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Original Article

Obesity accelerates secondary sexual maturity in girls

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Abstract

Background Worldwide incidence of obesity in children is increasing. Obesity may have many health effects including advancement of sexual maturity.

Objective The aim of this study was to assess the timing of secondary sexual maturation in obese vs. non-obese girls.

Methods Subjects were 105 obese and 105 non-obese girls, aged 7 to 8 years who had not entered puberty. Breast and pubic hair growth, secondary sexual characteristics, were assessed at baseline and every 4 months for two years. Onset of puberty was defined as Tanner stage for secondary sexual maturation of ≥ breast Tanner stage II (B2) and/or ≥ pubic hair Tanner stage II (P2). Survival analyses were used to estimate time to puberty in both groups. Cox regressions were used to analyze possible factors affecting secondary sexual maturation.

Results Mean onset of breast budding (B2) was 7.8 (95% CI 7.7 to 7.8) years in obese girls vs. 8.6 (95% CI 8.5 to 8.6) years in non-obese girls ($P<0.001$). Mean onset of pubarche (P2) was 8.7 (95% CI 8.6 to 8.8) years in obese girls vs. 9.0 (95% CI 8.9 to 9.0) years in non-obese girls ($P<0.001$). Hazard ratios of obese girls to experience an earlier secondary sexual maturation at maturity level B2, B3 and P2 were 1.34 (95% CI 1.19 to 1.52), 6.91 (95% CI 3.90 to 12.24) and 3.78 (95% CI 2.42 to 5.89), respectively.

Conclusions Obesity was associated with earlier onset of puberty in girls. Obese girls entered puberty approximately 3 to 9 months earlier than their non-obese peers. **[Paediatr Indones. 2012;52:213-8]**.

Keywords: *obesity, girls, secondary sexual maturity, puberty*

The incidence of obesity is increasing in children, in both developed and developing countries, including Indonesia. In 2000, the prevalence of obesity in children aged 6-11 years in the United States was 15.3%.[1] In Jakarta, it was 9.6% in 1997.[2] Our previous study in Yogyakarta showed that the prevalence of overweight in children aged 6 to 8 years increased from 5.3% in 1999 to 8.6% in 2004.[3]

Obesity influences health, both physically and psychologically. If obesity persists until pre-adolescent years, sexual maturity may occur earlier.[4] The age of onset of secondary sexual maturity also depends on other factors, including race and nutritional status. During the last 150 years, there has been a significant decrease in the age of menarche, especially in the last four decades. This earlier onset is thought to be the result of better nutrition, better environmental conditions, decreased burden of infectious diseases, and, perhaps, increased prevalence of obesity.[5] Children with excess weight have been reported to experience earlier onset of sexual maturation: in Caucasians OR 1.91 (95% CI 1.36 to 2.69); in African Americans OR 2.57 (95% CI 1.52 to 4.32), in Mexican-Americans OR 1.93 (95% CI 1.06 to

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3.49) and in Asian-Americans OR 1.79 (95% CI 0.35 to 9.01).[6]

The average age of initial pubic hair growth, breast growth and menarche were reported to be 9.5, 9.5, and 12.1 years for African Americans, respectively; 10.3, 9.8, and 12.2 years for Mexican-Americans, respectively; and 10.5, 10.3, and 12.7 years for Caucasians, respectively.[7] A Yogyakarta study reported that menarche occurred at a mean age of 12.21 (SD 0.92) years in well-nourished girls, and at a mean age of 13.0 (SD 0.94) years in malnourished girls (P=0.01).[8]

Most studies on secondary sexual maturity, especially those performed in Indonesia, have been cross-sectional studies. A longitudinal study may provide a better estimate on the onset age of sexual maturity. We aimed to assess the average onset age of secondary sexual maturation in obese vs. non-obese girls.

Methods

We performed a prospective, cohort study to assess the influence of obesity on the onset of secondary sexual maturation in girls. Subjects were primary school students aged 7 to 8 years from 32 primary schools in Yogyakarta, Indonesia.

