Does working long hours increase the risk of cardiovascular disease for everyone?

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Abstract

Introduction: It has been suggested that long working hours are associated with cardiovascular disease (CVD). Although studies on health inequality caused by income inequality have been performed, income levels of workers have been considered only as an adjusting factor in the relationship between long working hours and CVD. In the present study, we investigated the modifying effects of household income level in the relationship between working hours and estimated risk of CVD.

Materials and Methods: We analysed a total of 11,602 Koreans who were randomly enrolled in the Korea National Health and Nutrition Examination Survey (2007-2016) with complete data. Nonparametric associations between weekly working hours and estimated risk of CVD were explored according to quartiles of equalised household income by gender, and the size of linear associations among weekly working hours and estimated CVD risk after stratifying for equalised household income by gender was considered.

Results: A 4.1% increased risk of CVD was associated with 10 hours or longer per day weekly working hours among males with the highest household income after adjusting for age, equalised household income, occupation, and shift work, but such was not associated among lower income groups. Negative associations between equalised household income and estimated CVD risk were observed only among low household income males.

Conclusion: Long working hours and household income level can have differential effects on the risk of CVD by socioeconomic status. This study shows that positive income effect may dominate the potential negative effect of long working hours with respect to the risk of CVD in the low-income group.

Keywords: cardiovascular disease, health inequality, Korean national health and nutrition examination survey, long working hours, socioeconomic status
INTRODUCTION

Adverse health effects of working hours have been a major topic for well-being of working people. There is sufficient evidence to support the existence of an association between an individual’s long working hours and the risk of cardiovascular disease (CVD). Kivimaki et al published by far the largest meta-analysis of the relationship between working hours and CVD. The average risk ratio for CVD for those who worked more than 55 hours/week compared with those working 35 to 40 h/wk was 1.13 [95% confidence interval (CI): 1.02-1.26]. On the other hands, it was reported that short working hours is related with an increased risk for CVDs, and underemployment, working shorter hours than an individual wish, is negatively associated with self-assessed health.

Long working hours are known to have an adverse effect on development of CVD, but the effect could be heterogeneous depending on SES. In general, a large part of household income generally comes from labor. Hence, as working hours increase, so does household income. While a higher income decreases the risk of CVD, long working hours generally go along with increased risk of CVD. However, to the best of our knowledge, no study has examined whether income level may affect the association between working hours and risk of CVD. Although the negative association between income and risk of CVD has been reported in previous research, income level of workers was considered only as a confounding factor in those earlier studies that examined the relationship between working hours and CVD.

Working hours are closely linked with earned income, and income level is one of the critical determinants of health. Therefore, working hours may have a differential impact on workers depending on their economic backgrounds. For this reason, the influence of long working hours on a worker’s health should be investigated in the context of income level. The primary purpose of this study was to investigate the relationship between working hours and estimated risk of CVD with respect to household income level, using a nationally representative sample from a population-based survey in Korea.

MATERIALS AND METHODS

2.1 Data collection

We used data from the 2007 to 2016 Korean National Health and Nutrition Examination Survey (KNHANES). The KNHANES is a nationally representative survey conducted by the Korean Centers for Disease Control and Prevention (KCDC) and is designed as a cross-sectional survey using multistage probability sampling, with participants stratified according to geographic location, gender, and age. The survey collects participants’ data to evaluate the health and nutritional status of South Koreans including demographic and socioeconomic characteristics and health examination, health interview, and nutrition survey results. All participants of the KNHANES used in the current study provided written informed consent. This nationwide survey was approved by the Institutional Review Board of the KCDC.

In total, 81,503 individuals participated in the surveys (4594 in 2007; 9744 in 2010; 10 533 in 2009; 8958 in 2010; 8518 in 2011; 8058 in 2012; 8018 in 2013; 7550 in 2014; 7380 in 2015; and 8150 in 2016). We excluded participants who were younger than 30 years or older than 74 years (n = 45,938) because the prediction model for CVD was developed using Korean individuals aged between 30 and 74 years. Those who worked were classified into the following four categories: full-time employee, part-time employee, self-employed, and unpaid family worker. From among these, we included only those who were full-time employees (n = 13,688) in the present study. Those who had major diseases history including CVD, stroke, and cancer (n = 430) were additionally excluded. Respondents with any missing information on major covariates were also excluded; these included risk factors to calculate the risk for CVD and demographic variables such as working hours, household income, number of household family members, education, and occupation. The final analytic sample comprised 11,602 respondents (Figure 1).

