Original Article

Dietary optimisation with omega-3 and omega-6 fatty acids for 12–23-month-old overweight and obese children in urban Jakarta

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Background and Objectives: Diets with a specific omega-6/omega-3 fatty acid ratio have been reported to have favourable effects in controlling obesity in adults. However, development a local-based diet by considering the ratio of these fatty acids for improving the nutritional status of overweight and obese children is lacking. Therefore, using linear programming, we developed an affordable optimised diet focusing on the ratio of omega-6/omega-3 fatty acid intake for obese children aged 12–23 months. **Methods and Study Design:** A cross-sectional study was conducted in two subdistricts of East Jakarta involving 42 normal-weight and 29 overweight and obese children, grouped on the basis of their body mass index for-age Z scores and selected through multi-stage random sampling. A 24-h recall was performed for 3-nonconsecutive days to assess the children's dietary intake levels and food patterns. We conducted group and structured interviews as well as market surveys to identify food availability, accessibility and affordability. **Results:** Three types of affordable optimised 7-day diet meal plans were developed on the basis of breastfeeding status. The optimised diet plan fulfilled energy and macronutrient intake requirements within the acceptable macronutrient distribution range. The omega-6/omega-3 fatty acid ratio in the children was between 4 and 10. Moreover, the micronutrient intake level was within the range of the recommended daily allowance or estimated average recommendation and tolerable upper intake level. **Conclusions:** The optimisation model used in this study provides a mathematical solution for economical diet meal plans that approximate the nutrient requirements for overweight and obese children.

Key Words: dietary optimisation, linear programming, omega-3, omega-6, obese children

INTRODUCTION

Globally, the prevalence of obesity in the general population has almost doubled between 1980 to 2008. Moreover, the prevalence of childhood obesity is critically high (6.7%), with more than 42 million children aged younger than 5 years being overweight or obese[1] and the majority of them living in developing countries.[2] In Jakarta, an urban Indonesian city, the prevalence of overweight in children aged younger than 5 years is 30.1%, which is higher than the national prevalence (18.8%) of childhood obesity.[3]

Obesity is a consequence of various interacting factors such as genetic predisposition, poor eating habits, sedentary lifestyle, and low socioeconomic status, which might be related to unhealthy food choices and increased exposure to energy- and nutrient-dense foods.[4,5] Childhood overweight and obesity have been reported to continue through adulthood[6,7] and increase the risk of developing several comorbidities.[8] They may also have negative impacts in later life such as lack of educational opportunities, which will be impacted to economic burden of the community.[2]

Some studies identified that development of obesity-associated complications was correlated with chronic low-grade inflammation in adipose tissue.[5,9] Endogenous substances were produced by omega-3 fatty acids potentially became anti-inflammatory and pro-resolving mediators as 'stop signals' of the response of inflammatory, thus promoting inflammation resolution. Omega-3-enriched diets were proven to improve the inflammatory status of adipose tissue and metabolic dysfunction.[5] The

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ratio of omega-3 and omega-6 fatty acids was also considered, because these fatty acids influence the metabolic pathways of each other.[10]

Intervention with supplementation of omega-3 alone or combined with omega-6 in certain doses, with or without dietary intervention, was demonstrated to exert body-weight-loss-related effects[11-16] such as in decreasing body fat mass[11-13] and hip circumference losses.[15] However, studies on dietary intervention alone focusing on omega-3 and omega-6 that have investigated the body weight loss-related effects is lacking.

Diet optimisation by considering the ratio of omega-6 and omega-3 has significant reduction on low-density lipoprotein-cholesterol,[17] and may be beneficial for controlling overweight and obesity. However, current diet optimisation plans for obesity focus on macronutrients[18] and do not consider the ratio of omega-3 and omega-6 fatty acids.

