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Original Contribution

Obesity and Cardiovascular Risk Factors in Korean Children and Adolescents Aged 10–18 Years from the Korean National Health and Nutrition Examination Survey, 1998 and 2001

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Childhood obesity is directly related to cardiovascular disease (CVD) risk factors, but there is limited information on their relation in Korean children and adolescents. The authors investigated the association between obesity and CVD risk factors among 2,272 Korean boys and girls aged 10–18 years, who participated in the Korean National Health and Nutrition Examination Survey in 1998 and 2001. Obesity was defined by body mass index cutoff points provided by the US Centers for Disease Control and Prevention. The prevalence of obesity increased significantly from 5.4% in 1998 to 11.3% in 2001 ($p < 0.0001$). Korean obese children and adolescents in 1998 and 2001 had 4.6- and 4.9-fold risks for systolic hypertension, 4.2- and 2.8-fold risks for high levels of total cholesterol, 9.4- and 2.7-fold risks for high levels of low density lipoprotein cholesterol, 4.1- and 3.7-fold risks for low levels of high density lipoprotein cholesterol, and 5.3- and 2.8-fold risks for high levels of triglycerides, compared with their normal-weight counterparts ($p < 0.05$ in all). Approximately 60% of Korean obese children and adolescents had at least one CVD risk factor. These findings suggest that Korean obese children and adolescents have an increased risk of CVD.

adolescent; cardiovascular diseases; child; Korea; obesity; risk factors

Abbreviations: CVD, cardiovascular disease; HDL, high density lipoprotein; KNHANES, Korean National Health and Nutrition Examination Survey; LDL, low density lipoprotein.

The increasing prevalence of childhood obesity is a worldwide trend and is becoming a significant public health problem (1). Obesity in children and adolescents is associated with various cardiovascular disease (CVD) risk factors, including hypertension, dyslipidemia, and elevated insulin levels (2–4), as well as an increased risk of CVD morbidity and mortality in adulthood (5, 6). A decrease in physical activity and an increase in caloric intake may be responsible for this increasing incidence (7). Therefore, lifestyle modification and weight control aimed at both preventing and treating childhood obesity should reduce the risk of CVD in adulthood (2, 8).

Among Korean adults aged at least 20 years in 2001, 32.6 percent of males and 29.4 percent of females are obese, as defined by a body mass index of 25 or more kg/m^2, and the prevalence of obese adults has increased (9). In addition, the mortality from CVD was one of the leading causes of death in 2003 in Korea (10). Strong linear relations between body mass index and hypertension, type 2 diabetes mellitus, dyslipidemia, ischemic heart disease, and stroke in Korean

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adults have been reported (11–14). Obesity is a serious public health problem in Korean adults. However, little information is available regarding the association between obesity and CVD risk factors in Korean children and adolescents. The purpose of this study was to estimate the prevalence of hypertension, dyslipidemia, and elevated fasting glucose and to determine the association between obesity and CVD risk factors in Korean children and adolescents.

MATERIALS AND METHODS

Study population

This study was based on the data obtained from the Korean National Health and Nutrition Examination Survey (KNHANES) among noninstitutionalized civilians in the Republic of Korea (referred to as "South Korea"), which was conducted by the Korean Ministry of Health and Welfare in 1998 and 2001. This survey is a nationwide representative study using a stratified, multistage probability sampling design for the selection of household units. The participants completed three parts of a questionnaire belonging to the Health Interview Survey, the Health Behavior Survey, and the Nutrition Survey, and they underwent a Health Examination Survey. Subjects aged 10–18 years numbered 1,651 in 1998 and 1,158 in 2001. Subjects who did not fast for at least 8 hours or had one missing measurement were excluded. The final sample population for analysis consisted of 1,412 and 860 subjects in 1998 and 2001, respectively.

