Long Working Hours May Increase Risk of Coronary Heart Disease

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Objective *To evaluate the association between long working hours and risk of coronary heart disease (CHD) estimated by Framingham risk score (FRS) in Korean adults.*
Methods *This study evaluated adult participants in Korean National Health and Nutrition Examination Survey IV (2007–2009). After inclusion and exclusion criteria were applied, the final sample size for this study model was 8,350. Subjects were asked about working hours and health status. Participants also completed physical examinations and biochemical measurement necessary for estimation of FRS. Multiple logistic regression was conducted to investigate the association between working hours and 10-year risk for CHD estimated by FRS.*
Results *Compared to those who work 31–40 hr, significantly higher 10-year risk was estimated among subjects working longer hours. As working hours increased, odds ratio (OR) for upper 10 percent of estimated 10-year risk for CHD was increased up to 1.94.*
Conclusions *Long working hours are significantly related to risk of coronary heart disease.* Am. J. Ind. Med. *© 2014 Wiley Periodicals, Inc.*

KEY WORDS: coronary heart disease; long working hours; framingham risk score; korean national health and nutrition examination survey; risk factors

INTRODUCTION

Long working hours have been an inevitable consequence of downsizing and restructuring in the labor force, and have been consistently linked to stress, dissatisfaction, and health outcomes [Sparks et al., 1997; Smith et al., 2000; Van der Hulst, 2003]. Overtime work is associated with various adverse health outcomes, such as hypertension, musculoskeletal discomfort, diabetes mellitus, occupational injury, increased suicide rate, sleep problems, preterm birth, and poor psychological health [Caruso et al., 2004]. A meta-analysis also showed that long working hours exacerbate unhealthy lifestyle conditions [Sparks et al., 1997]. Working hours not only affect physical health outcomes, but also lifestyle conditions, such as dietary patterns, exercise, smoking habits, and alcohol consumption. It is highly probable that cardiovascular diseases are affected by overtime work, because the risk factors of cardiovascular diseases are influenced by working hours.

However, the increased risk of cardiovascular disease related to excessive work remains a concern that has yet to be resolved. A number of researchers have investigated the relationship between cardiovascular disease and long working hours. Some researchers suggest that long working hours may affect cardiac health due to insufficient recovery time after work [Geurts and Sonnentag, 2006], high job demands [Van der Hulst et al., 2006], and work-family imbalance [Golden and Wiens-Tuers, 2006]. Other researchers insist that working hours per se have no clear relationship with coronary heart disease (CHD) [Chen et al., 2007; Netterstrøm et al., 2010].

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However, most of the above mentioned studies were conducted using specific occupational groups and the number of subjects was relatively small for each. It is thus difficult to make generalized conclusions across the different population groups. For this reason, we investigated the association between working hours and risk of CHD using data from a nationally representative population of Korean adults. Because an individual's risk for future cardiovascular events is modifiable by early interventions, it is important to identify workers who are at risk for CHD, in order to prevent the disease early on. The Framingham Risk Score (FRS) is one of the well-known prediction models used to determine an individual's chance of developing CHD. However, to our best knowledge, this risk prediction method has not been applied to working hours. Therefore, we conducted this study to evaluate the association between working hours and risk factors for CHD in Korean adults, using FRS to calculate CHD risk.

MATERIALS AND METHODS

Study Design and Participants

Korean National Health and Nutrition Examination Survey (KNHANES) is a cross-sectional, nationally representative survey conducted by the Korean Ministry of Health and Welfare. The survey consisted of the following four components: the Health Interview Survey, the Health Behavior Survey, the Health Examination Survey, and the Nutrition Survey. This study was based on KNHANES IV (2007–2009) data, which was the most recent KNHANES data available for analysis.

The target population of the survey was non-institutionalized civilians aged > 19 years in Korea. The sampling units were identified based on the 2005 population and housing census in Korea. A stratified, multistage probability sampling design was used for the selection of household units based on geographic area, sex, and age group, using household registries. Weights indicating the probability of being sampled were assigned to each participant, enabling the results to represent the entire Korean population. The Institutional Review Board of the Korea Centers for Disease Control and Prevention approved this survey, and all participants gave written informed consent for participation in the study.