Intervention for overweight and obesity in early life is recommended,[2,19] and dietary intervention is a promising approach to overcoming paediatric obesity.[20] Thus, recent evidence of the positive effects of diet optimisation for local foods in improving the nutritional status of undernourished children can serve as a model for overcoming overweight and obesity in children. Diet optimisation recommendations should be based on locally available and acceptable foods, and they should consider cultural factors, food patterns, food availability, food affordability, and realistic food portion sizes, as well as the impact of the recommendations on other nutrients and the environment.[21]

Currently, linear programming (LP) has been used for designing diet optimisation plans which simplifies the diet optimisation by ensuring that dietary requirements are approximated[22] and by considering food affordability.[23] LP is a beneficial mathematical tool for developing optimised diets for obese children because it enables accurate calculations of nutritional requirements. However, diet optimisation through LP has not yet been used for addressing childhood obesity.

For improving the nutritional status of overweight and obese children aged 12–23 months in East Jakarta, the present study presents optimised diet meal plans incorporating fatty-acid-rich food by considering the omega-6/omega-3 ratio.

MATERIALS AND METHODS

Study design and subjects

This cross-sectional study was conducted in two subdistricts of East Jakarta. Children aged 12–23 months who met the inclusion criteria such as residing in East Jakarta at least one month before the study start, had the body mass index for age z score (BAZ) with the normal weight (-2 SD <z score <+2 SD) or overweight and obese children (z score >+2 SD), and the caregivers were voluntarily willing to participate by signing the informed consent. Children were excluded from the study during screening if they had any type of congenital syndrome or oedema, their mothers were unable to communicate properly, and had a severe illness or an infectious disease.

This study protocol was approved by the Ethics Committee of the Faculty of Medicine Universitas Indonesia and Dr Cipto Mangunkusumo General Hospital, Indonesia no.858/UN2.F1/ETIK/2014.

Diet optimisation was performed by considering the actual intake of the target group which were overweight and obese children. However, because the food consumption pattern of these children shifted from adequate to high-frequency and portion size patterns,[24] this food pattern could not be used as a reference. Therefore, a normal-weight children group was used as the reference for a nutritious diet food pattern for children.

Sample size

Sample size of each group was calculated based on estimating for a population mean of fat intake from the previous studies (μ=22.6±5.9 for normal group and 80.9±20.5 for obese group; 95% CI; ε:10%).[25,26] With 20% attrition rate, a minimal of 62 children (32 normal children and 30 overweight and obese children) should be included.

Sampling procedure

Multistage random sampling was used for subject selection. Children who were aged 12–23 months and listed at the Integrated Health Post in four randomly selected villages were screened for their body weight and height through anthropometry. According to their BAZ scores, children were grouped into the normal-weight and overweight and obese groups.

Forty two children were randomly selected in the normal-weight group by using a random number table function in NutriSurvey 2007 software, and a total of 29 children were selected in the overweight and obese group.

Data collection

Food pattern

Food patterns of the children were characterised by their habitual dietary intake and were determined through a 24-h recall for 3 non-consecutive days (weekend or weekday). The food patterns were analysed to determine the usual eating time, food frequency, food item list, and food portion size of the children.

Eating time and food frequency were calculated on the basis of the average daily intake in the normal-weight group. Moreover, portion size was determined according to the minimum and maximum portion sizes of each food item consumed by the children in the normal-weight group in a day. Finally, a food list was obtained from both groups.

Other related information

Group interviews were conducted to obtain general information on child feeding practices in the area, particularly food taboos or beliefs, availability, and accessibility in the area. Specifically, breastfeeding status, food taboos or beliefs, daily food expenditure for children, and the socioeconomic characteristics of the children were gathered from the interviews; moreover, food accessibility and a price list per 100 g of edible portion were gathered from a market survey.

