Original Article

Obesity, abdominal obesity, and clustering of cardio-vascular risk factors in South Korea

Hye Soon Park MD, PhD [1], Yeong Sook Yun MD [2], Jung Yul Park MD, PhD [3], Young Seol Kim MD, PhD [4], Joong Myung Choi MD, PhD [5]

[1]*Department of Family Medicine,Ulsan University, Seoul, Korea;* [2]*Inje University, Seoul, Korea*
[3]*Department of Neurosurgery, Korea University, Seoul, Korea;* [4]*Department of Endocrinology Kyunghee University, Seoul, Korea* [5]*Department of Preventive Medicine, Kyunghee University, Seoul, Korea*

The aim of this study was first, to investigate the prevalence of obesity, abdominal obesity, and clustering of cardiovascular (CVD) risk factors, and secondly, to identify the BMI or waist circumference (WC) level at which clustering increases in South Koreans. A population-based, cross-sectional National Health Examination Survey was carried out in 1998. A total of 8,816 subjects (4,029 men and 4,787 women) aged 15-79y were selected by stratified multistage probability sampling design. The measurements taken of the subjects included: height, weight, waist and hip circumference, blood pressure, fasting glucose, and lipids. The prevalence of BMI ≥25 kg/m^2 was 25.3% for men and 28.3% for women. The prevalence of WC >90 cm in men, and >80 cm in women was 18.5%, and 38.5%, respectively. Clustering of 3 or more CVD risk factors was 22.7% in men ad 21.7% in women. Using <21 kg/m^2 as a referent, subjects with BMI of 23 kg/m^2 and 27 kg/m^2 had an odds ratio of 3.5 and 10.2 in men, and 3.1 and 6.7 in women, respectively for clustering of CVD risk factors. Using <65 cm as a referent, subjects with a WC of ≥90 cm in men and ≥85 cm in women had an odds ratio of 13.4, and 13.6, respectively for clustering of CVD risk factors. Considering the significant associations between clustering of CVD risk factors and BMI or WC, the present study suggests that high prevalence of overweight –may have important implications for the health care system, even at a lower level of BMI or WC.

Key word: obesity, abdominal obesity, BMI, waist circumference, clustering, CVD risk factors, Korea

Introduction

The prevalence and incidence of obesity are increasing rapidly in both developed and developing countries.[1] While the prevalence of obesity in Asian populations is lower than that of Caucasians, the health risks associated with obesity occur at a lower body mass index (BMI).[2] Accordingly, the criteria of overweight and obesity in the Asian-Pacific region of WHO have been proposed as BMI ≥23 kg/m^2, and BMI ≥25kg/m^2, respectively.[2] Abdominal obesity has also been found to be a contributor to CVD disease at a given level of obesity.[3-5] The cut-off values of WC used for abdominal obesity are 90cm for men and 80cm for women in Asian populations.[2] Abdominal obesity promotes insulin resistance and leads to metabolic syndrome.[6, 7]

The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) proposed the importance of metabolic syndrome in assessment and management of cardiovascular diseases (CVD).[8] The cut-off values for diagnosis of metabolic syndrome were established at lower levels compared to conventional values. As described in the NCEP ATP III report, participants having 3 or more of the following criteria were defined as having the metabolic syndrome; blood pressure: ≥130/≥85 mmHg; fasting glucose: ≥110 mg/dl; hypertriglyceridemia: ≥150 mg/dl; low high-density lipoprotein cholesterol (HDL-C): <40 mg/dl in men and <50mg/dl in women, and abdominal obesity: WC >102 cm in men and >88 cm in women. Clustering of CVD risk factors presented a higher risk of atherosclerotic diseases compared to a single risk factor.[9]

South Korea, like other Asian countries, has experienced rapid socioeconomic growth with prominent lifestyle transformation over the past several decades. The consumption of food has increased rapidly and physical labors have decreased as urbanization has grown. Cardiovascular diseases are rapidly increasing and becoming a common cause of death in South Korea.[10] The death rates for stroke ranked second in mortality for both men and women in South Korea. The death rate for ischemic heart disease has increased by 106.7% over the last decade. [11]

Correspondence address: Hye Soon Park, Dept. of Family Medicine, Asan Medical Center, University of Ulsan College of Medicine,388-1 Pungnap-dong,Songpa-gu,Seoul, St Korea 138-736
Tel: (82)-2- 3010-3813, Fax: (82)-2-3010-3290
Email: hyesoon@amc.seoul.kr
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Nevertheless, little is known regarding the recent prevalence of clustering of CVD risk factors, nor the BMI or WC cut-off points at which clustering increases among Koreans. The aims of this study were: 1. to assess the prevalence of obesity and abdominal obesity according to Asia-Pacific guidelines; 2. to identify clustering of CVD risk factors as defined by NCEP ATP III and 3. to identify the BMI and WC level at which clustering of CVD risk factors increases in South Koreans.

