Increasing Prevalence of Metabolic Syndrome in Korea

The Korean National Health and Nutrition Examination Survey for 1998–2007

Soo Lim, MD, PHD[1,2]
Hayley Shin, BS[3]
Jung Han Song, MD[1,4]
Soo Heon Kwak, MD[1]
Seon Mee Kang, MD[1,2]
Ji Won Yoon, MD[1,2]
Sung Hee Choi, MD[1,2]
Sung Il Cho, MD[5]
Kyong Soo Park, MD[1]
Hong Kyu Lee, MD[1]
Hak Chul Jang, MD, PHD[1,2]
Kwang Kon Koh, MD, PHD[6]

OBJECTIVE—The number of people with metabolic syndrome is increasing worldwide, and changes in socioenvironmental factors contribute to this increase. Therefore, investigation of changes in metabolic syndrome and its components in South Korea, where rapid socioenvironmental changes have occurred in recent years, would be foundational in setting up an effective strategy for reducing this increasing trend.

RESEARCH DESIGN AND METHODS—We compared the prevalence and pattern of metabolic syndrome among participants in the Korean National Health and Nutrition Examination Surveys for 1998, 2001, 2005, and 2007. In each survey, stratified, multistage, probability–sampling designs and weighting adjustments were conducted to represent the entire Korean population. The revised National Cholesterol Education Program criteria were used as the definition of metabolic syndrome. All biochemical parameters were measured in a central laboratory.

RESULTS—A total of 6,907 (mean ± SE age 45.0 ± 0.2 years), 4,536 (45.5 ± 0.2), 5,373 (47.1 ± 0.2), and 2,890 (49.9 ± 0.3) Koreans over 20 years of age have participated in the studies in 1998, 2001, 2005, and 2007, respectively. The age-adjusted prevalence of metabolic syndrome increased significantly from 24.9% in 1998, 29.2% in 2001, and 30.4% in 2005 to 31.3% in 2007. Among the five components, the level of low HDL cholesterol increased the most, by 13.8% over the 10 years. Abdominal obesity and hypertriglyceridemia followed, with 8.7 and 4.9% increases, respectively.

CONCLUSIONS—Because dyslipidemia and abdominal obesity were major factors in increasing the prevalence of metabolic syndrome in Koreans for the past 10 years, lifestyle interventions should be conducted at the national level to reduce the burden and consequences of metabolic syndrome.

Diabetes Care 34:1323–1328, 2011

Metabolic syndrome increases cardiovascular morbidity and mortality and all-cause mortality (1). Metabolic syndrome also increases the risk of developing diabetes because its components represent major risk factors for impaired glucose metabolism (2).

The prevalence of metabolic syndrome is increasing worldwide. According to data from the National Health and Nutrition Examination Survey (NHANES) III and NHANESs 1999–2006, the age-adjusted prevalence of metabolic syndrome increased from 29.2 to 34.2% in the U.S. (3). This increasing trend also has been observed in Asian countries (4), presenting a major challenge for public health professionals as well as becoming a social and economic problem in the near future.

The characteristics of metabolic syndrome can differ according to ethnicity and socioeconomic differences and changes. As a consequence, Asians have a higher prevalence of metabolic syndrome than whites after adjusting for body size (5). Hence, understanding the socioeconomic context of Asian populations is critical in establishing appropriate strategies for addressing this wide prevalence. South Korea is distinct for experiencing a major economic crisis in 1998, followed by a rapid recovery through adopting Western policies and cultures. This sudden change of the socioenvironment resulted in a dramatic lifestyle change for people living in South Korea. Today, South Koreans are eating more "Western" food and are less physically active than a decade ago. South Korea is one of the countries where the socioeconomic environment has changed rapidly to reflect more Westernization as well as its negative health consequences. Thus, documenting the changes in metabolic syndrome characteristics in South Korea during this period of socioeconomic changes is intriguing and important. In this study, we investigated the changes in the prevalence of metabolic syndrome in four nationwide surveys (the Korean NHANESs [KNHANESs] in 1998, 2001, 2005, and 2007) by applying the revised National Cholesterol Education Program (NCEP) definition (6). We also investigated the changes in the factors constituting metabolic syndrome.

