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Trends in the prevalence of major cardiovascular disease risk factors among Korean adults: Results from the Korea National Health and Nutrition Examination Survey, 1998–2012

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ABSTRACT

Background: Mortality from coronary heart disease in Korea has increased continuously, but there are few comprehensive national data on trend in the prevalence of risk factors for cardiovascular disease in this population. We examined the trends in the prevalence of major risk factors for cardiovascular disease, including smoking, obesity, hypertension, diabetes, and hypercholesterolemia, from 1998 through 2012 in a representative Korean population.

Methods: Using data from the Korea National Health and Nutrition Examination Survey I (1998) to V (2010–2012), we selected the adults aged ≥30 yr who participated in both a health examination and health interview survey.

Results: From 1998 to 2012, significant decrease in the prevalence of hypertension was observed in both men (32.5 to 31.5%) and women (26.9 to 24.3%). Smoking rates decreased only in men (65.1 to 47.0%), whereas the prevalence of diabetes did not change over time. Conversely, the prevalence of hypercholesterolemia significantly increased from 7.2% to 12.6% for men and from 8.4% to 14.9% for women, whereas the rates of awareness and treatment for hypercholesterolemia were relatively lower than that of hypertension and diabetes. During the period, prevalence of obesity significantly increased from 26.8% to 38.1% only in men.

Conclusions: The increased prevalence of hypercholesterolemia and obesity may have contributed to the increasing trend in the mortality from coronary heart disease in Korea. Further population-based surveillance of blood cholesterol levels and obesity needs to be performed, and national strategies for improvement of these factors should be established in Korea.

1. Introduction

The Asia–Pacific region accounts for about half of the global burden of cardiovascular disease (CVD) [1] and the mortality from coronary heart disease (CHD) has been steadily increasing in less developed and economically transitioning countries [2]. In South Korea, the mortality rate from stroke has continuously decreased in the 2000s, whereas the mortality rate from CHD per 100,000 population conversely increased from 2.3 persons in 1983 to 16.2 persons in 1998, and reached 25.1 persons in 2012 (Fig. 1) [3]. This increase in CHD mortality could be attributed to changes in risk factors for CVD as a result of changes in lifestyle, such as dietary habits and physical activity [2,4]. The known major risk factors for CVD, such as smoking, obesity, hypertension, diabetes, and dyslipidemia, are modifiable or can be controlled through changes in behavior and medical therapies [5,6]. More than 50% of the remarkable declines in CHD mortality in developed countries can be explained by the reductions in the prevalence of major CVD risk factors, except for obesity, along with improved medical management [7–9]. The Ni-Hon-San Study showed that death rates from CHD and distribution of CVD risk factors were markedly higher in Japanese Americans living in Hawaii and California than Japanese people in Japan, which may be due to environmental and behavioral changes after migration [10,11]. To develop strategies for CHD prevention in Koreans, trends in the prevalence of major risk factors for CVD using national data need to be characterized among a representative Korean population.

The objective of this study was to explore the trend in the prevalence of smoking, obesity, hypertension, diabetes, and hypercholesterolemia

Abbreviations: CVD, cardiovascular disease; CHD, coronary heart disease; KNHANES, Korea National Health and Nutrition Examination Survey; KCDC, Korea Centers for Disease Control and Prevention; SBP, systolic blood pressure; DBP, diastolic blood pressure; BP, blood pressure; BMI, body mass index; SE, standard error; NHANES, National Health and Nutrition Examination Survey.

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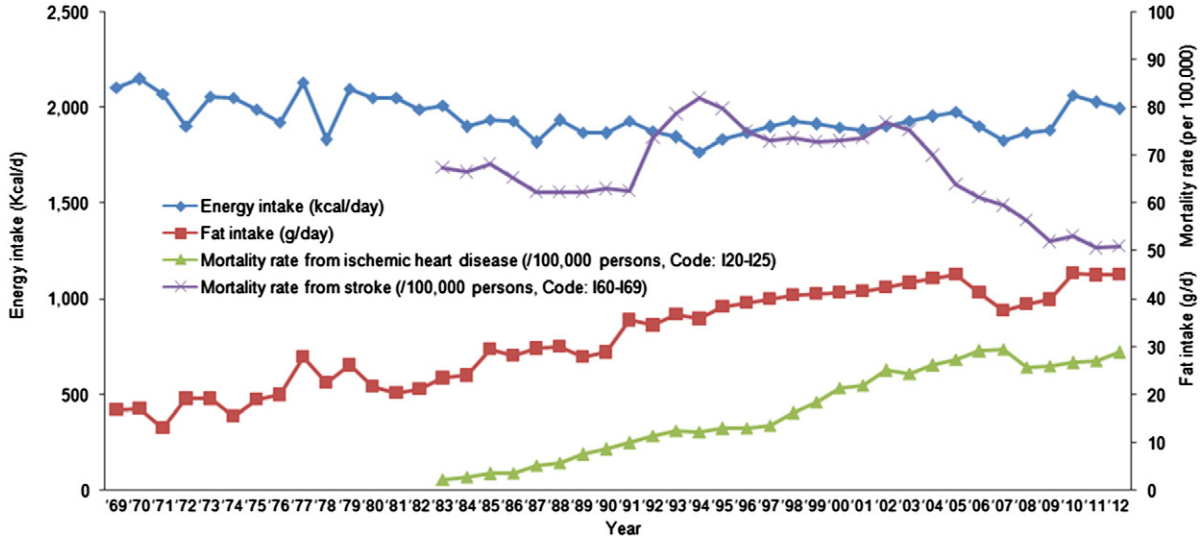

Fig. 1. Trends in mortality rate from coronary heart disease and stroke [3] and daily intake of energy and fat [18], 1969–2012, Korea.

in Korean adults aged ≥30 yr using data from the Korea National Health and Nutrition Examination Survey (KNHANES) between 1998 and 2012.

2. Materials and methods

2.1. Study population

This study was based on data from 5 consecutive KNHANES conducted from 1998 to 2012. The detailed description of the survey design and data collection in the KNHANES has been published elsewhere [12]. In brief, the KNHANES is a nationwide cross-sectional survey for assessing the health and nutritional status of the Korean population. The KNHANES was initiated in 1998 and has been conducted as a series of surveys: KNHANES I (1998), KNHANES II (2001), KNHANES III (2005), KNHANES IV (2007–2009), and KNHANES V (2010–2012). The first 3 KNHANES were conducted as a tri-annual survey: KNHANES I (1998), KNHANES II (2001), and KNHANES III (2005). Since then, beginning with the 4th KNHANES in 2007, it was converted to an annual survey to provide timely national statistics. To reduce the limitation of seasonal variations, KNHANES IV (2007–2009) and KNHANES V (2010–2012) were continuously conducted all year round. The KNHANES has been conducted by the Korea Centers for Disease Control and Prevention (KCDC) since 2007.

