Paediatrica Indonesiana

VOLUME 50 January • 2010 NUMBER 1

Original Article

Relationship of obesity and secondary sexual development in girls

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Abstract

Background Obesity is a pathological condition due to consumption of excessive amount of food and is associated with early sexual maturation and irregular cycle of menstruation. Early sexual maturation is estimated from the age of menarche.

Objective To determine relationship of obesity and age of secondary sexual development in girls.

Methods This cross-sectional study was performed on all elementary school students in 4 sub-districts at Denpasar. Nutritional status was determined by BMI. Radiologic examination was performed to determine the bone age. Data were analyzed with appropriate statstical methods.

Results Mean chronological age of breasts development for B2 and B3 stage on obese group was younger than non-obese groups (9.0 vs 9.9, P = 0.001; 9.7 vs 10.9, P = 0.006). Early menarche more frequent in obese group than non-obese groups {PR 5 (CI 95% 1.33 to 19.71)}. Mean age of children who experienced menarche on obese group was younger than non-obese group {10.9(SD 0.61) vs 11.1 (SD 0.28). Univariate analysis showed that maturation age of secondary sexual development on obese groups was differed with non-obese group {8.9 (SD 0.21) vs 9.4 (SD 0.13). Linear regression analysis showed relationship between age of breasts and pubic hair growth on both groups.

Conclusions This study established that mean age of secondary sexual development was younger in obese girl than non-obese group. Bone age range on obese girls was wider than non-obese girls. **[Paediatr Indones. 2010;50:49-5]**.

Keywords: *obesity, secondary sexual development, girls*

Obesity is a pathological condition mostly due to consumption of excessive amount of food that leads to excessive accumulation of body fat. Obesity is not always identical with overnutrition.[1] The incidence of obesity and overweight in children increase faster in developing countries. This statement is confirmed by *International Obesity Task Force* (IOTF)[2] that give an estimation to WHO that 1 of 5 children in Europe suffering from overweight. Previous study set on junior high schools in Denpasar obtained 13% students were overweight and 10.9% students were obese.[3] Recent study carried out on elementary schools in Denpasar found that in 1200 children from 1st grade to 6th grade, 140 children (11.7%) suffered from obesity.[4]

Obesity generally affects psychological and physiological aspect of a child, and if progresses further into adolescence age, the morbidity and mortality rate will increase respectively. Obesity also associated with early sexual maturation and irregular menstruation cycle.[5-6] Some studies from developed countries show

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that secondary sexual development influenced by some factors such as improvement of economical status, health and nutritional status, environmental factors, genetic, and race.[7-9] Early puberty development will lead to psychosocial stress on children. Early menarche also contribute on risk of early pregnancies and sexual assault on children.[10] The objective of our study is to determine the relationship of obesity and age of secondary sexual development on girls.

Methods

We conducted a cross-sectional study in elementary school students at 4 sub-districts of Denpasar (North, West, East, and South Denpasar), Bali, between July and September 2008. The selection of elementary school of each sub-district was taken randomly through computerized programs of simple random numbers. There were three elementary schools for each sub-district at Denpasar, so that 4 regions sub-district at Denpasar was represented by 12 schools with 1272 students.

The populations of the study were all elementary school students who met the inclusion and exclusion criteria. The inclusion criteria were: 1) girl age 8-13 years, 2) Obese (BMI $\geq P_{95}$) and non-obese (BMI P $\geq_5$ and $\leq P_{85}$), 3) child that ready to be examined, 4) parents signed the informed consent, 5) present in school at moment the survey was conducted. The exclusion criteria were: 1) suffering from chronic disease condition, 2) on hormone therapy like estrogen and growth hormone.

We used mean of two populations hypothesis to calculate the sample size,[11] with 90% power and 5% level of significance. Widhi at Surabaya conducted the previous community based studies and found that standard deviation were 2.509. One and a half year pubic hair development was assume to be of clinically important difference between obese and non-obese groups. According to calculation, the sample size was 44 students for each group. We did systematic random sampling to gain 44 obese and non-obese groups. Total sample analyzed were 88 subjects.