Health Examination Survey

Height was measured with a stadiometer, and body weight was measured on a balanced scale. Body mass index (weight (kg)/height (m)^2) was calculated. Waist circumference was measured at the midpoint between the bottom of the rib cage and the top of the lateral border of iliac crest during minimal respiration. Blood pressure was measured by use of a mercury sphygmomanometer. Two measurements were made on all subjects at 5-minute intervals. The first and fifth Korotkoff sounds represented the systolic and diastolic blood pressure, respectively. The average of two measurements was used in data analysis.

Blood samples were collected in the morning after the subjects had fasted overnight and were analyzed in a national central laboratory. Serum total cholesterol, triglycerides, high density lipoprotein (HDL) cholesterol, and plasma fasting glucose were measured by use of enzymatic techniques. Low density lipoprotein (LDL) cholesterol was calculated by use of the Friedewald equation if the triglyceride measurement was less than 400 mg/dl (15).

Definition of overweight and CVD risk factors

Overweight status in childhood and adolescence was defined according to the body mass index cutoff points for age and gender proposed by the US Centers for Disease Control and Prevention (16). Subjects were classified as normal weight (<85th percentile), at risk of overweight (85th–<95th percentile), or overweight (≥95th percentile) according to the Korean growth charts (17). Hypertension was defined as a systolic blood pressure or a diastolic blood pressure greater than or equal to the 95th percentile for age, gender, and height (18, 19). A total cholesterol concentration of 200 mg/dl or more, a LDL cholesterol concentration of 130 mg/dl or more, and a triglyceride concentration of 130 mg/dl or more were defined as high (20). A low HDL cholesterol level and a high fasting glucose level were defined as a concentration of less than 35 mg/dl (21) and a concentration of 110 mg/dl or more, respectively.

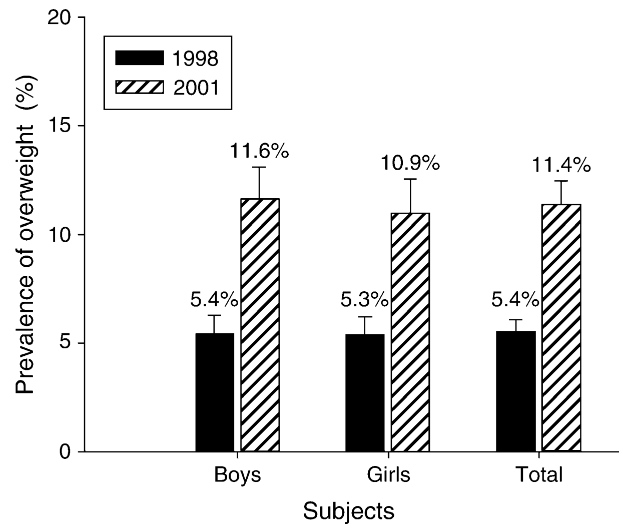

FIGURE 1. Prevalence of overweight among boys and girls aged 10–18 years, Korean National Health and Nutrition Examination Survey, 1998 and 2001.

Statistical analysis

The data were analyzed by use of SPSS software, version 11 for Windows (SPSS, Inc., Chicago, Illinois). Comparison of means of variables among the three groups stratified according to overweight status was done by analysis of variance with post hoc analysis (two sided). The chi-square test was used to examine differences in the prevalence of CVD risk factors between 1998 and 2001. The linear-by-linear association method was used for the trend test between overweight status and prevalence of CVD risk factors. Logistic regression analysis was used to examine the associations between overweight and CVD risk factors, and the referent was the normal-weight group. $p < 0.05$ was considered significant.

RESULTS

The prevalence of overweight boys increased significantly from 5.4 percent in 1998 to 11.6 percent in 2001 ($p < 0.0001$), while the prevalence of overweight girls increased significantly from 5.3 percent in 1998 to 10.9 percent in 2001 ($p = 0.001$) (figure 1). Characteristics of the subjects classified by overweight status were displayed in table 1

TABLE 1. Characteristics (mean (standard deviation)) of 1,412 subjects aged 10–18 years according to overweight status, Korean National Health and Nutrition Examination Survey, 1998

