Original Article

Inadequate dietary α-linolenic acid intake among Indonesian pregnant women is associated with lower newborn weights in urban Jakarta

Dudung Angkasa MSc[1,2,3], Victor Tambunan MD, MSc[1], Helda Khusun MSc, PhD[2], Fiastuti Witjaksono MD, MSc, PhD[1], Rina Agustina MD, MSc, PhD[1]

[1]Department of Nutrition, Faculty of Medicine, Universitas Indonesia - Dr. Cipto Mangunkusumo General Hospital, Jakarta, Indonesia
[2]Southeast Asian Ministers of Education Organization Regional Center for Food and Nutrition (SEAMEO RECFON)/Pusat Kajian Gizi Regional (PKGR), Universitas Indonesia, Jakarta, Indonesia
[3]Department of Nutrition, Faculty of Health Sciences, Universitas Esa Unggul, Jakarta, Indonesia

Background: Omega-3 fatty acid intake during pregnancy has been confirmed to affect newborn birth outcomes in the developed world. However, the association between maternal omega-3 fatty acid intake and birth size is unknown in developing countries. **Objective**: To examine the association of maternal omega-3 fatty acid intake with newborn birth size. **Methods and Study Design**: A cross-sectional study was conducted, involving 282 pregnant women aged 19–40 years who had a gestational age of >32 weeks and received antenatal care at 10 health centres and one referral hospital in East Jakarta, Indonesia. Maternal habitual intake of omega-3 fatty acids, including α-linolenic acid, docosahexaenoic acid, and eicosapentaenoic acid, was assessed using a semi-quantitative food frequency questionnaire. Birth weight and head circumference were measured using a paediatric weighing scale and tape, respectively, and birth length was obtained from medical records. Multiple linear regression analysis was performed to provide adjusted associations. **Results:** The median total intake of omega-3 fatty acids, docosahexaenoic acid, eicosapentaenoic acid, and α-linolenic acid was lower than the recommended dietary intake. The newborns of mothers with an α-linolenic acid intake lower than 0.82 g/d had a significantly lower (β=114, 95% confidence interval=−216, −13.5; p=0.014) weight compared with those of mothers with high α-linolenic acid intake, after adjustment for confounding factors. **Conclusion**: Inadequate maternal intake of α-linolenic acid, but not omega-3 fatty acids, docosahexaenoic acid, or eicosapentaenoic acid, was associated with lower birth weight. Enhanced promotion of consumption of foods rich in essential fatty acids during pregnancy may facilitate attaining optimal infant weight in urban areas.

Key words: developing countries, newborn, birth weight, birth length, head circumference, omega-3 fatty acids, pregnancy

INTRODUCTION

Maternal nutritional status and dietary intake during pregnancy, including dietary fats and essential fatty acids (FAs), are crucial for birth outcomes.[1] An adequate intake of omega-3 FAs, such as α-linolenic acid (ALA), docosahexaenoic acid (DHA), and eicosapentaenoic acid (EPA), has been shown to be vital for neuro-behavioural development, immune function, growth, and mental and long-term metabolic health. Hence, low omega-3 FAs intake was determined in a previous study to potentially cause poor infant growth and development[2] in developed countries; however, similar evidence from developing countries is lacking.

Some studies in developed countries have shown that most pregnant women have adequate omega-3 FAs intake but inadequate DHA intake during pregnancy and lactation to meet their infants’ requirements for optimal growth and development.[3-6] A study among Canadian pregnant women indicated that mean omega-3 FAs intake was adequate (1.4 g/d), but mean DHA intake was approximately 0.082 g/d or 41% of the recommended dietary intake (RDI).[7]

These findings are consistent with those of the European Prospective Investigation into Cancer and Nutrition (EPIC-Norfolk) cohort study, which revealed that mean omega-3 FAs intake among European women was adequate (1.22 g/d), but mean DHA intake was 65% lower than the RDI (0.13 g/d).[8] A recent study among pregnant

Corresponding Author: Dr Rina Agustina, Department of Nutrition, Faculty of Medicine, Universitas Indonesia – Dr. Cipto Mangunkusumo General Hospital, Jl. Salemba Raya 6 Jakarta 10430, Indonesia.
Tel: +6221-3152-532; Fax: +6221-3152-532
Email: dr.rinaagustina@gmail.com and r.agustina@ui.ac.id
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women in the southern United States reported that the lowest mean and standard error of omega-3 FA intake was 1.67±0.05 g/d, which is higher than the RDI of 1.4 g/d for this nutrient during pregnancy. However, the study did not provide information regarding the DHA intake of these women.[6] Moreover, detailed data on EPA and ALA intake were not reported.