The target population of KNHANES IV (2007–2009) was 31,705, with a response rate of 78.4%. Therefore, the initial sample consisted of 24,871 subjects. The following inclusion criteria were used for this study: (1) age > 19 years, (2) workers who have a non-shift full-time job at the time of survey, and (3) those who do not have other major disease history, such as malignant neoplasm, myocardial infarction, angina pectoris, or stroke. A total of 8,585 subjects were eligible after applying these inclusion criteria. The final sample size for this study model was 8,350 after further excluding subjects with missing values (11 subjects did not have blood pressure values and 232 subjects did not have cholesterol level values) (Fig. 1).

Variables Measurement

Interviewers asked participants about lifestyle behaviors, including cigarette smoking, alcohol consumption, diagnoses of major diseases, and a list of medications being taken. Completed questionnaires were reviewed by trained staff and entered into a database. Working hours were measured as the actual number of hours the respondent works per week at all paid jobs. Standard working hours are defined as 40 hr/week or 8 hr/day in Korean labor law, and we defined overtime work as more than 30% increase of standard working hours (52 hr/week). Smoking exposure was categorized as non-smoker and current smoker. Measures of drinking patterns were based on the AUDIT (alcohol use disorders identification test) questionnaire including 10 screening question items [Babor et al., 2001]. Problem drinking was defined as AUDIT score 10 or more for men, 8 or more for women and 4 or more for the elderly (age ≥ 65).

Information about duration, frequency, and intensity of physical activity was ascertained using a Korean version of the International Physical Activity Questionnaire [Oh et al., 2007].

Blood pressure was measured in the right arm at the level of the heart using a standard mercury sphygmomanometer (Baumanometer, USA) while the subjects were seated and after they had rested for 5 min. The average of two systolic

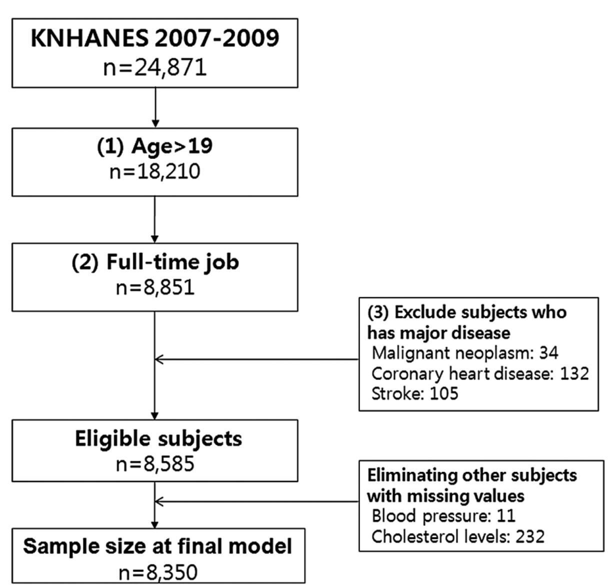

FIGURE 1. Schematic diagram depicting study population.

and diastolic blood pressure (SBP and DBP) readings, which were recorded at an interval of 5 min, was used for analysis.

After a 12 hr overnight fast, blood samples were obtained from the subjects through an antecubital vein. Fasting plasma glucose, total cholesterol, triglyceride, and high-density lipoprotein cholesterol were measured using an autoanalyzer (ADVIA 1650®, Bayer, Tarrytown, NY, USA).

The individuals' 10-year risk for CHD was determined using the Framingham risk model. With the Framingham algorithm as outlined by the National Cholesterol Education Program (NCEP), a global risk score was calculated based on categorical values of age, sex, total cholesterol, high-density lipoprotein (HDL) cholesterol, blood pressure, diabetes, and smoking [Wilson et al., 1998]. The first step is to calculate the number of points for each risk factor, after which the total risk score is calculated using the summation of the points for each risk factor.

Statistical Analysis

The general and clinical characteristics of the study population were summarized by gender. Continuous values were presented as means and standard deviation (SD), and categorical values as frequencies. The distribution of FRS by working hours was also presented. Multiple logistic regression analyses were used to analyze relations between high-CHD risk (defined as upper 10 percent of estimated 10-year risk for CHD) and working hour categories. Statistical analyses were performed using SURVEYLOGISTIC in SAS (Version 9.22, SAS Institute, Cary, NC), a software package that incorporates sample weights and adjusts analyses to account for the complex sample design of the survey. Survey sample weights were used in all analyses to provide nationally representative prevalence estimates. All probability values were two-tailed, and statistical significance was defined as $P < 0.05$.