The representative households of non-institutionalized Korean citizens residing in Korea were selected using a stratified and multi-stage clustered probability sampling method. All family members aged ≥1 yr in the selected households were targeted for the KNHANES. The response rates of the target population ranged from 70.2% to 86.5% in each survey cycle. To monitor the trends of major risk factors of CVD, we selected adults aged ≥30 yr who participated in both a health examination and health interview survey from the KNHANES I (1998) to IV (2010–2012). The number of participants aged ≥30 yr included in this analysis were 6469 for the KNHANES I, 5495 for the KNHANES II, 4814 for the KNHANES III, 15,105 for the KNHANES IV, and 16,383 for the KNHANES V. We censored those who had missing data on each item in each survey. All procedures and protocols of the study were approved by the institutional review board of the KCDC (2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C) since 2007. Written informed consent regarding the survey and blood analysis was obtained from all participants since 1998.

2.2. Health examination and interview

The KNHANES consists of 3 components: health interview, health examination, and nutrition survey. The health interview and health examination survey were performed by trained medical staffs and interviewers in mobile examination centers. The health interview survey collects detailed information on the socioeconomic status, smoking and drinking behaviors, and health care utilization. Prior diagnosis of hypertension and diabetes by a physician and current use of hypotensive or hypoglycemic agents have been included in the questionnaire in 1998–2012, whereas prior diagnosis of hypercholesterolemia and current use of cholesterol-lowering agents have been included in the questionnaire since 2005.

Through the health examination survey, the anthropometrical, biochemical and clinical profiles of major non-communicable diseases were measured. Height to the nearest 0.1 cm was measured using portable stadiometers. Weight to the nearest 0.1 kg was measured using a portable electronic scale. According to the standard protocol, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by trained nurses using a mercury sphygmomanometer (Baumanometer Desk model; Baum, NY, USA) on the right arm of the subject while sitting after at least 5 min rest. Between 2008 and 2010, after conducting the health examination survey in mobile examination centers, we found a systematic error in blood pressure (BP) measurements due to the height of the forearm. To correct the measurement error in an arm lower than or above the level of the heart, we calculated the adjusted BP according to the mean height of the arm at the level of the heart. To increase accuracy of BP measurements, BP was measured twice in the 1998–2001 KNHANES and the mean was calculated. Since 2005, BP was measured thrice, and the second and third BP measurements were averaged.

2.3. Blood sample collection and biochemical analysis

Venous blood samples were obtained from each participant in the morning after fasting for at least 8 h. All samples were processed according to the protocol of KNHANES. After blood collection, an 8-mL serum separating tube for analyzing blood lipid level was kept at room temperature for 30 min and the blood was subsequently centrifuged at 3000 rpm for 15 min. A 2-ml sodium fluoride tube for analyzing glucose level was mixed in a roller mixer for 10 min. All blood samples were refrigerated at 2–8 °C and then immediately transported to the central laboratory. Within 24 h of blood collection, plasma concentrations of glucose and lipids were assayed using Advia 1650 (Siemens, NY, USA) in 2005 and 2007, and a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan) since 2008. To control the quality of laboratory data, all laboratory analyses was performed according to the protocol and monitored whether the values met the acceptable standards with precision and reproducibility in a central laboratory since 2005.

2.4. Definition of CVD risk factors

Body mass index (BMI) was calculated as the ratio of weight to height squared (kg/m^2). Obesity was defined as a BMI of ≥25 kg/m^2, according to the re-defined criteria of the World Health Organization for obesity in the Asia–Pacific region [13]. According to the criteria based on the seventh report of the Joint National Committee [14], hypertension was defined as an average SBP and/or DBP ≥ 140/90 mm Hg or the presence of anti-hypertensive agents. Based on the criteria of the World Health Organization [15], diabetes was defined as fasting plasma glucose of ≥126 mg/dL, a previous diagnosis of diabetes by physician, or current use of anti-diabetic agents or insulin. According to the guideline for cholesterol of NCEP ATP III [16], hypercholesterolemia was defined as plasma total cholesterol of ≥240 mg/dL or current use of cholesterol-lowering agents. Quality control for biochemical analysis of blood was started in 2005 by the KCDC and the participants were not asked about their previous diagnosis of hypercholesterolemia and current use of cholesterol-lowering agents before KNHANES III (2005); therefore, in this study, we only compared the prevalence of diabetes and hypercholesterolemia since 2005.

The rates of awareness and treatment of hypertension, diabetes, or hypercholesterolemia were defined as the percentage of subjects who were reported in the health interview survey as having had a previous diagnosis by a physician and as taking agents for treatment among the people who were defined as having hypertension, diabetes, or hypercholesterolemia. Control rates were defined based on individuals who reached the treatment goals (BP < 140/90 mm Hg, glycated hemoglobin < 6.5%, or blood cholesterol < 200 mg/dL) among the people defined as having hypertension, diabetes, or hypercholesterolemia, respectively.

2.5. Statistical analysis

All analyses were conducted with SAS PROC SURVEY procedure (SAS version 9.3; SAS Institute Inc., Cary, NC, USA) for analyzing complex sample survey data and separated by sex. To represent the Korean population, the sampling weights assigned to participants

was applied to all analyses. Sampling weights were generated by considering complex sample design, non-response rate of the target population, and post-stratification. To adjust differences in results from change in age structure of each cycle, age-standardized prevalence was calculated using the age- and sex-specific structures of estimated population based on the 2005 Korea Census. Data were presented as percentage and standard error (SE) for categorical variables and mean ± SE for continuous variables. Significance of time trend was tested using linear regression analysis for continuous variables and logistic regression analysis for prevalence. *P*-values less than 0.05 were considered statistically significant.

3. Results

3.1. Basic characteristics

General characteristics of participants in the KNHANES I to IV are shown in Table 1. The mean age of participants aged ≥30 yr steadily increased from 49.2 ± 0.2 yr for KNHANES I to 54.2 ± 0.1 yr for KNHANES V (*P* for trend < 0.0001). The percentage of college graduates and above (*P* for trend < 0.0001) and the average of household incomes (*P* for trend < 0.0001) gradually increased from KNHANES I to KNHANES V.