Body weight and height were measured to determine nutritional status. We used a weighing machine stand up type EB9005 (weight range 0-150 kg, accuracy 0.1 kg) and a microtoise measure tape (accuracy 0.1 cm) to take the measurements. We calculated the Body Mass Index (BMI) to determine nutritional status. The result of these measurement were plotted to CDC-NCHS 2000 Standard according to child age. Pediatric endocrinologist studied bone X-ray images of the subjects to verify the bone age. We assessed breasts development by means of inspection and palpation. While the pubic hair growth was examined by inspection and compared with the figure from Tanner's scale. We defined secondary sexual maturation as breasts development on $\geq$ stage B2 or pubic development on $\geq$ stage P2. We recorded the date when the subject got her first menstruation and the regularity of menstruation, as well as mother's menarche and menstruation regularity.

We analyzed the data in several steps. The first step was to account the reliability of research instrument. We conducted normality test for numerical data to choose parametric or nonparametric test. We used univariate Anova to determine the mean age of secondary sexual development on obese and non-obese groups. We analyzed the relationship of obesity and age of secondary sexual development on girls (breasts, pubic hair) using linear regression and presented on chart. The number of subjects who experienced menarche were analyzed using chi square test. We performed an anova test to determine the difference of mean age at breasts development between obese and non-obese groups. The difference considered significant if $P<0.05$. Mean of bone age in obese and non-obese groups was presented on box flot chart.

Results

There were 1272 elementary school students who underwent screening examination during the study period. Of them, 123 (9.7%) were obese and 46 (3.6%) were girls. Two obese girls suffered from chronic disease were excluded from the study. We included 44 obese and 44 non-obese girls in to the study. Characteristics of two groups were similar, just characteristic of BMI were different between both groups (**Table 1**).

Number of subjects with breasts development on stage B1 in obese and non-obese groups were (6 vs 18), stage B2 (20 vs 20), stage B3 (11 vs 5), stage B4 (7 vs 1), respectively with P value 0.005 (**Figure 1**). We

found that the stage B2 and B3 breasts development on obese group appear on earlier age than non-obese group (9.0 vs 9.9, P=0.001; 9.7 vs 10.9, P=0.006, respectively, **Table 2**).

Table 1. Baseline characteristics of subjects

Characteristics	Obese N=44	Non-obese N=44
Age, mean (SD), year	9.4 (1.05)	9.5 (1.08)
Age group, (n(%))		
8-<9	18 (40)	16 (37)
9-<10	12 (27)	13 (30)
10-<11	9 (20)	9 (21)
11-<12	6 (13)	5 (12)
Body weight - mean (SD) kg	46.1 (9.19)	34.4 (6.70)
Body height - mean (SD) cm	137.71 (9.89)	135.5 (8.23)
BMI - mean (SD) kg/m2	24.1 (1.78)	18.5 (1.83)
Education of mother - n (%))		
Elementary school	1 (2)	2 (4)
Junior high school	3 (7)	5 (11)
Senior high school	11 (25)	20 (45)
University	29 (66)	17 (38)
Occupation of mother - n (%)		
House wife	1 (2)	1 (3)
Private employee	6 (14)	5 (12)
Civil employee	20 (45)	20 (46)
Entrepreneur	17 (39)	17 (39)
Age of menarche mother - mean (SD) year	12.8 (1.33)	13.2 (1.24)
Education of father - n (%)		
Elementary school	1 (2)	4 (9)
Junior high school	4 (9)	10 (23)
Senior high school	21 (48)	18 (41)
University	18 (41)	12 (27)
Occupation of father - n (%)		
Jobless	10 (23)	10 (22)
Private employee	6 (14)	15 (34)
Civil employee	4 (9)	5 (12)
Entrepreneur	24 (54)	14 (32)
Number of family member - mean (SD)	3.6 (1.08)	3.8 (1.10)
Ethnic - n (%)		
Balinese	27 (61)	23 (52)
Javanese	19 (34)	15 (43)
Chinese	2 (5)	2 (5)

There was significant differentiation of the pubic hair development according to classification of Tanner's scale on both groups. Subjects who experienced stage P2 pubic hair development was 29% vs 11% in obese and non-obese groups, respectively (P = 0.034). Chronological age of pubic hair development on stage P2 on obese group occurred earlier than non-obese group, but statistically non significant (**Table 3**).

Fifteen subjects have experienced menarche. Twelve subjects were on obese and three were on non-obese groups. Menarche occurred more frequent in obese group than non-obese group (PR 5, 95% CI 1.33 to 19.71). Mean age of children who experienced menarche on obese group was younger than on non-obese group 10.9 (SD 0.61) vs 11.1 (SD 0.28), mean difference 0.23 (95%CI -0.01 to 0.48), P=0.001}.

