Original Article

A comparison of the prevalence of the metabolic syndrome in the United States (US) and Korea in young adults aged 20 to 39 years

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This study estimated and compared the prevalence of the Metabolic Syndrome and its individual components in young adults (ages 20-39 years) in the US and Korea using 2003-2004 US and 2005 Korean National Health and Nutrition Examination Survey data. The mean body mass index and rate of metabolic abnormalities in the US were significantly higher than in Korea. The prevalence of the Metabolic Syndrome in the US was nearly three times higher than in Korea using National Cholesterol Education Program-Adult Treatment Panel III and International Diabetes Federation criteria (21.6% vs. 6.9% and 23.0% vs. 6.9%, $p<0.001$). The prevalence of abdominal obesity, hyperglycemia, and hypertriglyceridemia was higher in the US while the prevalence of low high density lipoprotein-cholesterol level was higher in Korea. The rate of hypertension showed no significant difference while mean systolic blood pressure and diastolic blood pressure varied between the two countries. The proportion of subjects having at least one component of Metabolic Syndrome was similar in both countries; however, multiple abnormalities were more common in the US. These findings indicate the need for the development of race/ethnic-based norms for components of the Metabolic Syndrome and detailed analysis of the risk factors for the Metabolic Syndrome in the two countries. National health policies designed to prevent the Metabolic Syndrome, its individual abnormalities, and its complications using population-based characteristics of each nation will generate improved outcomes.

Key Words: National Health and Nutrition Examination Survey, the US, Korea, National Cholesterol Education Program-Adult Treatment Panel III, International Diabetes Federation, metabolic syndrome

INTRODUCTION

The Metabolic Syndrome (MetS) is characterized by abdominal obesity, insulin resistance, hyperglycemia, hypertension, and dyslipidemia, and is a major risk factor for cardiovascular disease (CVD) and type 2 diabetes.[1-4] This syndrome has been recognized as a serious health problem principally in Western countries during the decade since Reaven[5] coined the term Syndrome X in 1988 to describe the clustering of those risk factors. However, MetS has become common in Asian countries as well.[6] Numerous articles have reported the prevalence of the MetS[4,7-13] in individual nations although few cross-sectional comparisons have been made, especially between Western and Asian countries.

Prevention, early screening, and early intervention of the MetS are recognized to be important in decreasing the morbidity and mortality associated with CVD, diabetes, and their complications.[2,14,15] Young adults with the MetS are especially at increased risk for CVD and type 2 diabetes.[1,7,8,16-21] Behavioral risk factors for the MetS and CVD,[22-24] such as tobacco use,[25] alcohol consumption, and low levels of physical activity,[26-28] often start during early adulthood under the influence of social and cultural pressures. Such behaviors can contribute to the risk of the MetS and CVD[14,17,18,29-31] and may continue through late adulthood.[19, 32-34] Thus, understanding the prevalence of the MetS in young adults is essential to the formulation of strategies to prevent and treat the MetS.

Since the World Health Organization initially proposed a definition for the MetS in 1998,[35] several other organizations have promulgated alternative criteria.[36-39] The National Education Cholesterol Program Adult Treatment Panel III (NCEP-ATP III) definition, published in 2002[37] and partially modified in 2004[40], has become most widely used worldwide because of its convenience in clinical

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applications.[40] A newer definition, proposed by the International Diabetes Federation (IDF), emphasized the importance of central adiposity as determined by race/ethnic group-specific thresholds of waist circumference.[8,41] Although little is known about the prevalence of central adiposity and MetS in Asian populations using the IDF criteria, the Korean Society for the Study of Obesity (KSSO)[42] utilizes Korean-specific waist circumference standards for IDF-defined abdominal obesity.

Representative population-based surveys are important resources for establishing national health policies. Data from the US National Health and Nutrition Examination Survey (NHANES) have been used to determine the prevalence of the MetS among three ethnicities: non-Hispanic Whites, non-Hispanic Blacks, and Mexican Americans.[8, 9] Asians, however, were classified as 'other race' in the survey. Korea conducted a similar national survey called the Korean National Health and Nutrition Examination Survey (KNHANES). To date, few studies have compared the prevalence of the MetS in the US to Asian countries and no studies have specifically compared the prevalence in the US to that in Korea. We sought to fill this gap in order to provide insight into underlying disease mechanisms and to help guide national health strategies for the prevention and treatment of the MetS. The objectives of this study were 1) to estimate the prevalence of the MetS and its individual components using NCEP-ATP III and IDF criteria among young adult populations in the US and Korean NHANES data sets, and 2) to compare the results between the two countries.

MATERIALS AND METHODS

Study population and data sources

This study was based on data from the 2003-2004 US NHANES and 2005 KNHANES. Both were cross-sectional nationally representative surveys of the US and Korean civilian non-institutionalized populations, and used standardized protocols for all interviews and medical examinations. Subjects selected from the US NHANES were Mexican-Americans, non-Hispanic Whites, and non-Hispanic Blacks and from the KNHANES were Koreans. Because of the limited sample available in the US NHANES for subjects designated as "other race–including multiracial" and "other Hispanic," these subgroups were excluded. The subjects from both data sets were limited to men and non-pregnant women aged 20 to 39 years who participated in the medical examination of each NHANES and who had fasted at least 8 hours prior to the blood collection. Only subjects who had all five indicators of the MetS measured according to NCEP-ATP III and IDF criteria were included in the study. Accordingly, representative samples of 481 (264 male) and 1,792 (745 male) subjects from the US and Korean NHANES, respectively, were collected, and the estimated US and Korean population represented by each sample was 63.1 million and 15.3 million, respectively.