3.2. Smoking

In men, the age-standardized current smoking rate significantly declined from KNHANES I (65.1%) to KNHANES V (47.0%). The smoking rate in women decreased in 2001 (5.4%) compared to 1998 (6.9%), but no change was observed thereafter (*P* for trend = 0.0828). However, women aged 30–39 yr showed a continuous increase in the smoking rate (*P* for trend < 0.0001), whereas women aged ≥60 yr showed a continuous decrease in the smoking rate over time (*P* for trend < 0.0001) (Table 2).

3.3. Obesity

In men, there was a significant increase over time in the age-standardized mean BMI (23.2 kg/m^2 for KNHANES I, 24.1 kg/m^2 for KNHANES III, and 24.2 kg/m^2 for KNHANES V; *P* for trend < 0.0001) and prevalence of obesity (26.8% for KNHANES I, 37.6% for KNHANES III, and 38.1% for KNHANES V; *P* for trend < 0.0001), and these increases were consistent across all age groups (Table 3). However, the prevalence of obesity among men aged ≥30 yr has remained stable since KNHANES III. The prevalence of obesity in women aged ≥30 yr decreased over time, but was not significant (*P* for trend = 0.1385). An increasing prevalence of obesity was observed in elderly women aged ≥70 yr (*P* for trend = 0.0374).

3.4. Hypertension

Age-standardized mean SBP and DBP as well as prevalence of hypertension showed a decreasing trend from KNHANES I to KNHANES IV and was followed by a slight increase between the last 2 surveys in both men and women (*P* for trend = 0.0242 for men; *P* for trend = 0.0034 for women) (Table 4). However, among elderly men and women aged ≥70 yr, an increasing trend in the prevalence of hypertension was observed.

3.5. Diabetes

In men, the age-standardized mean level of plasma glucose and prevalence of diabetes showed an increasing tendency from KNHANES III to KNHANES V (10.5% for KNHANES III, 10.9% for KNHANES IV, and 11.0% for KNHANES V), but an increase of prevalence was not significant (*P* for trend = 0.6735) (Table 5). The prevalence of diabetes over time did not change considerably for women (7.7% for KNHANES III, 8.2% for KNHANES IV, 7.9% for KNHANES V; *P* for trend = 0.6710).

3.6. Hypercholesterolemia

Age-standardized mean level of plasma total cholesterol and prevalence of hypercholesterolemia significantly increased over time in both men and women (7.2% for KNHANES III, 10.0% for KNHANES IV, 12.8% for KNHANES V, *P* for trend < 0.0001 for men; 8.4% for KNHANES III, 11.8% for KNHANES IV, 14.1% for KNHANES V, *P* for trend < 0.0001 for women), and these increases were consistent across all age groups of men and women (Table 6). The prevalence of hypercholesterolemia every year was consistently higher in women than in men.

3.7. Awareness rate, treatment rate, and control rate

The rates of awareness, treatment, and control of hypertension, diabetes, and hypercholesterolemia have significantly increased over time (Fig. 2). In the last period, the rates of awareness and treatment of hypertension were 59.6% and 54.3% for men and 69.2% and 63.0% for

Table 1
General characteristics of participants above 30 yr old, KNHANES I–V.

	KNHANES					*P* for trend[a]
	I	II	III	IV	V	
	(1998)	(2001)	(2005)	(2007–09)	(2010–12)	
Total no. (≥30 yr)	6469	5495	4814	15,105	16,383	
Sex (men, %)	45.4	43.8	42.9	42.3	42.8	<0.0001
Age (yr, mean ± SE)	49.2 ± 0.2	49.2 ± 0.2	50.5 ± 0.2	53.0 ± 0.1	54.2 ± 0.1	<0.0001
30–39 yr (%)	30.4	30.3	25.5	23.1	20.7	<0.0001
40–49 yr (%)	25.2	27.7	27.9	22.6	20.0	<0.0001
50–59 yr (%)	19.5	17.3	19.0	19.2	21.5	0.0002
60–69 yr (%)	15.6	14.6	16.8	18.5	19.2	<0.0001
≥70 yr (%)	9.3	10.1	10.7	16.6	18.6	<0.0001
Marital status (%)						
Single	3.1	3.5	4.3	3.8	4.6	<0.0001
Married	83.0	82.4	80.0	79.1	80.9	0.0004
Married (widowed, divorced, and separated)	13.9	14.1	15.7	17.1	14.5	0.0711
Educational level (%)						
≤Elementary school	37.4	27.8	29.2	33.6	29.2	0.0005
Middle school	16.8	15.2	13.1	12.6	12.1	<0.0001
High school	30.8	35.1	35.1	30.7	30.5	0.0073
≥College	15.0	21.9	22.5	23.2	28.2	<0.0001
Household monthly income (10^4 KRW, mean ± SE)	130.0 ± 1.2	179.5 ± 1.7	221.1 ± 2.2	278.9 ± 4.4	424.2 ± 9.3	<0.0001

Values are % or mean ± SE; KNHANES: Korea National Health and Nutrition Examination Survey; KRW: South Korean Won.
[a] *P* for trends were calculated by logistic regression for percentage values and by linear regression for mean values.

Table 2
Trends in the rate of current smoking according to sex and age among Koreans above 30 yr old, KNHANES I–V.