Thus far, studies on maternal dietary intake of omega-3 FAs in developing countries have been limited.[9,10] Such studies have been conducted among pregnant women in India and among breastfeeding mothers of infants aged 24–35 months in Bangladesh,[11] revealing potentially low intake of omega-3 FAs, DHA, EPA, and ALA. Specifically, the study in India revealed that median omega-3 FA, DHA, EPA, and ALA intakes during the third trimester of pregnancy were 11.1 g/d, 0.0112 g/d, 0.003 g/d, and 0.58 g/d, respectively.[12] By contrast, the study in Bangladesh revealed that omega-3 FAs, DHA, and ALA intakes were 3.47 g/d, 0.03 g/d, and 0.37 g/d, respectively.[11,13] The low fish consumption among the general Indonesian population (approximately 35 kg per capita per year) compared with the fish consumption in other Association of Southeast Asian Nations (ASEAN) countries[14] may be a contributing factor to the low intake of omega-3 FAs, DHA, ALA, and EPA among Indonesian pregnant mothers, particularly those living in urban areas.

Increasing evidence indicates the critical role of omega-3 FAs, particularly DHA, during pregnancy.[11,15-17] Pregnant women are recommended to maintain adequate DHA intake, particularly during the last trimester of pregnancy, where 60–70 mg of DHA is accreted in the fetal brain per day, increasing to 70–80 mg/d during lactation.[15,18,19] Studies have shown that pregnant women who do not eat fish as the main source of DHA and EPA during the third trimester have a higher risk of preterm delivery[20,21] and delivering a low birth weight (LBW) infant than those who do.[12] A scientific review revealed that DHA intake during pregnancy was associated with higher head circumference (HC), birth length, and birth weight values,[15] whereas low EPA intake during the third trimester of pregnancy was associated with an increased risk of delivering an LBW infant.[12]

Women living in urban areas in developing countries, including Indonesia, may have poor food patterns indicated by low consumption of animal products.[22-24] Low intake of meat, fish, and eggs[24] was observed among pregnant women in urban areas. This food pattern may predispose pregnant women to the development of crucial nutrient deficiencies such as omega-3 FAs. The Indonesian Basic Health Survey indicated that the prevalence of LBW in Jakarta is 10.2%, similar to the national prevalence.[25] This prevalence is higher than that in other ASEAN countries,[26] such as Vietnam (7%) and Thailand (6.6%), as well as the recommended <10.0% at the World Summit for Children.[27] Inadequate intake of omega-3 FAs, particularly DHA and EPA, might be an emerging risk factor for suboptimal infant birth size in Indonesia. Therefore, we investigated the habitual dietary intake of omega-3 FAs among pregnant women and the association between omega-3 FAs intake and HC, birth weight, and birth length in the most urbanised area of Indonesia.

METHODS

This was part of a cohort study entitled ‘Role of Nutrition, Maternal Factors, and Health Service in Microbiota Composition and Birth Weight in Jakarta’, conducted in the urban area of East Jakarta by the Department of Nutrition, Faculty of Medicine, Universitas Indonesia. This study focused on assessing the dietary intake of omega-3 FAs by pregnant women during the third trimester and the association between omega-3 FAs intake and infant birth weight, birth length, and HC. The participants were apparently healthy pregnant women who were aged 19–40 years, had a gestational age of >32 weeks, and were registered for antenatal care in 10 subdistrict public health centres (PHCs) and 1 referral hospital in East Jakarta. The pregnant women were recruited between November 2014 and April 2015 and had planned to give birth in the PHCs and referral hospital in the study area. Pregnant women with chronic diseases, such as HIV/AIDS and tuberculosis, according to the medical records of the PHCs were excluded from the study. In total, 315 pregnant women who fulfilled the inclusion and exclusion criteria and provided approval for birth size measurements were consecutively enrolled. They were followed up until delivery to record birth outcomes. The expected date of delivery was estimated using a pregnancy calculator and was coordinated and confirmed by trained midwives.

The sample size was calculated based on the correlation coefficient (r) of maternal fat and omega-3 FAs with birth weight, birth length, and HC. According to previous studies,[28,29] the lowest estimated r for omega-3 FAs intake and birth length was 0.250, indicating a minimum of 120 mother-infant pairs. In consideration of a statistical power of 80%, a 95% confidence interval (CI), a design effect of 1.5, and a 10% nonresponse rate, the final sample comprised of 191 mother-infant pairs.