2.2 Data collection

The KNHANES survey included questions about a wide array of characteristics. Completed questionnaires were reviewed by trained staff and entered into a database. Weekly working hours were measured as the actual number of working hours per week not including mealtimes at all
Based on BMI, we classified subjects into two groups: those with a BMI <25 kg/m² and those with a BMI ≥25 kg/m². Height (cm) and weight (kg) were measured through physical examination, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.

Household income was queried as follows: “What is [your] approximate gross household income over the last year, including labor income, real estate income, pensions, interest income, public income transfer, and private transfers from relatives and your family?” For personal information protection, gross household incomes ≥15 million KRW were top-coded at 15 million, and families having six or more members were top-coded at a limit of six. We adjusted household income for household size, using the organization for economic co-operation and development equivalence scale by dividing the income by the square root of number of household members.

We categorized smoking status as either nonsmoker, exsmoker, or current smoker. The amount of consumed alcohol in grams per day was calculated using drinking frequency and the average amount of drinking. Height (cm) and weight (kg) were measured through physical examination, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Based on BMI, we classified subjects into two groups: those with a BMI <25 kg/m² and those with a BMI ≥25 kg/m². Blood pressure (BP) was measured in the right arm at the level of the heart using a standard mercury sphygmomanometer (Baumanometer; WA Baum, Copiague, NY, USA) after the subjects were seated for about 5 minutes. Systolic BP (SBP) and diastolic BP (DBP) were measured two times with an interval of minutes, and the averages of these two values for each were reported. Total cholesterol (TC), high-density lipoprotein (HDL), and blood glucose were measured from blood samples obtained from the subjects through an antecubital vein after a 12-hour overnight fast. TC and HDL were measured using the ADVIA 1650 autoanalyser (Bayer, Tarrytown, NY, USA) from 2007 to 2008 and the Hitachi 7600 autoanalyser (Hitachi, Tokyo, Japan) from 2009 to 2012. The value of HDL corrected by the conversion formula suggested by the KCDC was used for the present study. A diagnosis of diabetes mellitus (DM) was defined as at least one of the following conditions: (a) fasting plasma glucose level ≥126 mg/dL; (b) medical diagnosis of DM by a physician; or (c) undergoing current treatment with oral hypoglycaemic agents or insulin injections.

2.3 | Estimation of the 10-year risks for CVD

Jee et al previously developed a model for estimation of Korean individuals’ 10-year risk for CVD that is based on the Framingham Risk Score using nationwide population data derived from national health screenings, national cause-of-death statistics, and national health insurance claims. In their health risk appraisal model, CVD outcomes were acute myocardial infarction, sudden death, and other coronary-related deaths. They used half of the entire dataset to construct the risk appraisal model and the other half to validate the constructed model. Through the study, risk factors as age, the squared of age, gender, TC, HDL, SBP, DBP, smoking status, and DM by gender were included for estimating the 10-year risk for CVD. As Jee et al suggested, in the present investigation, we estimated 10-year risk for CVD by considering the risk factors among our subjects.