	KNHANES					*P* for trend[a]
	I	II	III	IV	V	
	(1998)	(2001)	(2005)	(2007–09)	(2010–12)	
Men (no.)	3294	2962	2926	6321	6724	
Smoking (pack-year[b], mean ± SE)	–	20.9 ± 0.4	21.7 ± 0.5	22.2 ± 0.3	22.0 ± 0.3	0.0002
Smoking (pack-year, age-standardized mean ± SE)	–	21.3 ± 0.4	22.3 ± 0.4	22.0 ± 0.3	21.3 ± 0.2	0.9026
Current smoker (%, SE)						
Total (≥30 yr)	66.0 (1.0)	60.4 (1.1)	51.3 (1.1)	45.5 (0.7)	46.5 (0.8)	<0.0001
Total (≥30 yr, age-standardized)	65.1 (1.0)	59.7 (1.1)	50.5 (1.0)	45.5 (0.7)	47.0 (0.7)	<0.0001
30–39 yr	71.6 (1.4)	67.9 (1.5)	60.2 (2.1)	56.7 (1.4)	59.8 (1.5)	<0.0001
40–49 yr	67.9 (1.6)	66.7 (1.7)	55.2 (1.9)	49.0 (1.4)	50.0 (1.6)	<0.0001
50–59 yr	62.2 (2.1)	55.5 (2.6)	47.7 (2.2)	40.1 (1.7)	43.7 (1.6)	<0.0001
60–69 yr	58.2 (2.6)	49.9 (3.1)	38.3 (2.6)	33.6 (1.8)	30.1 (1.6)	<0.0001
≥70 yr	50.5 (3.9)	33.8 (4.0)	27.5 (3.3)	25.3 (1.8)	25.6 (1.6)	<0.0001
P-value[c]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Women (no.)	3738	3481	3539	8646	9062	
Smoking (pack-year, mean ± SE)	–	12.6 ± 1.0	9.4 ± 0.8	9.3 ± 0.4	8.1 ± 0.5	0.0004
Smoking (pack-year, age-standardized mean ± SE)	–	8.6 ± 0.6	7.9 ± 0.6	8.9 ± 0.4	8.2 ± 0.5	0.3170
Current smoker (%, SE)						
Total (≥30 yr)	7.0 (0.6)	5.5 (0.5)	5.7 (0.5)	5.7 (0.3)	5.8 (0.3)	0.1610
Total (≥30 yr, age-standardized)	6.9 (0.5)	5.4 (0.4)	5.6 (0.5)	5.7 (0.3)	6.0 (0.3)	0.0828
30–39 yr	4.5 (0.7)	3.6 (0.7)	4.4 (0.8)	6.9 (0.7)	8.5 (0.8)	<0.0001
40–49 yr	4.4 (0.8)	3.7 (0.8)	5.7 (0.9)	5.4 (0.6)	5.4 (0.6)	0.0555
50–59 yr	7.2 (1.3)	4.0 (1.0)	6.7 (1.2)	3.9 (0.5)	6.1 (0.8)	0.7047
60–69 yr	12.0 (1.5)	6.2 (1.2)	3.5 (0.9)	4.6 (0.7)	2.8 (0.5)	<0.0001
≥70 yr	14.5 (2.1)	18.0 (2.0)	9.3 (1.4)	7.5 (0.9)	4.4 (0.7)	<0.0001
P-value[c]	<0.0001	<0.0001	0.0027	0.0067	<0.0001	

Values are mean ± SE or % (SE); KNHANES: Korea National Health and Nutrition Examination Survey; Age-standardized prevalence was calculated using the 2005 Census Korean population.

[a] *P* for trends were calculated by logistic regression for percentage values and by linear regression for mean values. *P* for trends for age-standardized values were adjusted for age in the model.

[b] Pack-year = packs smoked per day × number of yr smoked among current and past smokers.

[c] *P*-values for differences between age group were calculated by logistic regression.

Table 3
Trends in the prevalence of obesity according to sex and age among Koreans above 30 yr old, KNHANES I–V.

	KNHANES					*P* for trend[a]
	I	II	III	IV	V	
	(1998)	(2001)	(2005)	(2007–09)	(2010–12)	
Men (no. of ≥30 yr)	2938	2400	2053	6347	6980	
BMI (kg/m^2, mean ± SE)	23.3 ± 0.1	23.8 ± 0.1	24.1 ± 0.1	24.1 ± 0.0[b]	24.2 ± 0.0[b]	<0.0001
BMI (kg/m^2, age-standardized mean ± SE)	23.2 ± 0.1	23.8 ± 0.1	24.1 ± 0.1	24.1 ± 0.0[b]	24.2 ± 0.0[b]	<0.0001
Obesity (%, SE)[c]						
Total (≥30 yr)	27.6 (1.1)	33.4 (1.2)	37.9 (1.3)	37.6 (0.7)	37.8 (0.8)	<0.0001
Total (≥30 yr, age-standardized)	26.8 (1.0)	33.6 (1.2)	37.6 (1.3)	37.3 (0.7)	38.1 (0.8)	<0.0001
30–39 yr	28.4 (1.7)	35.0 (2.3)	38.1 (2.3)	39.0 (1.3)	41.2 (1.6)	<0.0001
40–49 yr	33.3 (2.1)	39.0 (2.1)	41.1 (2.4)	40.8 (1.4)	43.0 (1.4)	0.0004
50–59 yr	28.3 (2.0)	32.4 (2.5)	41.0 (2.7)	41.5 (1.5)	34.8 (1.5)	0.0005
60–69 yr	20.0 (2.2)	28.0 (3.0)	31.0 (3.0)	31.7 (1.6)	35.1 (1.6)	<0.0001
≥70 yr	8.0 (2.2)	23.0 (3.6)	27.4 (4.1)	20.6 (1.5)	23.7 (1.5)	0.0019
P-value[d]	<0.0001	0.0046	0.0145	<0.0001	<0.0001	
Women (no. of ≥30 yr)	3504	3052	2708	8675	9347	
BMI (kg/m^2, mean ± SE)	23.6 ± 0.1	23.8 ± 0.1	23.8 ± 0.1	23.6 ± 0.0[b]	23.7 ± 0.1	0.7878
BMI (kg/m^2, age-standardized mean ± SE)	23.6 ± 0.1	23.8 ± 0.1	23.7 ± 0.1	23.5 ± 0.0[b]	23.6 ± 0.1	0.1123
Obesity (%, SE)						
Total (≥30 yr)	30.3 (0.9)	32.6 (1.0)	31.8 (1.1)	30.3 (0.6)	31.4 (0.7)	0.8497
Total (≥30 yr, age-standardized)	30.5 (0.9)	32.2 (1.0)	31.4 (1.1)	29.2 (0.6)	30.3 (0.7)	0.1385
30–39 yr	20.9 (1.3)	19.1 (1.4)	19.0 (1.7)	17.2 (0.9)	21.5 (1.3)	0.8585
40–49 yr	29.8 (1.8)	33.6 (2.1)	29.0 (2.0)	27.2 (1.2)	29.3 (1.2)	0.0786
50–59 yr	42.7 (2.4)	40.8 (2.4)	43.1 (2.5)	37.3 (1.4)	35.2 (1.2)	0.0010
60–69 yr	38.6 (2.4)	46.6 (2.8)	47.1 (3.0)	45.3 (1.5)	43.2 (1.5)	0.3379
≥70 yr	29.4 (2.5)	33.4 (2.9)	34.0 (2.8)	36.6 (1.6)	34.7 (1.4)	0.0374
P-value[d]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

Values are mean ± SE or % (SE); KNHANES: Korea National Health and Nutrition Examination Survey; BMI: Body Mass Index; Age-standardized prevalence was calculated using the 2005 Census Korean population.

[a] *P* for trends were calculated by logistic regression for percentage values and by linear regression for mean values. *P* for trends for age-standardized values were adjusted for age in the model.

[b] SE < 0.05.

[c] Obesity: ≥25 kg/m^2 for Body Mass Index.

[d] *P*-values for differences between age group were calculated by logistic regression.

Table 4
Trends in the prevalence of hypertension according to sex and age among Koreans above 30 yr old, KNHANES I–V.