Data collection

Training for field enumerators or interviewers, supervisors, and research team members was conducted 2 weeks prior to data collection. The training covered interview techniques, dietary assessment, and maternal anthropometric and haemoglobin (Hb) measurement. Training in the anthropometric measurement of infants was also provided to the research team and midwives. A structured questionnaire and semiquantitative Food-Frequency Questionnaire (SQ-FFQ) were pretested in five PHCs. The wording and options on the questionnaire that guided the flow of the interview, as well as an omega-3 FAs food list, were revised after pretesting. A guidance book on the standard operational procedures for interview techniques, the probing of sociodemographic profiles, the assessment of dietary intake, and the measurement of maternal height and infant birth size was provided to the enumerators, midwives, and research team members. The enumerators and research team collected omega-3 dietary intake assessments and maternal anthropometric characteristics. Infant birth weight was measured by the research team and midwives, and the birth length was obtained from medical records at the PHCs. The data were reviewed daily and supervisors in each PHC ensured the use of standard anthropometric measurement techniques.

Maternal variables

The main independent variable of the study was maternal dietary intake of omega-3 FAs, namely ALA, DHA, and EPA. The validated SQ-FFQ was used to assess FA intake for the month preceding the interview. Portion sizes were estimated mainly by using food photographs that aided in visualising the quantity of food. For fresh or unpackaged foods that were not shown in the food photographs, portion sizes were estimated by weighing a duplicate food consumed by the participant in the study area. For processed or packaged food, a market survey was conducted to determine portion sizes. The final list of FA food sources for the SQ-FFQ consisted of 53 items (data unpublished).

Omega-3 FAs food composition sources were collected from food composition tables from Vietnam and Thailand[30,31] and the United States Department of Agriculture.[32] The omega-3 FAs content for each food ingredient was calculated using Microsoft Excel 2007. Calculations were conducted based on the water content of food ingredients; for instance, to find the omega-3 FAs content of Indonesian eggs, we divided the water-free mass of Indonesian eggs (total mass of Indonesian egg – water content) by the water-free mass of Vietnamese eggs (total mass of Vietnamese egg – water content), and the quotient was then multiplied by the mass of omega-3 FAs in Vietnamese eggs (in grams).

Maternal anthropometric measurements were conducted twice and the average of the two measurements was used. Maternal height was measured to the nearest 0.1 cm by using a calibrated scale (Stadiometer Shorr Height Measuring Board, Olney, MD, USA), and the maternal mid-upper arm circumference (MUAC) was measured to the nearest 0.1 cm by using a calibrated MUAC tape (SECA 201, UK). Maternal Hb levels were measured using the portable HemoCue Hb 201+ (HemoCue AB, SE-26232, Angelholm, Sweden), which was calibrated on a daily basis. The Hb was measured twice on the HemoCue to the nearest 0.1 g/dL between the first and second reading.

Other variables that may be associated with maternal intake and birth outcome were also considered, including age at recruitment, educational status, working status, socioeconomic status, pregnancy, obstetric experience (birth spacing, parity, preterm birth, aborted delivery, delivery mode, and gestational age), and second-hand smoke exposure; these data were collected using a structured questionnaire. Maternal age was calculated using the interview and birth dates. Educational status was categorised into complete 12 years of schooling and incomplete 12 years of schooling. Mothers were classified as working or not working based on activities which provided monetary return. Socioeconomic status was indicated by a wealth index derived from durable goods ownership (such as televisions, air conditioners, liquid petroleum gas tubes, refrigerators, cars, motorcycles, and water heaters) and housing conditions (such as floor and wall materials, sharing of toilet facilities among family members, and final waste disposal).[26] The final wealth index was classified into low, medium, and high economic status based on a tertile rank.[33]

For the obstetric profile, birth spacing was defined as the interval between the current pregnancy (counted from the first week) and the previous pregnancy, expressed in months or years. Parity was defined as the number of times a mother had given birth to a fetus (live or stillborn, singleton or twin) and was classified as less or more than two.[34]

Gestational age was defined as the time range from the delivery date to the first day of the last menstrual cycle, expressed in weeks. Smoking status was defined as having a smoking habit or exposure to cigarette smoke in the house during the current pregnancy.[25]

Infant variables

The outcome variables assessed in this study pertained to infant birth size. Birth outcomes were measured by researchers and midwives immediately after or within 24 hours of delivery. Birth weight was measured using a paediatric weighing scale (Misaki, Japan), whereas birth length was obtained from medical records. The HC was measured using a standard tape measure (MUAC SECA 201, UK). The paediatric weighing scale was calibrated routinely. The birth weight and HC were measured twice and recorded to the nearest 0.1 kg and 0.2 cm, respectively. The delivery mode was also recorded and categorised as vaginal or caesarean section.

Statistical analyses

Dietary data were entered into an SQ-FFQ template, which was developed by the research team and analysed using Nutrisurvey for Windows 2007.[32] Maternal sociodemographic characteristics, obstetric and infant profiles, and infant birth weight, birth length, and HC were analysed using SPSS for Windows, version 20.

