

The association between long working hours and health: A systematic review of epidemiological evidence ¹

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¹ Appendices A and B

Appendix A. Characteristics of 12 prospective cohort studies. [ADA=American Diabetes Association; ANCOVA=analysis of covariance; ANOVA=analysis of variance; BMI=body mass index; CHD=coronary heart disease; CIDI=Composite International Diagnostic Interview; CoxPH=Cox proportional hazard analysis; dBP=diastolic blood pressure; DM=diabetes mellitus; GHQ=General Health Questionnaire; h/d=hours per day; HDL=high-density lipoprotein; h/m=hours per month; h/w=hours per week; ICD-10=International Statistical Classification of Diseases and Related Health Behavior, tenth revision; IFG=impaired fasting glucose; LDL=low-density lipoprotein; LogRA=logistic regression analysis; MANCOVA=multiple analysis of covariance; MDE=major depressive episode; MI=myocardial infarction; ns=no association; sBP=systolic blood pressure; SD=standard deviation; Sig=significant; UM-CIDI=University of Michigan's of the version Composite International Diagnostic Interview; WHO=World Health Organization; (+)=positive association; (-)=negative association]

Author	Participants	Baseline→Follow-up	Outcomes (measures)	Statistical analysis	Covariates	Working hours	Results
Nakamura et al, 2012 (24)	N=1235, Japan, 611 assembly-line workers, 315 clerks and 309 engineers/special technicians in light metal products manufacturing factory, all male, age 39.3 (SD=10.2, range 20-59) years old	2004→2005	1-year change of sBP and dBP (measured twice by trained nurses with an automatic manometer and the mean value of the first and second reading was used in the analysis)	ANCOVA, multiple post-hoc comparison (Bonferroni correction)	age, BMI at baseline, 1-year change in BMI, alcohol intake, smoking habits, exercise habits, sleeping hours, and blood pressure (systolic or diastolic) at baseline	number of overtime <40.0h, 40.0-79.9, ≥80.0 h/m (scheduled working hours; 40 h/w)	Assembly-line workers: sBP: ns dBP: Sig: 1.5 mm Hg (reference), 2.3 mm Hg (overtime 40.0-79.9 h/m), 5.3 mm Hg (overtime ≥80.0 h/m, Sig (+): compared with reference) Clerks: sBP and dBP: ns Engineers/special technicians: sBP and dBP: ns
Virtanen et al, 2012 (25): study A	N=2123, U.K., civil servants, male77%, mean age 46.7 years	1991-1993 (phase 3)→1997-	major depressive episode (UM-CIDI)	LogRA	age, gender, occupational grade, marital status,	working 7-8 h, 9, 10, 11-12 h/d	Sig (+): 2.52-fold (working 11-12 h/d)

	old	1999 (phase 5)			chronic physical disease, smoking, alcohol use, job strain, and social support at work		
Virtanen et al, 2011 (26): study B	Basic participants: N=2960, U.K., civil servants, male 76%, mean age 55.3 years old, eligible for depressive symptoms: N=2549, anxiety symptoms: N=2618	1997-1999 (phase 5) →2001 (phase 6) and 2002-2004 (phase 7)	depressive symptoms, anxiety symptoms (questions derived from GHQ)	CoxPH	age, gender, occupational grade, marital status at baseline, employment status at follow-up, chronic illness, smoking, and alcohol use at baseline	working 35-40 [¶] , 41-55, >55 h/w	Total analysis depressive symptoms: Sig (+): 1.66-fold (working >55 h/w) (linear trend* Sig (+): 1.17-fold) anxiety symptoms: Sig (+): 1.74-fold (working >55 h/w) (linear trend* Sig (+): 1.22-fold) Men only depressive symptoms: ns (linear trend* ns) anxiety symptoms: ns (linear trend* Sig (+): 1.19-fold) Women only depressive symptoms: Sig (+): 2.15-fold (working 41-55 h/w) 2.67-fold (working >55 h/w) (linear trend* Sig (+): 1.40-fold) anxiety symptoms: Sig (+): 1.69-fold (working 41-55 h/w) 2.84-fold (working >55 h/w) (linear trend* Sig (+): 1.31-fold)
Virtanen et al, 2010 (27): study C	N=6014, U.K., civil servants, male 71%, mean age 48.7 years old (range 39-61)	1991-1994 (phase 3) →2002-2004 (phase 7)	CHD (coronary death, incidence of non-fatal MI or incidence of definite angina pectoris), coronary death or incidence of non-fatal MI, all-cause mortality (death certificate,	CoxPH	CHD, coronary death or incidence of non-fatal MI; age, gender, marital status, occupational grade, diabetes, sBP and dBp, LDL	working 7-8 [¶] , 9, 10, 11-12 h/d	CHD: Sig (+): 1.56-fold (working 11-12 h/d) Incidence of coronary death or non-fatal myocardial infarction: Sig(+): 1.67-fold (working 11-12 h/d)