Subjects and methods

Study population

The Korean National Health Examination Survey was conducted among non-institutionalized civilian Korean population groups examined in 1998 in South Korea. A stratified multistage probability sampling design was used, with selection made from sampling units based on geographic area, sex, and age groups using household registries. A number of 9,771 persons took part in the Health Examination Survey. Among them, we analyzed the data of 8,816 subjects, aged ≥15 y and <80 y of whom 45.7% (4,029 persons) were men while 54.3% (4,787 persons) were women. The study was approved by the Ethics Committee of the regional society.

Anthropometric measurements

The examinations were conducted in a home setting by well-trained examiners. Technicians were educated to precisely measure anthropometic measurements according to guidelines. Anthropometric measurements were performed with subjects wearing light clothing but without shoes. Height was measured in metres to the nearest 0.1 cm using the Harpenden portable stadiometer. Weight was measured in the upright position using a calibrated balance beam scale to the nearest 0.1kg. Body mass index (BMI) was calculated by dividing weight (kg) by height^2 (m^2). Waist and hip circumferences were taken with a non-elastic tape measure. The waist circumference (WC) was measured at the end of normal expiration at the midpoint between the lower border of the rib cage and the iliac crest.[1] For hip circumference, the tape was positioned around the hips at the level of the symphysis pubis and the greatest gluteal protuberance. Waist-to-hip ratio (WHR) was calculated by dividing waist circumference by hip circumference. According to Asia-Pacific regional guidelines,[2] obesity for men and women was defined as BMI ≥25 kg/m^2. Abdominal obesity was defined as WC >90 cm for men and >80 cm for women.

Cardiovascular (CVD) risk factors

Blood pressure was measured in a home setting using a mercury sphygmomanometer in the sitting position after a 10 min rest. Korotkov sound I and V were taken as the systolic and diastolic blood pressure. Blood samples were obtained in the morning after 12 hours of overnight fasting from an antecubital vein and stored in a vacutainer tubes containing EDTA and subsequently analyzed at central laboratory, which is certified under a lipid standardization program. Plasma glucose was measured by glucose oxidase method and total cholesterol and triglyceride levels by enzymatic procedures using an autoanalyzer. The high density lipoprotein (HDL) fraction was obtained after precipitation of apo-B containing lipoproteins with $MnCl_2$. Low density lipoprotein (LDL) cholesterol was calculated by Friedewald equation if triglyceride was below 400mg/dl.[12] We assessed CVD risk factors as prevalent conditions for each item by NCEP ATP III[8]: (1) blood pressure ≥130 / or ≥85 mmHg, (2) fasting glucose ≥110 mg/dl, (3) LDL-C ≥130 mg/dl, (4) triglyceride ≥150 mg/dl, (5) HDL-C <40 mg/dl for men, and <50 mg/dl for women. Clustering was defined as presence of three or more of the above CVD risk factors.

Statistical analysis

Statistical analysis was conducted using the SAS version 8.1. Data were expressed using gender-specific mean values and standard deviations for continuous variables and age- and gender- specific proportions for discrete variables. We used student t-test and chi-square test to examine the gender difference of continuous variables and categorical variables, respectively. Chi-square test for trend was used to examine the significance of increase in frequency across age. The study subjects were divided into five groups according to either BMI or WC percentiles (< 25 %, 25-50 %, 50-75 %, 75-90 %, and >90 %) for each gender to investigate the relationships between BMI or WC and clustering of CVD risk factors. The values of each percentile of BMI were 21.0, 23.0, 25.0, 27.0 kg/m^2 for men, and 21.0, 23.0, 25.0, 27.5 kg/m^2 for women. The cut-off points for each percentile of WC were 77.0, 83.0, 88.5, 94.0 cm for men, and 71.0, 78.0, 85.0, 91.5 cm for women. The Cochran-Mantel-Haenszel test was used to clarify the relationship between clustering of CVD risk factors and BMI or WC in stratified age groups. The odds ratios were calculated using multiple logistic regression analysis with adjustments for age, residential area, marital status, education level, economic status, and smoking. In all analysis, the category of 21 kg/m^2 was used as a referent for BMI, while the category of <65 cm was used as a WC referent. The linear trend in risk across BMI or WC categories was evaluated by using the likelihood ratio test. All analyses were two-tailed and a P value <0.05 was considered statistically significant.

