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☐ Original Article ☐

A Study on Obesity-promoting Factors for the Elementary School Children

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ABSTRACT

The purpose of this study is to examine the relationships among body composition, dietary intake, exercise, and life style in children(M=80, F=102) of the 5th and 6th grades of elementary school. Anthropometry and multifrequency bioelectrical impedance analysis were conducted to estimate body composition. Dietary intake, exercise, and life style were determined by using questionnaires.

When obesity was classified greater than 120% of the ideal body weight, the prevalence rates of obesity were 31.2% for boy and 20.6% for girl. There were significant differences in body composition between nonobese(NO) and obese(OB) groups. Mean fat mass(FM) and lean body mass(LBM) were 8.6kg and 27.7kg for NO group and 16.7kg and 32.3kg for OB group, respectively. Also a significant difference was found in hydration rate(TBW/body weight) between groups($p<0.01$). No significant difference was found in total calorie intake and nutrient intakes between groups. No difference was found in the frequency and duration of outdoor exercise and indoor activities. Mean sleeping hours was 8 - 9 hours for 62% of nonobese children and for 59% of obese children. However, calorie intake per body weight was significantly lower in obese children than in nonobese. The present study showed that significant differences existed in their body size and composition between NO and OB groups, while no differences existed in daily calorie intake, excercise, and life style. This may indicate that important obesity-promoting factors of early onset obesity may rely on other factors such as hereditary or environmental factors besides factors considered. Further studies are required to understand obesity-promoting factors in children. (*Korean J Community Nutrition* 2(5) : 680~686, 1997)

KEY WORDS : obesity-promoting factors · body composition · anthropometric measurement · elementary school children.

Introduction

As the Korean economy grows, the individual's life style has been altered. Modernized transportation and lowered activity level result in the reduction of daily energy expenditure(Moon et al. 1992). The 1995 Nutrition Census show that about 20% of the average adult population are classified as obese(Health and Welfare Department 1997). Although obesity

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itself is not a disease, it is closely related to risk factors of multiple adult diseases such as hyperlipidemia, fatty liver, diabetes, hypertension, and cardiovascular disease(Kim et al. 1993 ; Klesges et al. 1995 ; Lee 1990 ; Lee et al. 1995 ; Stunkard et al. 1972 ; Yamazaki & Murata 1990). Obesity has become an important health issue worldwide and WHO declared 'Obesity is a disease'.

Heredity, diet, and energy expenditure are the three factors usually considered to control fat deposition in the development of obesity. Although diet and energy expenditure are considered direct inducers of obesity, heredity is indirect ; it regulates an individual's response to diet and/or activity. Regardless of the obesity-promoting factors, the underlying assumption in fat deposition is the principle of energy balance : if individuals consume more energy than they expend, weight gain follows, and if individuals expend more energy than they consume, weight loss follows.

However, this principle of energy balance may be more complicated than originally assumed. For example, studies have shown that dietary fat and sugar can promote obesity without excessive energy intake (Muecke et al. 1992). This implies that diet composition may be as important as energy content in promoting obesity. Several studies have attempted to determine the relationships among adiposity, diet composition, energy intake, food preferences, and eating behavior(Lee et al. 1996 ; Miller et al. 1990).

Early onset obesity is frequently caused in grade school children and adolescents. The increasing number of adipose cells and hormonal changes accelerate the weight gain and the growth rate. Recently childhood obesity has been intensively studied in the field of eating habits and daily life styles(Moon & Lee 1987 ; Park & Park 1995), blood triglyceride level and obesity(Lee et al. 1991 ; Park et al. 1993 ; Son & Lee 1997).

The purpose of this study was to evaluate the relationships among body fat, diet composition, energy intake, and exercise patterns in children of the 5th - 6th grade with the assessment of body composition. The experiment was conducted at a private school. The subjects were divided into nonobese and obese group based on their weight to height. Questionnaries were used to evaluate daily food intakes and life styles.

Subjects and Methods

1. Subjects

Subjects for this study were boys(n=80) and girls (n=102) from private elementary school 5th or 6th grade students residing in Pusan city. This study was conducted on April 23rd and 24th of 1997.

