, job insecurity and shift work.
Conclusion: The results support the hypothesis that long working hours and short sleep duration contribute independently to the risk of cardiovascular diseases in men.

1. Introduction

The associations between long working hours and poor health have been extensively studied for decades. Accumulating epidemiologic evidences suggests that prolonged working hours are associated with numerous health risks, including hypertension, cardiovascular diseases, mental health problems, sleep disturbances, somatic complaints and occupational injuries [1–7]. Among all, coronary heart diseases (CHD) are the most extensively studied, because they are the predominant cause of death and disability in the general working populations.

Despite of a long history of research interest on this topic, however, the association between long working hours and coronary heart disease is not conclusive. Virtanen and colleagues recently published a review with meta-analysis of 12 studies — 7 studies were case–control studies, 4 studies were prospective and 1 was cross-sectional. They reported that long working hours were associated with a 1.8-fold increased risk of coronary heart diseases [7]. However, generalization of this finding to other populations should be made with caution, because the definition of long working hours and the reference used for comparison purpose differed across studies, and all of these studies were from wealthy countries — 2 studies were from the United States, 5 studies from Nordic and Western European countries, and 5 studies were from Japan. Information from peripheral countries wherein longer working hours are more prevalent is quite limited. Another limitation is that the associations of both working hours and sleep duration with cardiovascular risks have rarely been examined simultaneously, despite the fact that insufficient recovery due to sleep deprivation, which is supposedly more common among people with long working hours, has also been found as a risk factor for cardiovascular diseases [2,8–11]. Furthermore, few studies had taken into consideration the contributing effects of other psychosocial work factors, including high demands, low control, job insecurity, shift work and workplace injustice, which have been shown to be associated with the risk of cardiovascular disease [12–15].

In the present study, we conducted a case–control study to examine whether long working hours and short sleep duration were independently associated with an increased risk of coronary heart diseases in Taiwanese workers, after controlling for established work-related factors including shift work, job control, psychological demands, job insecurity and workplace justice.

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[1] This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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2. Material and methods

2.1. Study subjects

A matched case–control study design was performed. The case group consisted of male patients from a hospital, and their matched control subjects were drawn from a national survey of representative working population. More specifically, eligible cases were male patients who were first diagnosed with acute myocardial infarction (AMI) or angiography-confirmed severe CHD (SCHD) during the period from January of 2008 to November of 2011 at the division of cardiology of the National Taiwan University Hospital (NTUH) [16]. SCHD was defined as left main disease, triple vessel disease or two-vessel disease with involvement of the proximal left anterior descending coronary artery. In this study, cases were restricted to those who were younger than 60 years and actively working prior to the disease onset. The case group consists of the 322 male patients aged between 23 and 60 years old. Among them, 134 cases were confirmed AMI. A standardized questionnaire was administered by a trained interviewer during hospitalization, usually 2–3 days, or within 2 weeks after discharge from hospital.

For each case, two individually matched controls were randomly chosen from study participants of a household survey conducted in September of 2007 by the Council of Labor Affairs (CLA) of Taiwan. The matched variables were sex, age, education level (junior school or below/high school/college or above) and area of residence (city or county). The CLA has conducted nationwide surveys of working people every 3–5 years since 1980 in order to understand work conditions and occupational health and safety status. Participants of these surveys were selected through a two-stage random sampling process. In the first stage, all districts and villages throughout Taiwan were grouped into strata according to their levels of urbanization and a random sample of districts and villages was chosen from each stratum. In the second stage, a random sample of households was selected within each district or village, and residents of the sampled households who were currently working at the time of survey were identified and invited to participate in the survey. In the survey of 2007, a total of 22,476 subjects were sampled, and a total of 19,329 subjects completed and returned questionnaires (response rate 86%). Self-administered questionnaires were delivered to the selected households by trained interviewers and the purpose of the survey was explained in person. After one week, completed questionnaires were collected and on-site checking was performed by the same interviewer to ensure completeness.