Results

Basic characteristics of study subjects

The demographic features, anthropometric indices and CVD risk factors of study subjects by gender groups are presented in Table 1. Of a total of 8,816 individuals, men (N = 4,029) comprised 45.7% of the subjects and women (N = 4,787) 54.3%. Among the sample, 58.1% were urban residents. The married responders constituted 67.5% of the sample. In terms of socio-economic status, 20.8% had received college education and 66.9% of the study subjects belonged to the middle-income class. The smoking rate of subjects was 71.1% and 18.1% in men and women, respectively. The mean age was 40.8 years for men and 41.2 years for women. The mean BMI was not significantly different between men (22.9 kg/m^2) and women (23.0 kg/m^2). Men, in comparison to women, had higher WC, waist-hip ratio, blood pressure, triglyceride,

Table 1. Basic characteristics of the study subjects by gender groups

		Men (*N*=4029)	Women (*N*=4787)
		Number (%)	Number (%)
Residential area	Large city	1317 (32.7)	1634 (34.1)
	Middle/small city	1006 (25.0)	1168 (24.4)
	Rural area	1706 (42.3)	1985 (41.5)
Marital status *	Married	2823 (70.1)	3100 (64.8)
	Unmarried	1090 (27.1)	973 (20.3)
	Others	116 (2.9)	714 (14.9)
Education *	≤ Elementary school	747 (18.5)	1589 (33.2)
	Middle school	582 (14.5)	687 (14.4)
	High school	1681 (41.7)	1737 (36.3)
	≥College	1019 (25.3)	774 (16.2)
Income (dollar/month)	< 500	906 (22.5)	1179 (24.6)
	500-1000	1260 (31.3)	1478 (30.9)
	1000-2000	1480 (36.7)	1670 (34.9)
	≥ 2000	383 (9.5)	460 (9.6)
Smoking *	Non-smoker	596 (14.8)	3822 (79.8)
	Ex-smoker	570 (14.2)	98 (2.1)
	Smoker	2863 (71.1)	867 (18.1)
		Mean (±SD)	Mean (±SD)
Age *	(year)	40.8 (16.1)	41.2 (16.8)
Body mass index	(kg/m^2)	22.9 (3.0)	23.0 (3.4)
Waist circumference *	(cm)	81.9 (8.9)	77.6 (9.9)
Hip circumference	(cm)	93.4 (6.5)	93.3 (6.8)
Waist-hip ratio *		0.88 (0.07)	0.8 (0.08)
Systolic blood pressure *	(mmHg)	127.2 (17.7)	122.7 (20.3)
Diastolic blood pressure *	(mmHg)	80.1 (11.9)	75.7 (11.7)
Fasting blood glucose	(mg/dl)	100.9 (29.7)	99.7 (31.5)
Total cholesterol *	(mg/dl)	183.6 (37.8)	186.9 (37.8)
LDL-cholesterol *	(mg/dl)	109.0 (33.9)	113.0 (33.7)
Triglyceride *	(mg/dl)	131.2 (65.9)	109.9 (55.0)
HDL-cholesterol *	(mg/dl)	48.3 (12.0)	51.9 (12.6)

* *P*<0.05 for between group comparison using chi-square test or student t-test.

and lower LDL- and HDL-cholesterol (all *P*values <0.05).

Age- and gender specific prevalence of obesity, abdominal obesity and clustering of CVD risk factors

Age- and gender specific prevalence of obesity and abdominal obesity by WHO and Asia-Pacific guidelines in the study population is shown in Table 2. The prevalence of obesity defined as BMI ≥30kg/m^2 was 2.3%, while the prevalence of a BMI ≥25kg/m^2 was 25%. The prevalence of abdominal obesity with higher WC cut-offs of >102cm for men and >88cm for women was 1.3% for men and 15.3% for women. In contrast, when lower cut-offs were used (WC >90cm for men and >80cm for women) the prevalence of abdominal obesity was 18.5% for men and 38.5% for women.

