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Early maternal menarche associated with overweight and obesity in children

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Abstract

Background: The age of maternal menarche is thought to be intergenerationally associated with the incidence of overweight and obesity in their offspring, but studies are limited.

Objective: To determine the intergenerational relationship between maternal age at menarche and the incidence of childhood obesity and overweight at preschool age.

Methods: This research is an analytic cross-sectional study with a cluster sampling method which was conducted in preschool in Denpasar, Bali. Younger maternal menarche was defined as the age of maternal menarche less than 12 years. Overweight and obesity in children are expressed based on the growth curve of the World Health Organization (WHO) Body Mass Index/Age > +2 SD.

Results: This study was conducted from October to November 2019 involving 204 samples, with the proportion of overweight and obese children were 28.9%. The mean age of menarche in mothers was 13.28 (SD +1.97) years with 11% of mothers experiencing early maturation. The adjusted ratio prevalence of maternal menarche <11 years was 3.96 (95% CI 1.56-10.08) and the nutritional status of overweight and obesity in the father was 3.22 (95% CI 1.67-6.26).

Conclusion: In this study, it was found that there was a relationship between younger maternal age at menarche and overweight and obesity nutritional status in fathers with the incidence of overweight and obesity in children.

Keywords: Maternal menarche, Overweight, Obesity, Children

1. Introduction

Obesity and overweight are an epidemic that occurs in developing countries which is one of the biggest problems faced by community medicine. Obesity and overweight in childhood and adolescence are predictive factors for obesity and an increased risk of morbidity and mortality in adulthood, which has been associated with various diseases such as cardiovascular disease, cancer, and diabetes [1]. In Indonesia, between 1993 and 2014, the prevalence of overweight in children aged less than 5 years increased from 4.2% to 9.4%, and in children aged 6-12 years and 13-18 years the prevalence of overweight increased from 5.1% to 15.6% and from 7.1 % to 14.1% [2]. Increasing rates of obesity and overweight in preschool-age indicate the need for preventive strategies in the future related to the identification of predictive factors for obesity and overweight at an early stage [3]. Several risk factors that cause obesity and overweight children have been identified includes modifiable and nonmodifiable risk factors. Risk factors for overweight and obesity that cannot be modified include biological, sociodemographic, cultural, and community factors. One of the risk factors that is currently being studied is biological factors, one of which is suspected to be maternal menarche which affects the occurrence of overweight and obesity in their offspring [4].

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Menarche marks the start of reproductive capacity in women and the time when the building blocks the body needs for growth are allocated for reproductive purposes. Menarche is followed by an increase in body weight associated with high plasma estradiol levels and low levels of sex hormone-binding globulin due to puberty associated with adipose tissue levels [5]. In the last few decades, the age of menarche is known to have decreased significantly in various countries, especially in developing countries, where globally the current average age of menarche is 12 years [6]. Early age of menarche is associated with an increased risk of short stature, metabolic syndrome, cardiovascular disease, and polycystic ovary syndrome in adulthood in one generation [4]. Age at menarche is a trait that is passed down to offspring, which based on research found that neuropeptide pathways related to the occurrence of early menarche are also involved in pubertal activation but the actual factors that stimulate this central process are not widely known. There is a biological theory which states that there is a close relationship between nutritional status and the activation and maintenance of reproductive abilities. Factors that regulate growth in childhood, including genetic factors and epigenetic influences, can influence the timing of the onset of puberty [7].

The association between the age of early menarche and the possible increased risk of disease in the next generation is not clear. From the perspective of evolution, early exposure in life could not only have a long-term effect on the first offspring but can also be passed down to the next generation. Previous studies in developing countries found that younger maternal age at menarche was associated with the rapid development of children under five and childhood obesity [3, 8, 9]. Another study showed that mothers with younger menarche age tended to have overweight children at ages 4 to 5 years [7]. The relationship between maternal age at menarche and body mass index (BMI) of children at preschool age in developing countries has not been widely studied. The preschool period is a critical period for the development of adipose tissue and contributes to the development of adipose tissue at an older age [4]. This study aims to determine the intergenerational role of maternal age at menarche on the incidence of obesity and overweight children at preschool age.