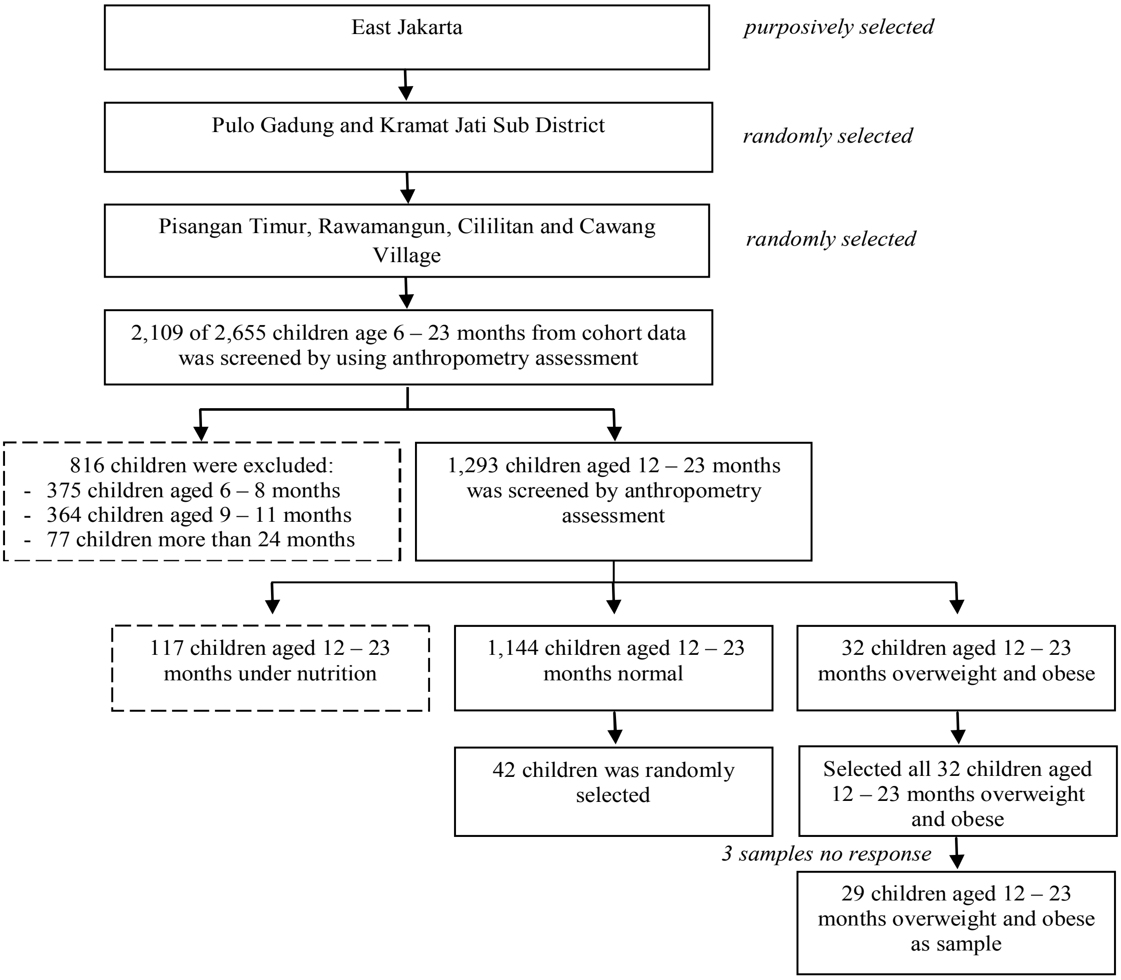

Figure 1. Sampling procedure.

Data analysis

Food intake analysis

Each food item and its nutrient content per 100 g of food were modified using the Indonesian composition table and the omega-3 and omega-6 contents were modified using the Vietnamese, Thai, and US food composition tables. The nutrient intake levels of both groups were analysed using NutriSurvey for Windows SEAMEO-TROPMED RCCN- Universitas Indonesia 2007.

Dietary diversity

To assess minimum dietary diversity, foods were grouped into seven groups on the basis of WHO recommendations. Children were considered to meet the minimum dietary diversity requirement if they consumed at least four of the defined food groups. The food groups consumed by each group were used as a reference for developing optimised diets.

Optimised diet design through linear programming

Linear Programming (LP) is a tool that used mathematical approach to achieve the best outcome with lowest cost. LP could also be used in development of optimised diet to fulfill nutritional adequacy with cost constraints.

In this study, NutriSurvey for Linear Programming 2004 software was used for developing optimised diets for each group based on three predominant feeding patterns of children: breastfed, formula fed, and mixed fed.

In using LP, first, a diet was proposed on the basis of the food patterns, and it included food amounts within the recommended intake ranges. Before the LP function was applied, the food price per 100 edible portions, minimum and maximum food items that were usually consumed (g), and nutrient requirements were considered as constraints (Figure 2).