US and Korean NHANES methodologies have been described in detail previously.[43-44] Briefly, socio-demographic data were collected by personal interview. Anthropometric indices and blood pressure were collected by a standard protocol, and the mean of the 2nd and 3rd systolic and diastolic blood pressure (BP) readings were used for this study. For both surveys, fasting blood glucose (FBG) was measured indirectly by spectrophotometry after an enzymatic reaction, and triglycerides (TG) were indirectly determined by spectrophotometry after hydrolyzation to glycerol and two stages enzymatic reactions. High density lipoprotein cholesterol (HDL-C) was indirectly measured by spectrophotometry after precipitation with sulfated alpha-cyclodextrin and a two stage enzymatic reaction. Low density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald equation (serum total cholesterol – HDL-C – serum TG/5).[45]

Definition of the MetS

The revised NCEP-ATP III [40] and IDF [39] definitions were used to identify individuals with MetS. For the NCEP-ATP III criteria, subjects who had three or more of the following criteria were defined as having the MetS: 1) abdominal obesity: waist circumference > 102 cm in men and > 88 cm in women; 2) hypertriglyceridemia: TG ≥150 mg/dl; 3) low HDL-C: HDL-C <40 mg/dl in men and <50mg/dl in women; 4) high BP: SBP/DBP ≥130/85 mmHg or taking antihypertensive medication; and 5) high fasting plasma glucose: FBG ≥100 mg/dl or taking antidiabetic medication (insulin or oral agents). For the IDF criteria, one must have central adiposity: 1) abdominal obesity: waist circumference ≥ 94 cm in non-Hispanic White men; ≥ 94 cm in non-Hispanic Black men; ≥ 90 in Mexican-American men; ≥ 80 cm for all US women; the KSSO thresholds were: ≥ 90 cm for Korean men; ≥ 85 cm in Korean women; plus two or more of the following factors: 2) hypertriglyceridemia: TG ≥150 mg/dl; 3) low HDL-C: HDL-C <40 mg/dl in men and <50mg/dl in women; 4) high BP: SBP/DBP ≥130/85 mmHg or treatment of previously diagnosed hypertension; and 5) high fasting plasma glucose: FBG ≥100 mg/dl or previously diagnosed type 2 diabetes.

Statistical analysis

Statistical analyses were performed using SAS (version 9.1.3, SAS Institute, Inc., Cary NC, USA) and SAS-callable SUDAAN (version 9.0.3, Research Triangle Institute, Research Triangle Park, NC, USA). A four-stage stratified systematic sampling method was used for sampling in the US and Korean NHANES. For the Korean NHANES, a population-based random sample covering 39,060 persons in 12,283 households across 600 national districts was selected. Data in all statistical analyses for our study were weighted to account for the complex sampling design of US and Korean NHANES which were multistage, stratified, unequally weighted, or clustered. Appropriate statistical sampling weights from each national dataset were selected as specified by each respective survey. Estimated frequencies of categorical variables and mean and standard error of continuous variables were calculated by the PROC DESCRIPT and PROC CROSSTAB procedures of SUDAAN with each national sample weight. Finally, data from the two countries were merged into a single file by creating a new variable that identified the original data set and treated this variable as stratification. T-tests with the NEST statement in the DESCRIPT procedure of SUDAAN were performed to

TABLE 1-1. Weighted average values of the factors used to diagnose the metabolic syndrome: the US NHANES 2003-04, Korea NHANES 2005.

	N†	WC‡	FBG§	TG¶	HDL-C††	SBP‡‡	DBP§§
Male,20-29yrs							
US	139 (15.5m)	94.9±1.1	94.1±1.5	142.1±14.6	48.4±1.3	117.9±0.9	67.3±1.3
Korea	264 (3.7m)	79.7±0.6***	86.3±0.6***	113.9±5.2	44.5±0.7**	114.9±0.7*	76.2±0.7***
Male,30-39yrs							
US	125 (17.6m)	100.5±1.8	97.4±1.0	145.4±11.4	48.8±1.6	118.3±1.5	74.1±1.9
Korea	481 (4.2m)	83.1±0.4***	90.7±0.5***	158.8±8.3	41.6±0.4***	116.5±0.6	79.2±0.6*
Male, Total							
US	264 (33.1m)	97.9±1.0	95.9±0.9	143.8±8.6	48.7±1.1	118.1±1.1	70.9±0.8
Korea	745 (8.0m)	81.5±0.4***	88.6±0.4***	137.8±5.1	43.0±0.4***	115.7±0.5*	77.8±0.5***
Female,20-29yrs							
US	98 (12.5m)	89.8±1.3	88.9±0.6	101.9±6.0	55.2±1.8	108.9±0.8	66.4±0.9
Korea	375 (3.5m)	72.0±0.6***	84.4±0.5***	83.8±2.6**	49.4±0.6**	103.9±0.6***	69.1±0.6*
Female,30-39yrs							
US	119 (17.5m)	94.5±1.9	92.6±1.3	130.5±11.6	57.1±1.8	111.0±1.0	69.4±0.8
Korea	672 (3.9m)	74.9±0.4***	88.8±0.8*	90.1±2.2***	48.4±0.5***	105.8±0.6***	70.8±0.5
Female, Total							
US	217 (29.9m)	92.6±1.1	91.1±0.8	118.6±7.5	56.3±1.4	110.1±0.8	68.1±0.7
Korea	1,047 (7.3m)	73.5±0.4***	86.7±0.5***	87.1±1.7***	48.9±0.4***	104.9±0.4***	70.0±0.4*
Country, Total							
US	481 (63.1m)	95.4±0.7	93.6±0.8	131.9±7.0	52.3±0.9	114.3±0.8	69.6±0.7
Korea	1,792 (15.3m)	77.7±0.3***	87.7±0.4***	113.5±2.9*	45.8±0.3***	110.5±0.4***	74.1±0.4***