This study was approved by the institutional Review Board of NTUH. Informed consents were obtained from all subjects at the time of enrollment.

2.2. Questionnaire

Information on working hours and sleep duration was obtained by a standardized questionnaire. The cases were asked to report their working hours and average sleep duration per day during the week prior to their disease onset. The controls were asked about the same information during the week prior to the survey.

For both the case and control groups, job control was assessed by 9 items (learning new things, non-repetitive work, creative work, allowing own decision, high level of skills, freedom to make decision, various tasks, influential opinions, and develop one's abilities) and job demands by 6 items (fast work, hard work, excessive work, insufficient time, hectic work, insufficient manpower). These two scales are based on Karasek's Demand-Control model and their Chinese version have been validated and widely used in Taiwan [17–19]. This model postulates that higher job demands in combination with lower job control contribute to job strain that in turn results in increased risks of stress-related illnesses.

A 9-item scale for workplace justice was also included, which consists of 3 items for distributive justice (work duties and responsibilities arranged fairly, rewards and benefits arranged fairly, performance evaluated fairly), 2 items for procedural justice (employees' opinions influential, employees well informed in decision making process), 2 items for informational justice (information not hidden, information reliable), and 2 items for interpersonal justice (supervisors trust employees, supervisors treat employees with respect)[20–23]. All these items were listed as statements and the responses were recorded on a four-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree).

The status of shift work (day shift vs. other shifts) and job insecurity (secure vs. insecure) were assessed by single items. Also obtained was information on smoking status and body mass index (BMI) which was calculated by dividing the weight in kilograms by the square of the height in meters.

2.3. Statistical analysis

Comparison analyses on demographics and work conditions were performed between the cases and the controls. The associations of working hours and sleep duration with the risk of CHD were examined by conditional logistic regression, which was performed by the PHREG procedure in the SAS software (9.1 edition, SAS Institute, Cary, North Carolina, US). Smoking status, body mass index and psychosocial work factors including job demands, job control, workplace justice, job insecurity and shift work were treated as confounding variables and controlled in the models. A subgroup analysis was performed by restricting the case group to confirmed AMI.

Table 1
Demographics, behavioral factors and psychosocial work conditions of cases and controls matched on age, education and area of residence.

