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Evaluating the prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia in Korea using the NHIS-NSC database

A cross-sectional analysis

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Abstract

This study aimed to evaluate the prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia in Korea according to sex and age, and to identify factors that were associated with the prevalence, awareness, and control of these cardiovascular risk factors among middle-aged Koreans.

A cross-sectional analysis was conducted using 2013 data from the National Health Insurance Service-National Sample Cohort (NHIS-NSC) database. A total of 136,755 individuals were considered eligible based on no history of stroke or heart disease, age of 40 to 64 years at the examination, and completion of health examinations. Data regarding demographic factors and cardiovascular risk factors had been obtained using questionnaires, physical examinations, and blood tests.

Hypertension was the most prevalent condition among middle-aged Koreans (25.76%), followed by dyslipidemia (16.58%) and diabetes (10.22%). Among these three conditions, dyslipidemia was associated with the lowest awareness rates (24.14%). Hypertension and diabetes were more prevalent among men than among women, although the prevalence of dyslipidemia was higher among women > 50 years old. The prevalence of hypertension and diabetes increased with advancing age among men and women, although the prevalence of dyslipidemia decreased with age among men (highest prevalence: 50.59% among men aged between 40 and 44 years). Among Korean men (relative to women), the odds ratios were 1.50 for hypertension, 1.96 for diabetes, and 0.82 for dyslipidemia. Age, central obesity, and body mass index were significantly associated with the development of all 3 conditions.

There are sex- and age-specific patterns in the prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia in Korea. Dyslipidemia is becoming increasingly common although most middle-aged Koreans are not aware of this condition leading to low control rate. These results may help identify population subgroups at a high risk of hypertension, diabetes, and dyslipidemia, and may guide the management of cardiovascular disease in Korea.

Abbreviations: BMI = body mass index, CI = confidence intervals, CVD = cardiovascular disease, DBP = diastolic blood pressure, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, NHI = National Health Insurance, NHIS-NSC = National Health Insurance Service-National Sample Cohort, OR = odds ratio, SBP = systolic blood pressure, SPRINT = systolic blood pressure intervention trial, WC = waist circumference.

Keywords: awareness, cardiovascular disease, diabetes mellitus, hypercholesterolemia, hypertension, prevalence

1. Introduction

Despite the remarkable decrease in mortality due to cardiovascular disease (CVD) in Western countries,[1,2] CVD-related mortality is increasing in South Korea.[3] In addition, CVD continues to be one of the leading causes of death among Korean adults > 50 years of age.[3] Furthermore, between 2012 and 2016, the number of patients with ischemic heart disease increased by 13% and the related medical costs increased by 27%.[4] Moreover, Koreans experience myocardial infarction and sudden cardiac deaths at ages that are approximately 7–10 years younger than those occurring in other comparable countries.[5,6] The average age of myocardial infarction is 56 years among Korean men, and approximately one-half of heart attacks occur among Korean men in their 40 s and 50 s.[7] These statistics highlight the prominent societal burden of CVD-related morbidity and mortality in Korea.

Hypertension, diabetes, and dyslipidemia are controllable major risk factors for CVD, and evidence suggests that controlling these risk factors is effective as a primary prevention strategy for CVD.[2,8] For example, the recent declining trend in CVD-related mortality in Western countries is largely attributable to better control of CVD risk factors through improvements

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in medical treatment.[2] Unfortunately, the prevalence of these risk factors is increasing among middle-aged Koreans.[9,10] For example, the prevalence of hypercholesterolemia among Korean men in their 50 s increased from 8.7% in 2001 to 21.8% in 2010, and the prevalence among women increased from 13.6% to 28.7%,[9] with a 56% increase in the prevalence of diabetes between 2001 and 2011 among Koreans in their 50 s.[10] Clustering of risk factors is also common among middle-aged Koreans, with 40% of 40-year-old Koreans having at least 2 cardiovascular risk factors, such as hypertension, diabetes, or dyslipidemia.[11] Approximately 12% of blue-collar workers (65.5% of men with an average age of 37 years) have been categorized as being at high risk for CVD based on the presence of 3 or more risk factors.[12] Therefore, aggressive CVD risk reduction through adequate control of modifiable cardiovascular risk factors is urgently needed among middle-aged Koreans.