Women had a significantly higher prevalence of obesity than men. This was also true in the case of abdominal obesity - women had a significantly higher prevalence throughout all age groups compared with men. The prevalence of obesity and abdominal obesity for men increased with age. The peak prevalence was in the forties and declined steadily afterwards, therefore the prevalence of obesity and abdominal obesity was lower in older men than in middle aged men. In contrast, the prevalence of obesity and abdominal obesity for women increased proportionately with age (from the age of twenty to sixty). Over one-third, and half of the women aged above 50 years had a BMI of greater than 25kg/m^2 and WC of 80cm, respectively.

The prevalence of clustering of CVD risk factors as defined by NCEP ATP III is shown in Table 2. It is clear that the proportion of men and women free of any risk factors decreased with increasing age, whereas the percentage of men and women with three or more risk factors rose with increasing age. The prevalence of aggregation of three or more CVD risk factors was 22.7% for men and 21.7% for women. The prevalence of clustering of CVD risk factors for men increased, starting from age twenty and throughout the fifties, but manifested a plateau after that. However, the prevalence of clustering of two or more CVD risk factors for women increased in linear proportion for age - from twenty to over sixty. Among the age group below 50 years, men had a significantly higher prevalence of clustering of CVD risk factors than women. However, the reverse phenomenon was found beyond the age of fifty - the prevalence of clustering of CVD risk factors in women aged over 50 years was much higher than that in men and the difference became more prominent as age increased. Among the risk factors, high blood pressure and high total cholesterol were the most commonly clustered factors with a prevalence of 16.1%.

Table 2. Age- and gender specific prevalence (%) of obesity, abdominal obesity, and clustering of CVD risk factors in the study population

Risk factors	Sex	Age group (year)						
		15-29	30-39	40-49	50-59	60-69	70-79	Total
BMI ≥ 30.0 kg/m² *	M†	2.2	1.8	2.1	1.2	0.2	0.0	1.6
	W†	1.4	2.7	3.4	3.9	5.2	3.2	3.0
BMI ≥ 25.0 kg/m² *	M†	16.1	28.8	32.9	26.1	18.2	9.7	23.6
	W†	12.4	21.2	32.5	42.0	37.4	32.1	26.4
WC > 102.0 cm *	M†	1.0	1.6	1.7	1.2	0.7	1.5	1.3
> 88.0 cm	W†	4.8	7.5	14.0	26.6	35.4	28.2	15.3
WC > 90.0 cm *	M†	9.9	16.0	27.4	26.4	21.8	12.8	18.5
> 80.0 cm	W†	15.8	27.5	44.0	62.2	66.9	53.5	38.5
Risk factor 0	M†	46.4	24.3	15.5	12.0	14.2	10.8	25.2
	W†	41.6	35.2	21.9	7.3	5.2	3.5	25.0
Risk factor ≥ 1	M†	53.6	75.7	84.5	88.0	85.8	89.2	74.8
	W†	58.4	64.8	78.1	92.7	94.8	96.5	75.0
Risk factor ≥ 2 *	M†	23.3	46.2	59.4	61.4	59.6	58.5	46.6
	W†	18.4	24.4	43.7	68.3	78.1	82.1	42.5
Risk factor ≥ 3	M†	8.0	23.5	30.8	33.0	28.1	28.7	22.7
	W†	5.3	8.2	19.3	38.8	49.8	55.1	21.7
Risk factor ≥ 4 *	M†	1.6	6.9	10.7	12.4	8.3	9.7	7.3
	W†	1.5	2.6	5.6	18.3	24.4	25.0	9.1
Risk factor 5 *	M†	0.2	0.7	2.2	1.9	2.0	1.5	1.2
	W†	0.2	0.0	1.3	4.2	6.6	5.5	2.0

* $P < 0.05$ significant differences between each gender group by chi-square test. † $P < 0.05$ significant linear trend for variables across age groups in each gender by chi-square test for trend. We assessed CVD risk factors as prevalent conditions for each item as follows: blood pressure ≥130 / ≥85 mmHg, fasting glucose ≥ 110 mg/dl, LDL-C ≥ 130 mg/dl, triglyceride ≥ 150 mg/dl, HDL-C < 40 mg/dl for men, and < 50 mg/dl for women.