			hospital acute electrocardiograms and cardiac enzymes etc., clinical records and use of nitrate medication)		and HDL cholesterol, triglycerides, smoking, alcohol use, fruit and vegetable consumption, exercise level, BMI, sleeping hours, sickness absence, psychological distress, job demands, decision latitude at work, and type A behavior pattern all-cause mortality; age, gender, marital status, and occupational grade		All-cause mortality: ns
Virtanen et al., June 2009 (28): study D	N=937-1594, U.K., civil servants, male 76%, mean age 52.2 years old	1997-1999 (phase 5)→2002-2004 (phase 7)	sleep (short sleeping hours (<7 hours/day), difficulty in falling asleep, frequent waking during the night, early waking, waking without feeling refreshed) (self-reported, Jenkins scale)	LogRA	age, gender, marital status, occupational grade, education, chronic illness, exercise level, BMI, smoking, alcohol use, and job demands	working 35-40 ^h , 41-55, >55 h/w	Short sleeping hours: ns (linear trend* Sig (+): 1.30-fold) Difficulty in falling asleep: Sig (+): 4.12-fold (working >55 h/w) (linear trend* Sig(+): 1.57-fold) Frequent waking: ns (linear trend* ns) Early waking: ns (linear trend* ns) Waking without refreshed: ns (linear trend* ns)
Virtanen et al., June 2009 (28): study E	N=886-1510, U.K., civil servants, male 76%, mean age 52.2 years old	1997-1999 (phase 5)→2002-2004 (phase 7)	sleep (short sleeping hours (<7 hours/day), difficulty in falling asleep, frequent waking during the night, early waking, waking without feeling refreshed) (self-reported, Jenkins	LogRA (working hours were measured in 1991-1994 and 1997-1999)	age, gender, marital status, occupational grade, education, chronic illness, exercise level, BMI, smoking, alcohol use, and job	working 35-40 ^h , 41-55, >55 h/w	Short sleeping hours: Sig (+): 1.55-fold (working 41-55 h/w) 2.80-fold (working >55 h/w) (linear trend* Sig (+): 1.56-fold) Difficulty in falling asleep: Sig (+): 7.94-fold (working >55 h/w)

			scale)		demands		(linear trend* Sig(+): 2.06-fold)
Virtanen et al, March 2009 (29): study F	N=2214, U.K., civil servants, male 77%, mean age 52.1 (SD=4.2, range 45-66) years old	1997-1999 (phase 5)→2002-2004 (phase 7)	cognitive function: high scores represent good cognitive function (short-term memory test, Alice Heim 4-I test (reasoning test), Mill Hill vocabulary test, phonemic fluency test, semantic fluency test)	MANCOVA, ANOVA	age, gender, marital status, follow-up employment status, occupational grade, education, income, physical health indicators, psychological distress, anxiety, sleep problems, health risk behaviors, social support, family stress, and job strain	working 35-40 ^h , 41-55, >55 h/w	Frequent waking: ns (linear trend* ns) Early waking: Sig (+): 2.03-fold (working >55 h/w) (linear trend* ns) Waking without refreshed: ns (linear trend* ns)
							Scores at baseline Mill Hill vocabulary test: Sig (-): working 41-55 h/w, >55 h/w (linear trend† Sig (-)) phonemic fluency test: ns (linear trend† Sig(+)) other three tests: ns
							Scores at follow-up Alice Heim 4-I test score: Sig (-): working >55 h/w (linear trend† Sig (-)) Mill Hill vocabulary test: Sig (-): working 41-55 h/w, >55 h/w (linear trend† Sig (-)) other three tests: ns
							Change in Alice Heim 4-I test score between baseline and follow-up: Sig (-): reference (-1.77), working 41-55 h/w (-2.23), working >55 h/w (-2.90) (linear trend† Sig (-))
Tarumi et al, 2003 (30)	N=867 (mental disorders) and 824 (circulatory disorders), Japan, white-collar office	1997-2000→2001	mental disorders (ICD-10: F00-F99, G90), circulatory disorders (ICD-10: I00-99) (medical insurance claim records)	CoxPH	mental disorders; age, gender, and type of occupation circulatory disorders; age,	working <45 ^h , ≥45 h/w	Mental disorders: ns Circulatory disorders: ns