RESEARCH DESIGN AND METHODS

Study cohort

The Korean Ministry of Health and Welfare conducted the KNHANES in noninstitutionalized Korean civilians in the years 1998, 2001, 2005, and 2007. Details of the surveys performed in 1998,

From the [1]Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea; the [2]Department of Internal Medicine, Seoul National University Bundang Hospital, Seongnam, Korea; the [3]Johns Hopkins Bloomberg School of Public Health, Johns Hopkins University, Baltimore, Maryland; the [4]Department of Laboratory Medicine, Seoul National University Bundang Hospital, Seongnam, Korea; the [5]School of Public Health and Institute of Health and Environment, Seoul National University, Seoul, Korea; and the [6]Division of Cardiology, Gachon University, Gil Medical Center, Incheon, Korea.
Corresponding authors: Kwang Kon Koh, kwangk@gilhospital.com, and Hak Chul Jang, janghak@snu.ac.kr.
Received 8 November 2010 and accepted 11 March 2011.
DOI: 10.2337/dc10-2109
This article contains Supplementary Data online at http://care.diabetesjournals.org/lookup/suppl/doi:10.2337/dc10-2109/-/DC1.

2001, and 2005 have been described (7,8). A similar design and method were used in the KNHANES for 2007. In brief, a stratified, multistage, probability–sampling design was used, with the selection made from sampling units based on geographical area, sex, and age-groups using household registries. Trained investigators conducted surveys in households and administered questionnaires to adults. Household surveys included the demographic, socioeconomic, dietary, and medical history of each respondent. Of 11,318 people who participated in the 1998 survey, complete data were obtained from 9,795 (86.5%). Similarly, 9,808 (83.9%) of 11,694 subjects in 2001, 7,597 (70.2%) of 10,816 subjects in 2005, and 4,246 (65.8%) of 6,455 subjects in 2007 participated in each survey. To show that there was no bias as a result of dropouts, we compared important demographic and other characteristics of the noncompleters with those of the completers. There was no significant difference between participants and nonparticipants in all studies. Among these subjects, 6,907 respondents in 1998, who were aged >20 years and had all the data for defining metabolic syndrome with the revised NCEP definition, were available for analysis. Likewise, for the 2001, 2005, and 2007 surveys, 4,536, 5,373, and 2,890 participants, respectively, aged ≥20 years had complete data.

To give an equal probability of being sampled, weights were assigned to each respondent, enabling the results to represent the entire Korean population. This weighting method guarantees unbiased point estimates of population parameters for the entire population and its subsets (9). All subjects in the studies participated voluntarily, and informed consent was obtained from them. The study protocol was approved by the Ministry of Health and Welfare in Korea.

Anthropometry

Anthropometric measurements were conducted by well-trained examiners in the same manner in the four studies. Height was measured to the nearest 0.1 cm using a portable stadiometer (Seriter, Bismarck, ND). Weight was measured to the nearest 0.1 kg using a calibrated balance-beam scale (Giant-150N; Hana, Seoul, Korea). Waist circumference measurements were taken at the end of normal expiration to the nearest 0.1 cm, measuring from the narrowest point between the lower borders of the rib cage and the iliac crest.

Measurement of metabolic risk factors

For each study, subjects were asked to refrain from smoking or consuming caffeine before the measurement. Blood pressure was measured twice, using a mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY), in the sitting position after at least a 10-min rest. If the first two measurements differed by >5 mmHg, additional checks were obtained.

After a 12-h overnight fast, venous blood samples were drawn. Samples were immediately sent to a central, certified laboratory, and plasma was separated immediately by centrifugation. The fasting plasma concentrations of glucose and lipids were measured enzymatically in a central laboratory; a 747-chemistry analyzer (Hitachi, Tokyo, Japan) was used in the 1998 and 2001 studies, and an Advia 1650/2400 (Siemens, New York, NY) was used in the 2005 and 2007 studies.

To confirm and compare accuracy and consistency in each survey, commutable frozen serum samples (n = 38) were taken from normal subjects and patients with dyslipidemia, according to the Clinical and Laboratory Standards Institute guidelines (www.clsi.org/). The commutable frozen serum samples were sent to the Centers for Disease Control and Prevention (Atlanta, GA) and were measured using the standard method. With data from the Centers for Disease Control and Prevention, the conversion rate for the KNHANES 2007 was obtained by a Passing and Bablok regression method (Supplementary Fig. A). The revised HDL cholesterol extrapolations were based on a regression line, and it may theoretically cause excess residual error for prediction. However, the fitted regression line had an R^2 = 0.977. Therefore, the revised HDL cholesterol values were statistically well substantiated. Conversion rates for other surveys were obtained by a similar method as follows:

- Revised HDL cholesterol = 0.989 × HDL cholesterol (KNHANES 2007) + 6.162
- Revised HDL cholesterol = 1.160 × HDL cholesterol (KNHANES 2005) − 1.800
- Revised HDL cholesterol = 0.712 × HDL cholesterol (KNHANES 2001 or 1998) + 12.470