Frequency of clustering of CVD risk factors according to BMI or waist circumference stratified by age

The frequency of clustering of 3 or more CVD risk factors according to BMI or WC in both genders, stratified by age, is displayed in Figure 1 and 2. Compared to the subjects who had BMI <21kg/m², the frequency of clustering in men and women increased significantly in proportion to increase in BMI or WC percentiles when adjusted for age. Women had a more prominent increase of clustering of CVD risk factors with advancing age than men. Nevertheless, the percentage of clustering of CVD risk factors in both young and middle aged men with high BMI or WC, was highly comparable to that in elderly men.

Relationships between high blood pressure, high fasting glucose, dyslipidaemia, and clustering of CVD risk factors and BMI or waist circumference

Logistic regression analyses were carried out to explore the relationship between high blood pressure, high fasting glucose, dyslipidaemia, and clustering of 3 or more CVD risk factors with BMI or WC after adjusting for age, residential area, marital status, socio-economic level, and smoking. Using a BMI range of <21 kg/m² and WC of <65 cm as the referent (odds ratio = 1.0), the odds ratio for clustering of 3 or more CVD risk factors in rest of the categories were significantly higher compared to the reference category, ranging from 1.67 to 31.8 (Fig. 3 & 4) There were increasing trends for most of the co-morbidities across increasing degrees of BMI or WC in both sexes (all *P*-values for the likelihood ratio were <0.0001). It was found that even at low categories of BMI and WC, the regression of high blood pressure, high fasting glucose, dyslipidaemia, and clustering of CVD risk factors were significant at 95% confidence interval.

The odds ratios of having at least three CVD risk factors in comparison to those within the reference range were obtained according to BMI categories and WC levels. The odds ratio of having a cluster of risk factors in subjects within the BMI category of 23 -24 kg/m² was 3. The odds ratios were 10.2 and 6.7 in men and women, respectively for those in the BMI category of 27- 28kg/m² (Fig. 3). Men with WC levels of 90-95 cm had an odds ratio of 13.4 and women with WC levels of 85-900 cm had an odds ratio of 13.6 for having at least three CVD risk factors, compared to those in the referent group (Fig. 4).

Discussion

In most parts of the world, there are increasing trends of obesity.[13] In South Korea, based on population-based national surveys, the prevalence of overweight (using BMI≥25 kg/m²) increased from 18.8 to 26% in men, and from 22.1 to 26.5% in women in 1995[14] and 1998,[15] respectively. In South Korea, the mean BMI of both men and women was only 22.9, and 23 kg/m². This value is