The clinical guidelines for CVD prevention emphasize the importance of individuals being aware of how many cardiovascular risk factors may be present.[13] However, few studies have explored levels of awareness and control of hypertension, diabetes, and dyslipidemia among middle-aged Koreans. In this context, the Korean National Health Insurance (NHI) operates as a compulsory social insurance system that covers health screening for all insured persons and their dependents. The NHI maintains the National Health Insurance Service-National Sample Cohort (NHIS-NSC) database and includes information from noninstitutionalized adults who have participated in health screening programs, which could be helpful for estimating the prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia among middle-aged Koreans. Therefore, this study used NHIS-NSC data to examine these issues according to sex and age, as well as to identify factors that were associated with prevalence, awareness, and control of CVD risk factors in Korea.

2. Methods

2.1. Data source and study design

The health examination dataset from the NHIS-NSC database was used for this retrospective study. The NHIS-NSC cohort is a population-based cohort that was established to provide public health researchers and policy makers with representative information regarding the citizens' utilization of medical services and health examinations. The original cohort of 1,025,340 individuals was selected in 2002 and accounted for 2.2% of the eligible Korean population. These individuals were followed for 11 years until 2013 unless they were disqualified because of death or emigration.[14] Individuals were selected using a stratified sampling with proportional allocation (18 age groups, both sexes, and 41 income-based groups) that provided satisfactory representativeness and data accuracy.[14] The database includes de-identified information to protect individual anonymity, and alternate identification numbers are assigned to facilitate matching of descriptive data for the same individual.

This cross-sectional study evaluated the 2013 health examination dataset that included de-identified data from laboratory tests and self-reported information regarding health behaviors. Eligibility criteria for the present study comprised:

1) completing the national health screening in 2013,
2) being aged between 40 and 64 years and,
3) having no diagnosis of established CVD. Based on these criteria, 136,655 middle-aged Koreans were included in the study.

The study's retrospective protocol was approved by the appropriate institutional review board (AJIRB-SBR-EXP-17–467).

2.2. Measurements

Hypertension was defined as a systolic or diastolic blood pressure (SBP/DBP) of $\geq$140/90 mmHg or a history of diagnosed hypertension.[15] The American Heart Association has presented a new standard for hypertension criteria (SBP/DBP $\geq$130/80 mmHg) based on results of clinical trials, including the Systolic Blood Pressure Intervention Trial (SPRINT)[16]; however, the Korean Society of Hypertension decided to maintain the existing hypertension criteria of SBP/DBP $\geq$140/90 mmHg because of a lack of research on effective prevention of CVD and on the cost-effectiveness of lowering the hypertension criteria for Koreans.[17]. Awareness of hypertension was defined as the proportion of individuals who had a history of diagnosed hypertension among all individuals with hypertension. Control of hypertension was defined as the proportion of individuals with a BP of $<$ 140/90 mmHg among all individuals with hypertension (control among prevalent) and among individuals aware of their hypertension (control among aware). Diabetes was defined as a self-reported history of diabetes or a fasting blood glucose concentration of $\geq$126 mg/dL.[18] For diabetes awareness, the number of those who reported a history of diagnosed diabetes was divided by the number of those with diabetes. For control of diabetes, the numerator was those controlled and the denominators were those with diabetes (control among prevalent) and those aware of having diabetes (control among aware). The National Cholesterol Education program guidelines has defined a high concentration of total cholesterol as $\geq$240 mg/dL,[13] which was defined as dyslipidemia. Awareness of dyslipidemia was defined as the proportion of individuals who had a history of diagnosed hypercholesterolemia among all individuals with dyslipidemia. Control of dyslipidemia was defined as the proportion of individuals with a total cholesterol as $<$240 mg/dL among all individuals with dyslipidemia and among individuals aware of their condition. Obesity was defined as a body mass index (BMI) of $\geq$25 kg/m^2 based on the World Health Organization's recommendations for the Asian-Pacific region.[19] Abdominal obesity was defined as a waist circumference (WC) of $\geq$90 cm among men and a WC of $\geq$85 cm among women, based on the recommendations of the Korean Society for the Study of Obesity.[20] Individuals were considered current smokers if they reported currently smoking. Levels of exercise and parental history of CVD (myocardial infarction or stroke) were also self-reported. In this study, we defined regular exercise as engaging in at least 30 min of moderate activity 3 days a week.

2.3. Data analysis

Data analysis was performed using SAS software (version 9.4) with sampling weights of 1/0.022. The *surveyfreq* function was used to estimate proportions, and the *surveymeans* function was used to estimate mean values. Odds ratios (ORs) and 95% confidence intervals (CI) were calculated using logistic regression analysis via the *surveylogistic* function.