Descriptive statistics for continuous data were expressed as the mean and standard deviation for normally distributed data and median (interquartile range, IQR, first–third quartile) for non-normally distributed data. Multiple linear regressions were used to explore the association between omega-3 FAs intake and birth size, after adjusted for confounding variables such as gestational age, delivery mode, maternal MUAC, energy intake, and smoking exposure ($p \leq 0.25$). The final model was determined using the highest Nagelker R-square value. Significance levels were set at $p < 0.05$ for all statistical tests. The results of multivariate analysis are presented with 95% CIs. Ethical approval was granted by the ethical committee of the Faculty of Medicine of Universitas Indonesia and Dr. Cipto Mangunkusumo General Hospital, Jakarta, under the serial number 859/UN2.F1/ETIK/2014. Permission was obtained from the local authority (East Jakarta District), district health offices in East Jakarta, and PHCs in the respective subdistricts.

RESULTS

Infant weight and height were compared among 282 paired pregnant women, and head circumference was compared among 268. Participants who were non-responders (3), had tuberculosis (1), did not comply with recommended dietary intake (9), incomplete outcomes (16 for birth weight and length, 30 for HC) or had extreme values (2) or under- or over-reported energy intake (8 for birth weight and length, 15 for HC), based on the

Table 1. Association of maternal sociodemographic characteristics, obstetric profiles, and infant profiles with infant birth weight and length in East Jakarta (n=282)

Variables	n (%)	Birth weight, g Mean (SD)	Birth weight, g Unadjusted β (95% CI)	Birth length, cm Mean (SD)	Birth length, cm Unadjusted β (95% CI)
Socio-demographic					
Mother's age, years		29 (25.0-32.0)‡			
<29	138 (48.9)	3144 (350)	-24.8 (-116, 66.7)	48.4 (1.6)	0.322 (-0.09, 0.74)
≥29	144 (51.1)	3169 (424)		48.1 (1.9)	
Education level, years					
<12	89 (31.6)	3134 (384)	-32.9 (-131, 65.4)	48.1 (1.8)	-0.243 (-0.69, 0.20)
≥12	193 (68.4)	3167 (392)		48.3 (1.8)	
Working status					
Working	71 (25.2)	3169 (416)	16.2 (-89.3, 122)	48.2 (2.1)	-0.018 (-0.49, 0.46)
Not-working	211 (74.8)	3153 (381)		48.2 (1.7)	
Economic status†					
Low (<-0.85)	86 (30.5)	3141 (381)	-75.4 (-121, 66.6)	47.9 (1.7)	-0.576 (-1.22, 0.07)
Middle (-0.85, 0.32)	147 (52.1)	3152 (384)	-44.9 (-147, 57.0)	48.3 (1.8)	-0.400 (-0.86, 0.06)
High (≥0.32)	49 (17.4)	3201 (422)		48.5 (1.8)	
Smoking exposure, yes	164 (58.2)	3175 (372)	43.30 (-49.4, 136)	48.3 (1.8)	0.161 (-0.26, 0.58)
Maternal intake					
Energy, kcal/d		1846 (1449-2371)‡			
<1846	141 (50.0)	3138 (389)	-38.1 (-130, 53.4)	48.0 (1.8)	-0.401 (-0.82, 0.01)
≥1846	141 (50.0)	3176 (390)		48.4 (1.7)	
Obstetric profiles					
History of prematurity	21 (11.7)	3078 (339)	-102 (-288, 83.3)	48.6 (1.5)	0.396 (-0.43, 1.23)
History of abortion	23 (12.9)	3121 (311)	53.5 (-232, 125)	48.1 (1.3)	-0.162 (-0.96, 0.64)
Gestational age, weeks		39.3 (38.4-40.4)‡			
37-40	189 (67.1)	3127 (374)	-92.4 (-189, 4.4)	48.0 (1.7)	-0.680 (1.12, -0.25)
>40	93 (32.9)	3219 (414)		48.7 (1.8)	
Parity, children					
<2	100 (56.5)	3144 (376)	-58.4 (-180, 63.5)	48.2 (1.7)	-0.066 (-0.61, 0.48)
≥2	77 (43.5)	3203 (443)		48.3 (1.9)	
Birth spacing, years					
<2	28 (16.0)	3136 (351)	-34.2 (-199, 131)	48.4 (1.9)	0.229 (-0.51, 0.97)
≥2	147 (84.0)	3170 (414)		48.2 (1.8)	
Delivery mode					
Vaginal	202 (71.6)	3136 (365)	73.3 (-175, 27.9)	48.2 (1.7)	-0.190 (-0.65, 0.27)
Caesarian	80 (28.4)	3209 (443)		48.4 (1.9)	
Infant's sex					
Boy	135 (47.9)	3182 (393)	48.2 (-43.3, 140)	48.4 (1.7)	0.381 (-0.03, 0.79)
Girl	147 (52.1)	3134 (386)		48.1 (1.8)	
Anthropometric and Hb level					
MUAC, cm	282	27.8 (3.44)	21.7 (8.7, 34.8)*	-	0.03 (-0.04, 0.09)
Height, cm	282	154 (5.36)	17.4 (9.1, 25.7)*	-	0.08 (0.04, 0.12)*
Hb level, g/dL	282	11.1 (1.37)	-37.7 (-70.8, -4.6)*	-	-0.04 (-0.19, 0.12)

SD: standard deviation; MUAC: mid-upper arm circumference.