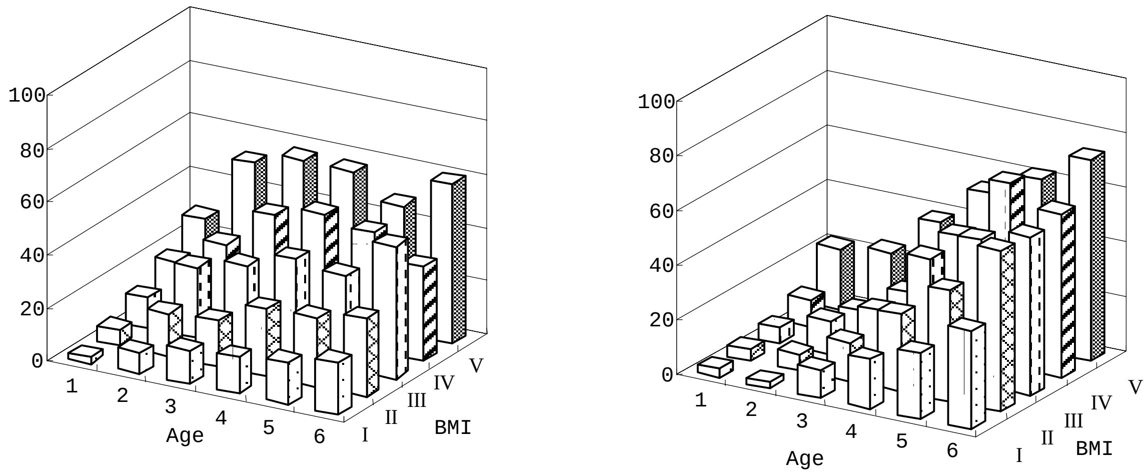

Figure 1. Relationship of clustering of 3 or more CVD risk factors according to BMI by age group in men and women.
P<0.05 significant relationship between clustering of CVD risk factors and BMI distribution adjusted by age groups in each gender by Cochran-Mantel-Haenszel test. Values are expressed as percent (%). Age groups : 1 = 20-29y, 2 = 30-39y, 3 = 40-49y, 4 = 50-59y, 5 = 60-69y, 6 = 70-79y, BMI distribution: I; <25%, II; 25-50%, III; 50-75%, IV; 75-90%, V; >90 percentile of BMI, I; <21.0, II; 21.0-23.0, III; 23.0-25.0, IV; 25.0-27.0, V;>27.0kg/m^2 for men and I; <21.0, II; 21.0-23.0, III; 23.0-25.0, IV; 25.0-27.5, V;>27.5kg/m^2 for women.

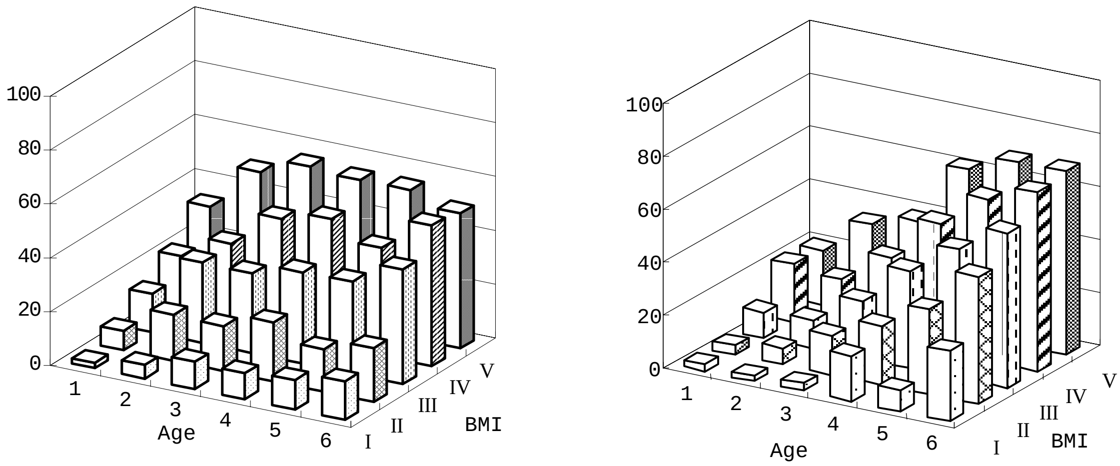

Figure 2. Relationship of clustering of 3 or more CVD risk factors according to waist circumference by age group in men and women. *P*<0.05 significant relationship between clustering of CVD risk factors and WC(waist circumference) distribution adjusted by age groups in each gender by Cochran-Mantel-Haenszel test. Values are expressed as percent (%). Age groups : 1; 20-29y, 2; 30-39y, 3; 40-49y, 4; 50-59y, 5; 60-69y, 6; 70-79y, WC distribution: I; <25%, II; 25-50%, III; 50-75%, IV; 75-90%, V; >90 percentile of WC, I;<77.0, II; 77.0-83.0, III; 83.0-88.5, IV; 88.5-94.0, V;>94.0cm for men and I;<71.0, II; 71.0-78.0, III; 78.0-85.0, IV; 85.0-91.5, V;>91.5cm for women.

similar to that reported in other Asian populations such as Japanese,[16] Chinese,[17] and Singaporeans.[18]

Constellation of CVD risk factors, rather than a single risk factor, presents a higher risk for the development of atherosclerotic diseases.[19] NCEP ATP III proposed that the metabolic syndrome, which includes multiple CVD risk factors, is another target for prevention and control of CVD disease.[8] It draws attention to the importance of clustering of CVD risk factors, even though each individual factor was not at a high risk level. This study indicated a relatively high prevalence of clustering of CVD risk factors in the Korean population, despite a lower BMI or WC than in Western populations. The result might be explained by a thrifty genotype or phenotype hypothesis in which the ability to store fuels during periods of food deprivation could lead to obesity given a western lifestyle with food excess.[20-23]