Definition of metabolic syndrome

According to the revised NCEP criteria (6), an individual may be diagnosed as having metabolic syndrome if he or she has three or more of the following criteria: *1*) waist circumference >90 cm in men and >80 cm in women using the International Obesity Task Force criteria for the Asian-Pacific population to determine waist circumference (10); *2*) triglycerides ≥150 mg/dL or medication use; *3*) HDL cholesterol <40 mg/dL in men and <50 mg/dL in women or medication use; *4*) blood pressure ≥130/85 mmHg or antihypertensive medication use; and *5*) fasting glucose ≥100 mg/dL or medication use (insulin or oral agents).

Statistical analysis

All data are presented as means ± SE or as prevalence (% and SE). Sampling weights were used to take the complex sampling into account, and statistical analyses were conducted using SAS version 8.1 software with survey procedure (SAS Institute, Inc., Cary, NC). Direct age adjustment of the data was done for the Korean population aged ≥20 years in the year 2007. Every comparison among the four studies was done after age adjustment. Multiple regression analysis, including survey year and age as categorical variables, was performed to compare the continuous variables associated with the cardiovascular risk factors in each survey. χ^2 Tests and linear-by-linear association were used to compare the prevalence of metabolic syndrome and its components, according to the survey year and/or sex. Statistical significance was defined as $P < 0.05$.

RESULTS—A total of 6,907 (mean ± SE age 45.0 ± 0.2 years), 4,536 (45.5 ± 0.2), 5,373 (47.1 ± 0.22), and 2,890 (49.9 ± 0.3) Korean men and women aged >20 years participated in the KNHANES in 1998, 2001, 2005, and 2007, respectively. The age-adjusted prevalence of metabolic syndrome increased significantly from 24.9% in 1998 to 31.3% in 2007. The total 6.4% increase of prevalence of metabolic syndrome over the 10-year period is estimated to be ~0.6% of the annual metabolic syndrome increase. If the original NCEP criteria for abdominal obesity of 102 cm in men and 88 cm in women were used, 15.4 and 20.6% of the Korean population would be classified as having metabolic syndrome in the 1998 and 2007 surveys, respectively (5.2% increase over 10 years).

Table 1 shows the mean anthropometric and biochemical parameters in the 1998, 2001, 2005, and 2007 surveys. Participants in the 2007 survey were ~4.9 years older than those in the 1998 survey. Obesity indices, such as BMI and waist circumference, and lipid profiles, such as triglycerides and LDL cholesterol, increased significantly over 10 years ($P < 0.05$). In contrast, systolic and diastolic blood pressure decreased significantly over the same period ($P < 0.05$).

Table 2 shows the prevalence of metabolic syndrome and its individual components among the U.S. NHANESs and the four KNHANESs. The prevalence of abdominal obesity, hypertriglyceridemia, and glucose criteria increased significantly in both countries. Compared with the U.S. NHANESs, the prevalence of high blood pressure has been decreasing in Korea. The prevalence of low HDL cholesterolemia decreased in the U.S. NHANES reports, but the opposite trend was observed in Korea. Of five individual metabolic syndrome components, the incidence of low HDL cholesterol criteria increased the most over 10 years (13.8%). Abdominal obesity and hypertriglyceridemia followed, showing 8.7 and 4.9% increases, respectively. In contrast, subjects meeting the blood pressure criteria decreased gradually. Even after stratifying subjects by antihypertensive medication status, a decreasing trend in blood pressured remained (Supplementary Fig. B).

There was a 5.5% difference in metabolic syndrome prevalence between men and women (22.4% in men and 27.9% in women) in 1998. In the 2007 KNHANES, there was a 3.9% difference between men and women; women had a significantly higher prevalence (32.9%) than men (29.0%; $P < 0.05$). However, the overall increase in metabolic syndrome prevalence over the 10 years was significantly higher in men (6.6%) than in women (5.0%; $P < 0.05$).

The prevalence of metabolic syndrome among Korean adults by sex in the four KNHANESs is shown according to age-groups (Fig. 1). In all studies, the prevalence of metabolic syndrome in men was higher than in women aged 20–49 years, but the prevalence of metabolic syndrome in women increased significantly at age 50 years and surpassed men thereafter.