2.4 | Statistical analysis

As 10-year CVD risk was not normally distributed, we used log-transformed values for analysis. For demographic characteristics, we provided frequencies with weighted percentages for each gender. Risk profiles used for estimating risks for CVD were presented as mean ± standard deviation, while categorical values were presented as frequencies and percentages for each quartile of equalised household income by gender. First, nonparametric analyses were performed to investigate the association between weekly working hours and 10-year risk for CVD for each gender. The generalized additive model was constructed after adjustment for age, the squared of age, survey year, equalised household income, education level, occupation, and shift work for males and females separately. We used the GAM package of R version 3.4.4 (R Foundation for Statistical Computing, Vienna, Austria). Next, nonparametric associations between weekly working hours and 10-year CVD risk were investigated according to quartile of equalised household income by gender, with adjustment for age, 2 education level, survey year, occupation, and shift work. We reported estimated degrees of freedom (edf) and adjusted R square values. Finally, multivariate linear regression models were employed to investigate the associations between weekly working hours, equalised household income, and 10-year risks for CVD. For investigating differences in associations among working hours, additional household income, and 10-year risk for CVD by income levels, we stratified participants according to quartile of household income and gender. Furthermore, multivariate linear analyses were performed after stratification by working hours (<40 h/wk vs ≥40 h/wk). Multivariate linear regression analysis was performed for the relationship...
among working hours, equalised household income, and 10-year risk for CVD following adjustment for age, the squared of age, year of survey, occupation, and shift work. Additionally, sensitivity analyses were performed after excluding subjects 60 years old or above, considering the general retirement age of Korea. We computed 10-year sampling weights as recommended by the KCDC. In light of the complex survey structure and sampling weights, multivariate linear regressions were performed using the PROC SURVEYREG protocol of SAS version 9.3 (SAS Institute, Cary, NC). Two-tailed p-values <0.05 were considered statistically significant.

3 | RESULTS

Table 1 shows the occupational characteristics of the study population. Among the 11,602 full-time employees, 7,023 (67.6%) were men and 4,579 (32.4%) were women. The average age was 45.3 ± 0.1 years in males and 46.1 ± 0.2 years

| TABLE 1 | Characteristics of the study population |
|---------|----------------------------------------|
|         | Total | Male | Female |
|         | n (%) | n (%) | n (%) |
| Total   | 11,602 | 7,023 | 4,579 |
| Age, y  |        |       |       |
| 30-39   | 3,928  | 2,509 | 1,419 |
| 40-49   | 3,732  | 2,217 | 1,515 |
| ≥50     | 3,942  | 2,297 | 1,645 |
| Education |       |       |       |
| Below elementary school | 1,345 | 530 | 815 |
| Middle school graduate | 1,094 | 580 | 514 |
| High school graduate | 4,006 | 2,321 | 1,685 |
| Above college graduate | 5,157 | 3,592 | 1,565 |
| Equalised household income\(^b\) (million KRW/month) |       |       |       |
| 1Q (≤1.24) | 2,777 | 1,476 | 1,301 |
| 2Q (1.25-1.92) | 3,085 | 1,981 | 1,104 |
| 3Q (1.93-2.88) | 2,838 | 1,785 | 1,053 |
| 4Q (2.89-12.50) | 2,902 | 1,781 | 1,121 |
| Occupation |       |       |       |
| Managers and professionals | 2,803 | 1,735 | 1,068 |
| Office workers | 2,589 | 1,674 | 915 |
| Service and sales workers | 1,634 | 602 | 1,032 |
| Agriculture, forestry, and fishery workers | 56 | 39 | 17 |
| Craft, device, and machine operators and assembly workers | 2,443 | 2,082 | 361 |
| Manual workers | 2,077 | 891 | 1,186 |
| Shift work\(^c\) |       |       |       |
| No | 9,865 | 5,881 | 3,984 |
| Yes | 1,737 | 1,142 | 595 |
| Weekly working hours (hours/week) |       |       |       |
| <40 | 1,880 | 744 | 1,136 |
| 40 | 2,896 | 1,648 | 1,248 |
| 41-51 | 3,764 | 2,444 | 1,320 |
| 52-59 | 1,215 | 831 | 384 |
| ≥60 | 1,847 | 1,356 | 491 |

\(^a\)Unweighted frequency and weighted percentage.
\(^b\)Gross household income was divided by square root of household size.
\(^c\)The shift-work group includes those working day-night shifts, fixed night shifts, regular rotations, 24-hour shifts, split shifts, irregular shifts, and other.
in females. The most common occupations were craft, device, and machine operators and assembly workers (31.8%), followed by managers and professionals (24.5%) and office workers (23.8%) in males. In females, the occupation of services and sales workers (23.3%) was the most common, followed by managers and professionals (23.2%) and office workers (20.1%) in female. The average number of weekly working hours was 48.5 ± 0.2 hours in males and 43.2 ± 0.2 hours in females, with those working 60 hours or more comprising 18.7% of males and 10.9% of females.