†Categorized based on the total score for socioeconomic indicators (i.e., ownership of durable goods such as televisions, air conditioners, liquid petroleum gas tubes, refrigerators, cars, motorcycles, and water heaters, and housing conditions such as floor and wall materials, sharing of toilet facilities among family members, and final waste disposal).

‡Median (first–third quartiles).

*Significant association when *p*<0.05 in multiple linear regression.

basal metabolism rate, were excluded.[35] Considering that 315 pregnant women were recruited, the current study's nonresponse rate was <15%.

Table 1 lists the sociodemographic characteristics, pregnancy and obstetric history, anthropometric characteristics, and Hb levels of the pregnant women. The mean age of the mothers was approximately 29 years. Most of them were nonworking (75%), had completed 12 years of schooling (75%), had low to medium socioeconomic status (83%), and were exposed to cigarette smoke (58%). More than half of them were in their second pregnancy and had a birth spacing of 2 years. Most of the infants were vaginally delivered and approximately 52% were female. The mean (SD) MUAC, height, and Hb level were 27.8 (3.44) cm, 154 (5.36) cm, and 11.1 (1.37) g/dL, respectively.

Factors found to be significantly associated with birth weight were maternal MUAC, height, and Hb level. Each unit increment of maternal MUAC and height was likely to increase birth weight by 21.7 g (95% CI=8.7, 34.8) and 17.4 g (95% CI=9.1, 25.7), respectively. Notably, each unit increment of the maternal Hb level was likely to decrease birth weight by 37.7 g (95% CI=−70.8, −4.6). Maternal intake of total omega-3 FA and ALA was associated with birth weight. Maternal height was associated with birth length. Each unit increment in maternal height was

Table 2. Maternal energy, fat, omega-3 fatty acid intake, and birth outcomes in East Jakarta (n=282)

Variables	RDI	Median (IQR)	Mean (SD)	Adequacy, n (%)[†]
Maternal intake				
Energy, kcal	2550[‡]	1846 (1449-2371)	1955 (695)	53 (18.8)
Fat, gr	60[‡]	56.3 (40.5-83.8)	63.4 (32.6)	130 (46.1)
Total n-3, g	1.4[‡]	1.07 (0.69-1.69)	1.35 (1.16)	101 (35.8)
EPA, g	0.1[§]	0.07 (0.03-0.15)	0.12 (0.14)	121 (42.9)
DHA, g	0.2[§]	0.12 (0.07-0.21)	0.17 (0.18)	80 (28.4)
ALA, g	1.1[¶]	0.82 (0.52-1.31)	1.06 (1.06)	95 (33.7)
Birth outcomes				
Head circumference, cm		33.6 (32.3-34.9)	33.6 (1.8)	
<33, n (%)	79 (29.5)			
≥33, n (%)	189 (70.5)			
Birth weight, g		3131 (2870-3400)	3156 (389)	
<3000, n (%)	100 (35.5)			
≥3000, n (%)	182 (64.5)			
Birth lenght, cm		48.0 (47.0-49.5)	48.2 (1.8)	
<48, n (%)	86 (30.5)			
≥48, n (%)	196 (69.5)			

RDI: recommended daily intake; IQR: interquartile range (first–third quartiles); SD: standard deviation; EPA: eicosapentaenoic acid: DHA: docosahexaenoic acid: ALA: alpha-linolenic acid.

[†] Adequacy was calculated by dividing individual intake by RDI.

[‡] Indonesian RDI.[38]

[§] Early Nutrition Academy.[11]

[¶] Institute of Medicine.[39]

likely to increase birth length by 0.08 cm (95% CI=0.04, 0.12).

Maternal intake of fat and essential FAs and birth outcomes are presented in Table 2. The medians of maternal fat, total omega-3 FAs, EPA, and DHA, and ALA intakes were 56.3 g/d, 1.07 g/d, 0.07 g/d, 0.12 g/d, and 0.82 g/d, respectively. The pregnant women met 18% of energy, 46.1% of fat, and 35.8% of omega-3 FA requirements, based on the RDI[36] of Indonesia and the Institute of Medicine[37] (for ALA). Mean birth weight and length were 3156±389 g and 48.2±1.8 cm, respectively, and the prevalence of suboptimal birth weight and length was 35.5% and 30.5%, respectively. The mean infant HC was 33.6±1.8 cm, and the prevalence of subnormal HC was 29.5%.