Data are mean ± SE.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$ show significant differences between the US and Korea.
† N, sample size (estimated population represented in millions).
‡ WC, Waist Circumference (cm) § FBG, Fasting Blood Sugar (mg/dl).
¶ TG, Triglycerides (mg/dl) †† HDL-C, High Density Lipoprotein Cholesterol (mg/dl).
‡‡ SBP, Systolic Blood Pressure (mmHg) §§ DBP, Diastolic Blood Pressure (mmHg).

compare stratum means and percentages between the two countries. All statistics were presented as mean ± standard error (SE) for continuous variables and frequency percentage (SE) for all categorical measures. A p value of < 0.05 was considered statistically significant.

RESULTS

In the US data, non-Hispanic Whites comprised the highest proportion of those surveyed (73.2%); Mexican-Americans and non-Hispanic Blacks constituted 12.9% and 13.9%, respectively (data not shown). Table 1-1 and table 1-2 show BMI and metabolic characteristics of young adults 20-39 years of age from both NHANES. The mean waist circumference of US males and females was significantly higher by 15 and 20 cm, respectively, than those of Koreans (both genders, $p<0.001$). US subjects had a significantly higher FBG than Koreans subjects ($p<0.001$). Triglycerides in US females were higher than in Korean females ($p<0.001$), but there was no significant difference in males. Koreans had significantly lower concentrations of HDL-C than Americans ($p<0.001$). The average SBP of Americans was higher than that of Koreans overall ($p<0.001$) except for males aged 30 to 39 years, whereas DBP in both US age groups was significantly lower than Koreans ($p<0.05$ to $p<0.001$). The mean BMI, LDL-C, TC, and pulse pressure of US subjects was significantly higher than that of Koreans (all, $p<0.001$).

The estimated prevalence of the MetS and abnormalities of individual components as defined by the IDF and NCEP-ATP III are shown in table 2. The estimated prevalence of the MetS in the US (21.6%) was nearly three times higher than in Korea (6.9%) using NCEP-ATP III criteria ($p<0.001$) and likewise was more than three fold higher in the US (23.0%) versus Korea (6.9%) using IDF criteria ($p<0.001$). The difference was more pronounced in females than in males. Americans had a significantly higher prevalence of abdominal obesity than Koreans using both criteria (overall, $p<0.001$). The prevalence of abdominal obesity using the NCEP-ATP III criteria in US males 30-39 years of age (39.9%) was nearly 30 times higher than in Koreans (1.5%), and the highest rate using the IDF abdominal obesity definition was in the US female 30-39 age group (81.2%). The estimated prevalence of elevated FBG in the US was also higher than in Korea ($p<0.001$), and the difference was markedly greater among males than females.

Hypertriglyceridemia did not show a significant difference between subjects combining both genders in the US and Korea; Korean males 30-39 years had significantly

TABLE 1-2. Weighted average values of other CVD risk factors related to the metabolic syndrome: the US NHANES 2003-04, Korea NHANES 2005.

	BMI †	LDL-C‡	TC§	LDL:HDL	TC:HDL	Pulse pressure¶
Male,20-29yrs						
US	27.0±0.4	102.7±2.4	176.7±3.1	2.2±0.1	3.9±0.1	50.6±1.6
Korea	23.3±0.2***	105.6±1.9	172.9±2.3	2.5±0.1*	4.0±0.1	38.6±0.6***
Male,30-39yrs						
US	28.8±0.7	120.5±4.4	196.7±4.1	2.6±0.2	4.3±0.2	44.2±1.0
Korea	24.2±0.2***	110.2±2.1*	183.6±1.7**	2.7±0.1	4.6±0.1	37.3±0.4***
Male, Total						
US	28.0±0.3	112.2±2.6	187.3±2.4	2.4±0.1	4.1±0.1	47.2±0.8
Korea	23.8±0.1***	108.1±1.4	178.6±1.4**	2.6±0.0	4.3±0.0	37.9±0.4***
Female,20-29yrs						
US	26.5±0.3	99.2±2.9	174.8±3.6	2.0±0.1	3.4±0.1	42.5±1.0
Korea	21.6±0.2***	98.0±1.4	164.2±1.7**	2.1±0.0	3.4±0.0	34.8±0.5***
Female,30-39yrs						
US	29.1±0.9	115.9±3.1	200.9±4.9	2.2±0.1	3.8±0.2	41.6±0.5
Korea	22.6±0.1***	105.4±1.1**	171.8±1.4***	2.3±0.0	3.7±0.0	34.9±0.4***
Female, Total						
US	28.1±0.5	108.9±2.7	190.0±3.8	2.1±0.1	3.6±0.1	42.0±0.5
Korea	22.1±0.1***	101.9±0.9*	168.2±1.2***	2.2±0.0	3.6±0.0	34.9±0.3***
Country, Total						
US	28.0±0.3	110.6±1.8	188.6±2.2	2.3±0.1	3.9±0.1	44.7±0.4
Korea	23.0±0.1***	105.1±0.9**	173.6±1.0***	2.4±0.0	4.0±0.0	36.5±0.3***