Obesity was defined as body mass index (BMI) at or above the 95th percentile according to the Centers for Disease Control (CDC) 2000 reference standard. Obese girls, identified in the previous obesity screening, were compared to non-obese girls, whose BMI was below the 85th percentile of the same standard. Subjects were matched for age and schools.

For an estimated relative risk (RR) of 1.95, P1 = 0.75,[9] P2 = 0.385, α =1.645, and e=0.2, revealed 105 subjects were required in each group. We included girls aged 7 to 8 years, willing to participate and with written informed consent from their parents. We excluded girls who had already experienced secondary sexual maturation and those with short stature.

Secondary sexual maturation was assessed at the start of the study and every four months subsequently for two years (2006-2008). Breast and pubic hair growth were assessed using the Tanner scale for girls.[10] Subjects were considered to have started puberty if their Tanner stage for secondary sexual maturation was ≥ B2 and/or ≥ P2.

Examinations were performed at school clinics, or if there was no clinic in certain schools, examinations were conducted in a classroom. Every measurement was performed by an observer who was accompanied by a female teacher, to minimize discomfort to the girls. Reliability of the examinations was assessed with agreements between examiners. Agreements (κ, kappa) for breast examinations between observer 1 vs. 2, 1 vs. 3, and 2 vs. 3 were 0.8, 0.9 and 0.8, respectively, while for pubic hair examinations were 0.8, 0.8 and 0.7, respectively.

Other information, such as age in months, paternal and maternal education level and occupation, as well as maternal age of menarche was collected by questionnaire at the beginning of the study. The Commission on Medical Research Ethics and Health, Gadjah Mada University, Faculty of Medicine approved this study.

Data was processed by survival analysis. Cox regressions were used to analyze factors that might affect secondary sexual maturation in girls. Kaplan-Meier tests were used to analyze the survival data for onset of sexual maturity in both groups. Significance level was defined to be $P < 0.05$.

Results

We performed obesity screening on 1,235 girls aged 7-8 years from 32 elementary schools in Yogyakarta, yielding 109 (8.8%) obese girls. The basic characteristics of subjects are shown in **Table 1**.

Hazard ratios (HR) and 95% confidence interval (CI) for obesity status, paternal and maternal education and occupations, as well as maternal age of menarche compared to the onset of secondary sexual maturity are presented in **Table 2**. Cox regression analysis revealed that only obesity status significantly influenced the onset of secondary sexual maturation at ≥ B2, ≥ B3 and ≥ P2.

Figure 1a, **1b**, and **1c** show that by the end of the 24 month study period, 176 (83.8%) girls (obese and non-obese) were at secondary sexual maturation stage B2, 89 (42.4%) at B3 and 86 (40.9%) at P2.

A Kaplan-Meier curve in **Figure 2a**, **2b**, and **2c** show that at the end of the study, 102 (97.1%) obese vs. 76 (72.4%) non-obese girls had experienced breast growth maturation at stage ≥ B2. Mean onset for breast development at ≥ B2 in obese girls was 93.2 (95% CI 92.4 to 93.9) months of age. In non-obese

Table 1. Characteristics of subjects at the beginning of the study

Characteristics	Groups	
	Obese n=105	Non-obese n=105
Mean age, months (SD)	84.7 (2.4)	84.7 (2.4)
Mean weight, kg (SD)	30.0 (3.2)	24.5 (2.1)
Mean height, cm (SD)	118.8 (4.2)	121.0 (4.8)
Mean BMI, kg/m^2 (SD)	21.2 (0.9)	16.7 (0.6)
Mean number of family members, persons (SD)	4.6 (0.9)	4.7 (1.1)
Mean maternal age at menarche, years (SD)	11.6 (0.6)	11.8 (0.8)
Presence of other obese family members, n (%)	73 (69.5)	65 (61.9)
Pubic hair growth stage P1 at enrollment, n (%)	105 (100)	105 (100)
Breast maturation stage B1 at enrollment, n (%)	105 (100)	105 (100)
Paternal educational level		
≤ Senior high school, n (%)	32 (30.5)	39 (37.1)
> Senior high school, n (%)	73 (69.5)	66 (62.9)
Maternal educational level		
≤ Senior high school, n (%)	55 (52.4)	58 (55.2)
> Senior high school, n (%)	50 (47.6)	47 (44.8)
Paternal occupation		
Civil servant, n (%)	25 (23.8)	18 (17.1)
Private employee, n (%)	53 (50.5)	41 (39.0)
Armed forces, n (%)	3 (2.9)	6 (5.7)
Other employment, n (%)	21 (20.0)	17 (16.2)
Unemployed, n (%)	3 (2.9)	23 (21.9)
Maternal occupation		
Civil servant, n (%)	20 (19.0)	20 (19.0)
Private employee, n (%)	15 (14.3)	37 (35.2)
Armed forces, n (%)	0 (0)	2 (1.9)
Other employment, n (%)	7 (6.7)	0 (0)
Unemployed, n (%)	63 (60.0)	46 (43.8)