	KNHANES					*P* for trend[a]
	I	II	III	IV	V	
	(1998)	(2001)	(2005)	(2007–09)	(2010–12)	
Men (no. of ≥30 yr)	2923	2184	2058	6312	6685	
SBP (mm Hg, mean ± SE)	128.4 ± 0.5	128.0 ± 0.6	122.9 ± 0.5	119.1 ± 0.3	120.8 ± 0.3	<0.0001
DBP (mm Hg, mean ± SE)	81.9 ± 0.3	81.1 ± 0.3	81.4 ± 0.4	78.8 ± 0.2	79.0 ± 0.2	<0.0001
SBP (mm Hg, age-standardized mean ± SE)	129.1 ± 0.5	127.5 ± 0.6	123.3 ± 0.4	119.1 ± 0.3	120.5 ± 0.3	<0.0001
DBP (mm Hg, age-standardized mean ± SE)	81.8 ± 0.3	81.0 ± 0.3	81.3 ± 0.4	78.7 ± 0.2	78.9 ± 0.2	<0.0001
Hypertension (%, SE)[b]						
Total (≥30 yr)	31.1 (1.1)	34.4 (1.4)	30.9 (1.2)	28.9 (0.7)	32.4 (0.7)	0.5346
Total (≥30 yr, age-standardized)	32.5 (1.1)	33.2 (1.3)	31.5 (1.1)	28.8 (0.7)	31.5 (0.7)	0.0242
30–39 yr	18.6 (1.4)	17.6 (1.6)	14.1 (1.8)	13.3 (1.0)	14.2 (1.1)	0.0011
40–49 yr	30.5 (2.0)	28.6 (2.2)	27.8 (2.2)	23.5 (1.2)	26.8 (1.4)	0.0310
50–59 yr	42.0 (2.4)	40.0 (2.9)	44.1 (2.7)	37.7 (1.6)	39.2 (1.6)	0.2111
60–69 yr	43.8 (2.5)	56.8 (3.6)	53.9 (2.9)	46.8 (1.7)	53.8 (1.7)	0.2286
≥70 yr	48.8 (4.2)	52.5 (4.5)	43.9 (5.1)	53.3 (1.9)	55.8 (1.8)	0.0271
P-value[c]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Women (no. of ≥30 yr)	3512	2845	2737	8623	9053	
SBP (mm Hg, mean ± SE)	125.9 ± 0.6	122.0 ± 0.6	117.7 ± 0.5	115.6 ± 0.3	117.8 ± 0.3	<0.0001
DBP (mm Hg, mean ± SE)	77.5 ± 0.3	76.3 ± 0.3	75.4 ± 0.4	74.0 ± 0.2	74.0 ± 0.1	<0.0001
SBP (mm Hg, age-standardized mean ± SE)	125.8 ± 0.5	121.4 ± 0.5	117.0 ± 0.4	114.4 ± 0.2	116.1 ± 0.2	<0.0001
DBP (mm Hg, age-standardized mean ± SE)	77.6 ± 0.3	76.1 ± 0.3	75.3 ± 0.3	73.7 ± 0.2	73.7 ± 0.2	<0.0001
Hypertension (%, SE)						
Total (≥30 yr)	27.0 (1.0)	26.5 (1.2)	25.4 (1.1)	25.5 (0.6)	28.4 (0.7)	0.1349
Total (≥30 yr, age-standardized)	26.9 (0.8)	25.4 (1.0)	23.9 (0.9)	22.8 (0.5)	24.3 (0.5)	0.0034
30–39 yr	6.2 (0.8)	5.4 (1.0)	3.1 (0.7)	3.2 (0.5)	2.7 (0.4)	<0.0001
40–49 yr	19.6 (1.5)	15.2 (1.6)	11.2 (1.5)	12.7 (0.9)	13.4 (1.0)	0.0002
50–59 yr	37.2 (1.9)	33.2 (2.6)	38.4 (2.9)	31.4 (1.3)	31.2 (1.3)	0.0058
60–69 yr	50.5 (2.5)	57.5 (3.0)	53.6 (3.0)	49.4 (1.5)	56.0 (1.6)	0.7781
≥70 yr	63.4 (2.8)	61.5 (2.9)	61.3 (3.2)	64.0 (1.6)	70.4 (1.4)	0.0020
P-value[c]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

Values are mean ± SE or % (SE); KNHANES: Korea National Health and Nutrition Examination Survey; SBP: systolic blood pressure; DBP: diastolic blood pressure; SBP and DBP between 2008 and 2010 were adjusted to correct the height of arms; Age-standardized prevalence was calculated using the 2005 Census Korean population.

[a] *P* for trends were calculated by logistic regression for percentage values and by linear regression for mean values. *P* for trends for age-standardized values were adjusted for age in the model.

[b] Hypertension: ≥140 mm Hg for SBP, ≤90 mm Hg for DBP, or user of hypotensive agent.

[c] *P*-values for differences between age group were calculated by logistic regression.

women, respectively. The rates of awareness and treatment of diabetes were 69.3% and 60.3% for men and 73.4% and 64.6% for women, respectively. Among individuals with hypercholesterolemia, only 48.4% of men and 42.6% of women were aware of their hypercholesterolemic status, and 39.2% of men and 32.4% of women were taking cholesterol-lowering agents. The control rates of diabetes and hypercholesterolemia were less than 30% among subjects with each disease.

4. Discussion

Using data from KNHANES I (1998) to V (2010–2012), we found significant increases in the prevalence of obesity and hypercholesterolemia and significant decreases in the prevalence of hypertension and smoking in men. In women, the prevalence of hypercholesterolemia increased, whereas the prevalence of hypertension significantly decreased.

