

Risk Factors of Adolescent Obesity in Taiwan and Its Association with Physical activity, Blood Pressure and Waist Circumference

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Abstract

Purpose: This study was conducted to investigate risk factors of obesity and its associated health problems in adolescence in Taiwan.

Methods: We enrolled 559 adolescent volunteers with equal numbers of females and males in 2008. Participants were divided into two groups: obese (body mass index [BMI] $\geq 95^{\text{th}}$ percentile) and normal-weight adolescents (BMI: 15^{th} ~ 85^{th} percentile). Each of them completed a questionnaire about lifestyle and parents' stature.

Results: Obese mother had high likelihood of having obese girls and boys ($P=0.001$). Obese girls spent more time in watching TV ($P=0.03$) and had higher frequency of having sweetened soft drinks ($P=0.016$) than normal-weight group. Girls spent more time in TV watching associated higher frequency of having sweetened soft drinks ($P=0.012$). In boys, this associated with higher frequency of eating snack ($P=0.018$) and larger waist circumference ($P=0.011$). Boys who had more frequent effective exercise had lower frequency of eating outside ($P=0.01$) and more services of vegetables ($P=0.002$). There was no relation between hypertension and adolescent physical activity. Regardless of gender, obese group had higher waist circumference and blood pressure than normal-weight group ($P<0.001$).

Conclusion: There was a strong association between obese mother and adolescent obesity. More physical activity in adolescents associated with healthier dietary behaviors. Obese adolescents have higher waist circumference and blood pressure.

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INTRODUCTION

Obesity has become one of the most important public health problems worldwide, affecting 1

billion persons and leading to hypertension, type 2 diabetes mellitus, cardiovascular disease and death^[1, 2]. The prevalence of childhood obesity was also increasing annually and may persist into adulthood^[3, 4].

The prevalence of obesity among adolescents (13 to 16 years) increased from 12.4% to 16.4% in males, and from 10.1% to 11.1 % in females in Taiwan from 1980 to 1994^[5]. A large scale nationwide survey of 6 to 18-year-old children and adolescents was conducted in 2001 showed that the prevalence of overweight and obesity at different age group in Taiwan was around 12-34% in 2000-2001^[5]. Childhood obesity was not only associated with health problems but also with psychosocial problems including depression, distorted body image^[6,7] and low self-esteem^[8,9]. Due to above negative consequences and further economic burdens^[10], it is important to explore the causes of obesity in order to guide preventive measures.

The greatest proportion of obesity involves variants in multiple genes interacting with environmental factors^[11,12]. Lifestyles of children and adolescents, including dietary pattern, physical activity and sedentary behavior, are believed to be risks of developing obesity. In addition, familial and social characteristics also have great impact on individual's lifestyle. However, the relation between either eating habits or physical activity patterns and adolescent obesity is controversial in many reviews of papers^[13]. Energy intake is not strongly associated with weight status in epidemiologic studies, in part because overweight people tend to underreport food intake^[14]. Only 16 of 31 studies in children and 6 of 21 studies in adolescents had shown a significant correlation between physical activity and weight status^[15]. By contrast, sedentary behavior, particularly hours of television viewing, had been consistently related to overweight in youth^[16]. Moreover, there may be some relations between physical activity and dietary behavior to affect obesity status. Until now, there was no report about the risk factors of adolescent obesity in Taiwan.

Childhood is a critical period for developing obesity as well as for giving an opportunity to prevent or intervene in it, as eating and physical activity habits develop during this period^[17]. For purposes of intervention, it is necessary to clarify the relationship between risky behavior/familiar characteristics and obesity. We conducted a native study to investigate the risk factors (including lifestyle and familiar characteristics) of obesity in adolescence in Taiwan. In

addition, obesity associated health problems were also discussed.

