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Risks of Hyperlipidemia, Hypertension, High Blood Glucose and Liver Dysfunction in Moderately and Severely Obese Children

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This study was conducted to compare the rates of hyperlipidemia, hypertension, high blood glucose, and liver dysfunction, between 64 obese children (24 boys and 11 girls who were moderately obese, and 21 boys and 8 girls who were severely obese) and 45 normal weight children (31 boys and 14 girls) from 13 elementary schools in Kangnung city. Among the boys with severe obesity, the levels of serum triglycerides and LDL-cholesterol (133.60 ± 49.99mg/dl and 105.00 ± 41.12 mg/dl, respectively) were significantly higher compared to the normal weight group (81.16 ± 23.59 mg/dl and 87.74 ± 32.095 mg/dl, respectively) or moderately obese group (102.30 ± 36.03 mg/dl, 89.99 ± 32.10 mg/dl, respectively). In girls, only serum triglycerides were significantly higher in the severely obese group (154.30 ± 46.84 mg/dl), compared with the normal weight group (80.00 ± 25.31 mg/dl) or moderately obese group (106.40 ± 41.73 mg/dl). In boys, blood pressure in the severely obese group (systolic: 120.5 ± 9.74 mmHg; diastolic: 80.95 ± 10.44 mmHg) was significantly higher compared with the groups of normal weight or moderately obese children. The rate of hypertriglyceridemia was significantly different among normal weight, moderately obese, and severely obese boys (9.7%, 41.7%, and 76.2%, respectively). The proportion of boys who had an Atherogenic Index(AI) higher than 3 was found to be significantly higher in the severely obese group (28.6%), compared to 6.5% in the normal weight group and 4.1% in the moderately obese group. Among boys, a significantly higher rate of hypertension was found in the severely obese group, which showed high systolic blood pressure and high diastolic pressure (81.0% and 81.0%), compared with the normal weight group (16.1% and 22.6%) and moderately obese group (33.3% and 33.3%). In conclusion, the diagnosis and management of obese children needs to be tailored to gender and the degree of obesity. Furthermore, a systematic management program needs to be developed for early screening and detection of obesity in order to minimize the risk of hyperlipidemia and hypertension, especially in severely obese children.

Key words : obesity, complications, hyperlipidemia, hypertension

INTRODUCTION

Kang et al[1]) reviewed the trends in the incidence of obesity among primary school children in Seoul for the last 18 years; in 1996 the rates of obesity among primary school boys and girls were 23.0% and 15.5%, respectively, and this represented a 6.4-fold increase among boys and a 4.7-fold increase among girls, compared to the year 1979. Child obesity is similar to adult obesity in that blood cholesterol is increased,[2]) and increased rates of fatty liver, diabetes, hypertension and atherosclerosis are found.[3]) Thus, prevention, early diagnosis, and treatment of obesity in children are as important as the management of adult obesity.

According to the Department of Education and Human Resources,[4]) health examinations carried out in primary schools have revealed that 0.4% of school children are severely obese, and that a gradual increase in obesity is evident among school children. In addition, a study carried out in 1995 by the Korean Health Management Society in those children having an obesity index of at least 140% showed that 3.0% of the boys and 4.1% of the girls had high blood pressure, 0.9% of the boys and 0.5% of the girls had high blood sugar levels, and 17.6% of the boys and 21.6% of the girls had high total blood cholesterol.[5]) Also, a study carried out in 1989 by the Korean Pediatric Society[6]) on 324 severely obese children found out that 78.7% of the children had more than one abnormal measurement for blood lipids, fatty liver, or blood pressure.

It has been reported that once blood pressure and serum cholesterol levels are increased in childhood, these conditions may persist into adulthood.[7,8]) In addition, as

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atherosclerosis in adult can be a net result of a gradual progression from childhood, the importance of management of child obesity should be emphasized.

Recently, increased attention is being paid to the effect of childhood obesity on degenerative diseases in adults, and there are some reports on hyperlipidemia,[9),10),11),12)] abnormality in liver function tests,[10),13)] and hypertension;[14)] however, there are few studies which have looked at the effects of childhood obesity on a combination of these risk factors for degenerative diseases. Many research studies carried out so far in child obesity dealt with slightly overweight children or children with mild obesity,[7),10),15)] where children with temporary obesity - which occurs in periods of rapid growth - could have been included.

This study was conducted to compare the rates of hyperlipidemia, hypertension, high blood glucose, and liver dysfunction, between obese children and normal weight children from similar backgrounds.

SUBJECTS AND METHODS

1. Subjects

Sixty-four obese children (24 boys and 11 girls who were moderately obese, and 21 boys and 8 girls who were severely obese) and 45 normal weight children (31 boys and 14 girls), aged between ten and twelve years were selected from 13 primary schools in Kangnung City.

2. Methods

(1) Anthropometric measurements

Height in centimeters and weight in kilograms were measured to the first decimal point in children wearing light clothing, using a height meter and an electric scale (CAS, KSCBB). The values of 50 percentile weight for height from the Korean children's growth standards[16)] were used as weight standards. The present weight was divided by the standard weight, and the percentage was calculated to be used as an obesity index: normal weight = 90 to 110%; moderate obesity = 130% to 150%; severe obesity = over 150%. For each subject, the Body Mass Index (BMI: weight (kg) /height $(m)^2$) was calculated, and % body fat was measured by using a bioelectrical impedance fatness analyzer (GIF-891 DX, Gilwoo Trading Company). Mid upper arm circumference (in centimeters) was measured, and triceps skinfold thickness (in millimeters) was measured with an ultrasound fat thickness meter (AFT-101G, Gilwoo Trading Company.