In comparing the components of metabolic syndrome using the revised NCEP criteria (Fig. 2), men had a higher prevalence of fasting glucose, abnormal blood pressure, and hypertriglyceridemia criteria than women (all $P < 0.05$). In contrast, women showed a higher prevalence of abdominal obesity and low HDL cholesterolemia (both $P < 0.05$). The age-specific prevalence rates of the metabolic syndrome component using the revised NCEP definition for 1998, 2001, 2005, and 2007 are shown in Supplementary Fig. C. It is noteworthy that, in all four studies, there was a tendency for men to have a relatively higher prevalence of increased fasting glucose, blood pressure, and hypertriglyceridemia at younger ages (20–49 years) than women.

Table 1—*Age-adjusted anthropometric and biochemical parameters in the 1998, 2001, 2005, and 2007 KNHANESs*

	1998	2001	2005	2007
n	6,907	4,536	5,373	2,890
Age (years)	45.0 ± 0.19	45.5 ± 0.23	47.1 ± 0.21	49.9 ± 0.30
Women (%)	55.5	57.7	57.4	58.3
Weight (kg)*	60.7 ± 0.13	61.6 ± 0.16	62.2 ± 0.15	61.5 ± 0.21
Height (cm)*	161.5 ± 0.11	161.7 ± 0.14	161.7 ± 0.12	160.9 ± 0.17
BMI (kg/m^2)*	23.2 ± 0.04	23.5 ± 0.05	23.7 ± 0.04	23.7 ± 0.06
Waist circumference (cm)*	80.4 ± 0.11	80.9 ± 0.14	81.0 ± 0.13	82.4 ± 0.18
Systolic blood pressure (mmHg)*	125.8 ± 0.24	122.4 ± 0.29	119.2 ± 0.24	117.7 ± 0.32
Diastolic blood pressure (mmHg)*	78.5 ± 0.14	76.9 ± 0.17	77.3 ± 0.15	75.7 ± 0.19
Hemoglobin (g/dL)*	14.0 ± 0.02	13.6 ± 0.02	13.8 ± 0.02	13.8 ± 0.03
Hematocrit (%)*	41.5 ± 0.06	40.7 ± 0.06	42.1 ± 0.06	40.9 ± 0.09
AST (IU/L)*	28.1 ± 0.21	22.4 ± 0.12	24.4 ± 0.18	25.1 ± 0.27
ALT (IU/L)*	28.2 ± 0.28	20.3 ± 0.18	22.4 ± 0.26	24.4 ± 0.37
Creatinine (mg/dL)*	0.9 ± 0.01	1.0 ± 0.01	1.0 ± 0.01	1.0 ± 0.01
Total cholesterol (mg/dL)*	188.6 ± 0.45	188.2 ± 0.51	185.0 ± 0.48	188.8 ± 0.68
Triglycerides (mg/dL)*	122.5 ± 0.74	130.4 ± 1.16	135.6 ± 1.66	131.7 ± 1.45
HDL cholesterol (mg/dL)*	47.9 ± 0.11	45.3 ± 0.16	45.1 ± 0.15	47.8 ± 0.19
LDL cholesterol (mg/dL)*	114.1 ± 0.41	114.5 ± 0.46	112.8 ± 0.42	117.4 ± 0.60
Fasting plasma glucose (mg/dL)*	99.5 ± 0.36	97.6 ± 0.25	95.2 ± 0.31	96.2 ± 0.42

Data are means ± SE, unless otherwise indicated. AST, aspartate aminotransferase; ALT, alanine aminotransferase. *Age-adjusted value.

CONCLUSIONS—When the revised NCEP definition using the Asia-Pacific abdominal obesity criteria was applied, the age-adjusted prevalence of metabolic syndrome was 24.9% in the KNHANES 1998 and 31.3% in the KNHANES 2007. The estimated annual increase was ~0.6% over 10 years. Low HDL cholesterol, abdominal obesity, and hypertriglyceridemia played major roles in this increase.

The prevalence of metabolic syndrome in the KNHANES 2007 was 31.3%, which was similar to the result of the U.S. NHANESs for 1999–2006 at 34.2%, using the revised NCEP definition (3). However, it should be noted that lower criteria of abdominal obesity were used in the four KNHANESs than in the U.S. NHANESs. Indeed, the best BMI for Americans is 25 kg/m^2 for life expectancy, whereas the best BMI for Koreans is 23 kg/m^2, based on hundreds of thousands of people for the extended >20-year longitudinal follow-up (11,12). Our distinctive data reserve plenty of reasons to use the standard criteria for metabolic syndrome in Koreans.