2. Measurements

The subjects were measured while wearing light athletic tops and shirts. Height was measured to the nearest 0.5cm by using a linear height scale and weight was measured to the nearest 0.2kg by using an electronic weight scale. Triceps skinfolds thickness and midarm circumference were measured by caliper. A new electrode method for multifrequency bioelectrical impedance analysis has been conducted using eight tactile electrodes to estimate body composition such as LBM, body fat and intra- and extra-cellular fluid volumes. Segmental impedance was measured by a commercial multifrequency segmental impedance analyzer(Inbody 2.0, Biospace Co. Ltd., Seoul, Korea).

Subjects were then given a life style and exercise-behavior questionnaire. The questionnaire determines the sleeping time, time of watching TV and playing computer games or outside activity.

A dietary semi-frequency questionnaire done in the previous study(Kim et al. 1997) was used to estimate daily nutrient intakes. The nutrient intakes was compared with Data of the Korean Dietary Recommendation 6th edition. In addition, food habits including the frequency of fast food intake and eating out were examined by questionnaire.

After data analysis of each group as a whole, the group was subsequently divided into a non-obese and obese subgroup. Obesity was defined as a weight for height that was greater than 120% of the ideal body weight.

3. Statistical analysis

Statistical analysis was performed using a microcomputer software program, software of SAS(Statistical Analysis System). The strength of relationships among diet and body composition was measured by the Pearson' correlation coefficient. To compare differences among mean values for the non-obese and obese subgroups, student's t test and the chi-square test were used. Results were considered to be statistically significant at $p<0.05$.

Results and Discussions

Elementary school children of 10 - 12 years of age participated in the present study. The subjects were classified into boy and girl, and nonobese(NO) and obese(OB) groups by genders and individual weight to height ratios, respectively. Anthropometric measurement, body composition analysis using a bioelectrical impedance analyzer(BIA), and questionaries on daily food intakes and excercise were conducted. The results were summarized as follows.

A total of 182 participated subjects(M=80, F=102) were divided into nonobese and obese group by using their gender and different obesity indices. The percent body fat determined with the body composition analyzer classified 55.5% of participating children into the obese group. Using body mass index (BMI) and percent ideal body weight(PIBW), these percentages were 31.9% and 25.3%, respectively (Table 1).

In comparison, a previous study(Son & Lee 1997) reported that 15.3%(BMI$>$20kg/m^2) and 7.7%(Rohrer$\geq$150) of study children similar in age were classified as obese. In this study, 31.9%(BMI$>$20kg/m^2) and 18.7%(Rohrer$\geq$150) of the children were classified in the obese group. These two studies were conducted on similar subjects grouped by age. However, the subjects of this study were children going to a private elementary school which was known famous and very expensive in Pusan. Therefore these different results might indicate that the regional difference and the level of family income strongly affect the early onset obesity.

The results showed that the number of obese subjects depended on significantly the employed methodologies. Therefore it is important that a standard index be established for Korean children, which can be widely accepted in the field of nutritional research and diagnosis. Although an obesity index for children has not been established firmly, Shim and Go (1986) defined the standard weight as the weight corresponding 50% of weight distribution with respect to the height. The weight over 120% of the standard weight was classified as obesity(Cho et al. 1989 ; Lee & Kim 1994). In the present study, the PIBW index was utilized for the classification because BMI is known to be somewhat dependant on height and the percent of body fat differs between machines used.

In table 2, anthropometry measurements showed little differences between genders but significant diff-

Table 1. Proportion of obesity by different obesity indices

	Boy		Girl		Total	
	Non-obese	Obese	Non-obese	Obese	Non-obese	Obese
BMI	17.3±0.8[1]	22.5±0.5	16.8±0.2	23.1±0.5	17.0±0.1	22.8±0.4
(≥20)[2]	66.4(53)[3]	33.8(27)	69.6(71)	30.4(31)	68.1(124)	31.9(58)
%Fat	20.1±0.4	29.5±0.7	21.4±0.3	30.4±0.7	20.7±0.3	30.1±0.5
(≥25)	51.3(41)	48.8(39)	39.2(40)	60.8(62)	44.5(81)	55.5(101)
PIBW	105.4±0.0	134.6±2.7	99.2±1.1	136.4±3.6	101.7±0.8	135.5±2.2
(≥120)	68.8(55)	31.2(25)	79.4(81)	20.6(21)	74.7(136)	25.3(46)
Rohler	125.9±1.4	162.2±3.5	120.4±1.3	168.5±4.1	122.9±1.0	167.1±2.7
(≥150)	81.3(65)	18.8(15)	81.4(83)	18.6(19)	81.3(148)	18.7(34)