(2) Blood collection and analysis

Approximately 5ml of intravenous blood were collected from each subject in the morning after they had fasted from 9:00p.m. the previous evening. Whole blood glucose was measured. Serum was separated by centrifuging the whole blood at 4℃ at 2,000×g for 15 minutes. A serum autoanalyzer (Cobasmira, Roche) was used for the determination of triglycerides, total cholesterol and HDL-cholesterol; the Friedewald et al[17)] method was used for calculation of LDL-cholesterol. The Atherogenic Index (AI) was calculated using the formula [(total cholesterol - HDL-cholesterol) / (HDL-cholesterol)]. The LDL/HDL ratio was calculated by the formula (LDL-cholesterol) / (HDL-cholesterol), and the relative cholesterol was calculated by the formula (HDL-cholesterol) / total cholesterol).

Liver function tests were carried out by measuring sGOT and sGPT. Systolic and diastolic blood pressure was measured by using a standard sphygmomanometer after subjects had taken ten minutes of relaxation.

3. Statistical Analysis

Data were analyzed by using the SAS (Statistical analysis system)[18)] software package. Means and standard deviations of height and weight measurements, the obesity index and biochemical measurements were calculated, and statistical significance was determined at $p < 0.05$.

Comparisons of the respective means of the three groups (normal weight, moderate obesity, and severe obesity) were made by using the GLM (General Linear Model) method of the ANOVA (Analysis of covariance), and as well as by using Tukey's method. Pearson correlation coefficients were used to determine the relationships between anthropometric measurements and blood analysis.

RESULTS AND DISCUSSION

1. Gender and family backgrounds

The subjects of the study consisted of 35 moderately obese children (24 boys and 11 girls), 29 severely obese children (21 boys and 8 girls), and 45 normal weight children (31 boys and 14 girls). The incidence of moderate and severe obesity among boys was 2-2.5 times higher than among girls; this result agrees with other studies which also reported that there are more obese boys than obese girls (Kang et al,[1)] Lee and Chang,[19)] and Park[20)]). On the other hand, no significant differences were found in distribution of gender and age among the three different groups of subjects (normal weight, moderately obese, and severely obese groups).

Table 1 lists the education levels and occupations of the parents of the subjects. Education levels and type of occupation of the parents had no significant effect on child obesity in our study, even though another study has found that increases in child obesity are associated with increased education levels and incomes of pare-

Table 1. Education levels and occupations of subjects' parents by group

		Father			Mother		
		Normal weight	Moderate obesity	Severe obesity	Normal weight	Moderate obesity	Severe obesity
Education level	Elementary school	1(2.4)	1(3.0)	3(11.1)	1(2.4)	1(3.0)	3(11.5)
	Middle school	1(2.4)	5(15.2)	4(14.8)	6(14.3)	5(15.2)	4(15.4)
	High school	13(31.0)	12(36.4)	11(40.7)	21(50.0)	13(39.4)	12(46.2)
	University	16(38.1)	11(33.3)	8(29.6)	9(21.4)	6(18.2)	5(19.2)
	Graduate school	5(11.9)	1(3.0)	1(3.7)	5(4.8)	5(15.2)	0(0.0)
	Others	3(7.1)	3(9.1)	0(0.0)	3(7.1)	3(9.1)	2(7.7)
	Total	42(100.0)	33(100.0)	27(100.0)	42(100.0)	33(100.0)	26(100.0)
		x^2=9.239, df=10, p=0.510			x^2=9.061, df=10, p=0.526		
Occupation	Agriculture, Fishery	1(2.2)	1(3.0)	0(0.0)	2(4.8)	0(0.0)	0(0.0)
	Commerce	12(26.7)	10(30.3)	14(50.0)	10(23.8)	6(20.7)	11(40.7)
	Office work	26(57.8)	19(57.6)	8(28.6)	9(21.4)	5(17.2)	6(22.2)
	Profession	3(6.7)	3(9.1)	5(17.9)	2(4.8)	1(3.5)	0(0.0)
	No job	2(4.4)	0(0.0)	1(3.6)	19(45.2)	17(58.6)	10(37.0)
	Total	44(100.0)	33(100.0)	28(100.0)	42(100.0)	29(100.0)	27(100.0)
		x^2=12.152, df=10, p=0.275			x^2=7.959, df=8, p=0.438		