When comparing the percentage changes in the five components of metabolic syndrome, the prevalence of low HDL cholesterol increased the most (from 36.4 to 50.2%, a 13.8% increase). Thus, almost one-half of the Korean population has a low HDL cholesterol level. Besides HDL cholesterol, abdominal obesity and hypertriglyceridemia also have increased substantially. Both lipid levels and obesity are affected by lifestyle factors (13). Changing to a high-fat diet and low physical activity in Korean seems to have contributed to this high prevalence of abdominal obesity and dyslipidemia (14). In fact, Koreans' total energy intake increased from 1,985 and 1,976 kcal in 1998 and 2001, respectively, to 2,016 kcal in 2005 (15). Total fat intake also

Table 2—*Prevalence (% or SE) of metabolic syndrome and its individual metabolic abnormalities among the U.S. NHANES III, 1999–2006, and KNHANES 1998, 2001, 2005, and 2007*

	U.S. NHANES			KNHANES			
	III	1999–2006	1998	2001	2005	2007	*P**
n	6,423	6,962	6,907	4,536	5,373	2,890	
Metabolic syndrome							
Unadjusted	27.9 (1.1)	34.1 (0.8)	24.4 (0.6)	28.1 (0.7)	29.2 (0.6)	31.3 (0.6)	<0.01
Age-adjusted	29.2 (1.0)	34.2 (0.7)	24.9 (0.6)	29.2 (0.7)	30.4 (0.6)	31.3 (0.6)	<0.01
Men	31.4 (1.4)	34.9 (1.0)	22.4 (1.3)	26.9 (1.2)	31.7 (1.5)	29.0 (1.6)	<0.01
Women	27.1 (1.2)	33.3 (1.0)	27.9 (1.2)	31.8 (1.4)	29.5 (1.5)	32.9 (1.8)	<0.01
Abdominal obesity†							
U.S. adult criteria	38.6 (1.0)	49.6 (0.8)	—	—	—	—	—
Men (>102 cm)	30.4 (1.6)	41.1 (1.1)	—	—	—	—	—
Women (>88 cm)	46.0 (1.4)	58.0 (1.1)	—	—	—	—	—
Asian criteria	—	—	32.5 (0.5)	34.5 (0.6)	35.3 (0.5)	41.3 (0.9)	<0.01
Men (>90 cm)	—	—	20.4 (1.2)	22.4 (1.1)	26.6 (1.3)	27.5 (1.6)	—
Women (>80 cm)	—	—	42.2 (1.3)	43.4 (1.5)	41.7 (1.2)	51.2 (2.1)	—
Triglycerides (≥150 mg/dL or medication use)	30.3 (1.2)	32.0 (0.7)	28.3 (0.5)	33.2 (0.6)	29.9 (0.9)	33.2 (1.1)	<0.01
Men	36.0 (1.9)	36.1 (1.1)	36.1 (1.4)	43.0 (1.5)	39.7 (1.8)	40.8 (1.8)	—
Women	24.7 (1.2)	27.6 (0.8)	22.1 (1.6)	26.0 (1.7)	22.6 (1.9)	27.8 (2.0)	—
HDL cholesterol	38.0 (1.3)	30.7 (0.8)	36.4 (0.5)	48.4 (0.7)	51.9 (0.5)	50.2 (1.2)	<0.01
Men (<40 mg/dL or medication use)	36.4 (1.7)	27.6 (1.0)	25.5 (1.5)	32.6 (1.9)	35.2 (1.9)	34.7 (1.9)	—
Women (<50 mg/dL or medication use)	39.6 (1.4)	33.8 (1.1)	47.9 (1.7)	60.1 (1.8)	61.2 (1.7)	59.3 (2.3)	—
Blood pressure (≥130/85 mmHg or medication use)	32.0 (0.8)	40.0 (0.7)	41.0 (0.6)	37.0 (0.6)	37.5 (0.8)	34.5 (0.7)	<0.01
Men	36.2 (1.5)	42.9 (0.7)	48.0 (1.3)	44.3 (2.1)	46.6 (1.2)	40.6 (1.6)	—
Women	27.8 (0.9)	36.6 (0.8)	35.3 (1.6)	31.7 (1.9)	30.7 (1.4)	30.1 (1.5)	—
Fasting glucose (≥100 mg/dL or medication use)	32.5 (1.1)	36.9 (1.0)	23.9 (0.6)	25.5 (0.7)	23.3 (0.5)	26.3 (0.9)	<0.01
Men	41.5 (1.5)	44.7 (1.2)	25.1 (1.3)	26.7 (1.8)	29.3 (1.3)	31.8 (2.1)	—
Women	24.2 (1.2)	29.2 (1.0)	22.9 (1.5)	24.5 (1.6)	18.8 (1.9)	22.3 (2.5)	—