Data are mean ± SE.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$ show significant differences between the US and Korea.
† BMI, Body Mess Index (kg/m^2).
‡ LDL-C, Low Density Lipoprotein-Cholesterol (mg/dl), LDL-C = [total cholesterol level - HDL – (triglyceride level ÷ 5)].
§ TC, Total Cholesterol (mg/dl). ¶ pulse pressure= SBP-DBP.

higher TG than the US participants ($p<0.05$), whereas US females had a significantly higher prevalence in both age groups (both, $p<0.01$). The prevalence of low HDL-C levels in Korea was significantly higher than in the US ($p<0.001$), and the difference was most apparent in males 30-39 years of age and in females. There was no statistical difference in the prevalence of high BP between subjects combining both genders in the US and Korea. Stratified analyses of BP revealed that there was no difference between males in the two countries while among females aged 30-39 years ($p<0.05$), Americans had significantly higher rates of hypertension than Koreans.

Using the NCEP-ATP III definition, the proportion of subjects meeting at least one criterion was not different between the two nations; however, there was a difference using the IDF definition. Based on the IDF criteria, the proportion of individuals with more than one metabolic abnormality, which must include at least abdominal obesity, was significantly higher in the US than in Korea overall (64.4% and 14.2%, respectively, $p<0.001$) (Table 3). US subjects had a higher frequency of two or three component abnormalities than Koreans ($p<0.001$), and the frequency of Americans with more than four components was also more prevalent in males and females ages 30-39 years ($p<0.05$) than in Koreans.

DISCUSSION

This study utilized the 2003-2004 US NHANES and the 2005 KNHANES to assess the prevalence of the MetS and abnormalities in its component measures using two definitions. The results that we obtained differed markedly depending on the definition of the MetS that was applied. This can be attributed to the individual focus of each definition; i.e., ATP-III is concerned with CVD risk factors, and IDF with central obesity. The proportion of non-Hispanic Whites, Mexican Americans, and non-Hispanic Blacks in our US sample was similar to recent US Census figures for the US population as a whole.[46] The prevalence of the MetS using either the NCEP-ATP III or IDF criteria was approximately three times higher among US young adults (21.6% and 23.0%, respectively) than among Koreans (6.9% with both definitions). Using census data, this translates into approximately 14 million Americans and 1 million Korean young adults who meet the definition of MetS. There has been a steady increase in the prevalence of the MetS in the US 20-39 year age group. The current US figures have risen from NHANES III 1988-1994 (male 15.7%, female 10.8%) and NHANES 1999-2000 (male 16.5%, female 19.1%).[32] In comparison to our prevalence estimates of the MetS in young Korean adults (6.9%), a study of Korean workers aged 30 – 60 years old showed a prevalence of 7% and 13% using two versions of the NCEP-ATP III criteria.[47]

TABLE 2. Estimated prevalence of metabolic syndrome and individual components by NCEP/ATPIII (2004) and IDF (2005) criteria: the US NHANES 2003-04, Korea NHANES 2005.