2. Material and methods

This is an analytical observational study with a cross-sectional design to determine the relationship between maternal age at menarche and the incidence of obesity and overweight in preschool children. Sampling was done by cluster sampling method from preschool in Denpasar. Data was obtained using questionnaires distributed to all students and anthropometric examinations which included measurements of height, weight, body mass index, and waist circumference by applicable procedures. Sampling was carried out at PAUD Melati, Lokasari, Dwi Tunggal, Tadika Putri, Bhakti Mulia, Shantika Kumara, Angsa, Widya Mutiara, Sari Dewi, Kusuma, Kerti Budaya, Harapan Mulia, Kasih Sayang, Widya Mekar, Kumara Jaya, and Indraprasta which were located in the Denpasar, Bali from October to November 2019. The inclusion criteria were children who attended PAUD in Denpasar City. Exclusion criteria were parents who refused to participate in the study, incomplete questionnaire data, children from non-birth parents, and patients with poor nutritional status. The number of research samples was calculated by the unpaired categorical comparative sample formula with 5% type I error, 20% type II error, and the proportion of obesity in mothers with the menarche not earlier than reference age 12.3% [10]. Based on this calculation, the minimal samples obtained were 82.

Maternal age of menarche is defined as the first menstruation for women that occurs in early adolescence in the middle of puberty before entering the reproductive period. The age of menarche is expressed in years, divided into the younger age of menarche, which is menarche <11 years old. Overweight and obesity in children are defined by using Body Mass Index/age in WHO growth chart was > +2 SD. Overweight and obesity are stated based on BMI calculations, where BMI >25 is classified as overweight, and >30 as obese. Children's waist circumference was measured using a measuring tape and expressed in centimeters with an accuracy of 0.1 centimeters. Parent's income defined by the total income of the father and mother. Parent's income then classified according to Denpasar's minimum wage as below and above minimum wage. Birth weight is divided into two categories, >4000 grams, and ≤4000 grams.

The collected data then analyzed using a computer program. The descriptive of children characteristics were analyzed and the prevalence ratio was calculated using chi-square to determine the difference in the relationship between maternal age at menarche with the incidence of obesity and overweight in children. The influence of external variables and dependent variables was then analyzed by logistic regression. The statistical test was considered significant if the p-value <0.05.

This research has received ethical approval number 291/UN 14.2.2. VII. 14/LP/2019 from the Ethics Commission of the Faculty of Medicine, Udayana University, and Bali, Indonesia before the research started.

3. Results and discussion

Data collection was carried out from October to November 2019 at PAUD Melati, Lokasari, Dwi Tunggal, Tadika Putri, Bhakti Mulia, Shantika Kumara, Angsa, Widya Mutiara, Sari Dewi, Kusuma, Kerti Budaya, Harapan Mulia, Kasih Sayang, Widya Mekar, Kumara Jaya, and Indraprasta Denpasar city. Two hundred four children met the inclusion and exclusion criteria, and 58 (28.4%) children were overweight and obese. Table 1 shows the demographic and socioeconomic characteristics of PAUD students. The proportion of children who are overweight and obese is 28.9%.

Table 1 Demographic and socioeconomic characteristics of preschool students

Characteristic	Frequency (n=204)
Sex, n (%)	
Girl	105 (51.5)
Age, month, mean (SD)	61 (9.7)
Height, meter, mean (SD)	1.07 (0.78)
BMI, kg/m^2, mean (SD)	16.1 (2.92)
Waist circumference, centimeter, mean (SD)	61 (9.65)
Parent's education, n (%)	
High school or higher	186 (91.2
Parent's income, n (%)	
Above minimum wage	182 (89.2)
Maternal menarche age, n (%)	
≤11 years old	23 (11.3)
12 years old	56 (27.5)
13 years old	41 (20.1)
14 years old	38 (18.6)
≥15 years old	46 (22.5)
Paternal nutritional status, n (%)	
Overweight	68 (33.3)
Obese	16 (7.8)
Maternal nutritional status, n (%)	
Overweight	51 (25.0)
Obese	15 (7.4)
Family members, n (%)	
≤4	121 (5.,3)
>4	83 (40.7)
Child nutritional status, n (%)	
Well nourish	139 (68.1)
Overweight	32 (15.7)
Obese	27 (13.2)
Birth weight, gram, mean (SD)	3188 (531)

Note: SD = standard deviation; BMT = body mass index.

Table 2 shows the anthropometric characteristics of children based on maternal age at menarche. In this study, mothers with younger age at menarche tend to be overweight and obese. Children of mothers with younger menarche age also have greater body weight, body mass index, and waist circumference compared to children of mothers with older menarche age.