Data are percentage (SE). *Revised NCEP Adult Treatment Panel III and Asia-Pacific criteria for abdominal obesity were used for the U.S. NHANES and KNHANES, respectively. †Linear-by-linear association was used for significance of trend from the 1998 to 2007 KNHANES.

increased from 41.5 and 41.6 g in 1998 and 2001, respectively, to 46.0 g in 2005 (15). The percentage of subjects walking >30 min daily on >2 days a week decreased from 75.5% in 2001 to 60.7% in 2005 (16). In addition, television-viewing hours per week increased remarkably from 18.4 h per week in 1993 to 23.7 h per week in 2000, further contributing to the sedentary lifestyle (17). Such lifestyle changes are not unique to Korea, and other developed or developing countries report similar results (4,18).

Recently, several reports were published from the KNHANES with alternative analyses (19–21). Kim et al. (19) found that nutritional intakes were unequal by educational level and contributed this inequality to the economic crisis in Korea in 1998. This inequality of nutritional intake may be associated with a rapid increase of low HDL cholesterolemia. The other group reported that the treatment rate for hypertension was 59–90% (20). This high treatment rate may be associated with a decreasing tendency of hypertension over the period. Another study (21) provided increasing trends in obesity measures among men and older-aged women but not in young women. This result is in accordance with the current analysis.

When comparing the prevalence of metabolic syndrome between men and women stratified by age-groups, men had a higher prevalence than women for ages <50 years in every study (Fig. 1). In contrast, the prevalence of metabolic syndrome in women increased significantly from the age of 50 years and surpassed men thereafter. Considering that this remarkable increase in metabolic syndrome was observed for women starting at the age of ~50 years, it seems likely that menopause could be a reason for this dramatic change. A similar increasing pattern of abdominal obesity in women supports this hypothesis.

As shown in Table 1, obesity indices and metabolic impairments have been rising over the past 10 years. In contrast, blood pressures have been significantly decreasing over the same period. Interestingly, these Korean data show conflicting trends of HDL cholesterolemia and blood pressure when compared with the U.S. data. The prevalence of low HDL cholesterolemia increased, whereas the prevalence of high blood pressure decreased in Korea, and the inverse is true for the U.S. NHANES III to NHANESs 1999–2006 (3). Thus, the characteristics of metabolic syndrome may change differently according to ethnicity and socioeconomic status.

In this analysis, blood pressure decreased, whereas antihypertensive medication rate increased from 6.1% in 1998 to 18.5% in 2007. There is no clear explanation to the decreasing pattern of prevalence of blood pressure criteria over the past 10 years in Korea. Several possibilities can be suggested. Koreans were traditionally used to eating a high-salt diet; however, for the recent 10 years, daily salt consumption decreased significantly as a result of the national campaign encouraging the "Dietary Approach to Stop Hypertension Diet" (22). Thus, changes in the dietary pattern to a low-salt diet could be one reason for decreasing