1) mean±S.E. 2) Criteria of obesity indices

3) Percentage(No. of subjects)

BMI : Body mass index=body weight(kg)/height(m^2)

PIBW : Percent ideal body weight=Body weight/standard weight for height of Korea×100

erences between non-obese and obese groups in their body sizes. Body weight, circumference of the upper arm, skin-fold thickness of triceps and waist-hip ratio(WHR) were significantly greater in obese children than in normal children. The mean height was slightly greater in the obese group than in the normal group. However, it was not statistically significant.

Table 2. Anthropometric measurements in subjects

	Boy		Girl		Total	
	Non-obese (N=55)	Obese (N=25)	Non-obese (N=81)	Obese (N=21)	Non-obese (N=136)	Obese (N=46)
Height(cm)	142.3 ±0.8[1)]	144.6 ±1.5	144.6 ±0.8	144.5 ±1.7	143.7 ±0.6	144.5 ±1.1
Weight(kg)	35.5 ±0.6	47.8 ±2.0**	36.7 ±0.8	50.3 ±2.3**	36.2 ±0.5	49.0 ±1.5**
MAC(cm)[2)]	19.9 ±0.2	24.9 ±0.5**	19.8 ±0.3	25.7 ±0.7**	19.8 ±0.2	25.3 ±0.4**
TST(mm)[3)]	15.0 ±0.5	25.9 ±1.1**	16.6 ±0.5	27.1 ±1.5**	16.0 ±0.4	26.5 ±0.9**
Waist(cm)	61.6 ±0.6	74.6 ±1.7**	60.0 ±0.7	74.9 ±1.9**	60.7 ±0.5	74.7 ±1.3**
Hip(cm)	72.8 ±0.6	83.3 ±1.4**	75.1 ±0.7	86.1 ±1.6**	74.1 ±0.5	84.6 ±1.1**
WHR[4)]	0.85±0.01	0.89±0.01**	0.80±0.01	0.87±0.01**	0.82±0.00	0.88±0.01**
Fat%(%)	21.7 ±0.5	31.3 ±0.8**	24.5 ±0.5	35.9 ±1.3**	23.4 ±0.4	33.4 ±0.8**
BMI	17.5 ±0.2	22.7 ±0.6**	17.4 ±0.2	23.9 ±0.7**	17.4 ±0.2	23.2 ±0.5**

1) Values are mean±standard error **p<0.01 by Student t-test between non-obese and obese groups
2) MAC : Mid arm circumference 3) TST : Triceps skinfold thickness 4) WHR : Waist hip ratio

Table 3. Body composition in subjects

	Boy		Girl		Total	
	Non-obese (N=55)	Obese (N=25)	Non-obese (N=81)	Obese (N=21)	Non-obese (N=136)	Obese (N=46)
TBW[2)]	19.1 ±0.4[1)]	22.4±0.8**	18.9 ±0.4	22.0 ±0.9**	19.0 ±0.3	22.2 ±0.6**
LBM(kg)[3)]	27.8 ±0.5	32.6±1.1**	27.6 ±0.5	31.9 ±1.2**	27.7 ±0.4	32.3 ±0.8**
FM(kg)[4)]	7.7 ±0.2	15.2±0.9**	9.1 ±0.3	18.4 ±1.4**	8.6 ±0.2	16.7 ±0.8**
ICF(kg)[5)]	12.7 ±0.2	15.0±0.5**	12.4 ±0.3	14.6 ±0.6**	12.5 ±0.2	14.8 ±0.4**
ECF(kg)[6)]	6.4 ±0.1	7.5±0.3**	6.5 ±0.1	7.4 ±0.3**	6.4 ±0.1	7.4 ±0.2**
ICF/ECF	1.99±0.0	2.0±0.0	1.92±0.0	1.96±0.1**	1.95±0.07	1.98±0.06**

1) Values are mean±standard error **p<0.01 by Student t-test between non-obese and obese groups
2) TBW : Total body water 3) LBM : Lean body mass 4) FM : Fat mass
5) ICF : Intra cellular fluid 6) ECF : Extra cellular fluid N : Number of subjects