Table 2. Ages and anthropometric measurements of subjects by group

Variable	Male			Female		
	Normal weight	Moderate obesity	Severe obesity	Normal weight	Moderate obesity	Severe obesity
Age(years)	10.77±1.80	10.71±1.71	10.71±1.87	10.93±1.49	11.09±1.22	11.50±1.31
Height(cm)	140.50±11.57	143.50±12.01	143.00±12.76	139.20±8.44	145.90±8.83	144.40±11.83
Weight(kg)	36.24±8.93^a	53.42±13.56^b	63.08±18.90^b	35.15±8.44^a	52.83±10.14^b	63.98±15.77^b
Arm circumference(cm)	21.11±2.37^a	28.34±2.42^b	31.41±2.86^c	20.84±1.86^a	27.23±4.80^b	30.99±4.57^b
Triceps skinfold(mm)	7.71±1.60^a	11.29±2.90^b	11.95±2.40^b	7.00±1.71^a	10.09±2.70^b	12.88±3.36^b
Body fat(%)	11.55±4.65^a	26.21±9.73^b	36.59±17.94^c	11.51±3.69^a	23.43±6.54^b	33.89±11.25^c
BMI(kg/m^2)	18.02±1.74^a	25.47±2.38^b	30.08±3.44^c	17.77±1.74^a	24.59±2.12^b	30.24±3.67^c
Obesity index(%)	98.59±5.73^a	137.00±8.01^b	162.30±10.53^c	98.25±6.46^a	130.6±7.84^b	165.70±17.72^c
Rōhrerindex(kg/m^3)	128.30±7.74^a	177.70±10.71^b	210.10±11.36^c	127.50±8.45^a	168.70±11.19^b	209.70±21.80^c

BMI : Body mass index
Values in the same row with different superscript are significantly different at p<0.05.

nts.[21)]

2. Anthropometric measurements

Table 2 presents the results of anthropometric measurements of subjects. Between girls and boys, average age and height were not significantly different. Regarding weight and triceps skinfold thickness, there were no differences between the moderately obese group and the severely obese group; however, significant differences existed between the normal weight group and the two obese groups. In addition, values for body fat (%), BMI, the obesity index and the Röhrer index were significantly different among the three groups; the severely obese group had the highest value, followed by the moderately obese group, and then the normal weight group. Obesity indices for the severely obese group were 162.30 ± 10.53% for boys and 165.7 ± 17.72% for girls, while % body fat values for this group were 36.59 ± 17.94% for boys and 33.89 ± 11.25% for girls.

The mean heights (140.5cm for boys and 139.2cm for girls) and mean weights (36.2kg for boys and 35.2kg for girls) of the normal weight group in the present study were slightly lower than the reported values for 10-year old children in Annals of Educational Statistics in 2000,[4)]

Table 3. Serum lipid levels and blood pressure of subjects by group

Variable	Male			Female		
	Normal weight	Moderate obesity	Severe obesity	Normal weight	Moderate obesity	Severe obesity
Total cholesterol(mg/dl)	158.50±32.33[a]	167.20±32.06[ab]	187.20±40.41[b]	181.6±35.19	177.0±29.28	198.40±33.12
Triglyceride(mg/dl)	81.16±23.59[a]	102.30±36.03[a]	133.60±49.99[b]	80.00±25.31[a]	106.40±41.73[a]	154.30±46.84[b]
HDL-cholesterol(mg/dl)	54.58±5.03	56.75±4.42	55.48±5.49	55.43±5.37	56.27±3.82	53.29±5.06
LDL-cholesterol(mg/dl)	87.74±32.95[a]	89.99±32.10[a]	105.00±41.12[b]	110.20±33.70	99.45±24.74	114.3±37.46
LDL-cholesterol/HDL-cholesterol	1.63±0.62	1.60±0.61	1.95±0.89	2.01±0.66	1.78±0.51	2.20±0.88
Atherogenic index(A.I.)	1.93±0.62[a]	1.96±0.61[ab]	2.43±0.95[b]	2.30±0.69	2.17±0.65	2.78±0.89
Relative cholesterol	0.36±0.07	0.35±0.07	0.31±0.07	0.315±0.06	0.33±0.06	0.28±0.06
Systalic blood pressure[1)](mmHg)	108.40±8.60[a]	112.50±9.44[a]	120.50±9.74[b]	107.10±9.14	112.70±10.09	112.50±7.07
Diastalic blood pressure[2)](mmHg)	68.39±6.88[a]	70.83±8.30[a]	80.95±10.44[b]	67.86±8.93	71.45±5.59	71.25±6.41

Values in the same row with different superscript are significantly different at $p<0.05$.

while BMI values of 18.02 for boys and 17.77 for girls in the normal weight group in the present study were somewhat higher than the 16.3 for boys and 16.0 for girls quoted in the Annals of Educational Statistics. Himes and Dietz[22)] suggested a BMI value of 20 as a cut-off point for obesity in ten-year old children, and a cut-off point of 23 for obesity in children under ten years old. In the present study the mean BMI values for the moderately obese groups of children were 25.47 for boys and 24.59 for girls; for severely obese children the mean BMI values were 30.08 for boys and 30.24 for girls.

