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□**Original Article**□

The Longitudinal Study of Diet and Sexual Maturity as a Determinant of Obesity for Adolescents

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ABSTRACT

This study was conducted to investigate the determinants of obesity during adolescence. A total of 726 adolescents living in rural areas in Korea had been observed for four years from 1992 to 1996 regarding their diet, sexual maturity, blood profile and physical growth. Stepwise multiple regression analysis was used to identify priorities of the importance between the factors influencing obesity. The average nutrient intake over the three year period was higher than that of the Korean Recommended Dietary Allowances. The prevalence of obesity for the subjects based on BMI was 9.5%. Results of the stepwise multiple regression analysis showed that blood components and sexual maturity were more significant factors for determining the obesity than the dietary factors. The result may suggest that to understand obesity in children it is necessary to develop an analytical model for the children rather than using the existing analytical model developed mostly for adult patients of obesity. The model should include a wide range of variables such as diet, sexual maturity and changes in blood. (*Korean J Community Nutrition* 3(5) : 679~684, 1998)

KEY WORDS : obesity · longitudinal study · adolescents · diet · sexual maturity.

Introduction

Obesity is regarded as a risk factor of many degenerative diseases which lead to serious health problems among the general population(Lee 1990). There are many causes of obesity. Such as genetic factors(Stunkard et al. 1990), excessive caloric intake with unbalanced consumption between nutrients(Frank 1980), lack of exercise(Kang & Paik 1988), and hormonal and metabolic disorders(Hogar 1981). Obesity is defined as the state of excess fat in the body composition. There are two types of fat accumulation in the adipose tissue. In case of hypertrophic obesity, fat accumulates in the existing fat cells to increase the size in adults. In contrast, hyperplastic obesity which occurs mostly in children, increases the number of fat cells(Inoue 1992). Increased number of fat cells during childhood is considered to be maintained into the adult life even if the subject loses weight afterwards(Kim 1990). The type of obesity is classified according to the site of fat accumulation in the body. One is the upper body obesity and the other is lower body obesity. In upper body obesity, fat is accumulated in the visceral part of the body. In lower body obesity, fat is accumulated in the subcutaneous muscle around the hip(Kim 1990).

The prevalence of obesity in Korea varies by the studies. According to the National Nutrition Survey in 1995, the rate is 18.8% for male and 22.1% for female. For elementary school students, it ranges from

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2.0% to 16.3%(Kim et al. 1994 ; Lee et al. 1986 ; Moon et al. 1992). However it is more than 20% for the students in a high income group(Lee et al. 1991).

For the adolescents, it is 5.4% for male and 12 – 17 % for female from the study done by Chung et al. (1987) and Cho et al.(1989).

It has been already mentioned that obesity during childhood has longlasting effects into the adult life and it becomes an important risk factor to cause many degenerative diseases afterward. Therefore, the prevention of obesity during childhood is affective way to prevent those diseases during adulthood.

In order to prevent child obesity, it is important to identify the factors involved in the obesity during childhood. There are various factors involved in children's obesity. Biological factors as well as environmental factors are equally important, especially during a fast growing period in life.

In order to identify the determinants of children's obesity in this study, various biological enviromental variables were studied over a period of time with adolescents living in rural area in Korea.

Among the variables considered, sexual maturity as a biological change and diet as an enviromental factor were the major concern of this study.

Materials and Methods

1. Study subject

A longitudinal study was conducted from 1992 to 1996 for 726 students(341 boys, and 385 girls). They were students living in Kangwha county, Korea.

During the four years observation, physical growth, sexual maturity, blood profile change and diet were observed.

Four hundred eighty three out of 726 students had completed all those 4 categories of observations overtime.

2. Study variables

Four categories of variables were studied ; 1) the anthropometric variables including weight, height, and skinfold thickness to measure the physical growth, 2) blood profiles were investigated with variables of triglyceride, cholesterol, HDL-cholesterol, uric acid and creatinine, 3) sexual maturity, 4) nutrient intake from their diet.

3. Data collection and processing

The anthropometric measurement technique developed by the National Health and Nutrition Examination Survey : NHANES(U.S. DHHS 1990) was adopted to measure weight, height and tricep skinfold thickness. For weight measurement, a beam balance scale (Continental Scale Corp. Chicago, Ⅲ., USA) was used.

A lange skinfold caliper(Cambridge Scientific Industry, USA)was used for tricep skinfold thickness measurement. Blood profile data was analyzed using blood autoanalyzer of the Hitachi-747(Klotzch & Mcnamara 1990). Sexual maturity was diagnosed by medical doctors and the results were classfied into 5 stages of sexual maturity using Tanner classification(Tanner & Mashall 1969).

For sexual maturity, the data of baseline year observation(1992) were used since most of the students had completed their sexual maturity at the last year of observation(1996) and did not show individual variation.