RESULTS

The mean age (and corresponding SD) of the subjects is 45.9 (± 14.0 SD), and 42.9% of subjects were female. Subjects worked an average of 50.1 (± 16.7 SD) hr, and 38.0% of them worked over 52 hr per week. According to our data analysis, male participants, people aged 50–59, middle school graduates, service and sales workers, and those in the lower to middle income bracket were working longer hours than the other subjects. Frequencies of current smoking, problem drinking, and diabetes were higher among overtime workers. The other descriptive characteristics of the study population are shown in Table I.

A summary of the levels of blood pressure and cholesterol according to working hour categories is shown in Table II. Generally, the level of each variable presented in Table II increased as the work hours increased from 31–40 hr to 71–80 hr, but those who worked less than 30 hr showed higher values than those who worked 31–40 hr. Subjects who worked 80 or more hours a week did not have the highest SBP or DBP and their blood pressure levels were lower than subjects working 71–80 hr.

The results shown in Table III, which present the FRS according to working hour categories, have a similar pattern to the results in Table II. Subjects who worked less than 30 hr had a higher predicted 10-year risk for CHD than the others. However, the general trend showed that the risk for CHD within 10 years increased as the weekly working hours increased.

We categorized subjects into the low-risk group when the 10-year CHD risk was lower than 10 percent, and into the high-risk group when 10-year CHD risk was 10 percent or higher. To evaluate the association between working hours and high 10-year risk for CHD, the ORs and 95% CI values were calculated after adjusting for income level, occupation, physical activity, and AUDIT score. Because FRS is already calculated using sex and age, we did not adjust for these variables again. Relative to those who worked 31–40 hr, a significantly higher ORs of high 10-year risk for CHD were observed in subjects who worked longer hours. Moreover, the results showed a dose-response relationship between working hours and high 10-year risk for CHD. This means that the longer hours an employee works, the higher their chance of developing CHD (61–70 hr working group, OR = 1.42 (1.06–1.89); 71–80 hr, OR = 1.63 (1.22–2.18); more than 80 hr, OR = 1.94 (1.39–2.73)).

Interestingly, we found that working hours and 10-year risk for CHD were more closely correlated in women than in men. Among women, ORs increased up to 4.65 fold as working hours increased, compared with 1.47 fold among men. The effect modification by sex was statistically significant in the model (Table III). The result of stratified analysis by occupational category is also summarized in Supplementary Table I. This analysis showed that overall risk of CHD is higher among manual workers than non-manual workers, but the association between working hours and risk of CHD is stronger in non-manual workers (more than 80 hr, non-manual workers, OR = 2.89 (1.79–4.68); manual workers, OR = 1.27 (0.79–2.04); p-interaction = 0.0968).

DISCUSSION

We found that working hours were significantly related to the risk factors of CHD such as blood pressure, cholesterol levels, diabetes, and smoking habits. These findings indicate that long working hours have adverse effects on the cardiovascular system. Furthermore, a higher 10-year risk for CHD was predicted as working hours increased.

However, our results showed that levels of SBP and DBP were slightly lower among subjects who worked more than

TABLE I. General Characteristics, Working Hours, and Proportion of Overtime Workers of Selected Population