3. Serum lipids and blood pressure

Table 3 presents the results of the serum lipid analyses. Serum cholesterol levels of the children in the present study were lower than the 200mg/dl level considered by the American Pediatric Association[23)] as the minimum for hypercholesterolemia. However, the serum triglyceride level of the girls in the severely obese group was 154.30 ± 46.84mg/dl, which is higher than the 138mg/dl level proposed by the American Pediatric Association as the minimum for hypertriglyceridemia. Among boys, levels of HDL-cholesterol were not significantly different among the three groups; however, serum triglyceride and LDL-cholesterol levels of severely obese group were 133.60 ± 49.99mg/dl and 105.00 ± 41.12 mg/dl, respectively, which were significantly higher than those of the normal weight group (81.16 ± 23.59 mg/dl and 87.74 ± 32.95 mg/dl, respectively) or those of the moderately obese group (102.30 ± 36.03 mg/dl and 89.99 ± 32.10 mg/dl, respectively). Total cholesterol and atherogenic index (AI) values in the moderately obese group were not significantly different from either the normal weight group or the severely obese group, while the differences between the severely obese group and the normal weight group were significant. In summary, obesity index levels of over 150% in the present study appeared to be associated with increased blood lipid levels among boys. Among girls, the mean serum triglyceride level in the severely obese group (154.30 ± 46.84 mg/dl) was significantly higher than that of the normal weight group (80.00 ± 25.31 mg/dl) and the moderately obese group (106.40 ± 41.73 mg/dl).

The result of the present study supports the finding of Zonderland et al[24)] that the change in serum lipid levels with obesity is more clearly shown in boys than in girls. Im et al[11)] reported in their study of 4 to 12 year old children that serum triglyceride level was significantly higher in the obese group (111.0 ± 45.9 mg/dl) compared to the normal weight group (83.5 ± 39.4 mg/dl). Another study[9)] of children in grade 5 in Buchun city primary school reported a significantly increased serum total cholesterol level in obese girls compared to normal weight girls ($p<0.05$). In a study carried out with children from 4th to 6th grade in Jinju, serum triglyceride, HDL-cholesterol and LDL-cholesterol levels were significantly higher in the obese group compared to the normal weight group both in boys and girls.[10)]

In general, the moderately and severely obese subjects in our study had higher serum lipids compared to the mildly obese children in other study.[15)] In the study of Son et al[15)] whose subjects had a mean obesity index of 119.62 ± 20.09%, the serum triglyceride level was 104.33 ± 42.78 mg/dl, compared to 133.60 ± 49.99 mg/dl in boys and 154.30 ± 46.84 mg/dl in girls of the severely obese group in our study. In Son et als study, HDL- cholesterol and LDL-cholesterol levels, and total cholesterol (186.20 ± 34.96 mg/dl), of their obese subjects were similar to the present study.

The atherogenic index (AI) is commonly used to evaluate the risk of coronary heart diseases and is calculated as [(total cholesterol - HDL-cholesterol) / (HDL-cholesterol)]. The AI values in our severely obese group were 2.43 ± 0.95 for boys and 2.78 ± 0.89 for girls, which appeared to be lower than the values obtained by Im et al[11] from obese children in some parts of Seoul (AI = 2.81 ± 0.86).

In normal weight boys, systolic blood pressure was 108.40 ± 8.60 mmHg and diastolic pressure was 68.39 ± 6.88 mmHg; these values were not significantly different from the moderately obese group (systolic: 112.50 ± 9.44 mmHg; diastolic: 70.83 ± 8.30 mmHg). However, both systolic and diastolic pressure were significantly higher in severely obese boys (120.50 ± 9.74 mmHg and 80.95 ± 10.44 mmHg, respectively) compared to normal weight boys. Nevertheless, no significant differences in blood pressure were shown among girls.

In 1994 Kim et al[14] measured the blood pressure of 1,164 elementary school children in the Kangnung area, and published 50th, 90th, and 95th percentile values; the moderately obese boys in the present study showed systolic and diastolic blood pressure at the 90 percentile level for 4th, 5th grade, and the severely obese boys at the 90 to 95th percentile in 6th grade boys. Moderately and severely obese girls had blood pressure levels corresponding to the 90th percentile level in 4th grade girls in the study of Kim et al.[14] Even the blood pressure of the normal weight group in the present study appeared to be somewhat higher than the values obtained by Kim et al,[14] and there was a clear pattern of increased blood pressure with increased obesity among boys.

On the other hand, the blood pressure of the normal weight group was similar compared to values reported by Choi et al,[26] but the diastolic pressure of the obese groups in the present group exceeded Choi et al's values. According to the physical examinations of 4th to 6th grade children carried out by Lee et al[13] in Chang-Won city, neither systolic nor diastolic blood pressure was different between five groups (severely underweight, mildly underweight, normal weight, overweight, obese groups). Also, Kim et al[12] could not find differences in blood pressure between a moderately obese group and a severely obese group.

4. Rates of hyperlipidemia and hypertension

Table 4 shows rates of hyperlipidemia and hypertension for each of the three groups. When serum cholesterol levels of over 200mg/dl are used to define hypercholesterolemia, the rates in boys were 16.1%, 20.8%, and 42.9% and the rates in girls were 35.7%, 27.3%, and 50.0%, for the normal weight group, the moderately obese group, and the severely obese group, respectively; there were no significant differences between these groups. In a study of 5th grade children from Buchon city,[9] hypercholesterolemia (defined as blood cholesterol levels of over 200mg/dl) was found in only 3.2% of the boys and 3.7% of the girls, while 25.6% of the children who participated in a nutrition camp/health promotion program in a model elementary school in Changwon city had hypercholesterolemia.[13] Kim et al[27] in 1993 reported that the incidence of hypercholesterolemia among children with an obesity index of over 120% in Yeido apartment complex was 5% in boys and 9% in girls, while 27.3% of boys and 30.4% of girls were found to be hypercholesterolemic in a sample of elementary school children with an obesity index of over 120% in the northern Kyoungbuk area.[12] Lee et al[6] reported that 61.0% of the obese boys and 63.2% of the obese girls with an obesity index of over 150% had total cholesterol levels above 185mg/dl and LDL-cholesterol above 110 mg/dl. Ahn et al[28] reported that 81.8% of children whose average obesity index was 163% to 165% had hypercholesterolemia (cholesterol over 200mg/dl). All of the above studies confirm an increasing trend of hypercholesterolemia among children, and a positive relationship between obesity and hypercholesterolemia.