Variable	Normal weight (622 boys, 554 girls)	At risk of overweight (74 boys, 86 girls)	Overweight (40 boys, 36 girls)	p value for difference (ANOVA*)
Age (years)				
Boys	13.9 (2.5)	14.1 (2.7)	13.9 (3.0)	0.841
Girls	14.3 (2.6)	14.6 (2.6)	13.4 (2.8)	0.080
Body mass index (kg/m^2)				
Boys	18.8 (2.3)	24.3 (1.6)	27.8 (2.4)	<0.0001
Girls	18.9 (2.2)	23.9 (1.4)	26.2 (1.8)	<0.0001
Systolic blood pressure (mmHg)				
Boys	114.0 (11.2)	120.5 (11.6)	123.6 (10.9)	<0.0001
Girls	111.3 (10.0)	114.1 (10.4)	116.4 (8.5)	0.001
Diastolic blood pressure (mmHg)				
Boys	65.0 (14.0)	66.9 (14.7)	70.1 (12.0)	0.056
Girls	66.0 (23.4)	65.8 (12.4)	68.0 (10.6)	0.860
Total cholesterol (mg/dl)				
Boys	154.1 (26.8)	160.9 (27.0)	176.6 (31.4)	<0.0001
Girls	165.3 (28.6)	166.4 (27.8)	172.2 (38.3)	0.381
LDL* cholesterol (mg/dl)				
Boys	84.6 (21.8)	94.2 (23.3)	105.5 (29.3)	<0.0001
Girls	93.0 (25.7)	98.0 (22.6)	103.2 (33.4)	0.026
HDL* cholesterol (mg/dl)				
Boys	54.0 (12.0)	46.6 (9.1)	47.6 (9.4)	<0.0001
Girls	54.7 (11.5)	48.6 (11.0)	46.2 (10.1)	<0.0001
Triglycerides (mg/dl)				
Boys	77.7 (41.2)	100.4 (41.5)	117.8 (51.1)	<0.0001
Girls	88.6 (40.3)	100.0 (47.5)	114.2 (48.0)	<0.0001
Fasting glucose (mg/dl)				
Boys	94.7 (12.5)	94.3 (12.1)	95.9 (13.5)	0.813
Girls	92.4 (11.9)	94.9 (12.4)	93.4 (10.2)	0.174

* ANOVA, analysis of variance; LDL, low density lipoprotein; HDL, high density lipoprotein.

and table 2 on the basis of results from KNHANES 1998 and 2001, respectively. The overweight boys in 1998 had a significantly higher mean systolic blood pressure measurement; higher mean concentrations of total cholesterol, LDL cholesterol, and triglycerides; and a lower mean concentration of HDL cholesterol than did their normal-weight counterparts (in all: $p < 0.0001$). The overweight girls in 1998 had a significantly higher mean systolic blood pressure measurement ($p = 0.001$), higher mean concentrations of LDL cholesterol ($p = 0.026$) and triglycerides ($p < 0.0001$), and a lower mean concentration of HDL cholesterol ($p < 0.0001$) than did their normal-weight counterparts. The overweight boys in 2001 had a significantly higher mean systolic blood pressure measurement ($p < 0.0001$); higher mean concentrations of total cholesterol ($p < 0.0001$), LDL cholesterol ($p = 0.001$), and triglycerides ($p < 0.0001$); and a lower mean concentration of HDL cholesterol ($p = 0.011$) than did their normal-weight counterparts. The overweight girls in 2001 had a significantly higher mean systolic blood pressure measurement ($p = 0.004$); higher mean concentrations of total cholesterol ($p = 0.002$), LDL cholesterol ($p = 0.004$), and triglycerides ($p < 0.0001$); and a lower mean concentration of HDL cholesterol ($p = 0.003$) than did their normal-weight counterparts. In both 1998 and 2001, the mean diastolic blood pressure measurement and the mean concentrations of fasting glucose were not statistically different between the overweight and normal-weight subjects.

The prevalence changes of CVD risk factors from 1998 to 2001 were given in table 3. For boys, the prevalence of high LDL cholesterol, low HDL cholesterol, and high triglycerides significantly increased from 1998 to 2001 ($p = 0.029$, $p < 0.001$, and $p < 0.001$, respectively).