The risk profiles of each component for 10-year risk estimation for CVD according to Jee et al’s health risk-appraisal model were presented according to weekly working hours for each quartile in terms of equalised household income by gender (Supplementary Tables S1-S2). Among males, those who worked longer hours were more likely to be younger among all income groups. Also, in the highest household income group for males, smoking was more prevalent among the longer working hours group.

Figure 2 shows nonparametric associations between weekly working hours and 10-year CVD risk for each gender. The plotted association between weekly working hours showed a U-shape curve among males, but the association was not statistically significant (edf = 2.5, adjusted R² = 0.711, P = 0.171). A linear relationship between working hours and CVD risk among females was shown, but it was also not significant (edf = 1, adjusted R² = 0.898, P = 0.576). Figure 3 and Figure 4 show the associations between working hours and CVD risk according to the household income in male and female, respectively. Among males, only the highest quartile of the equalised household income group showed a significant positive association between weekly working hours and 10-year risk of CVD (edf = 2.5, adjusted R² = 0.681, P = 0.003) (Figure 3). Among females, none of the subgroups showed a significant association between working hours and CVD risk (Figure 4). Adjusted R² values of models with estimated smoothing terms of weekly working hours ranged from 0.681 to 0.902.

Table 2 shows the results of multivariate linear regression analyses according to equalised household income and gender. For males, the geometric means ± standard errors of 10-year CVD risk were 0.79% ± 0.02%, 0.63% ± 0.02%, 0.66% ± 0.02%, and 0.76 ± 0.02% from the lowest quartile to the highest quartile of equalised household income, respectively. Males in the lowest income quartile demonstrated a significantly negative association between equalised household income and 10-year CVD risk. An increase of 100,000 KRW of equalised household income was associated with a decrease of 1.19% (95% CI: −2.35 to −0.02) with respect to 10-year CVD risk, and no significant association was found between working hours and CVD risk. Conversely, males in the highest income quartile showed a significantly positive association between weekly working hours and 10-year CVD risk. An increase of 10 working hours per week was associated with an increase of 4.10% (95% CI: 1.37-6.91) in 10-year CVD risk. However, the association between equalised household income and 10-year CVD risk was not significant. For females, geometric means ± standard errors of 10-year CVD risk were 0.25% ± 0.01%, 0.14% ± 0.01%, 0.12% ± 0.004%, and 0.12% ± 0.004% from the lowest quartile to the highest quartile of equalised household income, respectively. There was no statistically significant association among weekly working hours, equalised household income, and 10-year risks of CVD for any quartile of equalised household income.

In the stratified analyses, males who worked 40 hours or longer showed similar associations (Supplementary Table 2)
**FIGURE 3** Nonparametric associations between weekly working hours and estimated 10-year risk for CVD for each quartile of equalised household income among males. Adjustments were made for age, the squared of age, survey year, equalised household income (household income by square root of household size), occupation, and shift work.

**FIGURE 4** Nonparametric associations between weekly working hours and estimated 10-year risk for CVD for each quartile of equalised household income among females. Adjustments were made for age, the squared of age, survey year, equalised household income (household income by square root of household size), occupation, and shift work.
Among males in the lowest income group, there was a marginally significant association between an increase of 100,000 KRW of equalised household income and a decrease of 1.30% of 10-year CVD risk (95% CI: −2.67 to 0.10, P < 0.07), and weekly working hours and CVD risk were not significantly associated. Males in the highest income group showed that additional 10 weekly working hours were associated with an increase of 3.83% of 10-year CVD risk (95% CI: 0.75 to 7.00). However, the results were not similar in males whose weekly working hours were less than 40 hours.

The results of sensitivity analyses after excluding subjects 60 years old or above were also robust and consistent with the findings from main analyses (Supplementary Table S4 and Figures S1-S3).