The incidence of hypertriglyceridemia in girls in the present study, was 14.3% in the normal weight group, 27.3% in the moderately obese group, and 62.5% in the severely obese group; these differences were not significant. However, significant differences were found among the groups in boys: the incidence of hypertriglyceridemia was 9.1% in the normal weight group, 41.7% in the moderately obese group, and 76.2% in the severely obese group. Kim et al[29] reported that serum lipid levels increased with increasing obesity in boys and girls; serum triglyceride levels increased with increasing obesity and high serum cholesterol levels were seen in obese children compared to their normal weight counterparts. Also, Cho et al[30] reported that serum cholesterol and triglyceride levels increased in obese adults compared to normal weight adults in the Youngdong area.

Comparison of the incidence of hypertriglyceridemia between different studies is very difficult because of the use of different definitions. When the cutoff points of 88mg/dl for boys and 93mg/이 for girls under the age of 9 years, and of 105 mg/dl for boys and 117mg/dl for girls of 10 years or more, are applied, 28% of boys and 18% of girls whose obesity index was over 120%, and 5.6% of the children who participated in a nutrition camp, had hypertriglyceridemia.[13] When the cutoff point of 120mg/dl was applied, Kim et al[12] found that 7.7% of boys and 8.9% of girls had hypertriglyceridemia. With a cutoff point of 150mg/dl, Son et al[9] found that 1.6% of boys and 4.4% of girls were hypertriglyceridemic. Among obese children and adolescents with an obesity index in excess of 160%, 78.8% had serum triglyceride levels above 140mg/dl.[28] 4.8% of boys and 6.7% of girls in the 5th primary school children in one study[9], and

Table 4. Rates of hyperlipidemia, hypertension and high atherogenic index by group

Serum lipid	Range	Male			Female		
		Normal weight	Moderate obesity	Severe obesity	Normal weight	Moderate obesity	Severe obesity
Cholesterol	<200mg/dl	26(83.87)	19(79.17)	12(57.14)	9(64.29)	8(72.73)	4(50.00)
	>200mg/dl	5(16.13)	5(20.83)	9(42.86)	5(35.71)	3(27.27)	4(50.00)
	Total	31(100.0)	24(100.0)	21(100.0)	14(100.0)	11(100.0)	8(100.0)
		x^2=5.095,	df=2,	p=0.078	x^2=0.595,	df=2,	p=0.595
Ttryglyceride	<Criteria[1)]	28(90.32)	14(58.33)	5(23.81)	12(85.71)	8(72.73)	3(37.50)
	>Criteria[1)]	3(9.68)	10(41.67)	16(76.19)	2(14.29)	3(27.27)	5(62.50)
	Total	31(100.0)	24(100.0)	21(100.0)	14(100.0)	11(100.0)	8(100.0)
		x^2=23.654,	df=2,	p=0.001	x^2=5.675,	df=2,	p=0.059
LDL-cholesterol	<130mg/dl	26(83.9)	21(87.5)	14(66.7)	9(64.3)	9(81.8)	6(75.0)
	>130mg/dl	5(16.1)	3(12.5)	7(33.3)	5(35.7)	2(18.2)	2(25.0)
	Total	31(100.0)	24(100.0)	21(100.0)	11(100.0)	11(100.0)	8(100.0)
		x^2=3.499,	df=2,	p=0.174	x^2=0.982,	df=2,	p=0.612
HDL-cholesterol	<35mg/dl	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(12.50)
	>35mg/dl	31(100.0)	24(100.0)	21(100.0)	14(100.00)	11(100.00)	7(87.50)
	Total	31(100.0)	24(100.0)	21(100.0)	11(100.0)	11(100.0)	8(100.0)
		x^2= ,	df= ,	p=	x^2=3.223,	df=2,	p=0.200
Atherogenic index	<3.0	29(93.55)	23(95.83)	15(71.43)	12(85.71)	9(81.82)	6(75.00)
	>3.0	2(6.45)	1(4.17)	6(28.57)	2(14.29)	2(18.18)	2(25.00)
	Total	31(100.0)	24(100.0)	21(100.0)	11(100.0)	11(100.0)	8(100.0)
		x^2=7.847,	df=2,	p=0.020	x^2=0.393,	df=2,	p=0.822
Systolic Blood Pressure	<95th[2)]	26(83.9)	16(66.7)	4(19.0)	11(78.6)	6(54.5)	6(75.0)
	>95th[2)]	5(16.1)	8(33.3)	17(81.0)	3(21.4)	5(45.5)	2(25.0)
	Total	31(100.0)	24(100.0)	21(100.0)	14(100.0)	11(100.0)	8(100.0)
		x^2=22.257,	df=2,	p=0.001	x^2=1.824,	df=2,	p=0.402
Diastolic Blood Pressure	<95th[2)]	24(77.4)	16(66.7)	4(19.0)	9(64.3)	5(45.4)	5(62.5)
	>95th[2)]	7(22.6)	8(33.3)	17(81.0)	5(35.7)	6(54.6)	3(37.5)
	Total	31(100.0)	24(100.0)	21(100.0)	14(100.0)	11(100.0)	8(100.0)
		x^2=18.606,	df=2,	p=0.001	x^2=0.999,	df=2,	p=0.607