	Male			Female		
	N (%)[a]	Working hours	Overtime worker N (%)[b]	N (%)[a]	Working hours	Overtime worker N (%)[b]
Age						
<30	519 (10.6)	51.9 ± 15.8	223 (43.0)	594 (16.1)	45.9 ± 10.8	123 (20.7)
30∼40	1296 (26.4)	52.2 ± 14.3	514 (39.7)	741 (20.1)	46.4 ± 15.0	189 (25.5)
40∼50	1297 (26.5)	51.2 ± 15.1	485 (37.4)	937 (25.4)	49.2 ± 17.4	344 (36.7)
50∼60	944 (19.5)	51.6 ± 17.7	405 (43.1)	727 (19.7)	52.9 ± 19.0	347 (47.7)
60<	845 (17.2)	49.3 ± 19.9	363 (43.0)	685 (18.6)	47.8 ± 19.4	266 (38.8)
Smoking						
Current smoker	2352 (48.0)	51.7 ± 16.5	989 (42.1)	251 (6.8)	51.618.3	101 (40.2)
Non-smoker	2549 (52.0)	50.8 ± 16.4	1001 (39.2)	3433 (93.2)	48.4 ± 16.9	1168 (34.0)
Problem drinking						
Yes	2856 (58.3)	50.8 ± 16.9	1191 (41.7)	1212 (32.9)	48.1 ± 17.1	427 (35.2)
No	2045 (41.7)	51.6 ± 16.1	799 (39.1)	2472 (67.1)	49.6 ± 16.6	842 (34.1)
Diabetes						
Yes	294 (6.0)	51.1 ± 17.5	122 (41.5)	150 (4.1)	48.3 ± 18.2	61 (40.7)
No	4607 (94.0)	51.3 ± 16.4	1868 (40.6)	3534 (95.9)	48.6 ± 16.9	1208 (34.2)
Education						
Elementary school graduate or less	750 (15.3)	51.0 ± 19.3	360 (48.0)	1099 (29.3)	50.9 ± 20.1	503 (45.8)
Middle school graduate	562 (11.5)	53.1 ± 19.4	285 (50.7)	441 (32.3)	52.5 ± 18.8	202 (45.8)
high school graduate	1817 (37.1)	52.6 ± 16.6	807 (44.4)	1191 (32.3)	47.9 ± 15.8	390 (32.8)
College graduate or more	1770 (36.1)	49.4 ± 13.5	537 (30.3)	953 (25.9)	44.9 ± 12.0	174 (18.3)
Income (N = 8452)						
Lowest	1083 (22.5)	50.3 ± 18.1	475 (43.9)	905 (24.9)	49.0 ± 18.4	345 (38.1)
Lower-middle	1189 (24.7)	52.6 ± 16.4	515 (43.3)	885 (24.5)	49.4 ± 17.9	334 (37.7)
Upper-middle	1289 (26.7)	51.7 ± 16.1	527 (40.9)	922 (25.4)	48.7 ± 16.1	314 (34.1)
Highest	1260 (26.1)	50.4 ± 15.2	439 (34.8)	919 (25.3)	47.1 ± 15.2	254 (27.6)
Occupation (N = 8544)						
Managers and professionals	933 (19.2)	50.1 ± 15.5	291 (31.2)	577 (15.7)	44.4 ± 13.0	110 (19.1)
Office workers	617 (12.7)	47.2 ± 10.0	147 (23.8)	472 (12.8)	44.0 ± 8.7	54 (11.4)
Service and sales workers	722 (14.9)	57.8 ± 18.4	406 (56.2)	933 (25.4)	54.6 ± 20.1	460 (49.3)
Agriculture, Forestry and Fisheries Workers	681 (14.0)	48.7 ± 18.8	305 (44.8)	636 (17.3)	48.9 ± 17.2	293 (46.1)
Craft, device machine operators and assembly workers	1194 (24.6)	51.3 ± 14.7	511 (42.8)	180 (4.9)	49.4 ± 16.3	69 (38.3)
Manual workers	450 (9.3)	52.7 ± 18.8	207 (46.0)	547 (14.9)	46.0 ± 17.7	174 (31.8)
Others	266 (5.5)	52.0 ± 18.0	111 (41.7)	336 (9.1)	48.6 ± 15.8	108 (32.1)
Total	4901	51.3 ± 16.4	1990 (30.6)	3684	48.6 ± 17.0	1269 (34.5)

[a]percentage in the population.
[b]percentage of a particular group working overtime (≥52 hr per week).

80 hr a week than subjects who worked 70–80 hr a week. In addition, subjects who worked less than 30 hr per week had higher SBP, DBP, total cholesterol levels, and ultimately a higher 10-year risk of CHD than subjects who worked 31–40 hr per week. This means that compared to people who worked 31–40 hr a week, those who worked less than 30 hr a week tended to have a worse health status. Regarding this finding, we considered the possibility that selection processes may differentiate those who worked very long hours and reduced hours from the standard full-time workers. Health limitations as well as advantages may have influenced how much people worked. Persons who have worse cardiac health may not work long hours. Unfortunately, our cross-sectional study design cannot identify in which direction the selection process may have occurred; selection would probably lead to an underestimation of the true risk.