### DISCUSSION

The primary purpose of the present study was to investigate the relationship between working hours and estimated risk of CVD according to household income level. We found that working hours was not uniformly associated with the increased risk of CVD across income groups. Long working hours increased the risk of CVD among males in the highest income group, but this was not the case for the lower income group. On the contrary, males in the lower income group showed a significantly negative association with the increased risk of CVD. Long working hours were not uniformly associated with the increased risk of CVD across income groups. Long working hours could affect health status through the existence of less time for recovery and relaxation after work, work-life imbalance, and disturbing health behaviors.22-28

A recent study in Korea found that the health status of workers whose working hours were well-matched with their preference, as measured by subjective symptoms of fatigue or myalgia, was better than in those experiencing working hours-preference mismatch.31 Considering the concept of working hours-preference mismatch, we conclude that our results represent supporting evidence for the concept of working hours-preference mismatch. In addition, higher hourly wage or a pay raises were associated with better health status in general, which there is a complex inter-relationship among health, income, and working hours.

### TABLE 2

The results of multivariate linear regression analyses for the associations among weekly working hours, equalised household income, and 10-year CVD risk

| Equalised household income | Weekly working hours (mean ± SE) | GM of 10-year CVD risk (± SE) | % increase in CVD risk per additive 10 weekly working hours<sup>a</sup> | % increase in CVD risk per additive 100,000 KRW in equalised household income<sup>a</sup> |
|----------------------------|----------------------------------|-----------------------------|--------------------------------|-----------------------------------------------|
|                            | n                                |                             | %                             | 95% CI                                       | %                             | 95% CI                                       |
| Male, total                |                                  |                              |                               |                                               |                               |                                               |
| 1Q                         | 1476                             | 49.6 (±0.5)                  | 0.79 (±1.03)                  | 0.07 −1.78 to 1.96 0.94                      | −1.19 −2.35 to −0.02 0.04      |
| 2Q                         | 1981                             | 49.6 (±0.3)                  | 0.63 (±1.02)                  | −0.46 −2.39 to 1.51 0.64                      | −0.57 −1.77 to 0.64 0.35       |
| 3Q                         | 1785                             | 48.4 (±0.3)                  | 0.66 (±1.02)                  | −1.78 −4.03 to 0.51 0.13                      | −0.51 −1.52 to 0.51 0.32       |
| 4Q                         | 1781                             | 46.6 (±0.3)                  | 0.76 (±1.02)                  | 4.10 1.37 to 6.91 0.003                       | −0.18 −0.40 to 0.04 0.11       |
| Female, total              |                                  |                              |                               |                                               |                               |                                               |
| 1Q                         | 1301                             | 43.9 (±0.5)                  | 0.25 (±1.04)                  | −0.54 −2.40 to 1.35 0.56                      | −0.14 −1.11 to 0.85 0.79       |
| 2Q                         | 1104                             | 44.7 (±0.5)                  | 0.14 (±1.04)                  | 0.76 −1.06 to 2.63 0.40                      | −0.06 −1.36 to 1.25 0.93       |
| 3Q                         | 1053                             | 43.9 (±0.4)                  | 0.12 (±1.03)                  | 0.18 −1.74 to 2.12 0.86                      | −0.04 −0.91 to 0.84 0.93       |
| 4Q                         | 1121                             | 42.0 (±0.3)                  | 0.12 (±1.03)                  | 1.69 −0.94 to 4.43 0.20                      | 0.14 −0.05 to 0.34 0.15       |

Abbreviations: CI, confidence interval; CVD, coronary vessel disease; GM, geometric mean; SE, standard error.

<sup>a</sup>Adjusted for age, the squared of age, survey year, education level, occupation, and shift work. Working hours and equalised household income were analysed in the same model. Significant P values (< 0.05) are in bold.
Notably, if long working hours have harmful effects on cardiac health, we ought to see an effect in workers with lower income levels. There is a possibility that long work hours are hazardous even in low income groups as a result of other indirect mechanisms. However, the fact that we do not see such an effect suggests that the association is driven by confounding or indirect effects of other risk factors. Among the low SES group, financial hardship is a more fundamental health hazard than working longer hours. Given that household income may mostly come from labor earnings in exchange for work in the low SES group, it is possible that the negative effects of long working hours on CVD is attenuated by the increased income, which have protective effects on CVD in this group. However, when basic economic necessity is fulfilled, adverse impacts from longer working hours will outweigh the positive income effect and become detrimental to the health of those who have sufficient resources for living.