Dietary intake was measured by the food frequency method(Willet 1990). The food frequency questionnaire consisted of food items, portion size and frequencies of consumption.

The data base for nutrition analysis was constructed based on 1426 food items'(The Office of Rural Development 1991) general nutrient content(energy, water, protein, fat, carbohydrate, fiber, Ca, K, Na, vitamin A, retional, β-carotene, thiamin, ribofalvin, niacin, and vitamin C) as well as fatty acid for 106 food items(Korea Food Research Institute 1991).

4. Statistical analysis

T-test and ANOVA were used to analyze the association among physical growth, blood profiles and food consumption. Stepwise multiple regression analysis was used as the anayltical method to indentify the priorities of the importance between the factors. SAS computer program was used for data processing and all the statistical analysis.

Results and Discussion

1. General charecteristics of the study subjects

During the four year study period 2298 persons year observations(MacMahon 1970) was carried out. The number of subjects observed varied by the year since all the attending students registered in each academic year were observed collectively in two schools. However, the number of students who completed all three observations(1992, 1994, 1996) was 482.

Mean height, weight and skinfold thickness are shown in Table 1. The mean value of the weight and height were lower than the Korean average for the same age group. On the contrary, the mean tricep skinfold thickness in this research was higher than the results from other studies(Park et al. 1995).

2. Prevalence of obesity

Obesity was defined based on body mass index (BMI). A score of less than 20 was classified as underweight, a BMI of 20-25 was normal, and a BMI of more than 25 represented obesity.

The prevalence of obesity is shown in Table 2. 9.5 % of subjects were obese(8.1% boys and 10.4% girls) and about half(47%) of them were normal and 43.5% of them were underweight. The prevalence of obesity for the subjects was lower than in other studies. In one research(Lee 1990) it was 12.9% and by Cho et al.(1989) it was 9.9%.

Table 1. Average height, weight and skinfoldthickness for the subjects, 1996

Variable	Male(N=197) Mean±SD	Female(N=286) Mean±SD	t-test
Skinfold thickness(mm)	3.2± .9	1.7±5.2	−16.77**
Height(cm)	171.5±5.9	158.9±5.2	24.80**
Weight(kg)	61.0±9.5	3.3±8.1	9.36**

** : $p<0.01$

Table 2. Subject distribution based on BMI level

unit : person(%)

Variable	Female (N=286)	Male (N=197)	Otal (N=483)	χ^2
Underweight (BMI<20)	20(42.0)	90(45.7)	210(43.5)	
Normal (20≤BMI<25)	36(47.6)	91(46.2)	227(47.0)	1.15^{NS}
Obesity (BMI≥25)	30(10.4)	16(8.1)	46(9.5)	
Total	28(100.0)	197(100.0)	483(100.0)	

BMI : body mass index NS : not significant

3. Dietary intake

In order to have a single representing value of nutrient intake for individuals during the time, the dietary intake of nutrients for three observations(1992, 1994, 1996) were combined. Table 3 shows the result of the mean intake of the combined data. There were differences between the sexes in energy, protein, fat and cholesterol.

In general, girls tend to consum fewer nutrients than boys.

The contribution of carbohydrate(% of energy) for energy intake is lower than the Korean average. The percentage of fat in energy intake is higher than the Korean average(MHS 1995). It may be explained by the fact that the socioeconomic status of Kangwha area is higher than other rural areas in Korea.

4. Sexual maturity

By the end of the four year observation(1996), most of the students had reached their sexual maturity, and thus did not show individual variation in terms of the stage of sexual maturity. Therefore, the data for the initial period of study(1992) were used for the data of the individual student's sexual maturation. Table 4 shows the distribution of sexual maturity stages for the student in 1992. 5 stage of sexual maturity developed by Tanner(1969) were adopted for the idenification of individual's maturation stage.

There were significant differences in sexual maturation between boys and girls. More than half(57.3%) of the boys belong to the sexual maturity stage 1(early stage). Whereas, only 20.7% of girls belong to stage 1 of sexual maturity. Almost 80% of girls belong to the sexual maturity stage over 2 which confirms that girls show earlier sexual maturity than boys.

According to Tanner & Mashall(1969), pubic hair start to grow during the stage 2 of sexual maturity and the mean age was 11.7 years. The mean ages for initial pubic hair growth among ovr subjects was 12.4 years.