Table 2 Anthropometric characteristics of children based on maternal menarche age

Category	Variables	Maternal menarche age (years old)				
		<11 (n=23)	**12 (n=56)**	**13 (n=41)**	**14 (n=38)**	**≥15 (n=46)**
Mother	BMI, kg/m^2, mean (SB)	24.91 (3.62)	24.30 (3.39)	23.74 (4.38)	23.45 (4.71)	22.85 (5.01)
	Overweight and obesity, n (%)	11 (47.8)	22 (39.3)	13 (31.7)	10 (26.3)	10 (21.7)
Child	Height, meter, mean (SB)	1.06 (0.09)	1.06 (0.07)	1.09 (0.06)	1.06 (0.08)	1.06 (0.07)
	Body weight, kg, mean (SB)	19.41 (4.61)	18.79 (4.04)	19.2 (5.38)	18.21 (4.68)	17.72 (3.13)
	BMT, kg/m^2, mean (SB)	16.80 (2.87)	16.34 (2.57)	16.05 (3.51)	16.13 (3.38)	15.20 (3.23)
	Waist circumference, cm, mean (SB)	51.62 (7.65)	51.34 (5.97)	51.40 (8.82)	51.26 (6.07)	50.14 (5.01)
	Overweight and obesity, n (%)	7 (30.4)	18 (32.1)	7 (17.1)	9 (23.7)	12 (26.1)
	Birth weight, gram, mean (SB)	3181 (541)	3208 (490)	3199 (595)	3176 (392)	3165 (627)

Note: SD = standard deviation; BMT = body mass index.

Table 3 Younger maternal age at menarche and paternal nutritional status of overweight and obesity are associated with the incidence of overweight and obesity in children ($p<0.05$).

Variables	Overweight and obesity, n (%)	Well nourish, n (%)	RP (CI 95%)	*p*
Maternal menarche age				
≤11 years old	11 (5.4)	12 (5.9)	2.61	0.029
>11 years old	47 (23.00)	134 (65.7)	(1.08-6.32)	

Note: RP = rasio prevalence; CI = confident interval.

Table 4 shows a multivariate analysis of factors associated with the incidence of overweight and obesity in children. Several related independent variables, such as maternal menarche age, paternal nutritional status, maternal nutritional status, and birth weight were included in the calculation using Enter logistic regression test. The adjusted odds ratio of maternal menarche <11 years was 3.96 (95% CI 1.56-10.08).

Table 4 Multivariate analysis of factors associated with the incidence of overweight and obesity in children

Variables	B	RP	CI 95%	p
Maternal menarche <11 years old	1.34	3.82	1.48-9.87	0.006
Paternal overweight or obesity	1.17	3.22	1.67-6.26	0.001
Maternal overweight or obesity	-0.10	0.90	0.45-1.81	0.77
Birth weight >4000 gram	0.26	1.29	0.31-5.47	0.73
Low paternal education status	-0.63	0.53	0.14-1.99	0.35
Low maternal education status	-0.6	0.93	0.37-2.32	0.53

Note: PR = prevalence ratio; CI = confident interval.

In this study, the proportion of overweight and obesity in children was 28.4%. This result is higher than the results obtained from the Indonesian Research Data in 2013 where the proportion of overweight in toddlers reaches 11.8%.

Bali Province wass ranked 16th province with the highest number of overweight and obese children wherein 2018 it reached 11.5% compared to 10% in 2013 [11]. This shows that currently in Indonesia, in particular Bali, overweight and obese children is still a problem. There was no difference between the proportions of boys and girls who were overweight and obese in this study.

Age at puberty has been used as an indicator of health in the population. The mean interval since breast budding first occurred (a marker of early puberty in girls) and the occurrence of menarche was ± 2-2.5 years. Menarche is the stage of puberty that occurs late but is the most easily used parameter for the occurrence of puberty. In this study, the mean age of menarche was 13.28 (SD +1.97) years, with 11% of mothers experiencing early maturation. In a study from 67 countries published between1960-1990, the mean age at menarche was reported to be 13.53 years (SD ±0.98). This trend indicates a declining rate of 3 to 4 months per decade, although in some European countries, the United States, and Asia it is still ongoing [3]. A national study in the United States showed that the age of menarche had fallen from the 1960s, 1990s, and 2000s, 12.75, 12, 5, and 12, 3 years respectively [12].