Table 2. Variables influencing onset of secondary sexual maturation

	Hazard ratios (95% CI)		
Maturation stage at	≥ B2	≥ B3	≥ P2
Paternal educational level			
≤ Senior high school (reference)	1	1	1
> Senior high school, OR (CI)	1.2 (0.8 to 1.7)	1.1 (0.7 to 1.6)	0.9 (0.7 to 1.4)
Maternal educational level			
≤ Senior high school (reference)	1	1	1
> Senior high school, OR (CI)	0.9 (0.6 to 1.4)	1.1 (0.7 to 1.6)	1.2 (0.8 to 1.7)
Paternal occupation			
Unemployed (reference)	1	1	1
Employed, OR (CI)	0.9 (0.6 to 1.4)	0.8 (0.5 to 1.2)	0.9 (0.6 to 1.4)
Maternal occupation			
Unemployed (reference)	1	1	1
Employed, OR (CI)	0.8 (0.6 to 1.0)	0.8 (0.6 to 1.1)	0.9 (0.6 to 1.1)
Maternal age of menarche			
≥ 12 years (reference)	1	1	1
< 12 years, OR (CI)	0.9 (0.7 to 1.3)	0.9 (0.7 to 1.3)	0.9 (0.7 to 1.2)
Obesity status *			
Non-obese (reference)	1	1	1
Obese, OR (CI)	1.3 (1.2 to 1.5)	6.9 (3.9 to 12.2)	3.7 (2.2 to 5.9)

* Only obesity status significantly affected the onset of secondary sexual maturation

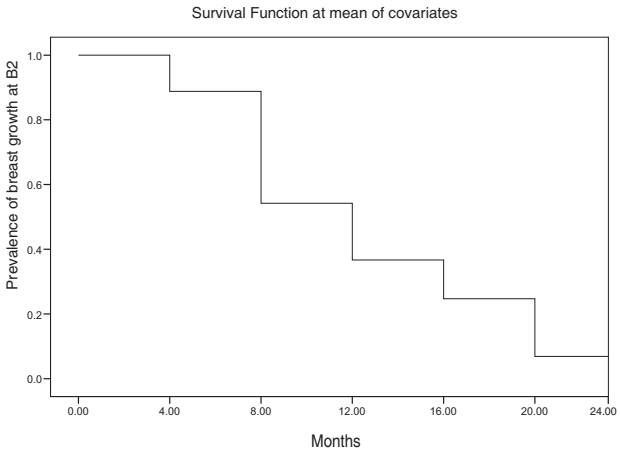

Figure 1a. Cox regression curves for breast growth at ≥ B2 throughout the 24 month study

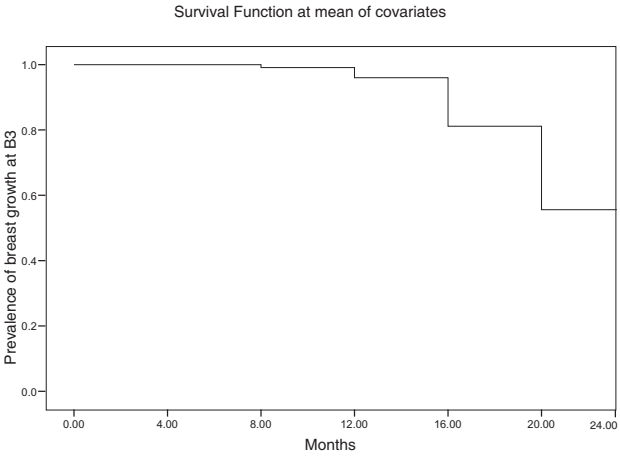

Figure 1b. Cox regression curves for breast growth at ≥B3 throughout the 24 month study