METHODS AND SUBJECTS

Study designs

Adolescents between the age of 12 and 18 years were recruited through school health examination in two urban high schools in Taoyuan County in the second half of 2008. The enrolled criteria included: 1) Age between 12 and 18 years; 2) Using body mass index curves proposed by the Department of Health (DOH) in Taiwan, we selected two groups for study. One is normal-weight group (15th ~85th percentiles), the other is obese group ($\geq 95^{\text{th}}$ percentile). Overweight group (15~95th percentile) did not enter this study to prevent interference; 3) With stratified random sampling, we collected the same number in gender in both groups; 4) Excluding aboriginals and foreigners; 5) Excluding those with chronic disease or with long-term medication. The participants and their parents signed the consent letter and completed a comprehensive questionnaire, including questions about lifestyle, family history of obesity related co morbidities, personal health and psychological status. All adolescents with incomplete records of blood pressure, waist circumference, body height and body weight were excluded. Finally, a total of 558 adolescents were enrolled in this study. This study was approved by the ethical committee of Taoyuan General Hospital, Department of Health, Taiwan.

Measures

Body height, Body weight, Blood pressure and Waist circumference: Body height and body weight were measured by school nurses using standardized stadiometers and weight scales. Body mass index (BMI) was calculated as body weight (kg) divided by the square of height (meter). Normal-weight was defined as BMI between 15th and 85th percentile and obesity was defined as BMI more than 95th percentile. Waist circumference was measured at the midline of iliac crest and lower costal margin. Blood pressure was

measured by electric sphygmomanometer. The width of cuff was approximately two thirds of the upper arm's length. The participant's arm was placed at the heart level. If elevated blood pressure was noted (systolic blood pressure >130 mmHg or diastolic blood pressure > 85mmHg based on the upper limit of normal blood pressure in adults), the second measurement was done after resting for 10 minutes. We chose the second measurement for statistics.

Study variables (obtained from questionnaire): The participants and their parents answered the questions about parents' stature including body weight and height. They were also asked about family history of obesity related chronic disease including diabetes mellitus, hypertension, cerebral vascular disease, cardiovascular disease, dyslipidemia and gout within three generations. Physical and sedentary activity were evaluated via questionnaire as "In addition to physical education in school, how often do you exercise with increasing heart rate and sweating for more than thirty minutes in a week?" "How much time do you spend in TV watching (including computer and video game time) in a day?". Obesity related co morbidities including obstructive sleep apnea/snoring, shortness of breath during exercise and arthralgia of unknown reason were also evaluated. They were asked about the frequency of having snack, sweetened soft drinks, fast food, eating outside home (excluding eating in school) and skipping of breakfast. The services of vegetable and fruit per day were also recorded. School performance and interpersonal relationship were evaluated. Finally, there was a question about a sense of crisis about obesity and any actions about weight losing.

Statistical analysis

All analyses were stratified by sex. Continuous variables (demographic measurements) were presented as mean values and standard deviation. Comparisons between continuous variables between groups were performed by t test. Relation between categorical variables was tested by chi-square test. Multivariate logistic regression models were used to examine the effects of the parental BMI, physical activity and dietary pattern on participants' BMI status. Linear regression was used to investigate the correlation between BMI and blood pressure/waist circumference. Statistical analysis was performed using STATA version 9.1 software and values of $P < 0.05$ were considered as statistically significant.

RESULTS

There were 558 adolescents with complete records of body weight, body height, waist circumference and blood pressure enrolled in this study. Two adolescents without retrievable questionnaire were excluded. The mean age was 15.6 +/- 1.4 years old. The male (274) to female (284) ratio was about 1: 1. In our study, 49.8% of the sample was classified as obesity group (278) and 50.2% was classified as normal-weight group (280). There were no differences found in demographic characteristics including age, sex and body height between these two groups (Table 1).

Table 1: Demographic characteristics of the population according to BMI status

	Female			Male		
	Non- obese	Obese	P-Value*	Non- Obese	Obese	P-Value*
Number	137(48.2%)	147 (51.8%)		133(48.5%)	141(51.5%)	
Age (years old)	15.5±1.3	15.6±1.4	0.542	15.7±1.5	15.7±1.5	0.9
Weight (kg)	51.0±4.6	73.5±10.9	<0.001	57.2±7.1	88.7±11.6	<0.001
Height (kg)	159.4±5.2	159.4±6.0	0.940	169.0±7.5	169.9±6.3	0.3
BMI ((kg/m²))	20.0±1.4	28.9±3.4	<0.001	20.0±1.4	30.0±3.1	<0.001