Table 4. Mean daily energy and nutrient intakes in subjects

	Boy		Girl		Total	
	Non-obese (N=55)	Obese (N=25)	Non-obese (N=81)	Obese (N=21)	Non-obese (N=136)	Obese (N=46)
Energy(kcal)	2177.3±47.1[1)]	2023.1± 95.4	2036.3±35.2	2013.4± 90.5	2093.3±28.9	2018.7±65.6
Protein(g)	86.3± 2.7	82.1± 4.7	82.8± 1.8	83.3± 5.0	84.2± 1.6	82.7± 3.4
Fat(g)	45.2± 1.3	41.4± 2.4	43.7± 1.0	41.2± 2.6	44.3± 0.8	41.3± 1.8
Carbohydrate(g)	356.4± 7.3	330.5± 15.0	328.0± 5.7	327.3± 13.0	339.5± 4.6	329.0±10.0
Calcium(mg)	864.8±31.6	809.9± 46.6	816.2±23.5	769.4± 55.8	835.9±19.0	791.4±35.6
Phosphorus(mg)	1296.8±40.5	1227.1± 66.3	1235.6±28.4	1221.8± 74.6	1260.3±23.6	1224.7±49.0
Iron(mg)	19.5± 0.7	18.6± 1.1	18.6± 0.5	19.0± 1.3	19.0± 0.4	18.8± 0.8
VitA(μgRE)	1473.6±66.1	1403.4±104.9	1395.0±50.6	1378.0±121.4	1426.8±40.2	1391.8±78.7
Thiamin(mg)	1.3± 0.04	1.2± 0.07	1.2± 0.03	1.2± 0.08	1.2± 0.02	1.2± 0.05
Riboflavin(mg)	1.9± 0.06	1.8± 0.10	1.8± 0.05	1.8± 0.12	1.9± 0.04	1.8± 0.08
Niacin(mg)	20.1± 0.7	19.3± 1.2	19.4± 0.5	20.0± 1.3	19.7± 0.4	19.6± 0.8
Ascorbic acid(mg)	183.8± 7.5	172.1± 12.8	168.3± 6.1	163.3± 13.4	174.6± 4.8	168.1± 9.2

1) Values are mean±standard error N : Number of subjects

Table 3 shows body compartments measured by a BIA body composition analyzer. The amount of most compartments were greater in the obese group than in the non-obese group in total body water (TBW), lean body mass(LBM), fat mass(FM) determined by the body composition analyzer. Especially, fat mass was 100% more in obese children. Interestingly, the hydration distribution ratio between intra- and extracellular fluid(ICF/ECF) was different between the nonobese and the obese female groups. This difference was statistically significant($p<0.01$). This may indicate that a slight reduction of extracellular space(dehydration) in obese children is related to obesity. Further studies are needed to investigate the physiological meanings.

Table 4 shows the mean of calorie intake and diet composition in NO and OB groups for each gender. The mean of daily calorie intakes was 2,177kcal/day in normal male children, 2,023kcal/day in obese male children, 2,036kcal/day in normal female children and 2,013kcal/day in obese female children. These were slightly higher than the recommended level for children.

When nutrient compositions were analyzed into

Table 5. Correlation coefficients between anthropometric measurements and nutrient intakes

	BMI	Fat%	PIBW	Height	Weight	MAC	TST	WHR
Kcal	-0.10	-0.18*	-0.10	0.06	-0.06	-0.06	-0.06	0.11
Protein	-0.03	-0.11	-0.05	0.09	0.01	-0.00	0.02	0.08
Fat	-0.17*	-0.18*	-0.16*	0.03	-0.12	-0.13	-0.10	0.04
Carbohydrate	-0.08	-0.19*	-0.08	0.05	-0.05	-0.05	-0.06	0.13

*$p<0.05$ MAC : Mid arm circumference TST : Triceps skinfold thickness WHR : Waist hip ratio

Table 6. Comparisons of dietary variables of non-obese and obese student

	Boy		Girl	
	Non-obese (N=55)	Obese (N=25)	Non-obese (N=81)	Obese (N=21)
Daily energy intake				
Total	2177.3±47.1	2023.1±95.4	2036.3±35.2	2013.4±90.5
By body weight(kcal/kg)	61.3± 1.7	42.3± 2.1**	55.5± 2.5	40.2± 1.3**
By lean body mass(kcal/kg LBM)	79.4± 2.0	63.9± 3.8**	75.9± 1.9	64.2± 3.2**
Nutrients(g/kg LBM)				
Protein	3.1± 0.1	2.6± 0.1**	3.1± 0.1	2.6± 0.2**
Fat	1.6± 0.1	1.3± 0.1**	1.6± 0.1	1.3± 0.1**
Carbohydrate	13.0± 0.3	10.5± 0.6**	12.2± 0.3	10.4± 0.5**