Factors associated with infant HC were the method of delivery, sex of the infant, and maternal MUAC (Table 4). Infants that were vaginally delivered were likely to have HCs that were 1.18 cm smaller (95% CI=−1.64, −0.73) than those of infants delivered through caesarean section. Male infants were likely to have an HC that was 0.53 cm higher (95% CI=0.11, 0.95) than that of female infants. Each unit increment of maternal MUAC was likely to increase the birth HC by 0.09 cm (95% CI=0.03, 0.15).

The intake of total omega-3 FA and ALA was significantly associated with birth weight in the unadjusted data presented in Table 3. Infants born to women with total omega-3 FAs intake lower than 1.07 g/d had birth weights that were 91.4 g lower (95% CI=−182, −0.52) than those of other infants, and infants born to women with an ALA intake lower than 0.82 g/d had birth weights that were 114 g lower (95% CI=−204, −23.3) than those of other infants. DHA and EPA intake did not show any significant association with birth weight. After adjustment for maternal energy intake, gestational age, delivery mode, maternal MUAC, height, and Hb level, ALA remained significantly associated with birth weight. Infants born to women with an ALA intake lower than 0.82 g/d had birth weights that were 114 g lower (95% CI=−216, −13.5) than those of other infants. Fat and omega-3 FAs, including EPA, DHA, and ALA, were not found to be associated with birth length (Table 3) or HC (Table 5), according to the adjusted data.

DISCUSSION

The present study revealed that low ALA intake among Indonesian pregnant women was significantly associated with lower weight in newborns after adjustment for maternal energy intake, gestational age, MUAC, height, Hb level, and delivery mode. However, DHA and EPA intake were not associated with any birth size outcomes.

The pregnancy period is a critical factor in the association of omega-3 FAs intake with birth weight and length. Birth weight reaches its velocity peak at 30 weeks of gestation.[38-40] The current study assessed omega-3 FAs intake in the final month of recruitment (at >32 weeks of gestation), enabling observation of the association between maternal ALA intake and newborn weight. In the normal state, ALA acts as a precursor of EPA and DHA, but the conversion rate is usually low.[41] Moreover, higher intake of ALA food sources may increase the conversion rate.[42] However, during pregnancy, omega-3 FAs requirements increase,[3,6,43] particularly at 28 weeks of gestation when DHA is accumulating in the brain, a process that continues until an infant is 24 months old.[44] This condition enhances the conversion rate of ALA to DHA and EPA. In accordance with our findings, some studies have shown the importance of the pregnancy period in explaining the association of omega-3 FAs with birth outcomes. The intake of cod-liver oil or fish (as sources of omega-3 FAs) in the second to third trimester is positively correlated with birth weight after adjustment for gestational age and other confounding factors.[1,12,45] A randomised controlled trial (RCT)[16] also reported an association between DHA supplementation and birth weight increase in the second half of pregnancy. A recent sys-

Table 3. Multivariable regression analysis of the association of birth weight and length with maternal fat intake in East Jakarta (n=282)

Maternal daily intake	Birth weight, g				Birth length, cm		
	N	Mean (SD)	Unadjusted β (95% CI)	Adjusted β[†] (95% CI)	Mean (SD)	Unadjusted β (95% CI)	Adjusted β[‡] (95% CI)
Fat, g							
<56.33	141	3128 (399)	-58.9 (-150, 32.4)	-84.3 (-209, 40.7)	48.1 (1.7)	-0.29 (-0.71, 0.12)	-0.19 (-0.81, 0.42)
≥56.33	141	3186 (379)			48.4 (1.8)		
Total n-3, g							
<1.07	141	3111 (388)	-91.4 (-182, -0.52)[*]	-101 (-208, 6.1)	48.2 (1.7)	0.12 (-0.53, 0.29)	0.44 (-0.46, 1.34)
≥1.07	141	3203 (387)			48.3 (1.9)		
EPA, g							
<0.07	127	3142 (387)	-27.8 (-120, 64.1)	-115 (-101, 84.0)	48.2 (1.7)	-0.07 (-0.49, 0.35)	-0.05 (-0.59, 0.47)
≥0.07	155	3169 (392)			48.3 (1.8)		
DHA, g							
<0.12	141	3150 (387)	-14.4 (-106, 77.1)	-6.2 (-104, 91.3)	48.2 (1.7)	-0.07 (-0.49, 0.34)	0.09 (-0.47, 0.64)
≥0.12	141	3164 (393)			48.3 (1.8)		
ALA, g							
<0.82	140	3100 (384)	-114 (-204, -23.3)[*]	-115 (-216, -13.5)[*]	48.1 (0.9)	-0.29 (-0.71, 0.12)	-0.39 (-1.22, 0.43)
≥0.82	142	3214 (387)			48.4 (1.8)		

SD: standard deviation; n-3: omega 3; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid; ALA: alpha-linolenic acid.