Data are presented as mean ± standard deviation

BMI: body mass index

Physical activity

For boys, the normal-weight group had more frequent effective exercise per week than the obesity group ($P=0.038$) in univariate analysis, but there was no statistical significance in further multivariate analysis. More boys (22%) than girls (4%) did exercise more than 3 times per week. More TV watching time per day was associated with adolescent obesity in females ($P=0.03$). About half of our participants (girls: 51%; boys: 57%) spend more than 2 hours in TV watching per day. Girls spent more time in TV watching (<1hr/day vs ≥ 2 hr/day) associated higher frequency of having sweetened soft drinks ($P=0.012$). In boys, this associated with higher frequency of eating snack ($P=0.018$) and larger waist circumference ($P=0.011$; 86.84 \pm 12.8cm vs 82.69 \pm 13.6cm). Boys who had more frequent effective exercise had lower frequency of eating outside ($P=0.01$) and more services of vegetables per day ($P=0.002$). There was no relation between hypertension and adolescent physical activity.

BMI correlated with waist circumference and blood pressure

Compared to the normal-weight group, both boys and girls in the obesity group had higher body mass index ($P<0.001$), waist circumference ($P<0.001$), systolic blood pressure ($P<0.001$) and diastolic blood pressure ($P<0.001$) (Table 2). There was a significant correlation between BMI and waist circumference (WC) (girls: $WC=36.241+1.793 \times BMI$, $r=0.842$; boys: $WC=28.60+2.251 \times BMI$, $r=0.932$), systolic blood pressure (SBP) (girls: $SBP=75.495+1.532 \times BMI$, $r=0.568$; boys: $SBP=88.30+1.435 \times BMI$, $r=0.57$) and diastolic blood pressure (DBP) (girls: $DBP=42.589+1.209 \times BMI$, $r=0.519$; boys: $DBP=50.294+0.90 \times BMI$, $r=0.428$). Using the criteria of risk factors of metabolic

syndrome in adults defined by Bureau of health promotion, Department of Health, R.O.C (Taiwan) in 2007, we found a cutoff value of BMI of our adolescence for developing central obesity and high systolic blood pressure in our study. Central obesity (WC: males ≥ 90 cm, females ≥ 85 cm) was easily found if $BMI > 27.28$ in boys and $BMI > 27.19$ in girls. High systolic blood pressure ($SBP \geq 130$ mmHg) was easily found if $BMI > 35.58$ in girls and $BMI > 29.06$ in boys.

The relation between family history of obesity, hypertension, diabetes mellitus and adolescent obesity

There was no significant difference in family history of hypertension or diabetes mellitus (within three generations) between normal-weight and obesity group. By the definition of adult obesity proposed by Department of Health in Taiwan, subjects with $BMI \geq 24$ kg/m² and <27 kg/m² were classified as overweight and those with $BMI \geq 27$ kg/m² were classified as obesity. The relation between parent's obesity and offspring's obesity is listed in Table 3.

At least one parent was obese had a higher probability of adolescent obesity than those whose parents were both normal-weight (in girls: $P=0.002$, odds ratio [OR] =2.78, 95% confidence interval [^{95%}CI] =1.6-4.84; in boys: $P=0.008$, OR=2.04, ^{95%}CI=1.16-3.61). Obese mother was associated with adolescent obesity in both girls and boys ($P=0.001$). Obese father was only associated with obesity in female adolescents ($P=0.005$) (Table 4).

Dietary pattern

Girls who had sweeten soft drinks 2~3 times per week had higher likelihood of obesity than those with intake less than one time per week ($P=0.016$, OR=2.04,

Table 2: Waist circumference and blood pressure of the population

	Female			Male		
	Non-obese	Obese	P-Value*	Non-Obese	Obese	P-Value
WC (cm)	72.2 \pm 4.6	87.9 \pm 9.1	<0.001	73.2 \pm 5.5	96.4 \pm 8.0	<0.001
SBP (mmHg)	105.9 \pm 10.5	120.0 \pm 13.0	<0.001	117.1 \pm 12.2	131.2 \pm 12.2	<0.001
DBP (mmHg)	66.8 \pm 9.6	77.5 \pm 11.6	<0.001	68.3 \pm 10.3	77.3 \pm 11.4	<0.001

Data are presented as mean \pm standard deviation

WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure

Table 3: The relation between parents' obesity and offspring's obesity

Parental stature	Offspring's stature		Total	Percentage of Offspring's Obesity
	Non-Obese	Obese		
Non-Obese	199	147	346	42.5%
Obese Father	42	55	97	56.7%
Obese Mother	19	32	49	62.7%
Both Obese	3	25	28	89.3%

^{95%}CI=1.05~3.95) (Table 4). For boys, there was no significant association between this dietary factor and obesity. Other dietary habits (intake of fast food, services of vegetables and fruits, skipping breakfast) didn't show statistical significance between normal-weight and obesity group.