Table 3. Average nutrient intake for the subjects

Nutrient	Male(N=197) Mean±SD	Female(N=286) Mean±SD	T-test
Energy(kcal)	3139.3±1218.2	2858.6±1210.2	2.50**
Carbohydrate			
Nonfiber(g)	418.6± 144.9	386.3± 142.9	2.43*
Fiber(g)	9.1± 5.2	8.7± 5.3	0.86
Fat			
Total(g)	93.6± 44.4	83.9± 43.0	2.42*
Cholesterol(mg)	79.1± 36.3	66.2± 35.6	3.87***
PUFA(g)	17.0± 9.4	15.4± 9.4	1.79
SFA(g)	25.3± 12.7	23.8± 12.9	1.26
MUFA(g)	29.5± 15.4	27.0± 15.3	1.77
Protein(g)	136.3± 66.0	122.1± 68.8	2.26
Mineral			
Na(mg)	767.6± 404.6	737.4± 399.3	0.81
K(mg)	3687.3±1985.4	3463.2±2054.0	1.19
Ca(mg)	880.2± 493.0	831.1± 486.9	1.08
P(mg)	1837.3± 841.6	1657.5± 860.8	2.28
Fe(mg)	20.0± 10.5	18.7± 11.2	1.29
Vitamin			
B_1(mg)	1.8± 0.8	1.6± 0.8	1.66
B_2(mg)	1.9± 1.0	1.8± 1.0	1.20
B_6(mg)	1.2± 0.7	1.2± 0.8	0.55
Niacin(mg)	29.0± 19.5	27.8± 21.3	0.60
A : Total(I.U.)	748.4± 469.1	724.5± 425.4	0.58
C(mg)	138.6± 91.9	138.3± 96.1	0.03

*** : $p<0.001$ ** : $p<0.01$ * : $p<0.05$

Table 4. Sexual maturation stage distribution by gender, 1992 unit : person(%)

Maturation stages	Female	Male	χ^2
1	59(20.7)	113(57.3)	
2	97(34.1)	54(27.4)	
3	88(30.9)	22(11.1)	76.94***
4	36(12.6)	7(3.5)	
5	4(1.4)	1(0.5)	
Total	284(100.0)	197(100.0)	

5. Blood lipid profile

In order to have a single representing blood lipid profile of individuals over time, the lipid profile in the blood of individual for the three observations(1992, 1994, 1996)were combined. Table 5 shows the mean value of cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol and uric acid.

Table 5. Average serum variable value by gender, 1992+1994+1996/3 unit : mg/dl

Variables	Female(N=286) Mean±SD	Male(N=197) Mean±SD	T-test
Triglyceride	110.1±34.2	106.2±42.3	-1.07
Total cholesterol	165.4±24.5	152.4±21.6	-6.01***
HDL-C	47.6±15.4	44.5± 7.7	-2.96**
LDL-C	95.8±22.1	86.7±18.3	-4.92***
Uric acid	4.2± 0.7	56± 1.0	11.16***

HDL-C : high density lipoprotein cholesterol
LDL-C : low density lipoprotein cholesterol
*** : $p<0.001$ ** : $p<0.01$

The mean total cholesterol for girls was 165.4mg/dl and that of boys was 152.4mg/dl($p<0.001$).

The mean value of triglyceride of girls was also higher than that of boys but the difference was not statistically significant. The mean value of HDL-cholest-

Table 6. Estimated coefficient of BMI(by stepwise multiple regression) for the subjects

Sex	Variable	Parameter estimate	Standard error	P-value
Male	CHOL	0.096	0.096	0.0001
	HDL-C	0.067	0.164	0.0001
	CREAT	0.064	0.228	0.0001
	SMR3	0.222	0.250	0.0180
	UA	0.063	0.063	0.0001
Female	CREAT	0.028	0.092	0.0029
	CHOL	0.018	0.110	0.0100
	SMR5	0.010	0.120	0.0717

CHOL : cholesterol
HDL-C : high density lipoprotein cholesterol
SMR : sexual maturity rating(pubic hair stage)
Standard : 0=SMR stage 1
CREAT : creatinine

erol and LDL-cholesterol for girls were also higher than that of boys.

6. Factors influencing obesity

In order to identify the priorities of importance among factors which affect obesity, a stepwise multiple regression analysis was carried out. The result of the analysis is shown in Table 6. For the boys, the priorities of factors affecting obesity in descending order was cholesterol, HDL-cholesterol, creatinine and sexual maturity. For the girls, it was uric acid, creatinine, cholesterol and sexual maturity. None of the dietary factors is proved to be a high priority factor for both the boys and girls. As a whole, the result of the stepwise multiple regression analysis showed that blood profile(cholesterol, uric acid, etc) followed by sexual maturity were more significant in determining obesity than dietary factors. The result may suggest that general growth factor such as change in blood profile and sexual maturity influence more than diet on obesity for this age group(adolescent).

Conclusion

Longitudinal observation of growth factors such as changes in blood lipid profile and sexual maturity influence adolescent obesity more than dietary factors. The findings may suggest that in order to understand obesity of children, there is a need to develop an analytical model rather than using the existing model developed mostly for adult obesity patients. And the wide range of variables such as diet, sexual maturity and blood profile should also be included in the model.

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