	Cases (n = 322)	Controls (n = 644)	Crude odds ratio[a] (95% CI)
Age (years): mean (SD)	51.6 (7.1)	51.3 (7.0)	
Range	26–64	27–64	
25–<35	7 (2.2%)	14 (2.2%)	NA
35–<45	43 (13.4%)	86 (13.4%)	NA
45–<55	149 (46.3%)	316 (49.1%)	NA
55–<65	123 (38.2%)	228 (35.4%)	NA
Education (years)			
Junior school (9 years)	46 (14.3%)	92 (14.3%)	NA
High school (12 years)	106 (32.9%)	212 (32.9%)	NA
College and graduate (≧16 years)	170 (52.8%)	340 (52.8%)	NA
Smoking status			
Non-smoker or former smoker	145 (45.0%)	406 (63.0%)	1
Current smoker	177 (55.0%)	238 (37.0%)	1.7 (1.3, 2.1)**
Body mass index (kg/m^2): mean (SD)	26.5 (3.7)	24.3 (2.8)	
<24	101 (31.4%)	366 (56.8%)	1
25–<27	88 (27.3%)	147 (22.8%)	1.7 (1.2, 2.3)**
≧27	131 (40.7%)	130 (20.2%)	2.3 (1.8, 3.0)**
Data missing	2 (0.6%)	1 (0.2%)	NA
Working hours (h/week): mean (SD)	54.0 (20.3)	45.5 (11.1)	
<40	45 (14.0%)	55 (8.5%)	2.2 (1.5, 3.1)**
40–≦48	107 (33.2%)	407 (63.2%)	1
>48–≦60	90 (28.0%)	148 (23.0%)	1.8 (1.4, 2.4)**
>60	80 (24.8%)	34 (5.3%)	3.4 (2.6, 4.6)**
Sleep duration (h/day)			
<6	125 (38.8%)	22 (3.4%)	3.7 (2.9, 4.6)**
6–≦8	171 (53.1%)	605 (93.9%)	1
>8	15 (4.7%)	17 (2.6%)	2.1 (1.2, 3.6)*
Data missing	11 (3.4%)	0	NA
Job control: mean (SD)	63.4 (13.0)	58.3 (13.7)	
High	104 (32.3%)	147 (22.8%)	1
Medium	121 (37.6%)	256 (39.8%)	0.7 (0.5, 0.9)*
Low	83 (25.8%)	241 (37.4%)	0.6 (0.4, 0.7)**
Data missing	14 (4.3%)	0	NA
Job demands: mean (SD)	53.1 (15.3)	49.4 (12.9)	
Low	79 (24.5%)	193 (30.0%)	1
Medium	77 (23.9%)	218 (33.9%)	0.8 (0.6, 1.1)
High	150 (46.6%)	233 (36.2%)	1.2 (0.9, 1.6)
Data missing	16 (5.0%)	0	NA
Workplace justice: mean (SD)	57.5 (12.9)	58.6 (14.4)	
High	87 (27.0%)	143 (22.2%)	1
Medium	64 (19.9%)	145 (22.5%)	1.0 (0.7, 1.3)
Low	97 (30.1%)	149 (23.1%)	1.3 (1.0, 1.6)
Data missing	74 (23.0%)	207 (32.1%)	NA
Job security			
Secure	179 (55.6%)	377 (58.5%)	1
Insecure	93 (28.9%)	267 (41.5%)	0.8 (0.6, 1.0)
Data missing	50 (15.5%)	0	NA
Shift work			
Fixed day shift	226 (70.2%)	501 (77.8%)	1
Irregular shift	96 (29.8%)	143 (22.2%)	1.3 (1.0, 1.6)

NA: not applicable.
[a] Adjusted for age and education categories by conditional logistic regression model.
* $p < 0.01$.
** $p < 0.001$.

3. Results

Table 1 summarizes the demographics, behavioral factors, weekly working hours, daily sleep duration and selected work-related factors conditions of the case and control groups. The cases and controls were similar in age and education level. Crude analyses showed that current smoking and high body mass index were more prevalent among cases and were associated with a significantly increased risk of CHD. Working hours longer than 60 h/week and sleep duration shorter than 6 h/day were more prevalent among cases, and there were U shape associations of working hours and sleep duration with risk of CHD. In contrast to expectation, lower job control was associated with lower risk for CHD, and none of the other work-related factors were associated.

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Table 2 shows the results of conditional logics regression analyses. When working hours and sleep duration were examined simultaneously in conditional logistic regression models that adjusted only smoking status and body mass index, the results show that men with average working hours longer than 60 h/week were found to have significantly increased risks for total CHD (OR = 2.3) as compared to those with weekly working hours in 40–48 h, and those with daily hours of sleep fewer than 6 h were found to have increased risks for CHD (OR = 2.7) as compared to those with sleeping hours in 6–9 h. These associations were non-linear because workers who had working hours less than 40 h/week or sleep duration longer than 9 h/day were also found to be at higher risk (Table 2, Model 1).

After further adjustment of job control, job demands, workplace justice, job insecurity and shift work, the associations of working hours and sleep duration with CHD risk remained consistent. It is noticed that lower workplace justice was associated with a small but significant increase in CHD risk, but in contrast to our hypothesis, lower job control was associated with reduced instead of increased risk of CHD (Table 2, Model 2).

Restriction to confirmed AMI yielded a greater risk and these associations remained consistent with adjustment of smoking status, body mass index and other work-related factors (Table 3).

4. Discussion

Findings of this study showed that long working hours and short sleep duration were independently associated with increased risk of CHD, but these associations were non-linear. It appeared that those with working hours in the range of 40 to 48 h/week and sleep duration in the range of 6 to 9 h were at the lowest risk for CHD. In addition, these observed associations were stronger when analyses were restricted to workers with AMI.