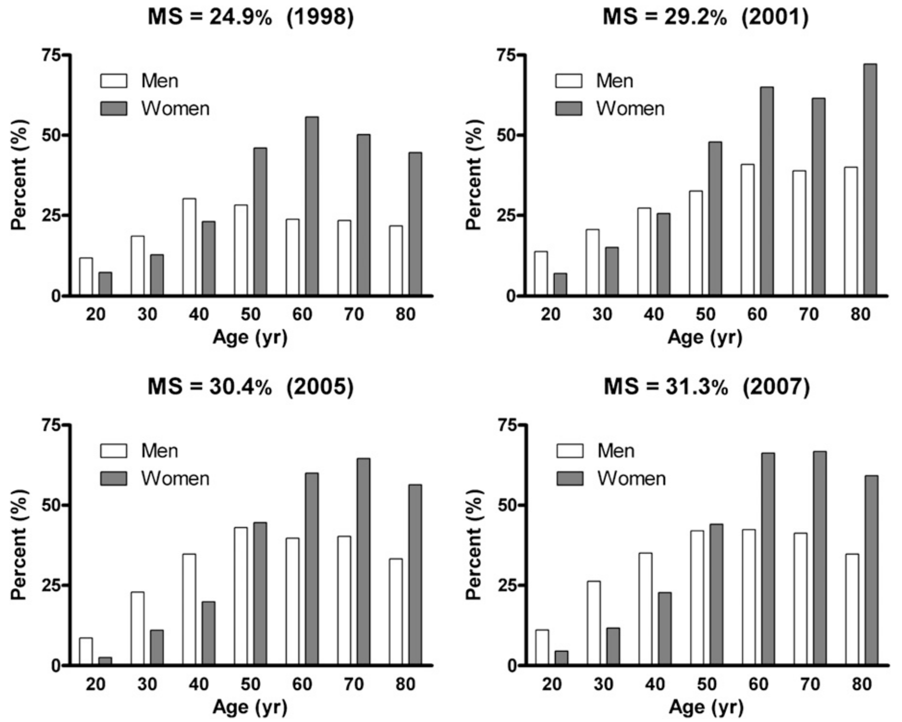

Figure 1—*Prevalence of metabolic syndrome (MS) among Korean adults by sex in the 1998, 2001, 2005, and 2007 KNHANESs, according to age-groups. The revised NCEP Adult Treatment Panel III definition with Asia-Pacific abdominal obesity criteria was used.*

blood pressure, which was proven in Japan (23). A decrease in the smoking rate in men from 69.9% in 2001 to 42.0% in 2007 is believed to contribute to the decreasing pattern of high blood pressure (24). A dramatic increase in cardiovascular mortality in 1999, when South Korea experienced an economic crisis, could be another possible explanation for the decreasing trend in high blood pressure (25). The high cardiovascular mortality in 1999 leveled off and returned to an average level in the following years. In addition, there may be a possibility that the measurement of blood pressure had become more stabilized over time.

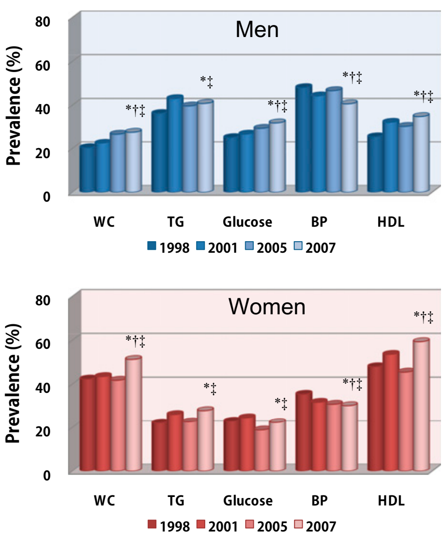

Figure 2—*Prevalence of each factor of metabolic syndrome in the 1998, 2001, 2005, and 2007 KNHANESs (*P < 0.05, 1998 vs. 2007; †P < 0.05, 2001 vs. 2007; and ‡P < 0.05, 2005 vs. 2007). BP, blood pressure; HDL, HDL cholesterol; TG, triglycerides; WC, waist circumference. (A high-quality color representation of this figure is available in the online issue.)*

South Korea is a good example demonstrating the impact of rapid lifestyle changes over a relatively short period on prevalence of metabolic abnormalities. South Korea experienced a major economic crisis in 1998, followed by a rapid and impressive economic recovery that is compatible to other developed countries. Thus, documenting such changes in metabolic syndrome characteristics in South Korea during this economic boom is critical in understanding the socioeconomic influence on public health.

In conclusion, the prevalence of metabolic syndrome increased rapidly from the KNHANES 1998 to the KNHANES 2007. Judging from this dramatic increase during these 10 years, a national strategy to prevent this increasing trend of metabolic syndrome should be developed. The first priority should be to reduce the burden of dyslipidemia and abdominal obesity. Lifestyle changes, such as regular exercise and a healthy diet with low sodium, carbohydrates, and fat, should be emphasized (6).

Acknowledgments—This study was supported by grants funded by the Ministry of Science and Technology (M10642140004-06N4214-00410) and by the Seoul Research and Business Development Program, Republic of Korea (10526).

No potential conflicts of interest relevant to this article were reported.

S.L. and H.S. wrote the manuscript, researched data, and contributed to the discussion. J.H.S., S.H.K., S.M.K., J.W.Y., S.H.C., S.I.C., K.S.P., and H.K.L. contributed to the discussion. K.K.K. and H.C.J. researched data, contributed to the discussion, and reviewed and edited the manuscript.

The authors appreciate Professors Arupendra Mozumdar and Gary Liguori from the Department of Health, Nutrition, and Exercise Sciences, North Dakota State University, for generously providing detailed information on NHANES III and NHANESs 1999–2006. The authors greatly appreciate the critical review and comments by Michael J. Quon, MD, PhD, Professor of Medicine, University of Maryland, Baltimore, and Robert H. Eckel, MD, Professor of Medicine, University of Colorado Denver Anschutz Medical Campus, Aurora.