	MetS †	Abdominal obesity	Hyperglycemia	Hypertriglyceridemia	Low HDL-C	High BP
NCEP/ATPIII criteria						
Male,20-29yrs						
US	16.6 (4.4)	25.4 (3.3)	19.1 (4.0)	25.2 (5.4)	23.8 (5.2)	19.1 (4.0)
Korea	4.7 (1.3)*	3.2 (1.4)***	2.8 (1.1)***	20.5 (3.2)	30.1 (3.4)	19.1 (2.7)
Male,30-39yrs						
US	28.2 (4.6)	39.9 (5.7)	31.4 (2.8)	27.5 (3.0)	23.2 (5.3)	32.9 (5.4)
Korea	14.4 (1.6)**	1.5 (0.6)***	13.3 (1.5)***	37.0 (2.7)*	48.2 (2.4)***	29.0 (2.2)
Male, Total						
US	22.8 (3.3)	33.1 (3.0)	25.6 (2.6)	26.4 (2.6)	23.5 (4.4)	26.4 (3.3)
Korea	9.8 (1.1)***	2.3 (0.8)***	8.4 (1.0)***	29.3 (2.1)	39.7 (2.2)**	24.4 (1.7)
Female,20-29yrs						
US	18.6 (3.0)	44.2 (3.4)	9.8 (2.1)	18.4 (4.0)	41.2 (6.2)	6.1 (2.6)
Korea	1.2 (0.5)***	5.2 (1.3)***	1.9 (0.9)***	6.7 (1.4)**	57.1 (3.1)*	2.6 (0.9)
Female,30-39yrs						
US	21.5 (4.5)	60.8 (6.7)	12.3 (3.3)	24.4 (4.1)	36.7 (5.6)	11.9 (2.8)
Korea	5.9 (1.0)**	8.3 (1.3)***	7.3 (1.0)	10.2 (1.3)**	59.1 (2.3)***	6.0 (1.0)*
Female, Total						
US	20.3 (2.8)	53.9 (3.8)	11.2 (2.3)	21.9 (3.5)	38.6 (4.4)	9.5 (1.7)
Korea	3.7 (0.6)***	6.9 (0.9)***	4.8 (0.7)**	8.5 (1.0)***	58.2 (1.9)***	4.4 (0.6)**
Country, Total						
US	21.6 (2.4)	43.0 (1.8)	18.8 (2.1)	24.3 (2.4)	30.6 (2.9)	18.4 (2.1)
Korea	6.9 (0.6)***	4.5 (0.7)***	6.7 (0.6)***	19.4 (1.3)	48.6 (1.5)***	14.8 (1.0)
IDF criteria						
Male,20-29yrs						
US	17.5 (4.5)	47.3 (4.9)	19.1 (4.0)	25.2 (5.4)	23.8 (5.2)	19.1 (4.1)
Korea	5.3 (1.5)*	11.6 (2.2)***	3.4 (1.2)***	20.5 (3.2)	30.1 (3.4)	19.1 (2.7)
Male,30-39yrs						
US	32.7 (4.4)	62.5 (6.0)	31.4 (2.8)	27.5 (3.0)	23.2 (5.3)	32.9 (5.4)
Korea	14.6 (1.7)***	21.8 (2.0)***	13.3 (1.5)***	37.0 (2.7)*	48.2 (2.4)***	29.0 (2.2)
Male, Total						
US	25.6 (3.4)	55.4 (3.9)	25.6 (2.6)	26.4 (2.6)	23.5 (4.4)	26.4 (3.3)
Korea	10.2 (1.1)***	17.0 (1.5)***	8.7 (1.0)***	29.3 (2.1)	39.7 (2.2)**	24.4 (1.7)
Female,20-29yrs						
US	17.8 (3.5)	65.0 (4.0)	9.8 (2.1)	18.4 (4.0)	41.2 (6.2)	6.1 (2.6)
Korea	0.7 (0.4)***	8.8 (1.8)***	2.2 (0.9)**	6.7 (1.4)**	57.1 (3.1)*	2.6 (0.9)
Female,30-39yrs						
US	21.8 (4.4)	81.2 (3.2)	12.3 (3.3)	24.4 (4.1)	36.7 (5.6)	11.9 (2.8)
Korea	5.5 (1.0)***	13.1 (1.6)***	7.4 (1.0)	10.2 (1.3)**	59.1 (2.3)***	6.0 (1.0)*
Female, Total						
US	20.2 (2.8)	74.4 (2.4)	11.2 (2.3)	21.9 (3.5)	38.6 (4.4)	9.5 (1.7)
Korea	3.2 (0.5)***	11.0 (1.2)***	4.9 (0.7)**	8.5 (1.0)***	58.2 (1.9)***	4.4 (0.6)**
Country Total						
US	23.0 (2.4)	64.4 (2.4)	18.8 (2.1)	24.3 (2.4)	30.6 (2.9)	18.4 (2.1)
Korea	6.9 (0.6)***	14.2 (1.0)***	6.9 (0.6)***	19.4 (1.3)	48.6 (1.5)***	14.8 (1.0)

Data are percent (SE).
* $p<0.05$, ** $p<0.01$, *** $p<0.001$: Significant difference between the US and Korea.
† MetS, Metabolic Syndrome: NCEP/ATP III definition: participants who had three or more of the following risk determinants: abdominal obesity (WC >102 cm in male and >88 cm in female), hyperglycemia (FBG ≥100 mg/dl or the participants who currently reported using antidiabetic medication - insulin or oral agents), hypertriglyceridemia (TG ≥150 mg/dl), low HDL-C (HDL-C <40 mg/dl in male and <50 mg/dl in female), high BP (SBP ≥130 mmHg or DBP ≥85 mmHg or the participants who currently reported using antihypertensive medication). IDF definition: participants having central adiposity (WC: the US male : Mexican-American> 90 cm, non-Hispanic White >94 cm, non-Hispanic Black >94 cm; female : all races >80, Korean male ≥90cm, Korean female ≥85cm) plus two or more of the following four factors : hyperglycemia (FBG ≥100 mg/dl or previously diagnosed type 2 diabetes, hypertriglyceridemia (TG ≥150 mg/dl), low HDL-C (HDL-C <40 mg/dl in male and <50 mg/dl in female), high BP (SBP ≥130 mmHg or DBP ≥85 mmHg or treatment of previously diagnosed hypertension)

In our study, the IDF definition led to higher estimates of the prevalence of abdominal obesity than the NCEP-ATP III criteria. This is a result of the lower thresholds for central obesity used as part of the IDF criteria that are based on ethnicity. However, the difference in the prevalence of abdominal obesity did not markedly change the overall prevalence of the MetS since the other four criteria are defined nearly identically.[48] The IDF definition may provide a more accurate assessment of the prevalence of abdominal obesity in the US than the NCEP-ATP III definition because it uses ethnic-based cut points for waist circumference. There is still disagreement over the

TABLE 3. Distribution according to the number of metabolic abnormalities: the US NHANES 2003-04, Korea NHANES 2005