For several decades, SES has shown a consistent negative association with CVD in most industrialized countries, where disadvantaged groups are more likely to experience higher risk for incidence, severity, mortality, and recurrence of CVD. A 2006 review found strong evidence that lower SES is associated with increased risk of CVD. Since 2006, a large volume of cohort studies, either population- or hospital-based, has been published on the relationship between SES and risk of CVD in several countries, which all reported similar associations. It has also been claimed that absolute income, especially that of those close to or under the poverty level, could possibly single-handedly explain the association between SES and health.

Several factors may cause the socioeconomic inequalities observed in our study. A large number of epidemiological studies have suggested that socioeconomic differences in the risk of CVD can be attributed to established risk factors, including hypertension; DM; unfavorable cholesterol profile; or unhealthy lifestyle such as higher smoking rate, lower intake of vegetables and fruits, and physical inactivity. Some of these factors were also observed in our analysis (Supplementary Tables S1-S2). In addition to inequalities in the prevalence of risk factors, health care provisions for both disease prevention and treatment vary substantially among SES groups. A large number of studies have suggested that the existing disparities in accessibility or effective use of medical services before or after the occurrence of CVD may contribute to the socioeconomic inequality seen in health status. Because of lower participation in health check-ups, lower degrees of awareness and pharmaceutical treatment for CVD risk factors were observed in lower SES groups. Unawareness of elevated BP, blood glucose, and/or dyslipidaemia may lead to lack of opportunities to receive proper medical care or improve lifestyle to prevent CVD events. Those who work long hours may experience a similar situation in that they may have missed opportunities for accessing the necessary hospital facilities due to lack of time. There are other explanatory theories on how inequality affects health, such as psychosocial pathways, social capital theories, or early life influences.

It was observed only among men that longer working hours and lower household income showed a statistically significant association with the risk for CVD (Table 2). Although these results could be due to the relatively small number of female subjects included in this study compared with the number of male subjects, it might reflect the difference in risk for CVD related with socioeconomic factors by gender. In the same context, attitudes and reactions to long working hours were also different by gender according to a study that reported that happiness was negatively associated with working hours only in males when considering income level. However, the association between working hours and life satisfaction is less clear for women. Some studies suggest that women are more satisfied when they work part-time rather than full-time. Empirical research also shows that women have a higher likelihood of leaving the labor market when their male partner is more economically successful. One of the central substantive findings in the literature is that the subjective well-being of women with children (mothers) is highly relative to all other members of the family, regardless of how much they work. This could explain in part why our analysis showed weak results about whether working hours and income level contributes to CVD risk in women.

Nonparametric associations between weekly working hours and CVD risk showed that short working hours are related with increased CVD risk in males, although these associations were not statistically significant. Our analysis showed that optimal working hour for lowest CVD risk was around 50 hours in the gross after adjusting income level (Figure 2 and Supplementary Figure S1). A case-control study using 348 patients diagnosed with CVD and 769 controls reported that short weekly working hours (≤40 hours) showed 3.49 times higher OR for CVD comparing with those who worked 40.1-40.8 hours a week. There has been several studies that underemployment, a lower quality of employment relative to some standard of comparison, is associated with self-rated functional health and self-rated life satisfaction. These studies suggest that short working hours could be associated with CVD risk through other mechanisms different from long working hours. Although we could not find significant associations between short working hours and CVD risk, it is worth investigating these associations in further studies, for suggesting the optimal balance between working hours and income level to prevent CVD risk.