[†] Adjusted for maternal energy intake, gestational age, delivery mode, maternal mid-upper arm circumference, height, and haemoglobin levels.

[‡] Adjusted for maternal energy intake, socioeconomic status, gestational age, infant sex, and maternal height.

[*] Significant association at $p<0.05$.

Table 4. Association of maternal sociodemographic characteristics, obstetric profiles, and infant profiles with infant head circumference in East Jakarta (n=268)

Variables	N (%)	Head circumference, cm	
		Mean (SD)	Unadjusted β (95% CI)[§]
Socio-demographic			
Mother's age, years			
<29	131 (49)	33.6 (1.6)	-0.06 (-0.49, 0.37)
≥29	137 (51)	33.6 (1.9)	
Education level, years			
<12	88 (33)	33.6 (1.9)	0.06 (-0.39, 0.52)
≥12	180 (67)	33.6 (1.7)	
Working status			
Working	67 (25)	33.5 (1.7)	-0.13 (-0.62, 0.37)
Not-working	201 (75)	33.6 (1.8)	
Economic status[†]			
Low (<-0.847)	84 (31)	33.5 (1.6)	0.02 (-0.62, 0.67)
Middle (-0.847, 0.3236)	138 (51)	33.6 (1.8)	0.06 (-0.54, 0.66)
High (≥0.3236)	46 (17)	33.5 (2.0)	Reference
Smoking exposure, *yes*	152 (57)	33.4 (1.7)	-0.38 (-0.81, 0.05)
Obstetric profiles			
History of prematurity	20 (11)	33.7 (1.7)	0.31 (-0.52, 1.14)
History of abortion	23 (13)	33.4 (2.0)	-0.12 (-0.90, 0.66)
Gestational age, weeks			
37-40	181 (68)	33.4 (1.8)	-0.48 (-0.94, -0.03)
>40	87 (32)	33.9 (1.7)	
Parity, children			
<2	98 (57)	33.3 (1.8)	-0.28 (-0.82, 0.26)
≥2	75 (43)	33.6 (1.7)	
Birth spacing, years			
<2	28 (16)	33.5 (1.6)	0.10 (-0.62, 0.82)
≥2	143 (84)	33.4 (1.8)	
Delivery mode			
Vaginal	192 (72)	33.2 (1.7)	-1.18 (-1.64, -0.73)[*]
Caesarean	76 (28)	34.4 (1.7)	
Infant's sex			
Boy	127 (47)	33.8 (1.7)	0.53 (0.11, 0.95)[*]
Girl	141 (53)	33.3 (1.8)	
Maternal anthropometric and Hb level			
MUAC, cm	268	27.8 (3.4)	0.09 (0.03, 0.15)[*]
Height, cm	268	153.6 (5.3)	0.02 (-0.03, 0.06)
Hb level, g/dL	268	11.1 (1.4)	-0.01 (-0.17, 0.15)
Maternal Intake			
Energy, kcal/d	2474 (1908-3068)[‡]		
<1846	138 (51)	33.5 (1.9)	-0.09 (-0.52, 0.34)
≥1846	130 (49)	33.6 (1.7)	

SD: standard deviation; MUAC: mid-upper arm circumference.

[†] Categorized based on the total score for socioeconomic indicators (i.e., ownership of durable goods such as televisions, air conditioners, liquid petroleum gas tubes, refrigerators, cars, motorcycles, and water heaters, and housing conditions such as floor and wall materials, sharing of toilet facilities among family members, and final waste disposal).

[‡] Median (first–third quartiles).

[§] Multivariable regression analysis.

[*] Significant association at *p*<0.05.

tematic review revealed the importance of omega-3FAs in fetal weight gain in the third trimester of pregnancy.[11]

The timing of maternal omega-3 FA intake assessment was another sensitive factor in investigating the association between omega-3 FAs and birth length. This factor may explain why no association between third-trimester maternal essential FAs intake and birth length was observed in our study. A previous FAs study[46] reported an association between dietary omega-3 FAs and fetal growth in the first trimester but not in the second and third trimesters. Other studies have revealed that the increase in fetal length is greater during the second trimester than third trimester.[47,48] Even a study showed fetal length is 10 times greater during the second trimester (0.24 cm) than during the third trimester (0.02 cm).[40] This implies that the dietary intake of omega-3 FAs might be associated with fetal length during the first trimester. Nevertheless, a recent RCT[16] revealed that DHA supplementation during the second half of pregnancy is positively associated with birth length, but the increment is small (0.7 cm). Another study found that the change in weight gain from the first to second trimester is a sensitive period for fetal linear growth.[49] The current study was conducted during the third trimester (>32 weeks of gestation), which could have resulted in an unobserved association between habitual dietary omega-3 FA intake and birth length.