Table 1

Characteristics of subjects ($n = 136,655$).

Characteristics			% or mean (95% CI)
Gender	Male	51.56	
	Female	48.44	
Age (yr)	40–44	24.99	
	45–49	19.51	
	50–54	23.82	
	55–59	17.16	
	60–64	14.52	
Residence	Urban area	45.98	(45.71, 46.24)
	Rural area	54.02	(53.76, 54.29)
Income	1st	16.69	
	2nd	23.85	
	3rd	30.33	
	4th	29.12	
Central obesity	Yes	20.27	(20.06, 20.48)
	No	79.73	(79.52, 79.94)
BMI ≥ 25	Yes	33.89	(33,64, 34.14)
	No	66.11	(65.86, 66.36)
Current smoking	Yes	22.86	(22.66, 23.05)
	No	77.14	(76.95, 77.34)
Regular exercise	Yes	35.28	(35.03, 35.53)
	No	64.72	(64.47, 64.97)
Parental history of CVD	Yes	11.13	(10.96, 11.30)
	No	88.87	(88.70, 89.04)
SBP (mmHg)		121.89	(121.8, 121.96)
DBP (mmHg)		76.51	(76.46, 76.56)
LDL (mg/dL)		117.72	(117.54, 117.89)
HDL (mg/dL)		56.16	(55.08, 55.24)
TC (mg/dL)		199.21	(199.0, 199.40)
TG (mg/dL)		134.29	(133.8, 134.74)
Fasting blood glucose (mg/dL)		99.92	(99.79, 100.05)

BMI = body mass index, CI = confidence interval, CVD = cardio vascular disease, DBP = diastolic blood pressure, HDL = high density lipoprotein, LDL = low density lipoprotein, n = total sample, SBP = systolic blood pressure, TC = total cholesterol, TG = triglyceride, yr = years.

3. Results

3.1. Prevalence, awareness, and control rates of hypertension, diabetes, and dyslipidemia

Table 1 presents the general and CVD-related individual characteristics. Approximately 33% of middle-aged Koreans were obese and approximately 20% were centrally obese, based on the regional cut-off values for BMI and WC. Approximately 23% of the individuals were current smokers, and approximately 67% were considered as physically inactive.

The overall prevalence rates were estimated to be 25.76% (95% CI: 25.54, 25.99%) for hypertension, 10.22% (95% CI: 10.06, 10.38%) for diabetes, and 16.58% (95% CI: 16.39, 16.78%) for dyslipidemia (Table 2). Approximately 67% of individuals with hypertension were aware of their condition, and of these, about 70% had controlled BP values (< 140/80 mmHg). The proportion of those with diabetes awareness was 61.81%, and, of these, 42.47% had controlled blood glucose concentrations. Only 24.14% of individuals with dyslipidemia were aware of their condition, and of these, 84.53% of them had controlled total cholesterol concentrations (< 240 mg/dL). The prevalence rates for CVD risk factor clustering according to age and sex are shown in Figure 1. Two or more risk factors (hypertension, diabetes, or dyslipidemia) were present for approximately 7% of 40–44-year-old men and approximately 2% of 40–44-year-old women, with these proportions increasing to 18.4% of 60–64-year-old men and 20.2% of 60–64-year-old women.

3.2. Prevalence, awareness, and control rates of hypertension, diabetes, and dyslipidemia according to sex and age

Table 3 shows the prevalence, awareness, and control rates of hypertension, diabetes, and dyslipidemia according to sex and age. Hypertension and diabetes prevalence were higher in men than in women and generally increased with advancing age in both men and women. However, a different pattern was observed in regard to the prevalence of dyslipidemia. In women, the prevalence of dyslipidemia generally increased with age, while the prevalence in men was highest at the age of 40–44 years (15.81%) and subsequently decreased with age.

The awareness and control rates were generally higher in women than in men and increased with advancing age. Thus, the youngest men had the lowest rates of CVD risk factor control. For example, 42.54% of hypertensive 40–44-year-old Korean men were aware of their condition and, of these, 65.27% had controlled blood pressure. Furthermore, only approximately 42% of 40–44-year-old men were aware of having diabetes and, of these, 36.51% had controlled blood glucose concentrations. Dyslipidemia awareness was lower but the control rate among aware individuals was higher than those for hypertension and diabetes. For example, 12.38% of 40–44-year-old women were aware of having dyslipidemia and, of these, 82.89% had controlled total cholesterol concentrations.