The results of this present study should be interpreted within the context of its limitations. First, our findings are limited based on the cross-sectional design. Caution is warranted before drawing definite conclusions for causal relationships between working hours and income level and the risk of CVD because reverse causation could not be
excluded. To minimize these effects, we used a predictive method and excluded participants with existing cerebrovascular disease or cardiovascular disease in our analysis, but we acknowledge that this might not be enough to manage potential reverse causality. Hence, there remains a need for further research using longitudinal data. Second, since we estimated the 10-year risk of CVD by combining six risk factors, some participants had to be excluded from the final analytic samples even though only one value was missing from their data. Third, we could not assess several work-related factors related with the association between long working hours and CVD risk such as the physical demand of work and effort-reward imbalance. Finally, while we attempted to control confounding variables as much as possible, we could not preclude the influence of certain factors, such as job stress or family roles, which could have an impact on the relationships between long working hours and income level and the risk of CVD.

Despite the above limitations, however, there are several strengths in this study. First, we assessed a representative sample of the general population in Korea. Second, to the best of our knowledge, the present study is the first to investigate the combined effect of working hours and income level on risk of CVD, which can provide a better opportunity to understand the mechanism and identify populations at risk, potentially contributing to the development of improved public health policies. Third, using Jee et al’s health-appraisal model that was developed and validated for the Korean population for predicting 10-year risk for CVD, we could more accurately determine the level of risk and thus identify individuals who are at risk for CVD. Because CVD is preventable by early intervention, it is important to identify workers who are at risk for CVD to prevent the disease, using a prediction model. In addition, analysing each component of the CVD appraisal model, we were able to find that working hours had a close relationship with specific risk factors of CVD in certain SES groups (Supplementary Tables S1-S2). In particular, the difference in prevalence of smoking in the high-income group and that of DM between categories by working hours is noticeable in comparison with the other risk factors of CVD among males. On the other hand, among females, a gradient of smoking rate by working hour categories was observed in all income groups, but a difference of BP was prominent, especially in the high income group. We hope that these findings contribute to proper management of worker health.

5 | CONCLUSION

The present study showed that long working hours can have differential effects on the risk of CVD by SES. Our findings suggest that a positive income effect may dominate the potential negative effect of long working hours with respect to the risk of CVD in the low-income group. Recently, the Korean government has implemented strong guidelines to reduce working hours. Our results suggest that, to improve workers’ health and associated well-being, additional public efforts to preserve incomes should be made. We hope that our results can contribute to the accumulating evidence that supports the implementation of effective strategies for the health protection of workers.

DISCLOSURE

Approval of the research protocol: Ethics approval for the present study was not required because this was a retrospective analysis of national surveillance data that is free of personally identifiable information; Informed consent: All study participants provided informed consent; Registry and the registration no. of the study/trial: The dataset supporting the conclusions of this article are from the KNHANES’s (https://knhanes.cdc.go.kr/knhanes/eng/index.do); Animal studies: N/A; Conflict of interest: The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The study conception was by MYK and HRK. DWL conducted the statistical analysis. MYK, DWL, YCH, and JC interpreted the results and revised the reviewed the literature. MYK and DWL drafted the manuscript. MYK, MJP, and JC revised the manuscript. All authors have read and approved the final version of the submitted manuscript.

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REFERENCES

1. Kang M-Y, Park H, Seo J-C, et al. Long working hours and cardiovascular disease: a meta-analysis of epidemiologic studies. J Occup Environ Med. 2012;54:532-537.
2. Virtanen M, Heikkila K, Jokela M, et al. Long working hours and coronary heart disease: a systematic review and meta-analysis. Am J Epidemiol. 2012;176:586-596.
3. Kivimäki M, Jokela M, Nyberg ST, et al. Long working hours and risk of coronary heart disease and stroke: a systematic review and meta-analysis of published and unpublished data for 603,838 individuals. Lancet. 2015;386:1739-1746.
4. Jeong I, Rhie J, Kim I, et al. Working hours and cardiovascular disease in Korean workers: a case-control study. J Occup Health. 2013;12:0245-OA.
5. Bell D, Otterbach S, Sousa-Poza A. Work Hours Constraints and Health. Annals of Economics and Statistics. 2012;(105/106):35-54.
42. Dragano N, Siegrist J, Nyberg ST, et al. Effort-reward imbalance at work and incident coronary heart disease: a multicohort study of 90,164 individuals. *Epidemiology*. 2017;28:619-626.

**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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