The prevalence of systolic hypertension, high total cholesterol, high LDL cholesterol, low HDL cholesterol, and

TABLE 2. Characteristics (mean (standard deviation)) of 860 subjects aged 10–18 years according to overweight status, Korean National Health and Nutrition Examination Survey, 2001

Variable	Normal weight (346 boys, 313 girls)	At risk of overweight (58 boys, 46 girls)	Overweight (53 boys, 44 girls)	*p* value for difference (ANOVA*)
Age (years)				
Boys	13.6 (2.4)	13.7 (2.3)	13.3 (2.7)	0.623
Girls	13.9 (2.4)	14.4 (2.7)	12.6 (2.5)	0.001
Body mass index (kg/m^2)				
Boys	19.1 (2.2)	24.5 (1.6)	28.0 (3.2)	<0.0001
Girls	19.1 (2.2)	23.6 (1.6)	25.6 (2.5)	<0.0001
Systolic blood pressure (mmHg)				
Boys	111.8 (11.5)	116.6 (10.5)	120.0 (11.0)	<0.0001
Girls	106.1 (10.0)	107.5 (10.2)	111.5 (11.0)	0.004
Diastolic blood pressure (mmHg)				
Boys	64.5 (11.9)	66.7 (10.7)	68.1 (12.2)	0.065
Girls	63.7 (10.0)	63.8 (10.4)	64.1 (10.6)	0.971
Total cholesterol (mg/dl)				
Boys	155.4 (26.4)	171.0 (23.9)	169.7 (30.9)	<0.0001
Girls	165.6 (25.5)	172.9 (29.4)	179.1 (24.8)	0.002
LDL* cholesterol (mg/dl)				
Boys	91.1 (22.3)	100.4 (23.2)	101.0 (26.6)	0.001
Girls	97.1 (22.2)	104.6 (24.3)	107.5 (21.9)	0.004
HDL* cholesterol (mg/dl)				
Boys	46.5 (9.6)	45.5 (8.4)	42.2 (8.4)	0.011
Girls	50.2 (9.5)	47.0 (8.4)	45.8 (9.5)	0.003
Triglycerides (mg/dl)				
Boys	89.7 (46.7)	125.4 (84.4)	138.5 (93.4)	<0.0001
Girls	91.4 (42.8)	106.7 (56.8)	129.3 (71.0)	<0.0001
Fasting glucose (mg/dl)				
Boys	94.6 (12.1)	95.6 (10.5)	97.7 (11.6)	0.183
Girls	93.6 (11.8)	92.0 (12.1)	93.7 (8.7)	0.668

* ANOVA, analysis of variance; LDL, low density lipoprotein; HDL, high density lipoprotein.

high triglycerides increased in a graded fashion from the normal-weight group to the overweight group in both 1998 and 2001 (in all: $p_{\text{trend}} < 0.05$) (table 4). The age- and gender-adjusted odds ratios for systolic hypertension, high total cholesterol, high LDL cholesterol, low HDL cholesterol, and high triglycerides were highest in the overweight group in both 1998 and 2001 (table 4). In 1998, the overweight children and adolescents showed a strong association with systolic hypertension, diastolic hypertension, high total cholesterol, high LDL cholesterol, low HDL cholesterol, and high triglycerides (age- and gender-adjusted odds ratio = 4.55, 2.65, 4.15, 9.42, 4.10, and 5.30, respectively). In 2001, the overweight children and adolescents showed a strong association with systolic hypertension, high total cholesterol, high LDL cholesterol, low HDL cholesterol, and high triglycerides (age- and gender-adjusted odds ratio = 4.94, 2.78, 2.67, 3.64, and 2.77, respectively).

The clustering of CVD risk factors was shown in Korean obese children and adolescents (table 5). Among the overweight subjects, 65.8 percent in 1998 and 63.2 percent in 2001 had at least one of the significant five CVD risk factors, while 24.3 percent in 1998 and 28.6 percent in 2001 among normal-weight subjects had at least one significant CVD risk factor.