	≥1	≥2	≥3	≥4	5
NCEP/ATPIII criteria					
Male,20-29yrs					
US	59.2 (6.4)	33.5 (4.2)	16.6 (4.4)	2.4 (1.4)	0.7 (0.7)
Korea	52.1 (3.8)	18.1 (2.7)**	4.7 (1.3)*	1.0 (0.6)	0.0 (-)
Male,30-39yrs					
US	71.4 (5.2)	41.4 (4.7)	28.2 (4.6)	11.5 (3.2)	2.2 (1.5)
Korea	71.8 (2.2)	39.2 (2.5)	14.4 (1.6)**	3.7 (0.8)*	0.0 (-)
Male, Total					
US	65.7 (4.2)	37.7 (3.9)	22.8 (3.3)	7.3 (1.8)	1.5 (1.1)
Korea	62.6 (2.3)	29.3 (1.8)	9.8 (1.1)***	2.4 (0.5)*	0.0 (-)
Female,20-29yrs					
US	63.3 (5.3)	33.6 (4.2)	18.6 (3.0)	4.3 (2.1)	0.3 (0.2)
Korea	61.6 (3.0)	10.5 (1.9)***	1.2 (0.5)***	0.2 (0.2)	0.0 (-)
Female,30-39yrs					
US	73.5 (5.0)	41.2 (6.5)	21.5 (4.5)	8.9 (3.6)	1.2 (1.2)
Korea	63.9 (2.1)	19.5 (1.8)**	5.9 (1.0)**	1.2 (0.5)*	0.3 (0.2)
Female, Total					
US	69.2 (4.3)	38.0 (3.5)	20.3 (2.8)	7.0 (2.4)	0.7 (0.7)
Korea	62.9 (1.8)	15.3 (1.4)***	3.7 (0.6)***	0.8 (0.3)**	0.2 (0.1)
Country, Total					
US	67.4 (2.6)	37.9 (2.5)	21.6 (2.4)	7.1 (1.2)	1.1 (0.7)
Korea	62.7 (1.4)	22.6 (1.2)***	6.9 (0.6)***	1.6 (0.3)***	0.1 (0.1)
IDF criteria					
Male,20-29yrs					
US	47.3 (4.9)	33.8 (3.4)	17.5 (4.5)	2.8 (1.5)	0.7 (0.7)
Korea	11.6 (2.2)***	10.3 (2.1)***	5.3 (1.5)*	2.0 (0.9)	0.7 (0.6)
Male,30-39yrs					
US	62.5 (6.0)	47.4 (4.7)	32.7 (4.4)	13.5 (3.1)	2.2 (1.5)
Korea	21.8 (2.0)***	19.1 (1.8)***	14.6 (1.7)***	5.6 (1.0)*	2.6 (0.6)
Male, Total					
US	55.4 (3.9)	41.0 (2.9)	25.6 (3.4)	8.5 (1.7)	1.5 (1.1)
Korea	17.0 (1.5)***	15.0 (1.4)***	10.2 (1.1)***	4.0 (0.7)*	1.7 (0.4)
Female,20-29yrs					
US	65.0 (4.0)	39.8 (5.7)	17.8 (3.5)	4.3 (2.1)	0.0 (-)
Korea	8.8 (1.8)***	6.5 (1.5)***	0.7 (0.4)***	0.2 (0.2)	0.0 (-)
Female,30-39yrs					
US	81.2 (3.2)	47.5 (5.6)	21.8 (4.4)	8.9 (3.6)	1.2 (1.2)
Korea	13.1 (1.6)***	10.4 (1.4)***	5.5 (1.0)***	1.5 (0.5)*	0.3 (0.2)
Female Total					
US	74.4 (2.4)	44.3 (3.8)	20.2 (2.8)	7.0 (2.4)	0.7 (0.7)
Korea	11.0 (1.2)***	8.5 (1.1)***	3.2 (0.5)***	0.9 (0.3)*	0.2 (0.1)
Country, Total					
US	64.4 (2.4)	42.6 (2.6)	23.0 (2.4)	7.8 (1.2)	1.1 (0.7)
Korea	14.2 (1.0)***	11.9 (0.9)***	6.9 (0.6)***	2.5 (0.4)***	1.0 (0.2)

Data are percent (SE).
* $p<0.05$, ** $p<0.01$, *** $p<0.001$ show a significant difference between the US and Korea.

appropriate cut-off point for waist circumference that defines abdominal obesity in Koreans.[49] Some researchers have asserted that the NCEP-ATP III-defined waist circumference criterion is not appropriate for Koreans,[4, 34] while a recent study declared that the IDF definition is inferior to the NCEP-ATP III criteria for Koreans because a number of Koreans not meeting the IDF definition had more adverse metabolic profiles than others having the