3.3. Factors that predicted the prevalence, awareness, and control rates of hypertension, diabetes, and dyslipidemia

Tables 4 shows the results from regression models that estimated the prevalence, awareness, and control rates for all 3 conditions. Relative to Korean women, Korean men were more likely to have hypertension (OR: 1.50, 95% CI: 1.46, 1.53) and diabetes (OR: 1.96, 95% CI: 1.89, 2.04), but were less likely to have dyslipidemia (OR: 0.82, 95% CI: 0.79, 0.84). Furthermore,

Table 2

Prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia.

Variables	% (95% CI)			
	Prevalence	Awareness	Control among prevalent	Control among aware
Hypertension	25.76 (25.54, 25.99)	67.10 (66.62, 67.57)	47.51 (47.00, 48.03)	70.82 (70.24, 71.40)
Diabetes	10.22 (10.06, 10.38)	61.81 (61.02, 62.59)	26.25 (25.53, 26.97)	42.47 (41.43, 43.51)
Dyslipidemia	16.58 (16.39, 16.78)	24.14 (23.59, 24.68)	20.40 (19.89, 20.91)	84.53 (83.58, 85.47)

CI = confidence interval.

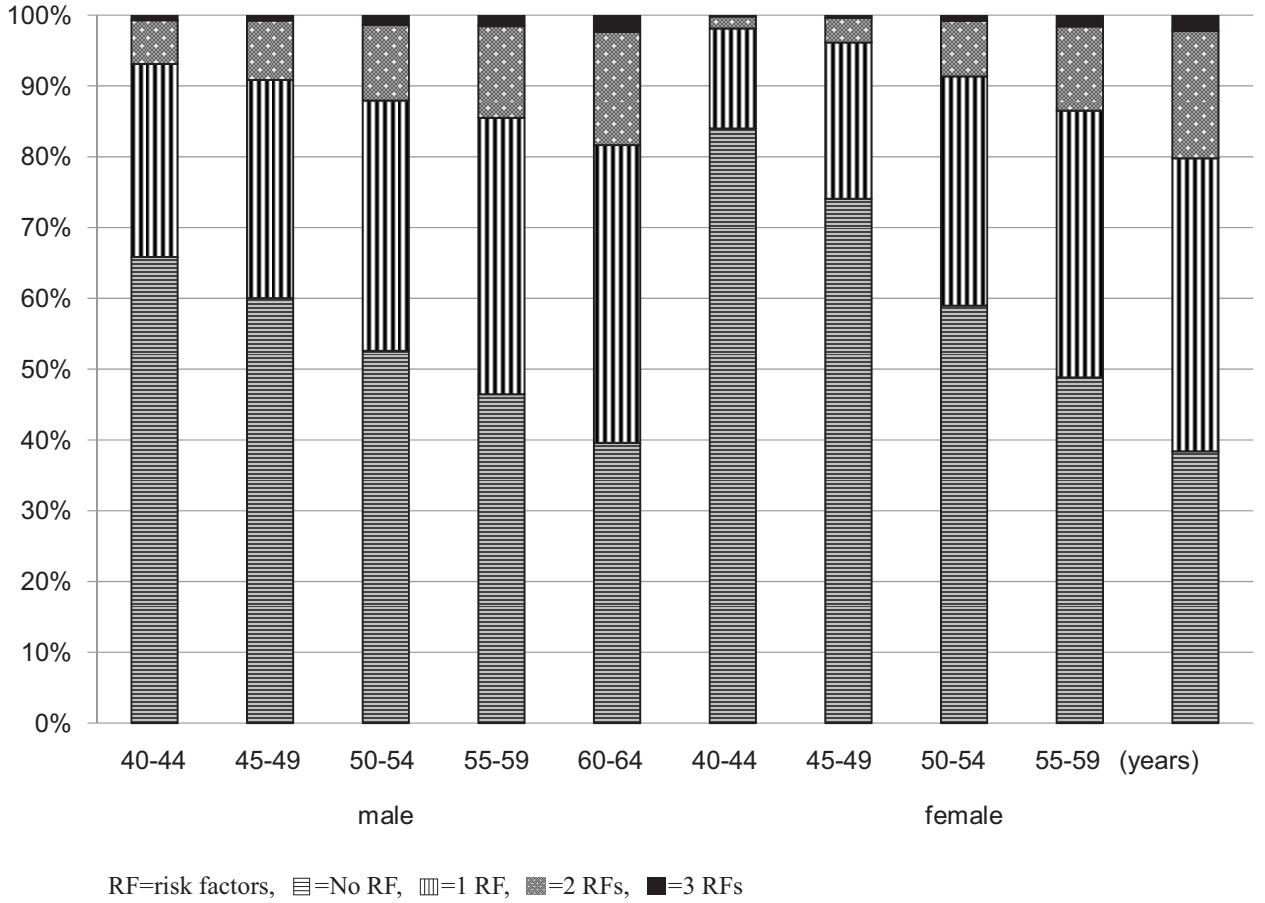

Figure 1. Clustering of CVD risk factors by sex and age groups. CVD = cardio vascular disease.

Korean men were less likely to be aware that they had hypertension (OR: 0.71, 95% CI: 0.68, 0.74), diabetes (OR: 0.71, 95% CI: 0.66, 0.76), and dyslipidemia (OR: 0.87, 95% CI: 0.82, 0.92). Moreover, Korean men were less likely to have control of their blood pressure (OR: 0.87, 95% CI: 0.82, 0.92) and blood glucose concentration levels (OR: 0.76, 95% CI: 0.70, 0.83).

Increasing age was associated with increases in prevalence, awareness, and control rates of the CVD risk factors. For example, compared to 40–44-year-old Koreans, 60–64-year-old Koreans had a higher prevalence of hypertension (OR: 5.00, 95% CI: 4.80, 5.21), diabetes (OR: 4.06, 95% CI: 3.82, 4.31), and dyslipidemia (OR: 1.88, 95% CI: 1.79, 1.97). Furthermore, 60–64-year-old Koreans were more likely to be aware that they had hypertension (OR: 5.71, 95% CI: 5.28, 6.18), diabetes (OR: 3.81, 95% CI: 3.38, 4.30), and dyslipidemia (OR: 3.64, 95% CI: 3.28, 4.05). Moreover, 60–64-year-old Koreans were more likely to have controlled their hypertension (OR: 1.23, 95% CI: 1.10, 1.37), diabetes (OR: 1.38, 95% CI: 1.17, 1.63), and dyslipidemia (OR: 3.22, 95% CI: 2.52, 4.11).

Table 3

Age-specific prevalence, awareness, and control rates of hypertension, diabetes, and dyslipidemia by sex.

	%																							
	Hypertension								Diabetes								Dyslipidemia							
Age group	Prevalence		Awareness		Control among prevalent		Control among aware		Prevalence		Awareness		Control Among prevalent		Control among aware		Prevalence		Awareness		Control among prevalent		Control among aware	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
40–44	18.82	7.49	42.54	41.75	27.77	28.83	65.27	69.04	7.13	2.73	42.19	50.58	15.40	23.08	36.51	45.62	15.81	7.83	15.22	12.38	10.74	10.26	70.56	82.89
45–49	24.22	13.33	55.45	57.11	37.54	41.12	68.83	72.01	10.16	4.40	50.34	51.76	17.99	21.07	35.73	40.71	15.48	12.42	18.72	14.15	15.04	12.05	80.34	85.19
50–54	30.77	22.63	64.83	69.46	45.88	51.10	70.77	73.57	14.31	6.64	57.60	62.88	21.91	28.23	38.05	44.9	15.74	21.19	23.67	20.82	19.81	16.97	83.69	81.52
55–59	37.47	30.67	72.08	77.29	50.51	57.14	70.07	73.93	17.62	10.04	63.90	70.12	26.19	31.79	40.99	45.34	14.47	25.55	29.08	29.39	25.86	24.84	88.93	84.52
60–64	45.85	42.48	79.68	81.80	55.89	58.18	70.14	71.14	21.51	14.67	73.12	77.84	32.37	39.18	44.27	50.34	13.74	26.88	36.64	38.59	34.10	34.22	93.08	88.66

F = female, M = male.

Table 4

Predictors of prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia.