DISCUSSION

The present study demonstrated that Korean overweight children and adolescents aged 10–18 years had more elevated blood pressure, more adverse lipid levels, and more clustered numbers of CVD risk factors than did normal-weight counterparts. In addition, a significant increase of overweight during a short period was observed. These findings were consistent

TABLE 3. Prevalence of cardiovascular disease risk factors among subjects aged 10–18 years, Korean National Health and Nutrition Examination Survey, 1998 and 2001

Cardiovascular disease risk factors	KNHANES,* 1998 (736 boys, 676 girls)		KNHANES, 2001 (457 boys, 403 girls)		*p* value for difference†
	No.	%	No.	%	
Systolic hypertension					
Boys	83	11.3	43	9.4	0.307
Girls	66	9.8	23	5.7	0.019
Diastolic hypertension					
Boys	46	6.3	19	4.2	0.122
Girls	42	6.2	10	2.5	0.006
High total cholesterol					
Boys	49	6.7	36	7.9	0.421
Girls	71	10.5	45	11.2	0.734
High LDL* cholesterol					
Boys	33	4.5	34	7.5	0.029
Girls	52	7.7	36	8.9	0.091
Low HDL* cholesterol					
Boys	24	3.3	38	8.3	<0.001
Girls	25	3.7	17	4.2	0.476
High triglycerides					
Boys	81	11.0	88	19.3	<0.001
Girls	107	15.8	80	19.9	0.669
High fasting glucose					
Boys	66	9.0	42	9.2	0.896
Girls	50	7.4	24	6.0	0.365

* KNHANES, Korean National Health and Nutrition Examination Survey; LDL, low density lipoprotein; HDL, high density lipoprotein.

† Chi-square test.

with the data reported in other studies (2, 22–24). However, caution should be taken when comparing the data with other results, because different definitions for overweight status and CVD risk factors are used. Herein, overweight was used interchangeably with obesity, similar to a majority of US studies (2, 17, 22).

Elevated blood pressure is more frequently present in overweight children than in nonoverweight children (25). The present study showed a similar finding on systolic blood pressure, but there was no significant association between overweight and diastolic blood pressure in 2001. In the Bogalusa Heart Study, overweight schoolchildren (body mass index: ≥95th percentile) have 2.4-fold risk of diastolic hypertension (2). In a German study, the degree of body mass index correlates positively with diastolic hypertension (24). The decreasing prevalence of diastolic hypertension from 1998 to 2001, as well as the smaller size of sample population in 2001 than in 1998, might be one reason for a different finding on diastolic hypertension.

Overweight is strongly related to concentrations of HDL cholesterol and triglycerides and weakly related to concentrations of total and LDL cholesterol (2). In a German study, total and LDL cholesterol concentrations did not correlate significantly with the degree of overweight (24). In the present study, all types of lipids were significantly associated with overweight.

In contrast to blood pressure and lipid profiles, fasting glucose concentrations did not increase according to the increase in overweight status. However, in the Taipei Children Heart Study, a significant correlation between obesity (body mass index: ≥85th percentile) and high fasting glucose (≥90th percentile) is reported (23). The small number of overweight subjects and very low prevalence of high fasting glucose made these findings statistically insignificant.

The fasting plasma insulin level is a proper measure of insulin resistance and has a significant relation with obesity and CVD (4, 26). In the Young Finns Study (27), the serum insulin concentration correlates positively with body mass index. In the Bogalusa Heart Study, overweight schoolchildren were found to have a 2.4-fold risk for high fasting plasma insulin (2). However, fasting plasma insulin was not measured in the Health Examination Survey of KNHANES. The relation between fasting plasma insulin and overweight is suggested indirectly through another Korean study where

TABLE 4. Prevalence and age- and gender-adjusted odds ratios for cardiovascular disease risk factors in subjects aged 10–18 years, Korean National Health and Nutrition Examination Survey, 1998 and 2001