	workers in manufacturing company, age 20-60 years old				gender, type of occupation, BMI, and physical exercise		
Nakanishi et al, September 2001 (31)	N=1266, Japan, office workers, all male, age 35-59 years old	1994→1999	IFG or type 2 DM, IFG, type 2 DM (ADA criteria (1997): IFG: fasting plasma glucose concentration of 6.1-6.9 mmol/l, type 2 DM: fasting plasma glucose concentration of ≥ 7.0 mmol/l or taking hypoglycemic medication)	CoxPH	age, occupation, position, BMI, smoking, alcohol intake, eating breakfast, vegetable consumption, fruit consumption, physical activity, family history of diabetes, sBP and dBP, fasting plasma glucose, total cholesterol, HDL cholesterol, and triglycerides at baseline	working <8.0 \ddagger , 8.0-8.9, 9.0-9.9, 10.0-10.9, ≥ 11.0 h/d	IFG or type 2 DM: Sig (-): 0.50-fold (working ≥ 11.0 h/d) (linear trend \ddagger Sig (-)) IFG: ns Type 2 DM: Sig (-): 0.30-fold (working ≥ 11.0 h/d) (linear trend \ddagger Sig (-))
Nakanishi et al, May 2001 (32)	N=941, Japan, white-collar workers, all male, age 35-54 years old	1994→1999	hypertension (WHO criteria (1978): sBP ≥ 160 mm Hg and/or dBP ≥ 95 mm Hg or receipt of antihypertensive medications), borderline hypertension (sBP ≥ 140 mm Hg and <160 mm Hg, and/or dBP ≥ 90 mm Hg and <95 mm Hg) (sphygmomanometer)	CoxPH	age, occupation, position, mean arterial blood pressure, BMI, alcohol intake, smoking, eating breakfast, vegetable consumption, fruit consumption, regular physical activity, salt intake, sleeping hours, and hours of commutation at baseline	working <8.0 \ddagger , 8.0-8.9, 9.0-9.9, 10.0-10.9, ≥ 11.0 h/d	Hypertension: Sig (-): 0.33-fold (working ≥ 11.0 h/d) (linear trend \ddagger Sig (-)) Borderline hypertension: Sig (-) 0.63-fold (working 10.0-10.9 h/d) 0.48-fold (working ≥ 11.0 h/d) (linear trend \ddagger Sig (-))