Obesity related disease

Both in girls and boys, more subjects in obesity group reported more frequent shortness of breath during exercise than normal-weight group (girls: $P<0.001$; boys: $P=0.005$). Only girls in obesity group snored more often than normal-weight group ($P=0.015$).

School performance and interpersonal relationship

There were no statistical differences in school performance and interpersonal relationship between obesity and normal-weight groups in both girls and boys.

A sense of crisis about obesity

A higher portion of parents in obesity group concerned about their children's obesity, especially in girls (girls: 94.9%; boys: 82.1%). But only some parents (girls: 55.6%; boys: 47.1%) tried to help children eat healthily and be more active to lose weight.

DISCUSSION

This study was cross-sectional and focused on risk factors of obesity in adolescents from urban high schools in Taoyuan County in Taiwan. The relation between physical activity and obesity of youth was inconsistent in past studies^[18]. For example, one study showed that insufficiently vigorous physical activity

Table 4: Multivariate logistic regression analysis on risk factors of adolescent obesity

Variable	Female <i>P</i> -Value*	Male <i>P</i> -Value*
Parental stature	0.005*	0.7
Maternal stature	0.001*	0.001*
TV watching time per day (including computer and video game time)	0.03*	0.4
Effective exercise per week	0.5	0.1
Sweeten soft drinks per week	0.016*	0.2
Fast food per week	0.9	0.3
Eating out-side per week	0.09	0.3
Snack per day	0.5	0.07
Skipping breakfast per week	0.8	0.3

* *P* value <0.05 indicated significant difference

was the only risk factor for higher body mass index for adolescent boys and girls^[13]. By contrast, another study revealed who was more susceptible to obesity was more physically active^[19]. In our study, there was no significant association between physical activity and adolescent obesity in multivariate analysis. Differences in physical activity may not correspond with differences in energy expenditure among obese and non-obese individuals^[20]. Furthermore, we also found that few adolescents in our study (boys: 22%; girls: 4%) did more than three times of exercise per week. One study reported that 59% of boys and 34% of girls met the physical activity guideline of 60 min/day^[13]. In comparison, our adolescents were less physically active. This phenomenon may explain that little physical activity was not a risk factor of obesity in adolescence in our study.

The amount of time spent in watching television had been proved to be directly related to the prevalence of obesity in children and adolescents^[21-24]. In this study, girls' obesity was related to much time spent in watching television. We also found that only about one half of our adolescents both including boys (43%) and girls (49%) spent less than 2 hours per day in watching television. Compared with the past study^[13], there were about 60-75% of adolescents spending less than 2 hours per day in watching television. Television watching perhaps has the best established environmental influence on the development of obesity during childhood. Thus, there is a need for concerted efforts to develop interventions for our adolescents to decrease time spent in watching television.

The status of adolescent physical activity was associated with some dietary behaviors in our study. Girls and boys spent more time in TV watching associated with unhealthy dietary behaviors (as more intake of sweetened soft drinks and snacks). Boys who had more frequent effective exercise had better dietary habits (as lower frequency of eating outside and more service of vegetables per day). More physical activity in adolescence associated with healthier dietary behaviors and leads to healthful life. School-based interventions are required to increase physical activity in adolescence and may be best achieved by school policies requiring physical education or after-school sports.

At least one parent was obese had a higher probability of obesity of their offspring than those who were both normal-weight. Maternal overweight and obesity increased the likelihood of obesity of offspring both in girls and boys. Paternal overweight and obesity was only associated with adolescent obesity in girls. Previous study also showed that parental overweight is a predictor of childhood obesity^[25]. A Brazil study revealed that mother's overweight was one risk factor of childhood overweight^[26]. It is possible due to genetic effect (such as X-linked dominant inheritance) but also shared familiar lifestyles. In our country, mothers may play a more important role in children's dietary pattern and behavior modification than fathers. We agreed that a family-based approach focusing on diet and physical activity modification has been more successful than conventional programs in achieving weight loss and compliance in obese children^[27].