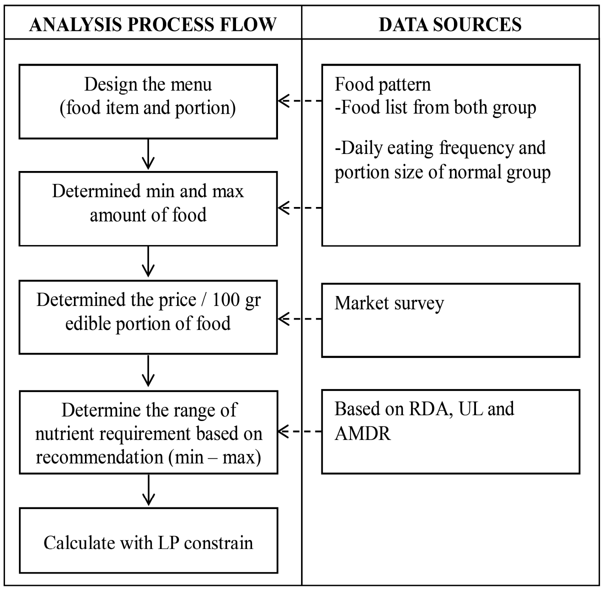

Figure 2. Analysis process flow using linear programming.

Energy requirement was calculated by multiplying the average energy requirement (calories) per kilogram body weight in the normal-weight group by that in children aged 12–23 months. Minimum and maximum energy requirements were calculated by collecting the minimum and maximum energy levels obtained from macronutrients. The range of the required macronutrients, including omega-3 and omega-6 fatty acids, was based on Acceptable Macronutrient Distribution Ranges (AMDR) of energy requirement; the omega-6/omega-3 ratio in an optimised diet should be less than 10. Micronutrient requirement, including vitamins and minerals, was determined according to the recommended daily allowance (RDA) 2013 for Indonesian children aged 1–3 years for the minimum requirement and tolerable upper intake level (UL) for the maximum requirement (Table 4).

Finally, the software program automatically analysed whether the designed diet fulfilled the nutritional recommendations, including an omega-6/omega-3 ratio less than the maximum ratio, and whether it was within the range of food prices and thus affordable. Furthermore, the software program generated alternatives for increasing or reducing the amount of food items to fulfill the nutrient requirements and optimise the diet.

RESULTS

A total of 1,293 children aged 12–23 months were screened through anthropometry and then classified on the basis of their BAZ scores. Of 1,144 children who met the inclusion criteria, 42 were randomly selected in the normal-weight group, whereas because of no response from three samples, all samples (29 children) in the overweight and obese group were selected. Therefore, the analysis included a total of 71 children (Figure 1).

The median age of the children in both groups was 20 months, and the sex distribution in both groups was similar. Most children came from extended families (66.7% in the normal-weight group and 65.5% in the overweight and obese group) with more than four members per household. Most parents' education levels in both groups were senior high school. Although mothers' education levels in both groups were similar, 81% of the mothers of children in the normal-weight group did not work, whereas 48% of the mothers of children in the overweight and obese group were working. In addition, most fathers of children in the normal-weight group had either permanent or non-permanent jobs, whereas those of the children in the overweight and obese group had permanent jobs (Table 1). The median household monthly income in both groups was IDR 3 million; the overweight and obese group was associated with a higher household income compared with the normal-weight group. Moreover, the median expenditure on children's food was IDR 22,000 (minimum IDR 3,000; maximum IDR 61,600; 1 USD=IDR 13,086, 2015; Table 2).

The median BAZ score in the normal-weight group was −0.54 SD, whereas that in the overweight and obese group was 2.62. In both groups, most children were no longer being breastfed (45.2% in the normal-weight group and 65.5% in the overweight and obese group; Ta-

Table 1. General characteristics of normal and overweight and obese children aged 12-23 months.