Several studies have shown the relationship between long working hours and heart disease. Uehata [1991]

TABLE II. Blood Pressures and Cholesterol Levels According to Working Hour Categories

	SBP		DBP		Total cholesterol		HDL	
Working hours	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**N**	**Mean ± SD**
<30	839	120.4 ± 18.7	839	77.0 ± 11.1	817	186.5 ± 37.0	817	49.5 ± 12.3
31–40	2091	115.5 ± 16.2	2091	76.5 ± 11.0	2042	185.9 ± 34.5	2042	50.4 ± 12.4
41–50	2362	116.5 ± 16.0	2362	77.5 ± 11.2	2292	185.9 ± 34.4	2292	50.2 ± 12.2
51–60	1569	118.1 ± 16.3	1569	77.9 ± 11.1	1535	188.1 ± 34.5	1535	49.8 ± 12.4
61–70	827	119.3 ± 16.9	827	77.3 ± 10.4	798	188.0 ± 35.5	798	50.2 ± 12.5
71–80	467	120.1 ± 16.3	467	79.5 ± 11.0	454	189.3 ± 33.5	454	49.5 ± 13.4
≥80	430	118.9 ± 16.0	430	78.3 ± 10.5	425	191.1 ± 37.4	415	49.2 ± 12.4
Total	8574	117.5 ± 16.6	8574	77.4 ± 11.0	8363	187.0 ± 34.9	8353	50.0 ± 12.4
Men only								
<30	394	124.0 ± 17.7	394	79.2 ± 11.0	386	186.6 ± 35.9	386	46.9 ± 12.3
31–40	1105	119.0 ± 15.2	1105	79.7 ± 10.8	1081	188.9 ± 33.4	1081	47.2 ± 11.6
41–50	1394	118.9 ± 14.3	1394	80.0 ± 10.4	1360	188.1 ± 33.8	1360	47.4 ± 11.0
51–60	989	120.3 ± 15.7	989	80.4 ± 10.9	972	189.1 ± 34.1	972	47.9 ± 11.5
61–70	471	120.1 ± 16.1	471	79.2 ± 9.9	458	188.5 ± 35.0	458	48.3 ± 12.5
71–80	290	121.0 ± 15.3	290	81.0 ± 10.7	281	187.4 ± 32.2	281	48.4 ± 14.6
≥80	258	120.9 ± 14.6	258	80.2 ± 9.8	252	188.6 ± 33.5	252	47.0 ± 11.3
total	4895	120.0 ± 15.4	4895	79.9 ± 10.6	4790	188.4 ± 33.9	4790	47.5 ± 11.8
Women only								
<30	445	117.1 ± 19.0	445	75.0 ± 10.9	431	188.3 ± 37.6	431	51.7 ± 12.1
31–40	986	111.6 ± 16.4	986	72.9 ± 10.0	961	183.3 ± 35.5	961	54.1 ± 12.2
41–50	968	113.1 ± 17.6	968	73.8 ± 11.3	932	183.9 ± 35.3	932	54.5 ± 12.7
51–60	580	114.2 ± 16.5	580	73.7 ± 10.3	563	187.6 ± 34.2	563	53.3 ± 13.2
61–70	356	118.2 ± 17.9	356	74.8 ± 10.6	340	188.6 ± 34.0	340	52.5 ± 12.4
71–80	177	118.6 ± 17.9	177	77.1 ± 11.0	173	191.6 ± 34.7	173	51.1 ± 11.2
≥80	172	115.9 ± 17.5	172	75.4 ± 10.7	163	196.0 ± 41.7	163	52.6 ± 13.0
Total	3679	114.3 ± 17.5	3679	74.0 ± 10.7	3563	186.2 ± 35.8	3563	53.4 ± 12.5

surveyed ‘karoshi’ victims who suffered fatal heart attacks due to heavy workload in Japan and found that about two-thirds of the victims were working 60 or more hours per week. The meta-analysis conducted by Kang et al. [2012] of five cohort studies and six case–control studies showed that the effect of longer working hours was significantly associated with the risk of cardiovascular disease.

A review article by Van der Hulst et al. [2006] summarized the association between long working hours and health. It showed that long working hours were associated with adverse health outcomes such as cardiovascular disease and diabetes mellitus. Furthermore, some evidence of an association between long working hours and changes in biological parameters related to cardiovascular system, such as systolic blood pressure, total cholesterol, and proportion of lymphocyte subpopulation, has been reported [Iwasaki et al., 1998; Yasuda et al., 2001].

Nevertheless, earlier studies about the effects of long working hours on hypertension have shown mixed results. A repeated-measures study revealed that blood pressure was higher during a busy period (96 overtime hours per month) than in the reference period [Hayashi et al., 1996]. However, a cohort study by Nakanishi et al. showed that those who worked 10 hr or more a day had a decreased risk of developing hypertension over a 3-year period [1999], and after a 5-year period [2001b].