In our study, intake of sweetened soft drinks 2-3 times per week was associated with adolescent obesity in females. But there was no significant association between these dietary factors with adolescent obesity in males. Several studies have investigated the association of sweetened soft drinks with obesity among children, adolescents and adults but have obtained inconsistent results^[28-32]. These inconsistent results may due to different study design about soft drinks (types, amounts or frequency) and weight status (BMI or with/without obesity). In addition, there were methodological biases due to the use of self-reported data in many studies. However, sweetened soft drinks are to be generally deemed as high-calorie food with low nutritive value. We suggested decreasing intake of sweetened soft drinks is a good idea for health and may be helpful for weight control for obese female adolescents.

Most adolescents in our study seldom skipped breakfast (0-1/wk) in both boys (89%) and girls (94%) and there was no association between skipping breakfast and obesity in our study. Other variables of dietary pattern were also not associated with obesity in our participants. There were some defects in evaluation of dietary pattern. At first, we only recorded the frequency of dietary, but not the detailed amount or content (such as sweetened soft drinks, breakfast and snacks). In addition, we did not precisely measure total calorie intake and energy expenditure. Another

explanation for these findings might be due to the underreporting of food intake by obese adolescents. This recognized problem had been seen in adults^[33,34] and maybe occurs in adolescents as well.

Consistent with past studies^[35,36], obese adolescents have higher, waist circumference and blood pressure (both systolic and diastolic) than normal-weight group in our study. Many studies reported that waist circumference was the adiposity parameter most strongly associated with cardiovascular risk^[37,38]. Several studies also showed that waist circumference was a good anthropometric parameter to evaluate cardiovascular and metabolic risks in children^[38,39]. In our study, Obese girls and boys felt shortness of breath during exercise more easily than those with normal weight. We also found that obesity was associated with higher frequency of snoring in female adolescents. Obese adolescents had more cardiovascular risk factors (higher blood pressure and waist circumference, more frequent snoring as a risk of obstructive sleep apnea syndrome and easily dyspnea during exercise indicating impaired cardiopulmonary function) in our study. Thus, we suggested that measurements of waist circumference and blood pressure should be included within routine health examination to remind parents of co morbidity of obesity.

Blood pressure correlates with age, height and weight. Although the US National High Blood Pressure Education Program (NHBPEP) defined high blood pressure in children and adolescents was above the 95th percentiles according to adolescents' sex, age and height^[40], for simplicity, we used the definition of metabolic syndrome, $SBP \geq 130\text{mmHg}$ was deemed as high blood pressure. We found it correlated with BMI. After linear regression analysis, high systolic blood pressure was easily found if $BMI > 35.58$ in girls and $BMI > 29.06$ in boys.

There were some limitations in our study. First, this study was restricted to one geographic region, thus the results of our study didn't apply to the exact figure of adolescents in Taiwan. Second, we used self-reported questionnaires for dietary pattern, physical activity, behavior and parents' stature. Thus bias maybe present due to inaccurate self-reporting or misunderstanding of the questionnaire items. Third, we did not precisely measure the energy expenditure and total calorie

intake. We only asked the frequency of dietary variables, not the actual amount and content of each variable. A comprehensive diary of diet and measurement of energy intake (including expenditure) are desirable to understand energy balance rather than the frequency of self-assessed serving. These results need to be modified by precisely objective measures about energy expenditure and total energy intake. It is important to identify the causal relationship between lifestyle and obesity, and this can't be easily performed in a cross-sectional study. Longitudinal or interventional studies are crucial to identify solutions to the increasing obesity.

CONCLUSION

More physical activity in adolescence associated with healthier dietary behaviors and may lead to healthful life. School-based interventions are required to increase physical activity in adolescence. There was a strong association between maternal obesity and adolescent obesity. We suggest to control obesity in adolescents should target on a family-based approach. Mothers may play a more important role in promotion of a healthy lifestyle to prevent obesity than fathers. The plans of weight control in female adolescents may focus on decreasing TV watching time and frequency of intake of sweetened soft drinks (less than one time per week). Obese adolescents have higher waist circumference and blood pressure than normal-weight adolescents. We recommend that measurement of blood pressure and waist circumference should be included in routine school health examine to remind parents of the co morbidities of adolescent obesity.

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