Characteristic	Normal group (n=42) n (%)	Overweight and obesity group (n=29) n (%)
Child's sex		
Boy	21 (50.0)	14 (48.3)
Girl	21 (50.0)	15 (51.7)
Child's age	20 (15–22)†	20 (17–22)†
Number of household's member		
Nuclear family (≤ 4 person)	14 (33.3)	10 (34.5)
Extended family (>4 person)	28 (66.7)	19 (65.5)
Mother's education level		
No schooling/ Primary School	3 (7.2)	0 (0.0)
Junior High School	15 (35.7)	3 (10.3)
Senior High School	19 (45.2)	14 (48.3)
College/ University	5 (11.9)	12 (41.4)
Father's education level		
No schooling/ Primary School	3 (7.2)	1 (7)
Junior High School	7 (16.6)	3 (10.3)
Senior High School	26 (61.9)	15 (51.7)
College/ University	6 (14.3)	9 (31.0)
Mother's occupation		
Working mother	8 (19.0)	14 (48.3)
Housewife	34 (81.0)	15 (51.7)
Father's occupation		
Permanent job	20 (47.6)	23 (79.3)
Non-permanent job	21 (50.0)	5 (17.2)
Did not have job	1 (2.4)	1 (3.5)
Breastfeeding Status		
Breastfed without consuming follow-on formula	6 (14.3)	2 (6.9)
Breastfed with consuming follow-on formula	17 (40.5)	8 (27.6)
Non breastfed but consuming follow-on formula	19 (45.2)	19 (65.5)

†Median (25^{th} – 75^{th} percentile).

Table 2. Household monthly income, food expenditure, and dietary diversity score of normal and overweight and obese children aged 12-23 months

Characteristic	Both groups	Normal group	Overweight and obese group	p value*
Household's monthly income (IDR thousand) §	3500 (2000–5000)†	3000 (1710–4500)†	4000 (2700–5400)†	0.174
Daily food expenditure of children aged 12–23 months (IDR thousand) §	22 (16.4–32.1)† (3–61.6)‡	22 (15.7–27)†	30 (20-37.1)†	0.003**
Median BAZ		-0.54 (-1.18–0.39)†	2.62 (2.20–3.18)†	0.0001***
Dietary diversity score†		4.0 (3.0-5.0)	4.0 (4.0-5.5)	0.072
Minimum dietary diversity fulfillment				
Fulfilled		31 (73.8)¶	25 (86.2)¶	
Not fulfilled		11 (26.2)¶	4 (13.8)¶	

†Median (25th – 75th percentile).
‡Median (min – max) data is needed in LP NutriSurvey.
§1 USD= IDR 13.086, 2015.
¶n (%).
*Mann Whitney with significance value $p<0.05$, ** p value ≤0.01, *** p value ≤0.001.

Table 3. Breastfeeding status and minimum dietary diversity fulfillment

Breastfeeding status	Minimum dietary diversity fulfilment, n (%)		p value
	Fulfilled	Not fulfilled	
Breastfed without consuming follow-on formula	3 (5.4)	5 (33.3)	
Breastfed with consuming follow-on formula	23 (41.0)	2 (13.3)	0.025*
Non breastfed but consuming follow-on formula	30 (53.6)	8 (53.4)	

*Kruskal-Wallis test with significance value $p<0.05$.

ble 1).

The daily eating frequency observed in this study was three meals and two snacks. One meal involves one meal plate that might consist of staples, animal and plant proteins, vegetables, and fruits. A snack might consist of one portion of snack food or fruits (Table 6). The daily frequency of each food group consumed in the normal-weight group was used as a reference for determining the frequency of each food group in the daily optimised diet menu (Table 5), except for dairy products. The consumption frequency of dairy products was designed to be two to three times a day.

A total of 245 food items were recorded in the dietary recall. Both groups obtained a score of 4 in the dietary diversity assessment; however, the percentile of the scores revealed that the overweight and obese group tended to have a higher score than did the normal-weight group. Most children in each group fulfilled the minimum dietary diversity requirement, and no significant difference was observed between the groups (Table 2). According to the breastfeeding status, most children who fulfilled the minimum dietary diversity requirement were not breastfed but consuming follow-on formula. Moreover, a significant difference ($p<0.05$) was observed in the breastfeeding status between children who fulfilled and those who did not fulfill the minimum dietary diversity requirement (Table 3).