	OR (95% CI)											
	Hypertension				Diabetes				Dyslipidemia			
Variables	Prevalence	Awareness	Control among prevalent	Control among aware	Prevalence	Awareness	Control among prevalent	Control among aware	Prevalence	Awareness	Control among prevalent	Control among aware
Sex (male)	1.50 (1.46, 1.53)	0.71 (0.68, 0.74)	0.75 (0.72, 0.78)	0.87 (0.82, 0.92)	1.96 (1.89, 2.04)	0.71 (0.66, 0.76)	0.68 (0.63, 0.73)	0.76 (0.70, 0.83)	0.82 (0.79, 0.84)	0.87 (0.82, 0.92)	0.85 (0.79, 0.91)	0.89 (0.77, 1.02)
Age												
45–49	1.51 (1.44, 1.57)	1.69 (1.56, 1.83)	1.62 (1.49, 1.76)	1.18 (1.05, 1.34)	1.51 (1.41, 1.61)	1.30 (1.14, 1.47)	1.11 (0.94, 1.31)	0.92 (0.76, 1.12)	1.19 (1.13, 1.24)	1.21 (1.08, 1.36)	1.60 (1.35, 1.89)	1.62 (1.24, 2.13)
50–54	2.31 (2.22, 2.40)	2.74 (2.55, 2.95)	2.38 (2.21, 2.57)	1.31 (1.18, 1.47)	2.16 (2.04, 2.30)	1.84 (1.64, 2.06)	1.51 (1.30, 1.75)	1.06 (0.89, 1.25)	1.64 (1.57, 1.71)	1.68 (1.51, 1.87)	2.36 (2.03, 2.74)	1.68 (1.34, 2.12)
55–59	3.29 (3.16, 3.43)	3.95 (3.66, 4.26)	2.94 (2.72, 3.18)	1.30 (1.17, 1.45)	3.00 (2.83, 3.19)	2.46 (2.18, 2.76)	1.88 (1.62, 2.17)	1.16 (0.98, 1.37)	1.79 (1.71, 1.88)	2.46 (2.22, 2.74)	3.60 (3.10, 4.18)	2.22 (1.75 2.81)
60–64	5.00 (4.80, 5.21)	5.71 (5.28, 6.18)	3.41 (3.16, 3.68)	1.23 (1.10, 1.37)	4.06 (3.82, 4.31)	3.81 (3.38, 4.30)	2.61 (2.27, 3.00)	1.38 (1.17, 1.63)	1.88 (1.79, 1.97)	3.64 (3.28, 4.05)	5.58 (4.82, 6.46	3.22 (2.52 4.11)
Residence (rural area)	1.03 (1.00,10.05)	0.95 (0.91, 1.00)	0.88 (0.84, 0.92)	0.84 (0.79, 0.89)	1.03 (0.99, 1.07)	1.02 (0.95, 1.09)	1.00 (0.93, 1.08)	0.99 (0.91, 1.08)	1.00 (0.97, 1.03)	0.88 (0.83, 0.94)	0.90 (0.84, 0.96)	1.07 (0.93, 1.24)
Central obesity	2.78 (2.71, 2.86)	1.32 (1.26,1.38)	0.94 (0.95, 1.04)	0.74 (0.70, 0.78)	2.39 (2.30, 2.48)	1.08 (1.00, 1.16)	0.93 (0.86, 1.01)	0.88 (0.80, 0.96)	1.51 (1.46, 1.56)	1.37 (1.28, 1.47)	1.41 (1.32, 1.52)	1.27 (1.08, 1.49)
BMI ≥25	2.57 (2.51, 2.64)	1.20 (1.15, 1.25)	0.97 (0.93, 1.01)	0.76 (0.72, 0.81)	2.00 (1.90, 2.04)	0.86 (0.81, 0.93)	0.86 (0.80, 0.93)	0.91 (0.83, 0.99)	1.50 (1.46, 1.55)	1.21 (1.14, 1.28)	1.23 (1.15, 1.31)	1.14 (0.98, 1.32)
Current smoker	1.06 (1.03, 1.09)	0.69 (0.65, 0.72)	0.79 (0.75, 0.83)	1.02 (0.95, 1.09)	1.50 (1.44, 1.56)	0.80 (0.74, 0.86)	0.76 (0.70, 0.82)	0.81 (0.74, 0.90)	0.91 (0.88, 0.95)	0.76 (0.71, 0.82)	0.72 (0.66, 0.78)	0.72 (0.60, 0.86)
Regular exercise	1.02 (0.99, 1.04)	1.04 (0.99, 1.09)	1.06 (1.02, 1.11)	1.07 (1.01, 1.14)	1.01 (0.98, 1.05)	1.12 (1.04, 1.20)	1.13 (1.05, 1.23)	1.09 (1.01, 1.19)	0.91 (0.88, 0.94)	1.09 (1.03, 1.17)	1.10 (1.03, 1.17)	1.04 (0.89, 1.22)
Family history of CVD	1.37 (1.32, 1.42)	1.53 (1.43, 1.64)	1.42 (1.33, 1.51)	1.18 (1.09, 1.28)	1.00 (0.94, 1.05)	1.17 (1.05, 1.31)	1.22 (1.08, 1.37)	1.16 (1.02, 1.33)	1.17 (1.12, 1.22)	1.79 (1.65, 1.95)	1.70 (1.56, 1.86)	0.92 (0.75, 1.11)

BMI = body mass index, CI = confidence interval, CVD = cardiovascular disease, OR = odds ratio.