During the past several decades, South Korea has experienced socioeconomic transitions with a rapid economic development [17], which can affect lifestyle transition, especially adoption of Westernized diets and decrease in physical activity. Daily intakes of animal foods (82 g in 1970, 98 g in 1980, 198 g in 1990, 261 g in 2001, and 301 g in 2010) and total fat (17.2 g in 1970, 21.8 g in 1980, 28.9 g in 1990, 41.6 g in 2001, and 44.8 g in 2010) as well as the proportion of energy supplied from fat (7.2% in 1970, 9.6% in 1980, 14.1% in 1990, 19.1% in 2001, and 19.7% in 2010) have substantially increased since the Korea National Nutrition Survey was launched in 1969 [18]. Conversely, the proportions of adults in Korea who engaged in moderate-to-vigorous physical activity including walking for recreation and transportation for at least 10 min at a time during a recent week have continuously decreased from 68.5% in 2005 to 46.8% in 2012 [18]. These transitions have resulted in arising prevalence of obesity in several developing countries [19]. Indeed, an increasing trend in the prevalence of obesity in men was observed in this study. However, the prevalence of obesity in women was conversely decreased, but was not significant. As a result, the prevalence of obesity in men and women was reversed in KNHANES II (2001) and since then it has been consistently higher in men than in women. This pattern of the sex differences differs from reports in other countries where the average BMI and prevalence of obesity are higher in women compared to men [20]. This phenomenon is probably due to the different trends in dietary energy intake according to sex. As shown in Fig. 3, the increase in daily energy intake of about 270 kcal/day in men over the past 14 yr (2156 kcal in KNHANES I, 2171 kcal in KNHANES II, 2261 kcal in KNHANES III, 2225 kcal in KNHANES IV, and 2427 kcal in KNHANES V for men aged ≥30 yr, *P* for trend < 0.0001) contrasts with the decreasing trend in daily intake of energy in women over time (1733 kcal in KNHANES I, 1744 kcal in KNHANES II, 1739 kcal in KNHANES III, 1583 kcal in KNHANES IV, and 1696 kcal in KNHANES V for women aged ≥30 yr; *P* for trend = 0.0005). In addition, the decreased tendency of obesity in women may be related to an increased participation in economic activity, reduced birth rates, and social preference for thinness [21,22]. In this study, the proportions of people trying to lose weight were consistently higher in obese women compared to obese men across time period (57.9% for men and 62.9% for women in KNHANES V; data not shown).

The rate of current smoking showed a decreasing trend in men aged ≥30 yr, but turned to increase again in KNHANES V. It was mainly due to the decreasing proportion of smoking cessation in men aged 30–49 between the last 2 surveys. However, smoking rate among Korean adult men is expected to keep on decreasing in the future, because men aged 19–29 yr show a large increase in the proportion of never smokers (22.0% in KNHANES I, 35.0% in KNHANES III, 45.9% in KNHANES V; data

Table 5
Trends in the prevalence of diabetes according to sex and age among Koreans above 30 yr old, KNHANES III–V.

	KNHANES			*P* for trend[a]
	III	IV	V	
	(2005)	(2007–09)	(2010–12)	
Men (no. of ≥30 yr)	1968	5913	6272	
Blood glucose (mg/dL, mean ± SE)	98.2 ± 0.6	100 ± 0.4	100.8 ± 0.4	0.0004
Blood glucose (mg/dL kg/m^2, age-standardized mean ± SE)	98.3 ± 0.6	99.9 ± 0.3	100.3 ± 0.4	0.0071
Diabetes (%, SE)[b]				
Total (≥30 yr)	10.2 (0.7)	11.0 (0.5)	11.5 (0.5)	0.1240
Total (≥30 yr, age-standardized)	10.5 (0.7)	10.9 (0.4)	11.0 (0.4)	0.6735
30–39 yr	1.7 (0.7)	3.4 (0.6)	2.9 (0.5)	0.1494
40–49 yr	9.3 (1.4)	8.2 (0.8)	7.1 (0.9)	0.1693
50–59 yr	18.9 (1.9)	15.7 (1.2)	17.6 (1.2)	0.6118
60–69 yr	17.9 (2.1)	23.7 (1.5)	21.8 (1.2)	0.1310
≥70 yr	16.7 (3.2)	16.5 (1.4)	21.7 (1.5)	0.1437
P-value[c]	<0.0001	<0.0001	<0.0001	
Women (no. of ≥30 yr)	2631	8018	8383	
Blood glucose (mg/dL, mean ± SE)	94.4 ± 0.6	96.8 ± 0.3	96.5 ± 0.3	0.0025
Blood glucose (mg/dL kg/m^2, age-standardized mean ± SE)	94.2 ± 0.6	96.2 ± 0.3	95.8 ± 0.3	0.0166
Diabetes (%, SE)				
Total (≥30 yr)	8.0 (0.6)	9.0 (0.4)	8.8 (0.4)	0.2769
Total (≥30 yr, age-standardized)	7.7 (0.6)	8.2 (0.3)	7.9 (0.3)	0.6710
30–39 yr	1.2 (0.5)	1.9 (0.3)	1.9 (0.4)	0.2954
40–49 yr	5.3 (1.1)	4.7 (0.6)	5.0 (0.7)	0.8303
50–59 yr	9.1 (1.5)	9.5 (0.8)	8.8 (0.8)	0.8439
60–69 yr	18.3 (2.2)	19.0 (1.2)	16.8 (1.2)	0.5413
≥70 yr	18.5 (2.8)	22.2 (1.5)	22.7 (1.3)	0.1966
P-value[c]	<0.0001	<0.0001	<0.0001	

Values are mean ± SE or % (SE); KNHANES: Korea National Health and Nutrition Examination Survey; Age-standardized prevalence was calculated using the 2005 Census Korean population.
[a] *P* for trends were calculated by logistic regression for percentage values and by linear regression for mean values. *P* for trends for age-standardized values were adjusted for age in the model.
[b] Diabetes: ≥126 mg/dL for blood glucose, a previous diagnosis of diabetes by physician, or user of hypoglycemic agent or insulin.
[c] *P*-values for differences between age group were calculated by logistic regression.

Table 6
Trends in the prevalence of hypercholesterolemia according to sex and age among Koreans above 30 yr old, KNHANES III–V.

	KNHANES			*P* for trend[a]
	III	IV	V	
	(2005)	(2007–09)	(2010–12)	
Men (no. of ≥30 yr)	1976	5878	6273	
Total cholesterol (mg/dL, mean ± SE)	186.6 ± 0.9	189.3 ± 0.5	191.2 ± 0.6	<0.0001
Total cholesterol (mg/dL, age-standardized mean ± SE)	186.4 ± 0.9	189.2 ± 0.5	191.0 ± 0.6	<0.0001
Hypercholesterolemia (%, SE)[b]				
Total (≥30 yr)	7.3 (0.6)	10.1 (0.5)	12.9 (0.5)	<0.0001
Total (≥30 yr, age-standardized)	7.2 (0.6)	10.0 (0.5)	12.6 (0.5)	<0.0001
30–39 yr	5.9 (1.1)	7.9 (0.8)	10.2 (1.0)	0.0063
40–49 yr	8.7 (1.3)	10.8 (0.9)	10.9 (0.9)	0.1851
50–59 yr	7.9 (1.5)	12.2 (1.1)	16.9 (1.2)	<0.0001
60–69 yr	8.8 (1.7)	11.3 (1.2)	15.6 (1.3)	0.0027
≥70 yr	3.6 (1.3)	8.1 (1.1)	13.0 (1.3)	<0.0001
P-value[c]	0.0934	0.0046	<0.0001	
Women (no. of ≥30 yr)	2651	7992	8384	
Total cholesterol (mg/dL, mean ± SE)	187.6 ± 0.8	190.6 ± 0.5	192.9 ± 0.5	<0.0001
Total cholesterol (mg/dL, age-standardized mean ± SE)	187.1 ± 0.7	189.4 ± 0.5	191.4 ± 0.5	<0.0001
Hypercholesterolemia (%, SE)				
Total (≥30 yr)	8.7 (0.7)	12.6 (0.4)	16.4 (0.5)	<0.0001
Total (≥30 yr, age-standardized)	8.4 (0.6)	11.8 (0.4)	14.9 (0.5)	<0.0001
30–39 yr	1.8 (0.5)	4.1 (0.5)	4.6 (0.6)	0.0017
40–49 yr	5.5 (1.0)	6.8 (0.6)	8.8 (0.9)	0.0226
50–59 yr	15.2 (1.9)	20.0 (1.2)	24.5 (1.2)	0.0001
60–69 yr	17.4 (2.1)	24.2 (1.3)	32.2 (1.5)	<0.0001
≥70 yr	13.2 (2.4)	19.2 (1.4)	24.5 (1.4)	0.0002
P-value[c]	<0.0001	<0.0001	<0.0001	