Analysis of variance test showed that age of secondary sexual maturity on obese group was different from with non-obese group (mean 8.9 (SD 0.21) vs 9.4 (SD 0.13), with mean difference 0.51 (95%CI 0.01 to 1.01), P=0.048}.

Linear regression analysis showed linear relationship between ages and stage of breasts

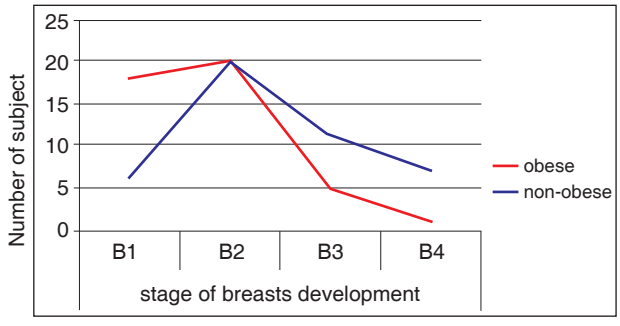

Figure 1. Profile of number of subject and breast development on obese and non-obese groups

Table 2. Profile of breast development according to chronological age on obese and non-obese groups

Chronological age	Tanner I (B1)	Tanner II (B2)	Tanner III (B3)	Tanner IV (B4)
	Mean	Mean	Mean	Mean
Obese				
Age – mean (SD) yr	8.2(0.26)	9.0 (0.81)	9.7 (0.65)	11.0 (0.20)
Non-obese				
Age – mean (SD) yr	8.6 (0.93)	9.9 (0.62)	10.9 (0.40)	10.2 (1.97)
Total	8.5 (0.83)	9.5(0.83)	10.0 (0.78)	10.9 (1.10)
P*	0.077	0.001	0.006	0.176

Note:*=Anova test

development on both groups. For obese group the R-square was 0.64 with regression equation of y=-3.950 + 0.638x and P=0.001. For non-obese group we found the R-square was 0.443 with regression equation of y=-3.201+0.505x and P=0.001 (**Figure 2**).

Linear regression analysis as seen on **Figure 3** showed relationship between ages and stage of pubic hair development on both groups. For obese group the R-square was 0.249 with regression equation of y=-576+0.198x (P =0.001). For non-obese group, the R-square was 0.344 with regression equation of y=-575+0.178x and P=0.001.

Intra-observer agreement evaluation performed on 10 bone age x-ray photo by a pediatric endocrinologist. It showed value of kappa 0.615 (P=0.035). The result of bone age photo examination showed that the bone age stages were normal on all girls in obese group. In non-obese group, bone age stages were normal on 35 children and late in 9 children. Mean of bone age on both groups revealed 8.5 (SD 1.88) vs 7.8 (SD 1.76),

Table 3. Profile of mean of chronological age subject that experienced pubic hair growth stage regarded to Tanner's classification on obese and non-obese groups

Chronological age	Tanner I (P1)	Tanner II (P2)
	Mean	Mean
Obese		
Age - mean (SD) year	9.0 (0.96)	10.3 (1.13)
Non-obese		
Age - mean (SD) year	9.2 (0.90)	11.2 (0.22)
Total	9.1 (0.93)	10.5 (1.03)
P*	0.368	0.109