Relative to being sedentary, being physically active was associated with a lower risk of dyslipidemia (OR: 0.91, 95% CI: 0.88, 0.94). Furthermore, physically active Koreans were more likely to control their blood pressure (OR: 1.07, 95% CI: 1.01, 1.14) and blood glucose concentration levels (OR: 1.09, 95% CI: 1.01, 1.19). Smoking was associated with an increased risk of having hypertension (OR: 1.06, 95% CI: 1.03, 1.09) and diabetes (OR: 1.50, 95% CI: 1.44, 1.56). Individuals with a parental history of CVD had a higher likelihood of having hypertension and diabetes, but were more aware and had better control of their condition.

4. Discussion

The most important finding of this study is that major CVD risk factors are highly prevalent among middle-aged Koreans without diagnosed CVD, and that these individuals have suboptimal awareness and control rates. The present study estimated that the prevalence rates were 25.76% for hypertension, 10.22% for diabetes, and 16.58% for dyslipidemia (Table 2). Thus, it appears that the prevalence of hypertension is lower than in previous epidemiological reports,[21] although the prevalence rates for diabetes and dyslipidemia are increasing, which could lead to a decrease in deaths not only due to cerebral hemorrhage but to an increasing mortality rate that could be attributed to the atherosclerotic features of CVD.[22] Hypertension provides the greatest contribution to the population-attributable risk of total CVD among Koreans, with an estimated 34% of Korean CVD cases being preventable solely through controlling high BP.[23] Thus, community-based national efforts have been made over the last 15 years to improve the early detection of hypertension in Korea and to track affected individuals' medication usage.[24] This may lead to increased levels of hypertension awareness and control, although our findings suggest that substantial improvement is still required for hypertension treatment, as < 50% of all hypertensive individuals had achieved a controlled blood pressure.

The clinical guidelines for CVD prevention classify diabetes as a CVD equivalent condition, which requires the most aggressive risk reduction efforts to prevent CVD among patients with diabetes. The present study revealed that the rates of diabetes and hypertension awareness were similar, although the diabetes control rate was approximately 50% lower than the hypertension control rate. In addition, Korea and the US have similar prevalence rates for diabetes, although the Korean diabetes control rate is considerably lower than the American diabetes control rate (56.8%).[25] Therefore, aggressive treatment based on the clinical guidelines is needed to improve the diabetes control rate and prevent CVD in Korea.

Another important cardiovascular risk factor is dyslipidemia, which appears to be a major public health issue among middle-aged Koreans. The Korean prevalence of dyslipidemia has increased sharply over the last decade, with the age-adjusted prevalence of hypercholesterolemia among > 30-year-old Koreans increasing from 7.3% in 2005 to 20.6% in 2016.[26] Similarly, the present study revealed that approximately 17% of middle-aged Koreans had hypercholesterolemia, with worryingly low rates of awareness and control. Poor awareness and unsatisfactory control of dyslipidemia have also been observed in previous studies,[27–29] with poor awareness potentially contributing to a low control rate. In this context, the American Heart Association recommends that dyslipidemia screening start when individuals are in their 20s and notes that consistent

monitoring is essential.[13] In the present study, 40–44-year-old men had the highest prevalence of dyslipidemia, which suggests that this condition may be developing at even younger ages. The lack of awareness regarding this condition may also be related to an absence of related symptoms, and because confirmation requires a minimum of 8 h of fasting followed by blood analysis.[28,30] In Korea, currently insured employees or self-employed individuals can undergo regular health screening provided by the NIH regardless of their age, although coverage of their dependents, family members, and medical aid beneficiaries only begins at the age of 40 years. Given the importance of related chronic diseases, it may be useful to perform earlier mandatory screening, even using rapid tests for dyslipidemia, to facilitate earlier detection and timely control.