Values are mean ± SE or % (SE); KNHANES: Korea National Health and Nutrition Examination Survey; Age-standardized prevalence was calculated using the 2005 Census Korean population.
[a] *P* for trends were calculated by logistic regression for percentage values and by linear regression for mean values. *P* for trends for age-standardized values were adjusted for age in the model.
[b] Hypercholesterolemia: ≥240 mg/dL for blood total cholesterol or user of cholesterol-lowering agent.
[c] *P*-values for differences between age group were calculated by logistic regression.

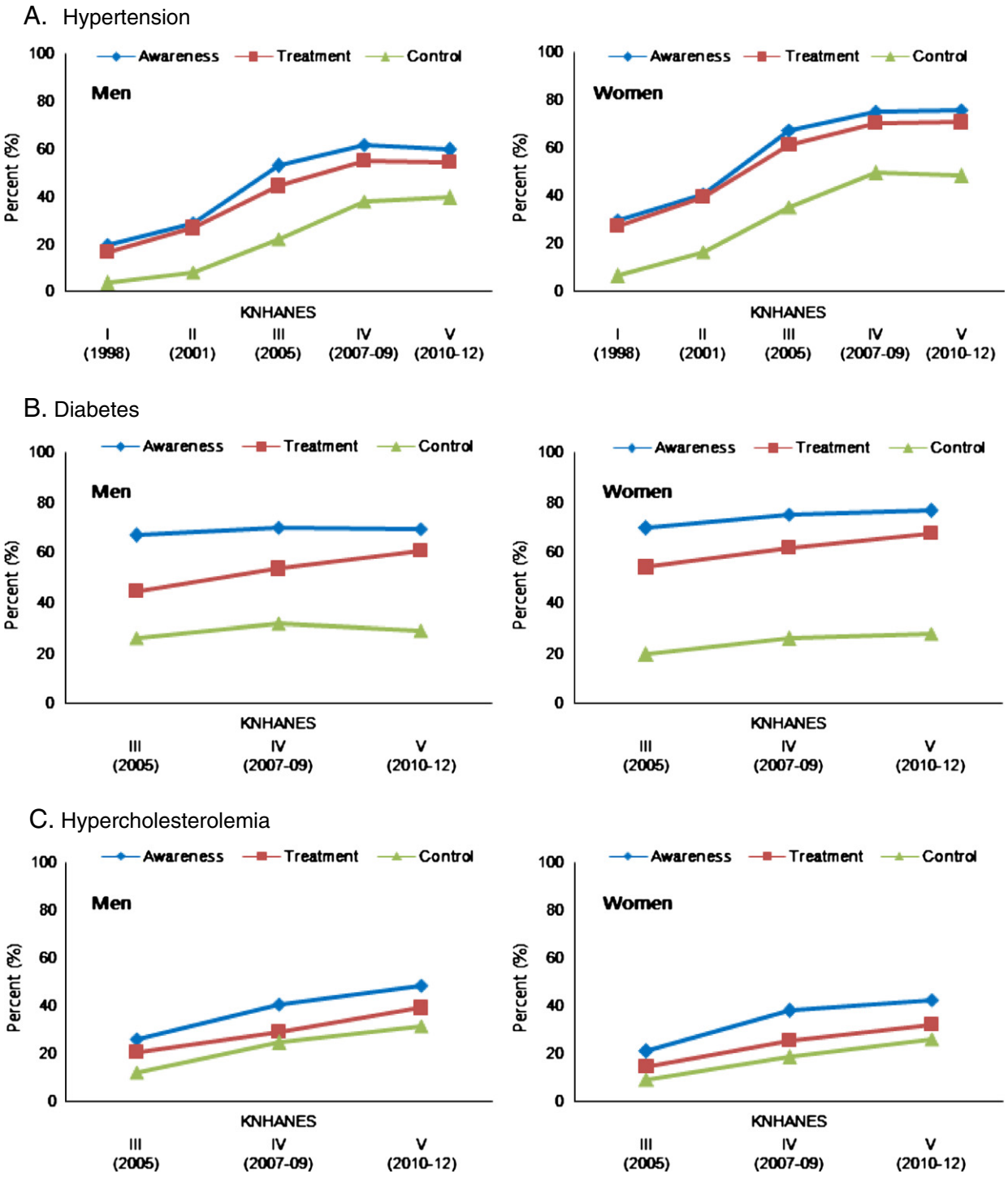

Fig. 2. Trends in the proportion of awareness, treatment, and control for (A) hypertension, (B) diabetes, and (C) hypercholesterolemia according to sex among Koreans above 30 yr old. KNHANES: Korea National Health and Nutrition Examination Survey. The rates of awareness, treatment, and control were calculated among the people defined as hypertension, diabetes, or hypercholesterolemia, respectively; *P*-values for trend in all graphs were <0.0001.

not shown) compared to men aged ≥30 yr (17.0% in KNHANES I, 17.8% in KNHANES III, 17.5% in KNHANES V; data not shown) and adult men aged ≥19 yr show a continuous decrease in current smoking rate in Korea (66.3% in KNHANES I, 60.9% in KNHANES II, 51.6% in KNHANES III, 46.9% in KNHANES IV, 46.4% in KNHANES V; data not shown).