The evidence linking long working hours and diabetes mellitus is also inconclusive. Some studies conducted in the US and Japan found an association between long working hours and incidence of type-2 diabetes [Kawakami et al., 1999; Kroenke et al., 2007]. However, in a cross-sectional analysis of middle-aged white-collar British civil servants, no significant association was found between long working hours and prevalence of diabetes mellitus [Virtanen, 2012]. Nakanishi et al. [2001a] even suggest that long working hours have health protective effects, after they found that daily working ≥ 11 hr was related to a lower risk of impaired fasting glucose or type-2 diabetes.

A cross-sectional study on 71 salesmen found that subjects who worked longer hours had significantly lower

TABLE III. 10-year Risk of CHD Estimated by FRS According to Working Hour Categories

Working hours	N	Means of 10-year risk	<10% N (%)	≥10% N (%)	OR[a] (95% CI)
<30	817	8.05 ± 7.64	530 (64.87)	287 (15.30)	2.33 (1.78–3.2)
31–40	2041	5.54 ± 5.81	1674 (82.02)	367 (17.98)	1 (reference)
41–50	2292	5.77 ± 5.66	1850 (80.72)	442 (19.28)	1.08 (0.88–1.32)
51–60	1533	6.36 ± 5.85	1194 (77.89)	339 (22.11)	1.26 (0.99–1.60)
61–70	798	6.92 ± 6.18	594 (74.44)	204 (25.56)	1.42 (1.06–1.89)
71–80	454	6.98 ± 6.67	334 (73.57)	120 (26.43)	1.63 (1.22–2.18)
>80	415	7.07 ± 6.01	298 (71.81)	117 (28.19)	1.94 (1.39–2.73)
total	8350	6.28 ± 6.12	6474 (77.53)	1876 (22.47)	
men only					
<30	386	11.63 ± 8.57	182 (47.15)	204 (52.85)	2.61 (1.86–3.65)
31–40	1080	7.75 ± 6.39	788 (72.96)	292 (27.04)	1 (reference)
41–50	1360	7.28 ± 6.01	1019 (74.93)	341 (25.07)	0.92 (0.73–1.17)
51–60	971	7.78 ± 6.27	693 (71.37)	278 (28.63)	1.06 (0.81–1.39)
61–70	458	8.36 ± 6.78	318 (69.43)	140 (30.57)	1.11 (0.79–1.56)
71–80	281	8.34 ± 7.53	190 (67.62)	91 (32.38)	1.42 (1.04–1.99)
≥80	252	8.65 ± 6.50	157 (62.30)	95 (37.70)	1.53 (1.07–2.20)
total	4788	8.08 ± 6.67	3347 (69.90)	1441 (30.10)	
women only					
<30	431	4.84 ± 4.82	348 (80.74)	83 (19.26)	2.60 (1.51–4.48)
31–40	961	3.07 ± 3.75	886 (92.20)	75 (7.80)	1 (reference)
41–50	932	3.56 ± 4.21	831 (89.16)	101 (10.84)	1.32 (0.79–2.21)
51–60	562	3.91 ± 3.97	501 (89.15)	61 (10.85)	1.16 (0.61–2.22)
61–70	340	4.99 ± 4.66	276 (81.18)	64 (18.82)	2.88 (1.46–5.70)
71–80	173	4.76 ± 4.10	144 (83.24)	29 (16.76))	2.22 (1.03–4.79)
>80	163	4.64 ± 4.11	141 (86.50)	22 (13.50)	4.68 (2.11–10.36)
total	3562	3.88 ± 4.23	3127 (87.79)	435 (12.21)	
p-interaction[b]		<0.0001			0.0466

[a]adjusted for income level, occupation, physical activity, and AUDIT score.
[b]interaction between working hours and sex.

total cholesterol levels [Iwasaki et al., 1998]. In contrast to this result, we observed that working hours were associated with elevated total cholesterol levels (Table II).