To develop an optimised diet, the food item list was grouped into 8 food groups, 70 subgroups, and 104 sub-sub-groups; in addition, food items that were rarely consumed or items that did not have a high nutrient value were omitted. Rice was most commonly consumed by the children (67; 94.4%), followed by carrots (56; 78.8%), biscuits (48; 67.6%), chicken (45; 63.4%), and follow-on formula (43; 60.6%). The portion size was obtained from the normal-weight group, whereas the serving size for breast milk intake was defined on the basis of the average breast milk intake in children aged 12–24 months in developing countries (Table 7).

According to the typical intake design, an optimised diet menu was developed using LP. In the LP software, some food items with its price were taken in and out of software until got the appropriate diet menu and could fulfill the nutrient requirements with proposed total price range. Table 8 presents examples of an optimised diet menu for each menu type based on the breastfeeding status and follow-on formula consumption. Alternative menus were selected on the basis of the following optimal omega-6/omega-3 ratios for each menu type: 7 for Type 1 (Day 5) in children who were breastfed and who consumed follow-on formula, 5 for Type 2 (Day 2) in children who were breastfed and who did not consume follow-on formula, and 4 for Type 3 (Day 7) for children who were no longer breastfed.

The percentage of energy fulfillment was within the AMDR range in the optimised diet developed in this study. In addition, the minimum and maximum ranges of the required macronutrients (carbohydrate, total fat, and protein) were within the AMDR range. According to the trade-off determined using LP, the omega-6/omega-3 ratio was between 4 and 10.

Figure 3 presents the contribution of omega-3 food sources in the developed optimised diet. In children who were breastfed and consuming follow-on formula, the highest contributor to omega-3 intake was plant proteins such as tempeh and tofu. By contrast, in children who were partially breastfed and no longer breastfed, the omega-3 intake contribution was from snacks, which included biscuits with high milk content.

The contribution of omega-6 food sources in the devel-

Table 4. Energy and nutrient constrain used in optimization models by linear programming

Nutrient constrain¶	Goal value	
	Minimum	Maximum
Energy†	677	1017
Macronutrient‡		
Protein (g)	10	42
Total fat (g)	29	34
Omega 3 (g)	0.5	2.9
Omega 6 (g)	5.3	9.6
Ratio n6 : n3		10
Carbohydrate (g)	94	136
Fat soluble vitamin§		
Vitamin A (µg)	400	600
Vitamin D (µg)	15	63
Vitamin E (mg)	6	200
Vitamin K (µg)	15	
Water soluble vitamin§		
Vitamin B-1 (mg)	0.6	
Vitamin B-2 (mg)	0.7	
Niacin (mg)	6	10
Pantothenic acid (mg)	2	
Vitamin B-6 (mg)	0.7	
Folic acid (µg)	160	300
Vitamin B-12 (µg)	0.9	
Vitamin C (mg)	40	400
Mineral§		
Calcium (mg)	650	2500
Phosphorus (mg)	500	3000
Magnesium (mg)	60	65
Iron (mg)	8	40
Zinc (mg)	4	7

†Energy requirement (E) was calculated by 86.5* mean body weight (9.79) = 847 Kcal, with min - max requirement based on accumulation calculation of macronutrient.
‡Macronutrient based on AMDR: Protein 5 – 20% E; Total fat 30 – 35% E; Carbohydrate 45-65% E; omega 3 and omega 6 based on AI as minimum goal and U-AMDR as maximum goal (0.6-3% E of omega 3 based on AMDR for ALA and 4.5-10% E of omega 6 based on AMDR for LA).
§Micronutrient based on RDA and UL.
¶Source: fat,[34] protein and carbohydrate.[32]

Table 5. Actual daily food intake frequency of normal group that was used in optimization models by linear programming

Food group	Daily food intake frequency		
	Lower†	Average‡	Maximum§
Staple	2	3	5
Animal Protein	0	2	3
Plant Protein	0	1	2
Vegetables	0	1	6
Fruits	0	1	1
Snack	0	2	4
Diary product	0	3	7
Vegetable oil	0	1	2
Sugar	0	0	1
Margarine	0	2	3

†5th percentile of consumption frequency
‡50th percentile of consumption frequency
§95th percentile of consumption frequency

oped optimised diet is presented in Figure 4. Plant proteins contributed more to omega-6 intake than did animal protein in the optimised diet for children who were breastfed, regardless of whether they consumed follow-on formula. In addition, plant proteins and snacks were the highest contributors to omega-6 intake in the developed optimised diet in overweight and obese children who were no longer breastfed.