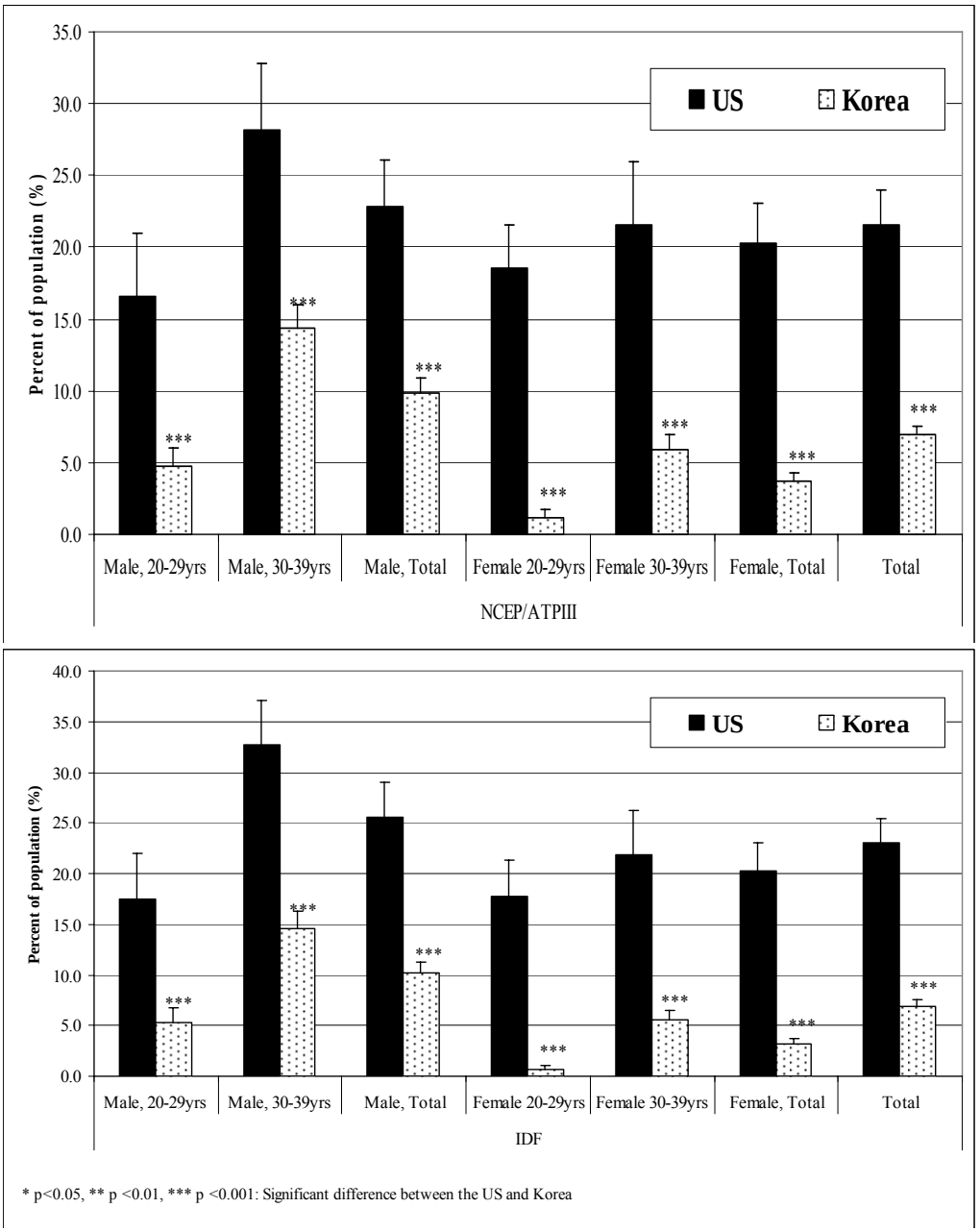

FIGURE 1. (Estimated prevalence of metabolic syndrome in the US and Korea), the fonts of figure between NCEP/ATPIII and IDF were different

MetS by both criteria.[50] The DECODA (Diabetes Epidemiology Collaborative Analysis of Diagnostic Criteria in Asia) Study Group indicated that waist circumference may not be the most sensitive measurement of central obesity in Asian populations. The Group also mentioned that while using IDF criteria brought a dramatic rise in the prevalence of central obesity, the overall prevalence of the MetS did not increase greatly compared with the NCEP-ATP III definition.[51] This finding was corroborated in our study.

Mean waist circumference and the prevalence of abdominal obesity were significantly higher in the US than in Korea, and they were most noteworthy in the ages of 30-39 years. Similarly, Patel et al.[52] reported that abnormal waist circumference was considerably more prevalent among individuals with the MetS in the US compared with their Asian counterparts aged 35 years and above. However, Nestel et al.[53] has noted a recent increase in the prevalence of the metabolic derangements associated with abdominal adiposity in East and Southeast Asia.

Ethnic differences in insulin sensitivity may explain the higher FBG levels and prevalence of hyperglycemia found in the US.[40, 54, 55] However, the DECODA Study Group indicated that lowering the cut-points for obesity and hyperglycemia did not help to identify more subjects who have three or more risk factors.[53] The US has a heterogeneous mixture of ethnicities, and there are many studies demonstrating different rates of insulin resistance and type 2 diabetes between races/ethnicities.[55-59] Additional ethnic-based standards need to be developed to evaluate elevated FBG and to modify the cutoffs appropriately.[41]

An increase in two factors, serum TG and obesity, accounted for much of the increased prevalence of the MetS during young adulthood.[10] Levels of TG's have been shown to be inversely associated with HDL-C,[60] and the

characteristic dyslipidemia with elevated TG and reduced HDL-C levels is regarded as a cardinal sign of insulin resistance.[61] However, subjects from the two countries in this study showed paradoxical lipid profiles, namely, higher TGs in the US and lower HDL-C in Korea. The high prevalence of subnormal HDL-C levels among Asians has been mentioned previously.[62] Decreased HDL-C among Korean adults has been associated with factors such as smoking, obesity, carbohydrate and fat intake in the diet, decreased alcohol consumption and physical activity, low education level, and family history.[63-66] On the other hand, other researchers have insisted that ethnic differences can be explained by genetic factors rather than environmental causes like lifestyle.[60, 67] Their contention that Asians are genetically predisposed to low HDL-C could also help to explain why low HDL-C was more prevalent in Korea than in the US in our study. Overall, there appears to be little difference between the two groups in cardiac risk associated with adverse lipid profiles. Both TC:HDL and LDL:HDL ratios have been used as predictors of future cardiac events,[68] and we saw no significant difference in these two markers between Koreans and Americans. The ethnic variation in dyslipidemias, whether of genetic or environmental origin, is a rich field for further research.