The anthropometric and CVD risk factors of women under 50 years showed lower values, as expected, than those in men. However, over 50 years, the risk status of obesity, abdominal obesity, and clustering of cardiovascular risk factors were either similar to men or exceeded those of men. Postmenopausal status is associated with a preferential increase in intra-abdominal fat that is independent of total adiposity.[24] Increased lipoprotein lipase activity or decreased lipolysis, resulting from estrogen deficiency and increased androgenicity induced by menopause transition, may explain the redistribution of fat to the intra-abdominal depot.[25] Increased abdominal fat is associated with a clustering of metabolic abnormalities which may predispose postmenopausal women to a greater risk for CVD diseases.[5] In the relationship between aggregations of CV risk factors with BMI and also with WC, the clustering increased

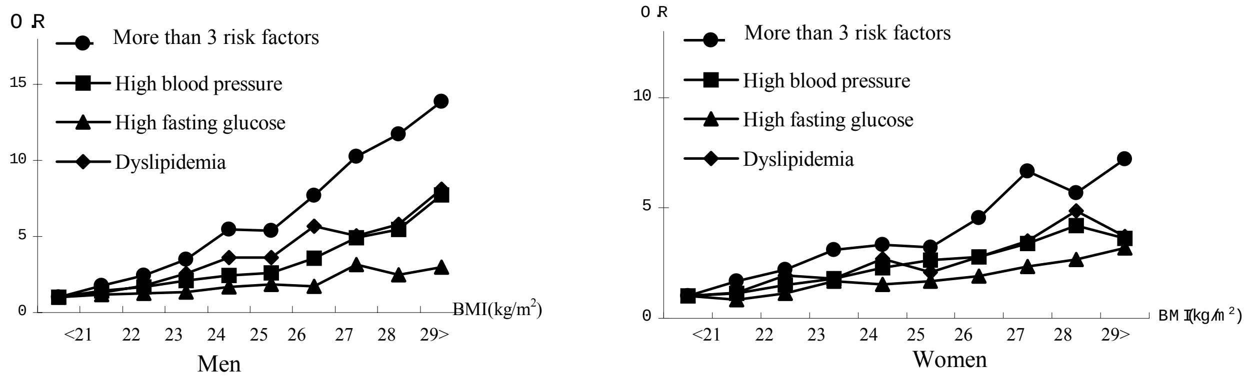

Figure 3. Odds ratio (OR) for clustering of 3 or more CVD risk factors, high blood pressure, high fasting glucose, and dyslipidaemia according to BMI categories in men and women. *P*<0.0001 by likelihood ratio test for increase odds ratios according to BMI categories adjusted by age, residential area, socioeconomic status, and smoking. In all cases, the reference category was BMI <21 kg/m^2. We assessed CVD risk factors as prevalent conditions for each item as follows: blood pressure ≥130 / ≥85 mmHg, fasting glucose ≥110 mg/dl, LDL-C ≥130 mg/dl, triglyceride ≥150 mg/dl, HDL-C <40 mg/dl for men, and <50 mg/dl for women. Dyslipidaemia was defined as presence of one or more of the above abnormal lipid profiles.