Values are mean±standard error **$p<0.01$ by Student t-test between non-obese and obese groups

Table 7. Average time spent for sleeping, exercise, watching TV and playing computer game

	Boy		Girl		Total	
	Non-obese (N=55)	Obese (N=21)	Non-obese (N=81)	Obese (N=21)	Non-obese (N=136)	Obese (N=46)
Average sleeping time						
< 7hour	40(22)	44(11)[1)]	33(27)	38(8)	36(49)	41(19)
8- 9hour	56(31)	56(14)	66(53)	62(13)	62(84)	59(27)
>10hour	4(2)	0(0)	1(1)	0(0)	2(3)	0(0)
Exercise						
Yes	55(30)	72(18)	42(34)	52(11)	47(64)	63(29)
No	45(25)	28(7)	58(47)	48(10)	53(72)	37(17)
Exercising time(min)	37.3±3.2[2)]	39.2±4.7[2)]	38.2±3.2	30.1±4.9	37.8±2.3	35.9±3.5
TV & Play Computer(min)	82.8±8.7	73.8±7.8	82.9±6.5	84.3±11.5	82.9±5.2	78.6±6.7

1) Percentage(No. of subjcts) 2) Values are mean±standard error N : Number of subjects

carbohydrate, protein, fat, minerals and vitamins, there was no significant difference between the groups.

The relationships between diet and indexes for obesity are shown in Table 5. Among diet composition, fat is related to obesity indexes, BMI, fat% and PIBW statistically. Among obesity indexes, fat% determined by the BIA was related to all diet compartments ; protein, fat, and carbohydrate. The weight and height were related to neither calorie intake nor diet composition. BMI and PIBW were related to only fat compartments.

There were no statistical difference between groups in daily total energy intake. However daily energy intake expressed as calories per lean body mass were less in OB than NO group. Therefore it can be assume that even though the obese subject ate fewer calories per kilogram of body weight than did the non-obese subjects, NO group may maintain their weight due to the metabolic differences between the groups.

There were no statistical differences between groups in daily expenditure hours for sleep, outdoor exercise, and TV watching. Also no differences were found in the frequency of fast food intake and eating-out whose data were not tabled in this paper.

Since any obesity-promoting dietary and environmental factors were not observed in this study, further studies are required to understand obesity-promoting factors for the early onset of obesity. Assessment of a long-term dietary history, more accurate measurement of food intakes, hereditary and other environmental factors besides factors considered should be examined in the next study.

Summary and Conclusion

The purpose of this study is to examine the relationships among body composition, dietary intake, exercise, and life style in children(M=80, F=102) of the 5th and 6th grade of elementary school. The subjects were classified into boy and girl, and non-obese(NO) and obese(OB) groups by genders and PIBW.

1) The percent body fat determined with the body composition analyzer classified 55.5% of participating children into the obese group. Using BMI and PIBW, these percentages were 31.9% and 25.3%, respectively. The results showed that the number of obese subjects depended on employed the methodologies significantly. The percentile of obesity was dependant not only on the study group but also on the index.

2) In comparison with an independent study conducted on a similar subject group in age(Son & Lee 1997), twice the percentage of the subjects were classified as obese. The results indicate that environmental differences and family income levels strongly affect child obesity.

3) Anthropometry measurements and body composition assessments showed little differences between genders but significant differences between NO and OB groups.

4) There were no statistical differences between groups in daily total energy intake. However daily energy intake expressed as calories per lean body mass were less in OB than NO group.

5) No significant obesity-promoting factors were found in food intakes, diet composition, excercise and daily life styles in the studied group.

Intensive approaches with strict low energy diets may not be appropriate for children because they retard growth. A well programmed diet control program is necessary to achieve the weight control and support growth for early onset obese children. Therefore further studies are required to understand obesity-promoting factors for the early onset of obesity, where factors such as hereditary or environmental factors should be included in the future work.

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