In this study, the proportion of mothers with younger age at menarche who were overweight and obese was 47.8%. This is thought to be due to the role of leptin serum which is positively correlated with body fat levels and earlier onset of puberty. This mechanism is likely because leptin affects puberty onset through activation of gonadotropin-releasing hormone (GnRH) generators via signaling activation of energy storage adequacy. Leptin activates hypothalamic neurons causing an increase in sympathetic outflow, further increasing energy metabolism and lipolysis of adipose tissue leading to increased energy use. Activation of the GnRH generator will stimulate early ovarian function with the result of estrogen secretion, increased growth hormone, and insulin-like growth factor (IGF)-1 secretion [13].

We also found that the age of maternal menarche was associated with the incidence of overweight and obesity in children. This is in accordance with a study in Shanghai where the age of early menarche in the mother is associated with a greater BMI of children at an early age [4]. This study is also in accordance with previous studies which stated that there was an intergenerational effect between early menarche in the mother and the BMI of the offspring, which may be mediated by maternal BMI. The mechanism underlying the intergenerational relationship between early maternal menarche and a large child's BMI is still unclear. Several mechanisms are thought to underlie this, the first is that menarche and BMI are genetic factors that are dominantly inherited from mothers to their offspring. This significant association can be explained by the presence of inherited genetic factors such as LIN28B and PXMP3 [15].

Several studies also show that early menarche is associated with the occurrence of single nucleotide polymorphisms that play a role in rapid growth during childhood and adolescence. Early menarche is also considered as one of the effects of intrauterine estrogen exposure, where mothers with early menarche may prolong their exposure to endogenous estrogen levels. There is no specific difference in the relationship between early menarche and BMI in offspring and this also emphasizes the importance of transgenerational hormonal influences. Animal studies have shown that estrogen-containing substances can affect pre-adipocyte cell differentiation and formation in vitro through upregulation of peroxisome proliferator-activated receptor (PPAR)-γ. The PPAR-γ receptor is a type II nuclear receptor encoded by the PPAR-γ gene which regulates fatty acid storage and glucose metabolism. Estrogen exposure *in utero* is also associated with metabolic disorders in the offspring, including overweight and obesity [4].

We also found that babies born from mothers with younger menarche age had lower birth weights than babies born to mothers with older menarche age. This is in accordance with a study in Austria where younger maternal menarche age was associated with lower birth weight and length of the baby. This may be due to maternal nutritional status unable to compensate for the negative effects of early maturation on intrauterine growth. High levels of estrogen in mothers with younger menarche age will carry over into adulthood, possibly being the cause of growth inhibition in the offspring of these mothers [14].

In this study, the relationship between the incidence of paternal overweight and obesity was associated with the occurrence of overweight and obesity in children. This is in accordance with a study in Ukraine where children of overweight and obese fathers have a 1.4 to 2 time's higher risk of suffering from overweight and obesity [16]. This is thought to be due to the influence of genes and environmental and behavioral influences. Children usually imitate their parents, where eating habits and family habits may influence the parents' abnormal eating habits, low levels of physical activity, and long duration of screen time [17]. Another study involving children and parents in Iran also found that parent obesity is a factor associated with obesity in children and adolescents. Prevention of obesity in children who have one or both parents with obesity is very important [18].

The obesity risk factors are multifactorial. We found that early menarche may have an intergenerational effect on the BMI of children during childhood. Other studies are needed to provide a further understanding of the intergenerational

effect of BMI in children which offers a new perspective on obesity interventions in children. This is the first study to examine the relationship between early menarche in mothers and the incidence of overweight and obesity in children using BMI parameters in Indonesia. Body mass index is not the best parameter to assess overweight and obesity, but in a recent study BMI in childhood can be considered as the most important parameter to predict future obesity (positive predictive value 53-90%), and the measurement of BMI is easy to perform, easy to re-evaluate, and non-invasive [19].

There are several weaknesses in this study. First, a possibility that recall bias can occur because the data obtained are based on interviews. This study also did not examine the factors that influence the occurrence of overweight and obesity in children, such as diet, early nutritional status, and lack of activity. This study is a cross-sectional study, it is necessary to conduct a prospective cohort study to determine the risk of overweight and obesity in children by controlling confounding variables. Research on early menarche and its association to obesity, other physical conditions, and also psychological problems needs to be studied further regarding the complications that can be caused.

4. Conclusion

In this study, the prevalence of overweight and obese children was 28.4%. There is a relationship between younger maternal age at menarche and overweight and obesity in the father and the occurrence of overweight and obesity in children.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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