Several interesting findings concerning BP in the two countries were noted in our study. First, when genders were combined, the prevalence of high BP did not significantly differ between the two countries. The prevalence of hypertension in US adults over the last few decades has declined rapidly from 64% (NHANES 1971-1974) to 37% (NHANES 1999-2000),[69] which can partially explain the similar prevalence in the two countries. Secondly, there was no difference in the prevalence of high BP between the two countries despite the three-fold higher prevalence of the MetS in the US. Although BP is a criterion for the MetS, the association between hypertension and "insulin resistance" has been controversial. Some researchers have argued that there is minimal correlation between high BP and the metabolic derangements associated with hyperinsulinemia.[70-73] Finally, we found a higher mean SBP in the US, whereas a higher DBP in Korea, demonstrating a racial/ethnic specific variation in BP patterns. An increased difference in systolic and diastolic pressures (or "pulse pressure") has been implicated in the pathogenesis of atherosclerosis and higher rates of CVD. We found that Americans had higher pulse pressures (44.8 +/- 0.5 vs 36.5 +/- 0.3, $p<0.001$). This finding implies an earlier onset of atherosclerosis in the US and an increased risk for future coronary events.[74-81]

The difference in components of the MetS, such as lipid profiles and BP, between Asians and other races has not been well studied; however, there have been some reports of differences among non-Asian ethnicities in the United States.[55, 82, 83] Banerjee & Misra[41] suggested that the high BP criterion used in the diagnosis of the MetS should be altered by either changing the cutoffs for different populations or weighting the individual criteria based on their risk contribution to CVD in each population.

The proportion of subjects having at least one component of the MetS was similar in both countries. However, the difference between subjects in the two countries grew with the number of metabolic abnormalities measured. Although Korean young adults had a lower prevalence of the MetS than Americans, the number of risk factors increased faster with age in Koreans than in the Americans. In particular, 30-39 year-old Korean females had a greater than five times increase in risk factors in comparison with their 20-29 year-old counterparts. Therefore, our study suggests that in-depth analyses by gender in each country relating to lifestyle and other contributors of the MetS over time in young adulthood are needed.

Our study had several limitations. While both surveys used similar laboratory methods, each survey used its own set of reference laboratories to analyze the samples, which may contribute to differences in results between countries. The studies were cross-sectional and therefore causal inferences cannot be made. Finally, our samples may not be representative of each country since not all participants were selected for and/or completed the required fasting phlebotomy.

In conclusion, our study reported several metabolic abnormalities in US and Korean young adults. Young adults in the US had a much higher prevalence of the MetS than in Korea; however, the prevalence of abnormalities in the individual components increases faster with age in Koreans. Most indicators of the MetS, viz. the prevalence of abdominal obesity, hyperglycemia, and hypertriglyceridemia, were higher in US young adults while the prevalence of low HDL-C levels was higher in Koreans. Cardiac risk from adverse lipid profiles did not appear to be significantly different in the two groups. The prevalence of hypertension overall did not differ, but young American adults had higher pulse pressures, which suggests earlier onset and greater prevalence of atherosclerosis. These findings also demonstrated that race/ethnic specific norms for components of the MetS such as waist circumference, FBG, and BP should be developed after these variables are correlated in outcomes-related research. This would guide health policy by quantifying CVD risk, identifying determinants of the syndrome for young adults in both countries, and encouraging young adults to make healthy lifestyle choices. While our study does not elucidate the underlying pathophysiologic origins of the Metabolic Syndrome, comparative studies between ethnic/racial groups may help find commonalities and differences which help to unlock the basis of the syndrome. Our findings also support early screening and intervention in each nation and their implementation into national health policies as the MetS causes an increase in morbidity and mortality, resulting in greatly increased US and Korean health care costs. National health policies designed to prevent the MetS, its individual abnormalities, and its complications using population-based characteristics of each nation will generate improved outcomes.

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AUTHOR DISCLOSURES

Jinkyung Park, Jason A. Mendoza, Carol E. O'Neil, David C. Hilmers, Yan Liu, and Theresa A. Nicklas, no conflicts of interest.

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Original Article

A comparison of the prevalence of the metabolic syndrome in the United States (US) and Korea in young adults aged 20 to 39 years

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美國與韓國年輕成人(20-39 歲)代謝综合症盛行率之比較

本研究采用 2003-2004 年美国和 2005 年韩国健康和营养调查的数据来对年轻成年人(20-39 岁)中新陈代谢综合症及其个别成分的流行性作了评估和比较。美国年轻成人的平均身体质量指数和代谢异常盛行率比韩国人显著的高。采用美国胆固醇教育计划-ATPIII 和国际糖尿病联盟的标准来衡量，美国人代谢综合症盛行率比韩国人約高三倍(21.6%比 6.9%及 23.0%比 6.9%，p<0.001)。腹部肥胖, 高血糖和高甘油三酯症的盛行率在美国比较高，而低的高密度脂蛋白胆固醇的比例在韩国比较高。高血压盛行率並没有显著的差别，但两国年轻成人的平均血管收缩压和舒张压都有差異。具有至少一个代谢综合症成分的对象的比例在这两个国家是相似的，但是有多重异常性的人在美国更常见。这些发现表明: 有必要开发研究基于种族/族群的代谢综合症的成分的标准，以及详细分析代谢综合症在这两个国家的危险因子。制定以每个国家的人口特征为基础的，用以預防代谢综合症以及个别异常症和并发症的国家健康政策，将产生改善效果。

關鍵字：国家健康和营养调查、美国、韩国、美国胆固醇教育计划-ATPIII、国际糖尿病联盟、新陈代谢综合症