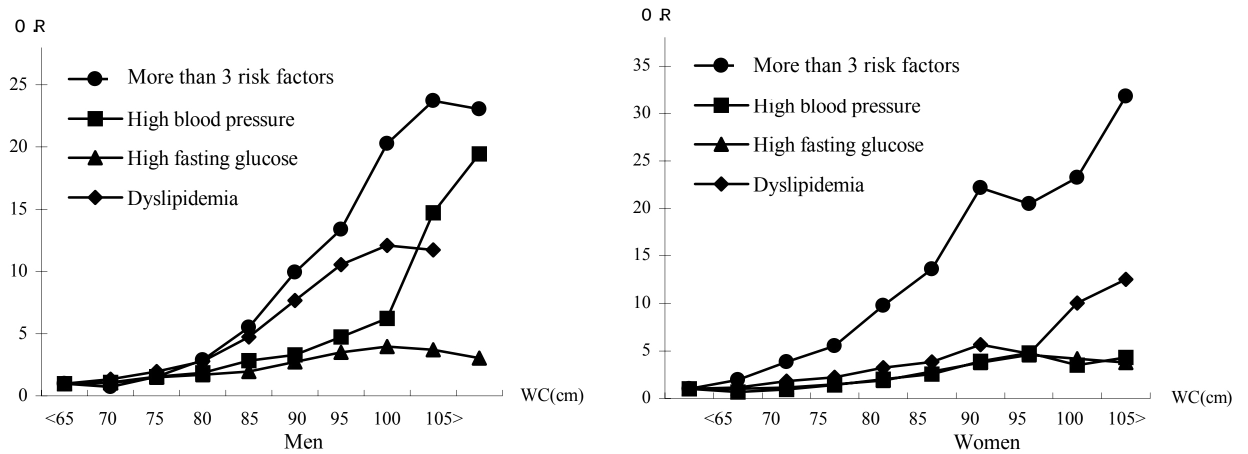

Figure 4. Odds ratio (OR) for clustering of 3 or more CVD risk factors, high blood pressure, high fasting glucose, and dyslipidaemia according to WC categories in men and women. *P*<0.0001 by likelihood ratio test for increase odds ratios according to WC categories adjusted by age, residential area, socioeconomic status, and smoking. In all cases, the reference category was WC <65 cm. We assessed CVD risk factors as prevalent conditions for each item as follows: blood pressure ≥130 / ≥85 mmHg, fasting glucose ≥110 mg/dl, LDL-C ≥ 130 mg/dl, triglyceride ≥150 mg/dl, HDL-C <40 mg/dl for men, and <50 mg/dl for women. Dyslipidaemia was defined as presence of one or more of the above abnormal lipid profiles.

with either a high BMI or high WC, as presented in other studies.[26] Clustering of CV risk factors was significantly prevalent among men with either extreme BMI or WC even at a young age. Modernization and sedentary life style, alcohol drinking, and stress contributed to rapid increase of obesity, abdominal obesity, and CVD risk factors in both young and middle aged Korean men. Therefore, if the Korean men had a higher BMI or WC regardless of youth, more attention would be needed to both prevent and treat obesity and abdominal obesity since the percentage of clustering of CVD risk factors would be greater. In women, generally, the prevalence of individual or multiple CVD risk factors increased in proportion to age, in any distribution of BMI or WC, as expected. The finding that elderly women had a higher prevalence of either individual or clustered CVD risk factors at a given age might be attributed to a higher survival rate among elderly women compared to men, even with CVD present.

The death rate of South Korean men in their middle ages was 2-3 times higher than women in those ages.[10] These findings strongly suggest that the BMI value, of 23, and 27 kg/m^2, can serve as the cut-off points for overweight and obesity respectively in South Korea. The WC values, of 90cm, and 85cm, can serve as the cut-off points for abdominal obesity in men and women in South Korea. This can also be supported by the fact that the odds ratios for at least three CVD risk factors at those cut-off points were abruptly increased compared to the odds ratios for the preceding categories. These categories of BMI and WC are all below the currently recommended WHO cut-off values.[1] However, while the WHO has considered a BMI range of 23.0-24.9 kg/m^2 as normal, with the lowest risk at this BMI level, South Korean subjects already had at least a threefold increased risk of having three or more CVD risk factors compared to those with a BMI of <21 kg/m^2. In agreement with other Asian data,[17, 27-31] our findings confirmed that South Koreans exhibited lower

BMI distributions than those seen in Western countries.[1, 32] The findings in this study are similar to those found in Hong Kong Chinese which proposed BMI cutoff points for overweight and obesity as low as 23 and 26 kg/m^2, respectively.[33] Our findings also accorded with the Japanese report[16,34] that an increased health risk was apparent at a BMI of 23 kg/m^2. The discrepancy between high CVD mortality with relatively lower prevalence of obesity (defined as a BMI of $\geq$30 kg/m^2) could be partially explained by the presence of excessive body fat among Asians at low levels of BMI when compared to Caucasians.[27] The consequence of lowering BMI cut-off values of overweight to 23 kg/m^2 and obesity to 27 kg/m^2 would be that the prevalence of overweight among Koreans would increase from 22.8 to 36.3% and obesity rates from 2.4 to 10.4%.

The limitation of this study involves the lack of information on other subclinical diseases or malnutrition that may be associated with low BMI. However, our data showed the relationship between clustering of CVD risk factors with BMI or WC in a population-based representative sample was free of selection bias. This enabled us to suggest the cut-off levels for BMI or WC in South Koreans. In conclusion, this analysis presented a high prevalence of clustering of CVD risk factors among South Koreans even at lower levels of BMI or WC compared to Western populations. The significant associations between clustering of CVD risk factors and BMI or WC and high prevalence of overweight in South Koreans has important implications for the health care system, even at lower levels of BMI or WC. A population approach to prevent CVD risk factors is probably needed in South Korea.

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