HC is an indirect measure of brain size and may be as-

Table 5. Multivariable regression analysis of birth head circumference and maternal fat intake in East Jakarta (n=268)

Maternal daily intake	N	Head circumference, cm		
		Mean (SD)	Unadjusted β (95% CI)	Adjusted β[†] (95% CI)
Fat, g				
<56.33	137	33.5 (1.8)	-0.25 (-0.68, 0.17)	-0.49 (-1.06, 0.08)
≥56.33	131	33.7 (1.7)		
Total n-3, g				
<1.07	137	33.5 (1.8)	-0.09 (-0.52, 0.34)	-0.13 (-0.62, 0.36)
≥1.07	131	33.6 (1.8)		
EPA, g				
<0.07	125	33.6 (1.7)	0.08 (-0.35, 0.51)	0.05 (-0.38, 0.47)
≥0.07	143	33.5 (1.8)		
DHA, g				
<0.12	138	33.7 (1.8)	0.24 (-0.18, 0.67)	0.23 (-0.22, 0.68)
≥0.12	130	33.5 (1.8)		
ALA, g				
<0.82	137	33.5 (1.7)	-0.16 (-0.59, -0.27)	-0.08 (-0.55, 0.39)
≥0.82	131	33.7 (1.9)		

SD: standard deviation; n-3: omega 3; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid; ALA: alpha-linolenic acid.

[†] Adjusted for maternal energy intake, smoking exposure, gestational age, delivery mode, infant sex, and maternal mid-upper arm circumference.

[*] Significant association at $p<0.05$.

sociated with infant neurodevelopment.[50] Unlike newborn weight and length, which depend on the pregnancy period, HC depends on infant body weight. Because the mean weights of newborns in our study were normal, we speculate that there may be a nonsignificant association between maternal essential FA intake and HC. An association between maternal essential FA intake and subnormal HC was clearly observed among very low birth weight infants in a previous study.[50] Physiologically, HC was compromised later compared with birth weight and birth length during fetal growth.[51]

Another finding of this study was that most of the pregnant women did not fulfil the recommended daily intake for fat as well as for total omega-3 FAs, EPA, DHA, and ALA. Although poultry (eggs), fish, and dairy products were frequently consumed by the pregnant women in our study population, the total amount was insufficient. Major contributors to ALA intake were tempeh, tofu, and the water extracts of specific legumes such as mung bean and soybean, which were available in commercial ready-to-drink packages.

The DHA intake of pregnant women in this study was higher than that of pregnant women in other developing countries, namely Bangladesh (30 mg/d)[11] and India (19.61 mg/d).[11,12] Regarding developed countries, the intake in our study was higher than the average US adult intake (20% of the RDI for EPA and DHA), approximately 40 g/d,[52,53] but it was lower than that in European women (0.13 g/d, approximately 65% of the RDI for DHA[8]) and women in the southern United States (1.67 g/d, approximately 119% of the RDI for total omega-3 FA[6]). The intake of EPA and DHA fulfilled 42.9% and 28.4%, respectively, of the RDI specified by the Early Nutrition Academy.[11] Although the DHA intake in our study (28.4% of the RDI) was higher than the average intake of US adults (20% of the RDI), it was still lower than that of European women (65% of the RDI) and the RDI (≤70%).[8] Colón-Ramos et al[6] conducted a study among pregnant women with the gestational age of 16–28 weeks. This study examined only total omega-3 FA and did not measure the DHA intake. Furthermore, diet was assessed using the self-reporting method, which tends to produce biased results. In a study by Welch et al,[8] dietary intake was assessed in normal women by using a 7-day food diary, and the estimated weight of food consumed was based on food photographs. Unlike the other studies, Raatz et al[52] conducted a national survey among adults. Our study used an SQ-FFQ, with food weight being estimated through photographs and weighing packaged food. Our findings confirmed that most pregnant women did not consume sufficient DHA.[3,5]

Our study has several strengths. We collected a sample with a relatively low nonresponse rate and a wide range of data on sociodemographic characteristics, pregnancy and obstetric history, nutritional status, Hb level, dietary intake, and infant size. Furthermore, we used a validated SQ-FFQ for omega-3 FA measurement. Nevertheless, a limitation existed regarding infant birth length data, which relied on assessment by midwives. To reduce potential error in the midwives' assessment, a standardised procedure was thoroughly explained.

In conclusion, our findings suggest that insufficient dietary intake of omega-3 FAs, particularly ALA, by Indonesian pregnant women during the third trimester is associated with lower birth weight in newborns. Further investigation on the effect of omega-3 FAs on birth size is required. Future studies are recommended to confirm that the association includes all the stages of pregnancy.

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AUTHOR DISCLOSURES

The authors declare that they have no competing interests.

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