Table 2
Odds ratios (95% CI) for coronary heart disease (CHD) in conditional logistic regression models with adjustment of age and education categories.

	Model 1 (n = 955)	Model 2 (n = 914)
Smoking status		
Non-smoker or former smoker	1	1
Current smoker	1.4 (1.1, 1.7)*	1.3 (1.0, 1.7)
Body mass index (kg/m^2)		
<24	1	1
25–<27	1.5 (1.1, 2.0)*	1.6 (1.1, 2.1)*
≧27	1.7 (1.3, 2.2)**	1.9 (1.4, 2.5)**
Working hours (h/week)		
<40	1.7 (1.2, 2.5)*	1.5 (0.9, 2.3)
40–≦48	1	1
>48–≦60	1.6 (1.2, 2.1)*	1.6 (1.2, 2.2)*
>60	2.3 (1.7, 3.1)**	2.2 (1.6, 3.1)**
Sleep duration (h/day)		
<6	2.7 (2.1, 3.5)**	3.0 (2.3, 3.9)**
6–≦9	1	1
>9	1.6 (0.9, 2.8)	1.8 (1.0, 3.1)
Job control		
High	–	1
Medium	–	0.8 (0.6, 1.1)
Low	–	0.6 (0.4, 0.8)**
Job demands		
Low	–	1
Medium	–	0.9 (0.6, 1.2)
High	–	1.0 (0.7, 1.4)
Workplace justice		
High	–	1
Medium	–	1.2 (0.9, 1.7)
Low	–	1.6 (1.2, 2.1)*
Job security		
Secure	–	1
Insecure	–	0.7 (0.6, 1.0)
Shift work		
Fixed day shift	–	1
Irregular shift	–	0.9 (0.7, 1.2)

NA: not applicable.
* $p < 0.01$.
** $p < 0.001$.

Table 3
Odds ratios (95% CI) for acute myocardial infarction (AMI) in conditional logistic regression models with adjustment of age and education categories.

	Model 1 (n = 402)	Model 2 (n = 375)
Smoking status		
Non-smoker or former smoker	1	1
Current smoker	1.9 (1.3, 2.8)*	1.8 (1.1, 2.8)
Body mass index (kg/m^2)		
<24	1	1
25 ~ <27	1.4 (0.9, 2.2)	1.4 (0.9, 2.4)
≧27	1.4 (0.9, 2.1)	1.5 (0.9, 2.4)
Working hours (h/week)		
<40	1.7 (1.0, 2.9)	1.3 (0.7, 2.7)
40–≦48	1	1
>48–≦60	1.6 (1.0, 2.5)	1.6 (1.0, 2.8)
>60	2.4 (1.5, 4.0)**	2.7 (1.6, 4.7)**
Sleep duration (h/day)		
<6	2.9 (2.0, 4.2)**	3.3 (2.1, 5.0)**
6–≦9	1	1
>9	1.0 (0.3, 3.3)	1.3 (0.4, 4.3)
Job control		
High	–	1
Medium	–	1.1 (0.7, 1.8)
Low	–	0.7 (0.4, 1.1)
Job demands		
Low	–	1
Medium	–	0.9 (0.5, 1.5)
High	–	1.0 (0.6, 1.9)
Workplace justice		
High	–	1
Medium	–	1.3 (0.8, 2.2)
Low	–	1.5 (0.9, 2.7)
Job security		
Secure	–	1
Insecure	–	0.8 (0.5, 1.3)
Shift work		
Fixed day shift	–	1
Irregular shift	–	0.7 (0.4, 1.1)

NA: not applicable.
* $p < 0.01$.
** $p < 0.001$.