Kawakami et al, 1999 (33)	N=2194, Japan, industrial workers in electrical company, all male, including shift workers (46.3%)	1984→1992	non-insulin dependent diabetes mellitus (NIDDM) (WHO criteria (1980), urine samples, fasting plasma glucose, 75 g oral glucose tolerance test) →see the details in the text	CoxPH	age, years of education, obesity (BMI), leisure time physical activity, alcohol consumption, smoking, shift work, type of occupation, job strain, social support at work, use of new technology at work, and family history of DM (at follow-up)	number of overtime 0-25¶, 26-50, >50 h/m (working hours of contract; 40 h/w)	NIDDM (type 2 DM): Sig (+): 3.73-fold (overtime >50 h/m) (linear trend‡ Sig (+))
Shields, 1999 (34)	N=3830, Canada, various job, male 57%, age 25-54 years old, including shift workers (19.7%)	1994/1995→1996/1997	major depressive episode (CIDI), unhealthy weight gain (weight gain >6.4% for men and >8.8% for women), increased daily smoking (occasional or non-smokers became daily smokers, or the number of cigarettes smoked per day by daily smokers increased by three or more), increased alcohol consumption (number of drinks consumed in the week before follow-up survey exceeded the number of those before the baseline survey), decreased physical activity (fewer period of exercise in follow-up than participants had in baseline)	LogRA	age, occupation, self-employment, shift work, multiple jobs, high job strain, high job insecurity, low supervisor support, marital status, educational attainment, household income, and the presence of children younger than 12 in the household	working ≥35 and <41 h/w (standard), ≥41 h/w (long) ¶: standard at baseline for MDE, standard-standard pattern for other outcomes	Major depressive episode men: ns women: Sig (+): 2.2-fold (working ≥41 h/w) Unhealthy weight gain men: ns (long-long) 2.2-fold (standard-long) women: ns (long-long, standard-long) Increased daily smoking men: ns (long-long) 2.2-fold (standard-long) women: ns (long-long) 4.1-fold (standard-long) Increased alcohol consumption men: ns (long-long, standard-long) women: ns (long-long) 2.0-fold (standard-long) Decreased physical activity men:

ns (long-long, standard-long)
 women:
 ns (long-long, standard-long)

¶ Reference working group

* Linear trend=increasing 10-hour working time (per 10-hour increase)

† Linear trend=entering total working hours into the model as continuous variable

‡ Linear trend =increasing categories of working hours per day or month

Appendix B. Characteristics of 7 cross-sectional studies. [AUDIT=Alcohol Use Disorders Identification Test; CFSI=Cumulative Fatigue Symptom Index; GHQ=General Health Questionnaire; h/d=hours per day; h/m=hours per month; h/w=hours per week; LogRA=logistic regression analysis; ns=no association; PSQ-I=Pittsburgh Sleep Quality Index; SDS=Self-Rating Depression Scale; Sig=significant; (+)=positive association; (-)=negative association]

Author	Participants	Survey	Outcomes (measures)	Statistical analysis	Covariates	Working hours	Results
Kobayashi et al, 2012 (35)	N=933, Japan, workers in manufacturing company, all male, age 19-70 years old, including shift workers (25.8%)	2009	metabolic syndrome (Japanese criteria (2005), using blood samples, sphygmomanometer, and waist circumference was measured by medical staff)	LogRA	age, occupation, (shift work), smoking status, frequency of alcohol consumption, and cohabiting status	working ≥ 7 and ≤ 8 ¶, > 8 and ≤ 9 , > 9 and ≤ 10 , > 10 h/d	All participants: Sig (+): 2.32-fold (working > 10 h/d) Participants without shift workers: ns Age stratified analysis ≥ 40 years old or < 40 years ≥ 40 group: Sig (+): 2.02-fold (working $> 8 \leq 9$ h/d) 3.14-fold (working > 10 h/d) ≥ 45 years old or < 45 years ≥ 45 group: Sig (+): 2.82-fold (working $> 8 \leq 9$ h/d) 5.13-fold (working > 10 h/d) ≥ 50 years old or < 50 years ≥ 50 group: Sig (+): 3.33-fold (working $> 8 \leq 9$ h/d) 4.86-fold (working > 10 h/d)