1) Age ≤ 9 years : > 88mg/dl in male, > 93mg/dl in female
Age > 10 years : > 105mg/dl in male, > 117mg/dl in female
2) Task Force Report

12.5% of the children in another study[13], had LDL-cholesterol levels in excess of 130mg/dl. In a 1993 study of obese children,[11] 5% of boys and 9% of girls were found to have LDL-cholesterol levels above 130mg/dl. A similar study in 2001[12] found that 17.9% of boys and 19.6% of girls had LDL-cholesterol levels above 130mg/dl. On the other hand, a study of obese inpatients in a pediatric ward found that 48.1% had LDL-cholesterol levels above 170mg/dl.[6] In our study, there was no subject having a HDL-cholesterol level lower than 35mg/dl, which is the same as the finding in Changwon city among the children who participated in a nutrition camp[13] or among obese primary school children in the Northen Kyoungbuk area.[12] Low HDL- cholesterol rates were found in 28% of boys and 22.2% of girls in Buchon,[9] and in 0% of obese boys and 9% of obese girls who live in a high-income apartment complex.[11] On the other hand, 80% of the inpatients in a pediatric ward had HDL-cholesterol levels lower than 40mg/dl.[28] When AI values of over 3.0 are considered as a risk factor for atherosclerosis, 6.5%, 4.2%, and 28.6% of boys, and 14.3%, 18.2%, and 25.0% of girls, in the normal weight group, the moderately obese group, and the severely obese group, respectively, were found to have a high risk in our study. 4.4% of primary school children in Changwon city,[13] 12.8% of obese boys and 19.7% of obese girls in the northern Kyoungbuk area,[12] and 22% of obese boys and 18% of obese girls who live in a high-income apartment complex,[11] were found to have AI values greater than 3.0.

A task force report[31] by the U.S. and the U.K. combined nine research studies, and suggested that a group with blood pressure higher than the 90th percentile is abnormally high, and a group with blood pressure higher than the 95th percentile is a risk group. Thus, the present study used this 95th percentile as a cutoff point as shown in Table 4. Among girls, the risk of hypertension was not significantly different between the 3 different groups: the normal weight, the moderately obese, and the severely obese group. However, among boys, high systolic pressure and high diastolic pressure were seen in 16.1% and 22.6%, respectively, of the normal weight group, in 33.3% and 33.3% of the moderately obese group, and in 81.0% and 81.0% of the severely obese group; the results for the severely obese group were significantly higher compared to the other groups. The subjects of our study had a much higher rate of hypertension compared to the study by Kim et al[14] who found only 3.1% had hypertension out of 1,164 children from 18 elementary schools in Kangnung in 1994.

In a study of 55 obese children[28] 87% of the subjects were found to have more than one complication, such as hyperlipidemia and hepatic dysfunction, or hyperlipidemia and urine with a high uric acid content, or hyperlipidemia and hepatic dysfunction together with high uric acid urine.

5. Fasting blood glucose and sGOT, sGPT

Table 5 lists the fasting blood glucose, serum GOT, and serum GPT levels of the subjects. Fasting blood glucose and serum GOT levels tended to increase with increasing obesity, even though there were no significant differences among groups. However, serum GPT levels in boys were significantly lower in the normal weight group (12.55 ± 7.17 IU/L) compared to the moderately obese group (23.88 ± 22.61 IU/L) or the severely obese group (24.05 ± 19.20 IU/L).

Kim et al[10] found that fasting blood glucose levels were higher in obese children than in non-obese children, and also found that obese girls had a significantly higher level of fasting blood glucose level (96.0 ± 12.7 mg/dl) than obese boys (86.0 ± 5.8 mg/dl).

Ahn et al[28] reported that serum GOT and GPT levels of children with an average obesity index of 164.7% were 34.6 ± 17.1 IU/L and 24.7 ± 15.3 IU/L, respectively; these values are higher than our findings. Ahn et al[28] also found that 25.5% of children and adolescents had suspected hepatic dysfunction, as their sGOT levels were higher than 40IU/L and their sGPT levels were higher than 35IU/L. Kim et al[10] reported sGOT and sGPT values of 24.3 ± 5.1IU/L and 28.8 ± 3.9IU/L for boys, and 20.6 ± 4.5IU/L and 23.6 ± 2.9IU/L for girls, respectively, in their study of children in Jinju city whose obesity index was above 120%; these values are higher than those obtained in our study. Kim et al[10] further reported that only sGOT levels between the obese group and the non-obese group were significantly different; however, our study showed that sGPT levels were significantly different between the normal weight group and the obese groups. In a study of hospitalized pediatric patients, 38.3% of 324 severely obese inpatients were suspected of having fatty livers, with sGOT levels lower than 27IU/L and sGPT levels higher than 30IU/L.[6]

In severe obesity, when sGOT and sGPT levels increase to 40 to 150IU/L, the development of a fatty liver due to obesity should be suspected. Simple fatty liver can progress to hepatitis, hepatic fibrosis, and eventually to hepatic cirrhosis; the mechanism for this progression is not clear, but an imbalance between carbohydrate and protein metabolism is conjectured.[6] None of the children in the present study appeared to have dangerous levels of sGOT and sGPT; however, the careful follow-up of fatty liver conditions in obese children is recommended.