The associations of long working hours and CVD risks had been reported in previous studies, and many of them were from Japan [7]. For instance, a case–control study in Japanese men showed that working >11 h/day was associated with a 2.44-fold increased risk of AMI as compared to men working 7–9 h/day [1]. In that study, workers with working hours less than 7 h/day was also found to have increased risk of AMI. The U-shaped association between working hours and CVD risk documented in that study was similar to our findings. In another case–control study in Japanese men by Liu et al. [2], a 2-fold increased risk of non-fatal AMI was found among those with weekly working hours of 61 h or more, as compared to those working less than 40 h/week, and sleep duration less than 5 h/day and frequent lack of sleep were also associated with greater risk.

There has been a growing research interest on the negative health effects of long working hours in western populations. In a study of workers living in California of the United States, Yang and colleagues reported that work hours greater than 50 h/week were associated with a 29% increased risk for hypertension [24]. Among British civil servants of the Whitehall study, Virtanen et al. reported that 3–4 h overtime work per day was associated with 1.60-fold increased risk of incident CHD as compared with those with no overtime work after adjustment of conventional risk CVD risk factors [5]. In another study among participants of the Whitehall study, insufficient sleep defined by sleeping 6 h/day or less was found to be associated with increased CHD risk among those with sleep disturbance [25].

There are several possible mechanisms linking long working hours and insufficient sleep to CHD risk. One explanation is that people with long working hours are more likely to be exposed to psychological stress, which in turn leads to dysfunction of the hypothalamic–pituitary–adrenal and sympatho-adreno-medullary axes. Working longer hours may trigger cardiovascular events via increased blood pressure and sympathetic over-activity. Furthermore, working long hours are expected to interfere with sleep pattern. A prospective study based on the Whitehall study reported that working more than 55 h a week, as compared with working 35–40 h a week, was related to the incidence of various forms of sleep disturbances, including shortened sleeping hours and difficulty falling asleep [26]. A previous study conducted in Taiwanese male workers also demonstrated that 12-hour night shift delayed the recovery of blood pressure and reduced heart rate variability [27], suggesting that sleep disturbances associated with shift work may result in increased cardiovascular risk.

In many Asian countries including Japan, South Korea and Taiwan, long working hours are commonplace and stress-related cardiac events have been the center of controversies [28–31]. According to the yearbook published by the Lausanne's International Institute for Management and Development, in 2010 the yearly working hours was 2074 h in Taiwan and 1997 h in Japan. In contrast, most of the western countries had averaged yearly working hours less than 1900 h [32]. To our knowledge, the present study demonstrated for the first time that long working hours and short sleep duration were risk factors for non-fatal coronary heart diseases in Taiwanese working men.

Our study had the following strengths. First, the CHD patients invited in this study had good compliance through intensive patient care and follow-up program organized by one of our authors (Dr. Su). Their working hours and sleep duration prior to disease event were ascertained at the time of recruitment and were reconfirmed at the different stages of the follow-up (one and fourth month respectively). In addition, the diagnosis of AMI or sCHD was made by attending physician and reconfirmed by discharge note and coronary angiographic report. Misclassification on CHD diagnosis was unlikely in this study.

However, there are several limitations in this study. First, in this study, cases were interviewed during their hospital stay, while control subjects were extracted from a large-scale government-funded house-hold survey in which questionnaires were self-administered at home with assistance of a trained interviewer. Differences in exposure assessment might lead to information bias between cases and controls. Secondly, due to the nature of case–control study design, recall bias might be greater among cases, i.e., cases might be more likely to over report the problem of long working hours and sleep deprivation that would in turn lead to an over-estimation of risks. Thirdly, disease status of control subjects was unknown. However, given the high response rate of this household survey (86%), the surveyed population from which our control subjects were drawn from can be considered as a representative sample of employees of Taiwan. In other words, regardless their cardiovascular disease status, exposure status of the control group should be representative of that of the source population from which the cases arose.

We conclude that results of this study support the hypothesis that long working hours and short sleep duration contribute independently to the risk of cardiovascular diseases in men. Studies with follow-up study design and more rigorous measures should be needed to confirm the effects of long working hours and sleep insufficiency on the development of cardiovascular events.

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