Note: *=Anova test

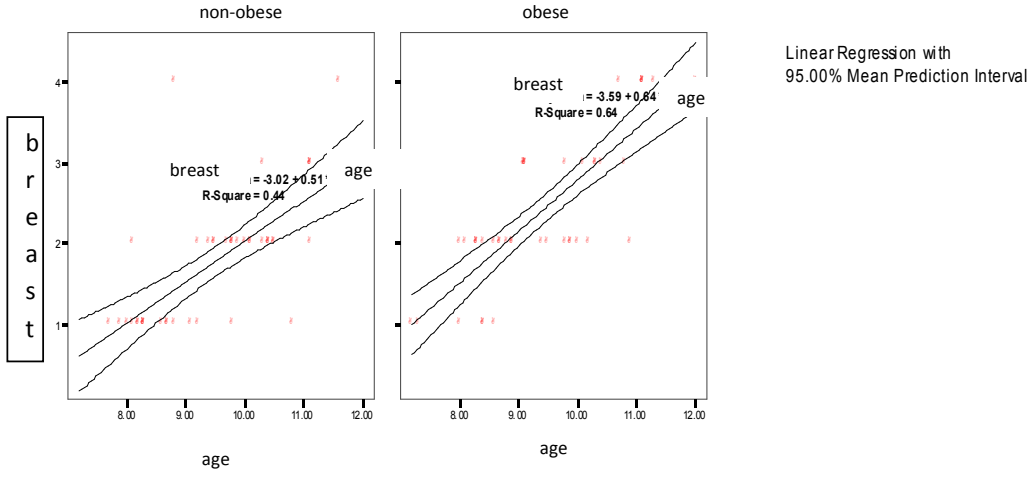

Figure 2. Pattern of age of breast growth between obese and non-obese groups

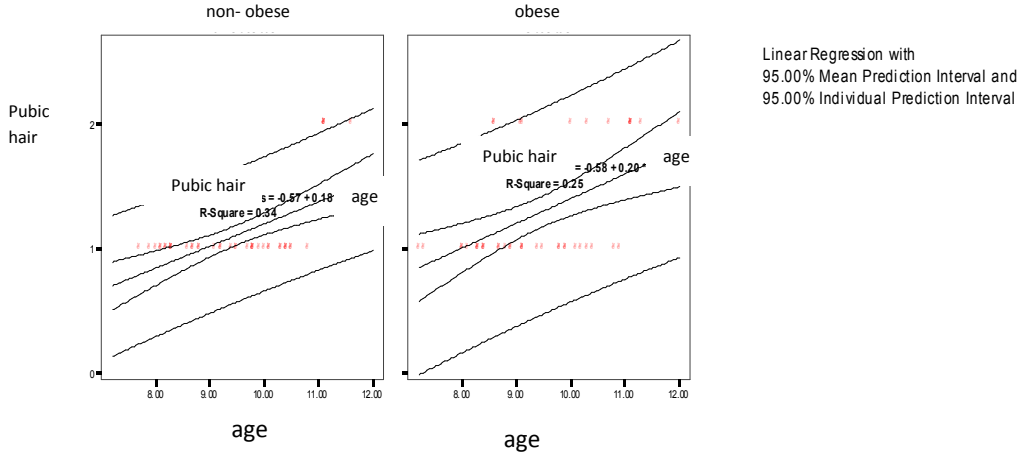

Figure 3. Pattern of pubic hair growth age on obese and non-obese groups

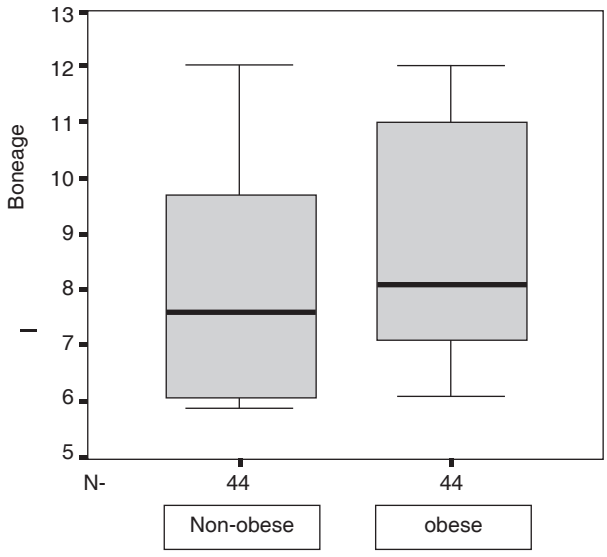

Figure 4. Box flot chart of mean value of bone age on obese and non-obese groups

mean difference -0.71, 95%CI -1.49 to 0.05, P=0.070. Mean range of bone age on obese group was wider than non-obese group (**Figure 4**).

Discussion

Our study showed that breasts development in obese group started earlier than non-obese group. This result was similar with Wang[12] who conduct a cross sectional study on 1520 girls and 1501 boys age 8-14 years old in America. Stage B2 of breast development was more frequent in obese children (16% vs 5%). Widhi[13] described breast development profile in obese group compared to non-obese group at stage of B2 (39.5% vs 39.5%), B3 (32.6% vs 14.0%), and B4 (23.2% vs 0).