Table 5. Fasting blood glucose, sGOT and sGPT levels of subjects by group

Variable	Male			Female		
	Normal weight	Moderate obesity	Severe obesity	Normal weight	Moderate obesity	Severe obesity
Glucose(mg/dl)	85.52±9.39	88.04±12.01	92.00±11.62	82.21±15.11	88.73±8.73	91.00±18.27
sGOT(IU/L)	19.29±8.45	21.79±14.25	24.10±17.55	25.14±26.24	22.27±10.34	18.71±10.86
sGPT(IU/L)	12.55±7.17^{a}	23.88±22.61^{b}	24.05±19.20^{b}	17.29±22.65	19.73±17.48	19.86±18.94

Values in the same row with different superscript are significantly different at $p<0.05$.

Table 6. Satisfaction with body weight and experience of dieting in subjects by group

		Male			Female		
		Normal weight	**Moderate obesity**	**Severe obesity**	**Normal weight**	**Moderate obesity**	**Severe obesity**
Current body weight(A)		36.24 ± 8.93^a	53.42 ± 13.56^b	63.08 ± 18.85^b	35.15 ± 8.44^a	52.83 ± 10.14^b	63.98 ± 15.77^b
Expected body weight(B)		36.74 ± 8.77	38.96 ± 9.36	38.59 ± 9.83	35.96 ± 9.19	40.64 ± 8.17	38.79 ± 10.13
Difference(A-B)		2.07 ± 4.84^a	17.67 ± 10.09^b	19.86 ± 11.30^b	2.89 ± 3.36^a	15.05 ± 7.03^b	22.13 ± 13.07^b
%, $\frac{(A-B)*100}{A}$		5.24 ± 12.04^a	31.61 ± 13.54^b	29.60 ± 13.62^b	7.35 ± 9.06^a	27.97 ± 11.68^b	34.08 ± 15.71^b
Satisfaction with body weight	Satisfied	16(53.3)	2(8.3)	4(19.1)	10(71.4)	0(0.0)	0(0.0)
	To be reduced	10(33.3)	22(91.7)	17(81.0)	4(28.6)	11(100.0)	8(100.0)
	To be increased	4(13.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Total	30(100.0)	24(100.0)	21(100.0)	14(100.0)	11(100.0)	8(100.0)
		x^2=24.290,	df=4,	p=0.001	x^2=19.472,	df=2,	p=0.001
Experience of dieting	Yes	4(14.8)	11(45.8)	15(75.0)	3(23.1)	6(54.6)	6(75.0)
	No	23(85.2)	13(54.2)	5(25.0)	10(76.9)	5(15.5)	2(25.0)
	Total	27(100.0)	24(100.0)	20(100.0)	13(100.0)	11(100.0)	8(100.0)
		x^2=17.247,	df=2,	p=0.001	x^2=5.758,	df=2,	p=0.056
Frequency of dieting		1.75 ± 0.50^a	4.08 ± 5.02^b	3.80 ± 2.83^b	1.33 ± 0.58^c	3.71 ± 3.04^b	3.83 ± 1.33^b

Values in the same row with different superscript are significantly different at $p<0.05$.

6. Expected weight and experience of dieting

The expected weight and the extent of desired weight reduction suggested by the children in all three groups are presented in Table 6. As was discussed previously, the weights of the obese groups were significantly higher than those of the normal weight group. Expected weights among the three groups were not significantly different. The amounts of weight the boys and girls wanted to lose were 2.07 ± 4.84kg and 2.89 ± 3.36 kg, respectively, in the normal weight group, 17.67 ± 10.09 kg and 15.05 ± 7.03 kg in the moderately obese group, and 19.86 ± 11.30 kg and 22.13 ± 19.07 kg in the severely obese group. Thus, the desired amount of weight loss was significantly higher in the obese groups compared to the normal weight group. When the proportion of desired weight reduction is compared with the present weight, in normal weight children it was found to be 5.24 ± 12.04% for boys and 7.35 ± 9.06% for girls, while it was significantly higher in moderately and severely obese group, ranging from 27.97% to 34.08%.

The level of satisfaction of the children with their present weight was studied; all girls in the obese groups wanted to reduce weight, while 8.3% of the moderately obese boys and 19.1% of the severely obese boys were satisfied with their weight. Even in the normal weight group, 33.3% of the boys and 28.6% of the girls wanted to reduce their weight. There is a need to educate children to have a correct perception of their body shapes and weights.

In both moderately and severely obese groups the expected weights were extremely low, and their attempts to implement dieting were significantly higher than normal weight children. Im et al[11] reported that 47.4% of obese children made attempts to diet, while normal weight and overweight children had no experience of attempts to diet ; these results were similar to those of our study. Weight reduction by using inadequate methods could result in physiological and mental problems. Total fasting or using extreme methods for short-term weight reduction is dangerous; thus, encouraging children to have proper food habits and physical exercise is very important.