Cardiovascular disease risk factors	Normal weight, prevalence (%)	At risk of overweight			Overweight		
		Prevalence (%)	Odds ratio	95% confidence interval	Prevalence (%)	Odds ratio	95% confidence interval
Systolic hypertension							
1998	9.1	20.0	2.95	1.89, 4.59	28.9*	4.55	2.65, 7.81
2001	5.2	9.6	2.01	0.95, 4.24	22.7*	4.94	2.72, 8.97
Diastolic hypertension							
1998	5.4	8.8	1.66	0.91, 3.03	13.2*	2.65	1.30, 5.41
2001	3.2	3.8	1.18	0.40, 3.51	4.1	1.35	0.45, 4.04
High total cholesterol							
1998	7.1	11.3	1.58	0.92, 2.71	23.7*	4.15	2.33, 7.40
2001	7.3	14.4	2.23	1.20, 4.17	18.6*	2.78	1.53, 5.05
High LDL† cholesterol							
1998	4.3	8.1	1.81	0.96, 3.43	27.6*	9.42	5.21, 17.04
2001	6.5	11.5	1.88	0.96, 3.71	15.8*	2.67	1.41, 5.05
Low HDL† cholesterol							
1998	2.5	8.1	3.43	1.74, 6.75	9.2*	4.10	1.73, 9.71
2001	4.9	8.7	1.77	0.81, 3.85	14.4*	3.64	1.84, 7.21
High triglycerides							
1998	10.4	23.1	2.58	1.70, 3.91	38.2*	5.30	3.20, 8.77
2001	15.6	29.8	2.35	1.47, 3.77	35.1*	2.77	1.73, 4.44
High fasting glucose							
1998	8.2	9.4	1.18	0.67, 2.10	5.3	0.61	0.22, 1.69
2001	7.7	5.8	0.74	0.31, 1.78	9.3	1.10	0.52, 2.32

* $p < 0.05$ (trend in prevalence according to overweight status using linear-by-linear association).
† LDL, low density lipoprotein; HDL, high density lipoprotein.

TABLE 5. Prevalence of clustering of cardiovascular disease risk factors according to overweight status among subjects aged 10–18 years, Korean National Health and Nutrition Examination Survey, 1998 and 2001

No. of significant risk factors*	Normal weight		At risk of overweight		Overweight	
	No.	%	No.	%	No.	%
0						
1998	889	75.7	88	55.0	26	34.2
2001	470	71.4	56	53.8	35	36.8
≥1						
1998	286	24.3	72	45.0	50	65.8
2001	188	28.6	48	46.2	60	63.2
≥2						
1998	72	6.1	29	18.1	29	38.2
2001	61	9.3	25	24.0	25	26.3
≥3						
1998	20	1.7	11	6.9	13	17.1
2001	9	1.4	4	3.8	9	9.5

* Significant cardiovascular disease risk factors: systolic hypertension; high levels of triglycerides and low density lipoprotein cholesterol; and low levels of high density lipoprotein cholesterol.

the mean concentration of fasting plasma insulin is significantly higher in overweight children than in normal-weight controls (28).

There were two limitations in the present study. First, because there are no formal cutoff points of blood pressure for age, gender, and height to define hypertension for Korean children and adolescents, the present study used US cutoff points after stratifying them into Korean height percentiles (16, 18). This was based on the assumption that there is no significant difference in blood pressure among ethnic groups during childhood and adolescence (29). Fortunately, the present study showed a significant association between systolic hypertension and overweight, which was consistent with results from other studies (2, 23, 24). The second limitation is that these results might not be representative of Korean children and adolescents. Although KNHANES used a stratified and multistage probability sampling design to estimate the representative indices in Koreans, the population distribution of the present study was slightly different from that of the original subjects in KNHANES because of the exclusion of subjects with missing values on the variables for logistic regression testing.

In summary, the numbers of overweight Korean children and adolescents have increased rapidly, and they have an increased risk of elevated blood pressure; high concentrations of total cholesterol, LDL cholesterol, and triglycerides; and a low concentration of HDL cholesterol. These findings suggest that overweight Korean children and adolescents might have an increased risk of CVD morbidity and mortality in adulthood.

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Conflict of interest: none declared.

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