Stage 2 breasts development or breast bud was characterized by accentuation of nipple and areola dilatation according to Tanner's classification. This stage is the first sign of puberty on 8-12 years old girls.[14] Breasts alterations are particularly influenced by estrogen hormone produced at puberty. This hormone alters immature breasts to form nipple, ductal gland, and fat tissue.[15] In our study, chronological age of stage II (B2) breast development on obese group occurred significantly earlier than non-obese group.

Our result was also similar with Papadimitriou et al,[16] who conducted a cross sectional study on 1032 girls of 6-14 years old in elementary schools in Greece. Their study reported that mean age of girls with Tanner's stage B2 are 10.3 years old (SD 1.13) on children with increasing BMI value.

Lee et al,[17] conducted a cohort study of 354 girls with average socioeconomic state at 10 region in America. Their study showed that increased BMI associates with early puberty development.

Our study showed that number of girls with pubic hair development at P2 stage in obese group larger than non-obese group, similar with study conducted by Himes et al,[18] where P2 stage of pubic hair development of Tanner's classification in girls with larger body composition were more likely to develop. Sumiartini conducted a study at elementary schools in Denpasar,[19] which also reported that pubic hair development tends to be more frequent in good nutritional status children.

In our study, chronological age of stage P2 pubic hair development of Tanner on obese group was younger than non-obese group. A study conducted by Widhy in Surabaya also revealed that stage P2 pubic hair development of Tanner occurs at 11.5 (SD 0.73) years old on obese group and 11.8 (SD 0.50) years old on non-obese group. This study concluded that pubic hair development on obese girls occured earlier than non-obese girls.[13] Early pubic hair development probably caused by increased synthesis of adrenal androgen hormones (adrenarche hormones), such as androstenedion, dehydroepiandrosteron (DHEA), and sulphate from androstenedion.[20,21]

We found that the obese group had 5 times higher risk to have early menstruation compared to non-obese group, similar with Wang[12] who reported that early puberty development occurred more frequent in obese girls. Logistic regression showed that obese girls have 1.96 time risk of early puberty development (95%CI 1.11 to 3.47). Past study stated that girls with early menarche were related to increase BMI.[22] Freedman et al,[7] in America also found that obese girls were likely to have earlier menarche than malnourished girls. Obese girls have their menarche at age less than 12 years old. A study in Surabaya also found that obese girls have earlier menarche than non-obese girls with mean age of menarche 11.6 (SD 0.53) years on obese group and 12.2 (SD 0.17) years on non-obese group.[13]

Linear regression analysis on our study showed that obese girls reached secondary sexual development faster than non-obese groups, since estradiol level was higher in obese girls. Estradiol stimulates FSH and LH secretion, resulting in estrogen production by ovarium. Estrogen stimulates early secondary sexual development. Leptin hormone plays an important role in body fat formation. Leptin act in hypothalamus-pituitary-gonad axis to stimulate GnRH secretion. GnRH stimulates anterior hypophyses to release FSH and LH, followed by estrogen and androgen secretion by ovarium, eventually, result in secondary sexual maturation. Leptin level is higher in obese children. Thus, leptin has essential role on initiation or progressivity of puberty.[23] Sumiartini[19] also found that nutritional status significantly associate with puberty on elementary school age children.

Secretion of sex hormone (estradiol) stimulates bone maturity, and at the end of puberty, bone growth stops. This can be determined by measuring bone age and ephyfiseal gap.[15] Our study showed that mean range of bone age on obese group was wider than non-obese group. Study by Klein et al,[23] also concluded that obese child have higher estradiol level than non-obese. High estradiol level in obese child resulted in early puberty and increased bone age than non-obese child.

Several limitations of our study should be taken into consideration. First, we used cross sectional design therefore we could not define the exact time of puberty initiation. Secondly, the study has narrow age range, and finally no evaluation of estradiol and leptin level in obese subjects that have essential roles on puberty.

We concluded that secondary sexual development in obese girls occurred earlier than non-obese girls. Range of bone age in obese girls was wider than non-obese girls. Further study is needed with better method, and wider range of age. Estradiol and leptin level should be measured to investigate the correlation between obesity and initiation of puberty.

Acknowlegments

We are indebted to Wayan Bikin Suryawan,MD, Raka Widiana,MD, the headmaster, teachers and all of the parents of elementary school student at 4 region sub district of Denpasar for all their help and support during this study.

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