In both Korean men and women, the prevalence of hypertension showed a significant decreasing trend over time but slightly increased between the last 2 surveys. Given the fact that the Korean population is aging and the prevalence of obesity increased in Korean men, the reduced trend in the prevalence of hypertension is an unexpected result. Lifestyle modification, such as a drop in smoking rates, would result in a decreased prevalence of hypertension. In men, the decreasing trend as well as the slight increase in recent hypertension prevalence exactly coincides with the trend for current smoking rates, when comparing the results in Tables 2 and 4. Although the daily intake of animal foods and total fat have continuously increased since 1998, absolute intake of total fat is still lower than that of Western countries and a high intake of vegetables is still observed in South Korea [4,18]. The trend in the

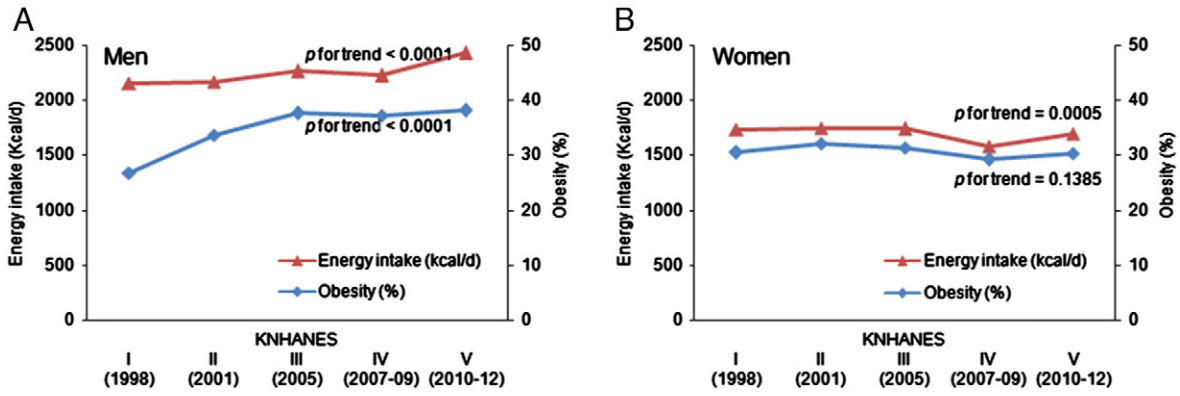

Fig. 3. Trends in the prevalence of obesity and daily intake of energy according to (A) men and (B) women among Koreans above 30 yr old. KNHANES: Korea National Health and Nutrition Examination Survey.

prevalence of hypertension is similar to what has been reported in the US; the prevalence of hypertension declined from the National Health and Nutrition Examination Survey (NHANES) I to the first 2 phases of NHANES III, but increased in the most recent NHANES [23]. In most developed countries, the prevalence of hypertension has remained stable or decreased over the past decade [23]. Although slight increase in the prevalence of hypertension between the last 2 surveys was observed and the prevalence of hypertension did not decrease a lot over the past 14 yr in Korea, the age-standardized mean SBP and DBP continuously decreased in both men and women. It indicates the possibility of increasing rate of control of hypertension. In our study, the rates of awareness, treatment, and control of hypertension have generally increased over time. It may have great impact on the incidence of cardiovascular disease in the future in Korea.

It has been predicted that the number of diabetics will be more than double from 2000 to 2030, as a consequence of population aging and changes in dietary and other lifestyle factors, especially in developing countries [24,25]. Unlike the significant epidemic of diabetes in the South Asian region [25], the Korean population did not show an increasing trend in the prevalence of diabetes over time. It is well known that Koreans consume relatively large amounts of carbohydrate, especially refined grain [18], which is significantly associated with an increased risk of diabetes [26]. The proportion of energy derived from carbohydrate has decreased continuously from 80.3% in 1969 to 64.9% in 2012 [18], which might be one of the reasons why the prevalence of diabetes did not increase over time in Korea.

Elevated serum total cholesterol is an independent risk factor for development of CVD [27]. Globally, mean levels of serum total cholesterol slightly declined from 1980 to 2008, but more significantly declined in the high-income regions [28]. In contrast, mean total cholesterol increased in the East and Southeast Asia–Pacific regions [28], which is consistent with our results that the prevalence of hypercholesterolemia significantly increased since 2005. It is widely recognized that animal-based fats and obesity lead to an increase in serum cholesterol levels across populations and over time [6,29]. In the US population, reduction in the intake of total fat, saturated and trans fatty acids, and dietary cholesterol has been demonstrated to be related to a decreased average level of serum cholesterol, and then led to a parallel decline in mortality from CHD [30,31]. In contrast, as shown in Fig. 1, Korean's daily intake of fat has continuously increased from 1969 to 2012. This trend coincides with the recent increase in the prevalence of hypercholesterolemia and parallels with the increasing trend in the mortality rates from CHD in Korea. This result supports the possibility that the relation between dietary fatty acids and CHD is partly mediated by effects on blood cholesterol levels [31]. Despite the significant increase in the prevalence of hypercholesterolemia, the rates of awareness, treatment, and control for hypercholesterolemia were lower than those of hypertension and diabetes in this study. Without improvements in blood cholesterol levels, CHD death rates could be increased in Korea in the future. Therefore, efforts for early detection and control of hypercholesterolemia are urgently needed in Korea.

A major strength of this study is that the KNHANES samples represent the non-institutionalized general Korean population. However, this study has some limitations. A limitation is that the period for observing trends in the prevalence of diabetes and hypercholesterolemia was shorter relative to those of other factors, because we excluded the results of the prevalence of diabetes and hypercholesterolemia for KNHANES I (1998) and II (2001) without query for prior diagnosis of hypercholesterolemia and current use of cholesterol-lowering agents. Therefore, these trends should be confirmed by the data from future surveys. Additionally, the change in the laboratory and method for measuring serum concentrations of glucose and cholesterol can affect the results of glucose and cholesterol. However, we conducted a parallel test for quality control of the laboratory analysis and confirmed the stability of the blood analysis. Nevertheless, this study is the first to evaluate the trends in the prevalence of major risk factors of CVD including behavioral factors in a national survey with a representative Korean population.

In conclusion, this analysis of data from KNHANES I to V shows that among risk factors of CVD, the prevalence of hypercholesterolemia in both men and women and obesity in men has increased over time in Korea. The mortality rate from CHD increased in parallel with the increasing trend in the prevalence of hypercholesterolemia, which is likely attributable to the increase in the intake of dietary fat. Moreover, the rates of awareness and treatment for hypercholesterolemia were relatively lower than that for hypertension and diabetes. Therefore, public and private efforts for medical treatment as well as weight loss and improvements in lifestyle, including changes in diet and physical activity, are urgently required to reduce the BMI, cholesterol levels, and mortality rate from CHD in the Korean population.

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