References

1. Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001;24:683–689
2. Haffner SM, Valdez RA, Hazuda HP, Mitchell BD, Morales PA, Stern MP. Prospective analysis of the insulin-resistance syndrome (syndrome X). Diabetes 1992; 41:715–722
3. Mozumdar A, Liguori G. Persistent increase of prevalence of metabolic syndrome among U.S. adults: NHANES III to NHANES 1999-2006. Diabetes Care 2011; 34:216–219
4. Nestel P, Lyu R, Low LP, et al. Metabolic syndrome: recent prevalence in East and Southeast Asian populations. Asia Pac J Clin Nutr 2007;16:362–367
5. Araneta MR, Wingard DL, Barrett-Connor E. Type 2 diabetes and metabolic syndrome in Filipina-American women: a high-risk nonobese population. Diabetes Care 2002; 25:494–499
6. Grundy SM, Cleeman JI, Daniels SR, et al.; American Heart Association; National Heart, Lung, and Blood Institute. Diagnosis and management of the metabolic syndrome: an American Heart Association/ National Heart, Lung, and Blood Institute

Scientific Statement. Circulation 2005;112: 2735–2752
7. Park HS, Oh SW, Cho SI, Choi WH, Kim YS. The metabolic syndrome and associated lifestyle factors among South Korean adults. Int J Epidemiol 2004;33: 328–336
8. Koh DH, Kim HR, Han SS. The relationship between chronic rhinosinusitis and occupation: the 1998, 2001, and 2005 Korea National Health and Nutrition Examination Survey (KNHANES). Am J Ind Med 2009;52:179–184
9. Brogan D. *Software for Sample Survey Data, Misuse of Standard Packages*. Armitage P, Colton T, Eds. John Wiley and Co., 1998, p. 4167–4174
10. World Health Organization, International Association for the Study of Obesity, International Obesity Task Force. *The Asia-Pacific Perspective: Redefining Obesity and Its Treatment*. Sydney, Health Communications, 2000, p. 15–21
11. Berrington de Gonzalez A, Hartge P, Cerhan JR, et al. Body-mass index and mortality among 1.46 million white adults. N Engl J Med 2010;363:2211–2219
12. Jee SH, Sull JW, Park J, et al. Body-mass index and mortality in Korean men and women. N Engl J Med 2006;355:779–787
13. Ross R, Dagnone D, Jones PJ, et al. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men: a randomized, controlled trial. Ann Intern Med 2000;133:92–103
14. Tchai BS. Changes of plasma lipids and biochemical markers for coronary artery disease in Korea. Ann N Y Acad Sci 1993; 676:279–288
15. Korean Ministry of Health and Welfare. *National Health and Nutrition Examination Survey Report 2005*. Seoul, South Korea, Ministry of Health and Welfare, 2006 [in Korean]
16. Statistics Korea. *Report on the Social Statistics Survey in Korea*. Seoul, South Korea, Statistics Korea, 2006 [in Korean]
17. National Statistical Office. *Annual Report on the Vital Statistics in Korea*. Seoul, South Korea, National Statistical Office of Korea, 2001 [in Korean]
18. Hoang KC, Le TV, Wong ND. The metabolic syndrome in East Asians. J Cardiometab Syndr 2007;2:276–282
19. Kim K, Hong SA, Kim MK. Trends in nutritional inequality by educational level: a case of South Korea. Nutrition 2010;26: 791–798
20. Lee K. Cardiovascular risk prevalence, awareness, treatment, and control from 1998 to 2007 in Koreans. Asia Pac J Clin Nutr 2010;19:261–265
21. Khang YH, Yun SC. Trends in general and abdominal obesity among Korean adults: findings from 1998, 2001, 2005, and 2007 Korea National Health and Nutrition Examination Surveys. J Korean Med Sci 2010;25:1582–1588
22. Korean Ministry of Health and Welfare. *National Nutrition Survey Report 1995*. Seoul, South Korea, Korean Ministry of Health and Welfare, 1997 [in Korean]
23. Shimazu T, Kuriyama S, Hozawa A, et al. Dietary patterns and cardiovascular disease mortality in Japan: a prospective cohort study. Int J Epidemiol 2007;36:600–609
24. Korean Ministry of Health and Welfare. *Report of Smoking Rate in Korea*. Seoul, South Korea, Korean Ministry of Health and Welfare, 2010 [in Korean]
25. Statistics Korea. Census [Internet], 2010. Daejeon, South Korea, Korean Statistical Information Service. Available from http://kosis.kr/index/index.jsp. Accessed 12 October 2010