7. Relationship between related variables

Table 7 presents correlation coefficients between anthropometric measurements and the results of biochemical analyses. Kim et al[10] in their study with children in Jinju city reported that BMI rather than WHR (waist hip ratio) was positively related with levels of serum triglyceride, LDL-cholesterol, glucose, and sGPT. Also, the obesity index was positively related with levels of sGOT, serum triglycerides, and serum cholesterol, while negatively correlated with HDL-cholesterol.[32]

Table 7. Correlation coefficients of anthropometric measurements with biochemical analysis

	Arm	Triceps	Body fat	BMI	Obesity index	Rŏhrer index
Total cholesterol	0.259**	-	-	-	0.248**	0.252**
Triglyceride	0.505***	-	0.379***	0.513***	0.501***	0.491***
LDL-cholesterol	-	-	-	-	-	-
HDL-cholesterol	-	-	-	-	-	-
Atherogenic index	0.239*	-	-	0.237*	0.236*	0.232*
Relative cholesterol	-0.221*	-	-	-0.223*	-0.216*	-0.212*
Glucose	0.232*	0.212*	-	0.227*	0.217*	0.208*
sGOT	-	-	-	-	-	-
sGPT	0.279**	-	0.196*	0.248**	0.213*	0.212*

* : 0.01≤p<0.05, ** : 0.001≤p<0.01, *** : p<0.001

Table 8. Correlation coefficients of fasting blood glucose, sGOT, sGPT and blood pressure with biochemical analysis

	SBP[1)]	DBP[2)]	Glucose	sGOT	sGPT
Total cholesterol	0.120	0.148	0.254*	0.261**	0.217*
Triglyceride	0.218*	0.229*	0.276**	-	0.303**
LDL-cholesterol	0.082	0.109	0.215*	0.225*	-
HDL-cholesterol	-0.093	-0.095	-	-	-
Atherogenic index	0.144	0.171	0.285**	-	-
Relative cholesterol	-0.121	-0.150	-0.269**	-0.197*	-
Glucose	0.228*	0.196*	-	0.209*	0.237*
sGOT	-0.139	-0.096	0.209*	-	0.762***
sGPT	0.031	0.045	0.237*	0.762***	-

* : 0.01≤p<0.05, ** : 0.001≤p<0.01, *** : p<0.001
1) Systic Blood Presure, 2) Diastolic Blood Pressure

Serum cholesterol levels were not significantly related to triceps skinfold thickness or % body fat, but were significantly correlated with mid-upper arm circumference (r = 0.259), the obesity index (r = 0.248), and the Röhrer index (r = 0.252). Especially, serum triglyceride levels were highly correlated with anthropometric measurements, as follows: body fat (r = 0.379), mid-upper arm circumference (r = 0.505), the BMI (r = 0.513), the obesity index (r = 0.501), and the Röhrer index (r = 0.491).

Son et al[9)] reported that serum cholesterol levels were significantly related to triceps skinfold thickness, mid-upper arm circumference, the BMI, the Röhrer index, and % body fat. Fasting blood glucose levels were positively correlated with all anthropometric measurements except % body fat. Serum GPT levels were positively correlated with all anthropometric measurements except triceps skinfold thickness; however, serum GOT levels were not correlated with any body measurements.

Hyperlipidemia, such as high serum triglyceride and cholesterol, is considered to be a primary risk factor for coronary heart disease[33)]; however, early detection and treatment before the age of twenty would reduce accumulated fat in blood vessel walls, while recovery is not possible if fibrosis occurs during the one's 30's and 40's.[33)] In children, LDL-cholesterol and VLDL-cholesterol increase with increasing body fat, and they return to normal with weight reduction. However, when obesity is continued to the adult stage, chronic degenerative diseases will develop.[35)] Also, recent pediatric research[36)] revealed that increased sGPT, total cholesterol, and sGPT in severely obese children, indicating abnormal liver function, would make the liver progress from simple fatty liver to liver cirrhosis.

Blood pressure was shown to be positively correlated with levels of serum triglycerides and fasting blood glucose levels as shown in Table 8. The correlation coefficients of systolic blood pressure with serum triglycerides and fasting blood glucose levels were 0.218 and 0.228, respectively. The correlation coefficients of diastolic blood pressure with triglyceride levels and fasting blood glucose levels were 0.229 and 0.196, respectively.

Also, fasting blood glucose level was significantly correlated with the levels of blood lipids except HDL-cholesterol (r = 0.215 to 0.285). Total cholesterol levels were significantly correlated with sGOT and sGPT levels, triglyceride levels were significantly correlated with sGPT, and LDL-cholesterol levels were correlated with sGOT. These results imply that the risks of obesity are related to diabetes, hyperlipidemia, and abnormal liver functions.

The above results show that the risks of hyperlipidemia, damage to liver functions, and hypertension are higher in obese children compared to normal weight children. In addition, the effects of obesity on serum lipids and blood pressure were different between boys and girls. Therefore, management of obesity should be tailored to gender and the degree of obesity (mild, moderate, and severe). Furthermore, more diversified methods of diagnosis depending on gender should be developed, and especially, a systematic management program needs to be developed to enable early screening for possible complications in obese children.

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