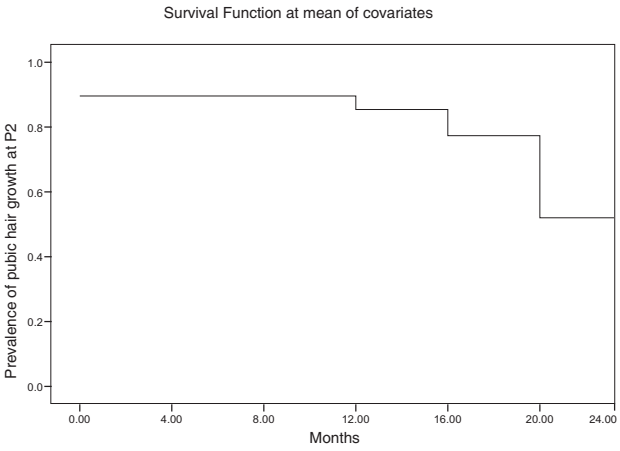

Figure 1c. Cox regression curves for the growth of pubic hair at ≥P2 throughout the 24 month study

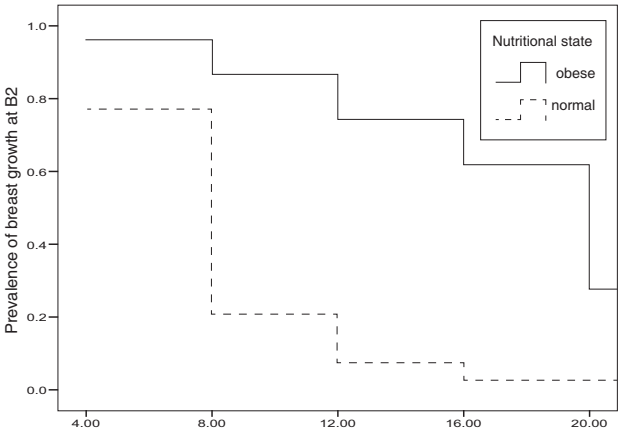

Figure 2a. Kaplan-Meier curves for breast growth maturation ≥B2 between obese and non-obese children

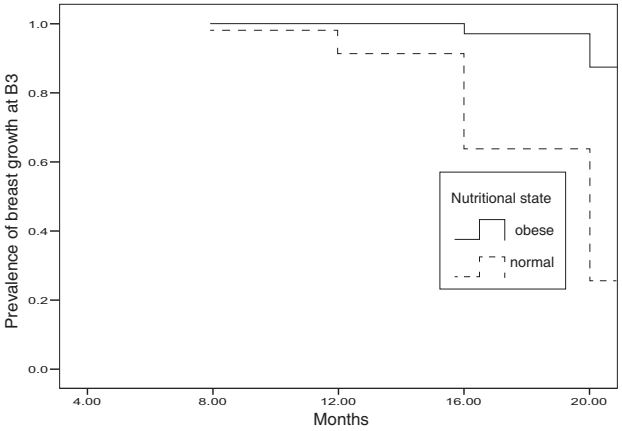

Figure 2b. Kaplan-Meier curves for breast growth maturation ≥B3 between obese and non-obese children