Another noteworthy finding of the present study is that there were sex- and age-specific patterns in the prevalence, awareness, and control of hypertension, diabetes, and dyslipidemia. Men had a higher prevalence of CVD risk factors throughout their middle age, although women had a remarkable increase in the prevalence of risk factors after the age of 55 years. Clustering of CVD risk factors was also more prevalent among men < 60 years, although higher clustering rates were noted among women > 60 years. For example, the clustering rates in the 40–44-year age group were approximately 7% for men and 2% for women, while these rates increased to 18.4% for men and 20.2% for women in the 60–64-year age group (Figure 1). Furthermore, men generally had lower awareness and control rates for all three risk factors, even with their higher prevalence rates. These sex-specific differences may be related to sex-based differences in the onset of CVD, symptom manifestations, and prognosis.[31] Therefore, risk assessment and prevention efforts to reduce the burden of CVD should incorporate these sex- and age-specific patterns in relation to frequent and comprehensive risk factor screening during the menopausal transition for women and for men in their 40 s.

The present study revealed that development of hypertension, diabetes, and dyslipidemia was associated with older age, central obesity, and higher BMI. Age exhibited an especially strong association with the development of all 3 conditions, with 60–64-year-old adults having an approximately 4-fold higher risk of developing diabetes than 40–44-year-old adults. The awareness and control rates also increased with advancing age.

Interestingly, current smoking significantly increased the risk of hypertension and diabetes, but not dyslipidemia. Previous reports have also described inconsistent relationships between dyslipidemia and smoking.[32–34] We identified dyslipidemia based on hypercholesterolemia, although previous studies have also described differences in the development of dyslipidemia according to smoking status among men and women.[33,35,36] For example, high concentrations of triglycerides and low-density lipoprotein cholesterol (LDL-C) were associated with smoking status among men, while high triglyceride concentrations and low high-density lipoprotein cholesterol (HDL-C) concentrations were associated with smoking among women.[33] A previous report has described a stronger association between smoking and dyslipidemia among women than among men,[33] although this may partially be related to the very low smoking rates among middle-aged women.[37] Therefore, further studies are needed to better understand the effects of current smoking on dyslipidemia, especially regarding LDL-C, HDL-C, triglycerides, and total cholesterol. Moreover, active smokers had a lower likelihood of being aware of and controlling the 3 CVD risk factors, which suggests that educational efforts should emphasize smoking-related effects on cardiovascular health.

The main strength of this study is that we analyzed the National Health Insurance Service-National Sample Cohort database which provided satisfactory representativeness and data accuracy;[14] however, the present study has important limitations that merit consideration. First, participation in the NHI's 2013 national health examination was not mandatory and varied according to socioeconomic status, which can significantly influence health behaviors. For example, in 2013, the participation rates were approximately 72% among insured individuals and 42% among medical aid beneficiaries, raising the possibility of selection bias. Second, the findings may have limited generalizability to the Asian population since defining abdominal obesity using waist circumference cut-off points was specifically customized to the Korean population.[18] Third, dyslipidemia was defined based on the levels of total cholesterol concentrations. However, LDL-C and HDL-C play important roles in the development of CVD. Future study is warranted to evaluate sex and age differences concerning detailed lipid profiles to gain further insight into guiding CVD management better in Koreans. In addition, the treatment rate was not included in this study because of limited information about the treatment status, such as prescribed medication and adherence to treatment. Fourth, health screening data were collected from multiple institutions, and measurement techniques may have differed according to each institution. However, South Korea has a compulsory social insurance system that covers health screening for all insured persons and their dependents. The selection of health screening institutions is undertaken by the Ministry of Health and Welfare. The selected screening institutions are evaluated every 2 years to improve the quality of screening methods.

5. Conclusions

This study examined the prevalence, awareness, and control rates of hypertension, diabetes, and dyslipidemia among a representative sample of middle-aged Koreans, and showed sex- and age-specific patterns. For example, hypertension and diabetes were more prevalent in men than in women, although the prevalence of hypercholesterolemia was higher in > 50-year-old women. The development of all 3 CVD risk factors was associated with increasing age, central obesity, and a BMI of > 25 kg/m^2 (the regional cut-off for obesity). Most importantly, dyslipidemia was a prevalent risk factor among middle-aged Korean adults, although it had the lowest awareness rates. These findings may be useful to identify subgroups of individuals at high risk of hypertension, diabetes, and dyslipidemia and in developing programs aiming to manage the risk of developing CVD.

Author contributions

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