Nakashima et al, 2011 (36)	N=1510, Japan, white-collar workers in light metal products manufacturing company, all male, mean age 42.6 years old (range18-59)	2004	sleep (PSQ-I; PSQ-I global score, subscales of poor sleep quality, short sleep duration (≤ 6 hours/day), daytime dysfunction)	LogRA	age, occupational category, sickness absence, presence of family or partner, leisure time physical activity, and drinking habit just before sleep	number of overtime <26 h/m¶, ≥ 26 and <40, ≥ 40 and <50, ≥ 50 and <63, ≥ 63 h/m (working hours of contract: 40 h/w)	PSQ-I global score: Sig (+): 1.67-fold (overtime ≥ 50 <63 h/m) 1.87-fold (overtime ≥ 63 h/m) Poor sleep quality: ns Short sleep duration: Sig (+): 1.43-fold (overtime ≥ 26 <40 h/m) 1.51-fold (overtime ≥ 40 <50 h/m) 1.75-fold (overtime ≥ 50 <63 h/m) 3.68-fold (overtime ≥ 63 h/m) Daytime dysfunction: Sig (+): 1.82-fold (overtime ≥ 26 <40 h/m) 2.06-fold (overtime ≥ 40 <50 h/m) 2.36-fold (overtime ≥ 50 <63 h/m) 2.58-fold (overtime ≥ 63 h/m)
Nash et al, 2010 (37)	N=2999, Australia, doctors, male 71%	2007	psychiatric morbidity (GHQ-28), hazardous alcohol use (AUDIT)	LogRA	age group, gender, medical specialty, solo practice, marital status, peer review in previous 12 months, continuing medical education requirements, holiday in previous 12 months, current medicolegal matter, psychoticism, extroversion, and neuroticism	working <40¶, 40-49, 50-59, ≥ 60 h/w	Psychiatric morbidity: Sig (+): 1.41-fold (working 50-59 h/w) 1.65-fold (working ≥ 60 h/w) Hazardous alcohol use: Sig (-): 0.67-fold (working ≥ 60 h/w)

Driesen et al, 2010 (38)	N=7217, Netherlands, employees representing almost all sectors and trades of the Dutch labour force from 45 companies and organizations, male 73%, mean age 41.9 years old	1998	depressive mood (single question "Did you feel down every day over the last two weeks?" derived from Balansmeter)	LogRA	age, educational level, living alone, long-term illness, decision latitude, supervisor social support, coworker social support, psychological job demands, emotional demands, and physical demands	working 36-40 $\frac{1}{2}$, >40 h/w	Men: Sig (-): 0.74-fold (working >40 h/w) Women: ns
Virtanen et al, 2009 (28)	N=2436-2459, U.K., civil servants, male 76%, mean age 52.2 years old	1997-1999 (phase 5)	sleep (short sleeping hours (<7 hours/day), difficulty in falling asleep, frequent waking during the night, early waking, waking without feeling refreshed) (self-reported, Jenkins scale)	LogRA	age, gender, marital status, occupational grade, education, chronic illness, exercise level, body mass index, smoking, alcohol use, and job demands	working 35-40 $\frac{1}{2}$, 41-55, >55 h/w	Short sleeping hours: Sig (+): 1.39-fold (working 41-55 h/w) 2.25-fold (working >55 h/w) (linear trend* Sig (+): 1.39-fold) Difficulty in falling asleep: ns (linear trend* ns) Frequent waking: ns (linear trend* ns) Early waking: ns (linear trend* ns) Waking without refreshed: ns (linear trend* ns)
Nagashima et al, 2007 (39)	N=715, Japan, chemical factory workers, all male, mean age 44.1 years old	2003	depressive state (SDS), anxiety (CFSI)	LogRA	age, marital status, smoking habit, volume of alcohol consumed, and exercise habit	working \leq 199 $\frac{1}{2}$, 200-219, 220-239, 240-259, 260-279, \geq 280 h/m	Depressive state: Sig (+): 2.75-fold (working 260-279 h/m) Anxiety: Sig (+): 2.28-fold (working 260-279 h/m) 2.51-fold (working \geq 280 h/m)

Sekine et al, 2006 (40)	N=3556, Japan, civil servants, male 67%, mean age 42.7 (SD =10.2, range 20-65) years old, including shift workers (21%)	2003	sleep (PSQ-I global score)	LogRA	age, (gender), grade of employment, work characteristics (control, demand, support, and shift work), family characteristics (roles, family-to-work conflict and work-to-family conflict), and longstanding illness	working7-9¶, 9-11, >11 h/d	All participants: Sig (+): 1.71-fold (working >11 h/d) Men only: Sig (+): 1.49-fold (working >11 h/d) Women only: Sig (+): 2.02-fold (working >11 h/d)
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¶ Reference working group

* Linear trend=increasing 10-hour working time (per 10-hour increase)