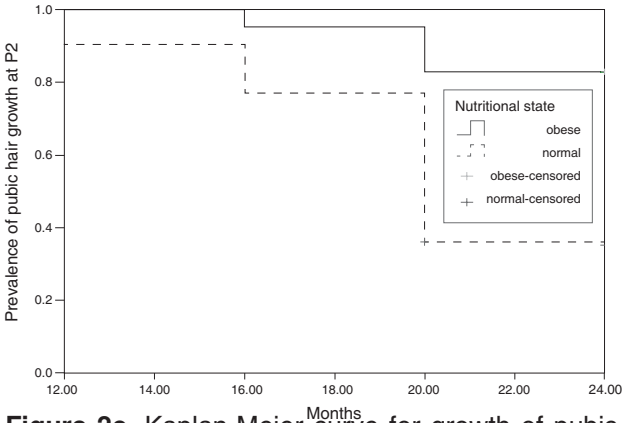

Figure 2c. Kaplan-Meier curve for growth of pubic hair maturation ≥ P2 between obese and non-obese children

girls, it was 102.6 (95% CI 101.5 to 103.7) months of age ($P < 0.001$). The data corresponded to an average age for breast budding of 7.8 years in obese girls and 8.6 years in non-obese girls.

At the end of the study, 76 (72.4%) obese girls had experienced breast growth maturation at ≥ B3, compared to only 11 (10.5%) non-obese girls. Mean (95% CI) onset for breast development at ≥ B3 in obese girls was 103.9 (103.1 to 104.6) months of age. In non-obese girls, it was 108.1 (107.8 to 108.4) months of age ($P < 0.001$). The data corresponded to average age for onset of maturity stage B3 of 8.7 years in obese girls and 9.0 years in non-obese girls.

Similarly for pubarche, at the end of the study, 68 (64.8%) obese girls had experienced pubic hair growth at ≥ P2, compared to only 18 (17.1%) non-obese girls. Mean (95% CI) onset for pubic hair development at ≥ P2 in obese girls was 104.9 (103.8 to 105.6) months of age. In non-obese girls, it was 107.8 (107.4 to 108.2) months of age ($P < 0.001$). The data corresponded to average age of pubarche at 8.7 years in obese girls and 9.0 years in non-obese girls.

Discussion

We observed that obese girls had a significantly earlier onset of secondary sexual maturity. Compared to their non-obese peers, obese girls began their puberty around three to nine months earlier. These results are support by previous studies by Hernawati,[8] Freedman *et al*.[9] and Chumlea *et al*.[11] who reported that obese girls experienced sexual maturation earlier than non-obese girls.

Accumulation of fat in obese girls leads to higher levels of estradiol.[12] Increased levels of estradiol may trigger the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH), which in turn stimulate further estradiol secretion from the ovaries by initiating the ovarian cycle. The increased level of estradiol, both from the ovary in addition to that contributed by the fatty tissue, is responsible for the appearance secondary sexual characteristics.[13]

In addition to estradiol, stored fat may also increase leptin levels.[14] Leptin may also promote the start of puberty through the neuroendocrine control of the pubertal process.[15] It appears that the trend in the decreasing age of menarche may be associated with increased prevalence of obesity.[5]

After controlling for possible confounding factors, e.g. paternal and maternal education and occupations, as well as maternal age of menarche, only obesity status was significantly associated with earlier onset of secondary sexual maturation.

The information obtained from this study is important in the assessment of precocious puberty. Obese girls in this study began to have breast budding at a mean age of 7.8 years, younger than the international consensus of early puberty in females, which is onset of puberty before the age of eight years.[6]

A strength of this study was its prospective, longitudinal design. We invited girls before the age of eight years because girls may have their normal onset of puberty after this age. The girls were followed every four months, in order to not miss the appearance of secondary sexual characteristics. After two years of follow up, we had expected that some subjects would have entered puberty. However, a limitation of this study was that in choosing the age range of 7 to 8 years, we may have excluded some younger girls already in puberty, resulting in underestimation of the influence of obesity in advancing puberty.

Early puberty may shorten a girl's final height. Again, this aspect was not addressed in our study, due to our 24 month follow up time period, which was not long enough to detect this adverse outcome of early puberty, and hence, obesity in children.

In conclusion, obesity was associated with earlier onset of puberty in girls. Obese girls entered puberty around 3 to 9 months earlier than their non-obese peers. Further study is needed to show whether this advanced puberty is associated with shorter final height.

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