An individual's lifestyle is also an important risk factor of CHD. Habitual behaviors, such as smoking and drinking, may mediate or confound the association between working hours and health. Maruyama and Morimoto [1996] surveyed divisional heads and foremen in Japanese companies about their working hours and lifestyles. They found that the foremen who worked 10 hr or more per day showed significantly higher prevalence of current smoking and frequent drinking. Westman et al. [1985] have reported a positive relationship between working hours and amount of smoking, as well as a negative relationship between working hours and smoking cessation rate. The evidence for an association between long working hours and alcohol consumption has been mixed. A study conducted by Baldwin et al. [1997] revealed a negative association between long working hours and alcohol consumption, while other studies [Hayashi et al., 1996; Nakamura et al., 1998; Nakanishi et al., 1999] found no association, and two different studies found a positive association [Steptoe et al., 1998; Trinkoff and Storr, 1998]. In our study, current smoking and problem drinking are more frequent in overtime workers (Table I). Results of previous studies on the association between long working hours and risk factors of cardiovascular disease are summarized in Supplementary Table II.

Working hours may affect health in a variety of ways, either directly or indirectly. First, incomplete physical recovery is an important pathway to chronic health impairment [Geurts and Sonnentag, 2006]. It is well recognized that long working hours are associated with reduced time for recovery and with limited relaxation time after work [Rissler, 1977]. The Effort–Recovery Model, proposed by Meijman and Mulder in 1998, suggests that work effort draws upon one's resources, thereby causing strain reactions [Meijman and Mulder, 1998]. Under optimal circumstances, recovery occurs after a short rest from work.

However, if no adequate recovery takes place, psychophysiological systems remain strained. The current study found that the association between working hours and risk of CHD is stronger in non-manual workers. One explanation for this is that among non-manual workers, long work hours lead to a decrease in physical activity, and thus an increase in CHD risk. More research on this topic is needed before we can clearly understand the mechanism by which long working hours affect health outcomes.

Another important pathway to chronic health impairment suggested by Spurgeon et al. [1997], is that long working hours are likely to coincide with high job demands. In a Dutch study that addressed the prevalence of overtime work in relation to psychosocial work characteristics and the need for recovery, the authors showed that overtime work was associated with a higher need for recovery only for employees who experienced high job demands [Van der Hulst et al., 2006].

Third, work-family life imbalance may be one of the most important links between long working hours and adverse health effects. People who work long hours may be unhappy with their work-life balance and may experience that their working patterns have a negative impact on their domestic relationships. Long working hours can contribute to the double burden of paid and domestic work. In a prospective cohort study among full-time, public-sector employees experiencing severe work–family spillover, respondents had higher rates of sickness-related absence, psychological distress and poor health than those with no such experience [Väänänen et al., 2005]. Golden and Wiens-Tuers [2006] have reported that the negative effects of long working hours, such as fatigue and work-family interference, were not mitigated by increased earnings. In our study, more significant associations between CHD risk and long working hours were found among women. For women, overall risk of CHD was lower than men, but the effect of long working hours on developing CHD was larger than men (Table III). These sex differences in response to overtime work can be explained in part by women's additional domesetic burden.

Several potential problems are inherent in the design of this study. First, drawing causal inferences from cross-sectional data rests on a priori assumptions about causal ordering. The present study cannot verify the hypothesized causal ordering about these relationships, even though we analyzed the data with a predictive method by using the FRS. Employees with pre-existing health problems may decrease their working hours in order to prevent worsening of symptoms. Analysis of longitudinal data would allow further exploration of the questions raised by this study. Second, we applied the FRS to predict the risk for CHD, so the potential for overestimation or underestimation of risk remains, because of genetic and lifestyle differences between study populations. To our best knowledge, the Framingham risk score has not yet been validated for the Korean population. However, a study based on KNHAES 2001 suggested that coronary heart disease based on estimated FRS is nearly comparable to that of western countries [Ko et al., 2001]. Finally, because we estimated the 10-year risk for CHD by combining seven risk factors, subjects had to be eliminated from the final analysis even when only one value for these risk factors was missing. As a result, some eligible subjects could not be included in the final model. However, these results were not significantly different from the results of additional analysis, in which the missing value was replaced with the mean value of each variable (Supplementary Table III).

While we attempted to control confounding variables as much as possible, we could not preclude the influence of other factors, such as poor mental health, which might affect the relation between long working hours and CHD. Nevertheless, the present study has a number of strengths. First, the study was performed in a representative sample of the general Korean population. Second, the large sample size with relatively longer working hours (compared to other studies) provided better opportunity to evaluate the effect of working hours on CHD risk.

In conclusion, working long hours is associated with an elevated risk for CHD based on the data representative of the Korean adult population. We hope that these findings contribute to the proper management of working conditions and enhance quality of health care for workers, particularly for those at risk for CHD.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

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