Some alternative meal plans to the optimised diet could not fulfill the RDA requirements for micronutrients, but fulfilled the estimated average requirements. However, almost all of these alternative meal plans exceeded the UL of vitamin A and magnesium (Table 8)

DISCUSSION

The optimised diet developed in this study by using LP fulfilled the nutrient requirements for overweight and obese children aged 12–23 months; in particular, an omega-6/omega-3 ratio within the range of 4–10 could be achieved. The optimised diet was certainly developed within the range of daily expenditure for child feeding in the family; thus, relatively affordable for the general population.

Designing dietary recommendations for overweight and obese children involved numerous challenges; this is because the children were in their growth phase during the study period, and the energy requirement could not be reduced for reducing body weight as in adults. The Indonesian Paediatric Association suggested that a nutritious diet based on the requirements is the most favourable alternative for overweight children.[27] Hence, the diet could be modified into a nutritious diet by optimising omega-3 and omega-6 fatty acid intake, given the benefits of omega-3 in reducing body weight.[11,12,14]

Dietary guidelines should reflect the actual consumption pattern of certain groups.[28] In this study, dietary diversity was also analysed to determine the quality of child dietary intake. Previous studies in numerous countries have demonstrated that dietary diversity was associated with nutritional status.[29] In the present study, the dietary

Table 6. Eating frequency and number of meals based on 3 non-consecutive day 24h recall of normal group (n=42)

Eating time		Mean total consumption during 3 non-consecutive day		Daily consumption	
		Frequency	Number of meals	Frequency	Number of meals
Wake up-12 am	Breakfast meal	3	3	1	1
	Snack	2	3	1	1
12 am -17 pm	Lunch meal	3	3	1	1
	Snack	2	3	1	1
5 pm-before sleep	Dinner meal	2	2	1	1
	Snack†	1	2	0-1	0-1

†Snacking after dinner in the design was excluded to accommodate the subject who did not take snack.

Table 7. Food group and portion size

Food group/sub group	Food item	n	Portion (g/day)		
			Median	Min	Max
1 Staple food					
Rice	Rice	67	88	10	304
Rice porridge	Rice porridge	37	150	50	480
Bread	Sweet bread (from small vendor), plain bread, cheese bread, chocolate bread , toasted bread with chocolate granule, fried bread	19	41	10	124
Potato	Potato	14	37.5	14	150
Noodle (dry)	Instant noodle, misoa	15	15	4	30
Rice with coconut milk	Rice with coconut milk	7	75	26	109
Rice noodle	Rice noodle	4	9	3	15
Cereal	Cereal	4	30	30	30
2 Animal Protein					
Chicken and its product					
Chicken	Chicken, fried chicken, fried chicken with flour	45	30	5	145
Chicken sausage	Chicken sausage	21	25	2	59
Chicken nugget	Chicken nugget	6	39	39	80
Chicken leg	Chicken leg	7	99	15	169
Chicken liver	Chicken liver	9	30	3	48
Egg					
Chicken egg	Chicken egg	31	33	2.5	80
Quail egg	Quail egg	14	30	10	60
Fish					
Catfish	Catfish	10	48	12	115
Mackerel	Mackerel	3	63	32	65
Tuna fish	Tuna fish	6	50	19	100
Milk fish	Milk fish	2	29	7	50
Pangasius	Pangasius	3	33	33	33
Pomfret fish	Pomfret fish	2	96	27.5	96
Meat					
Meat	Meat	8	18	10	27
Meat ball	Meat ball	35	30	5	75
3 Plant Protein					
Tofu	Tofu, fried tofu, fried tofu with vegetable inside	15	35	5	60
Tempeh	Tempeh, fried tempeh, fried tempeh with flour	15	45	11	100
Kidney bean	Kidney bean	3	5	1.2	5
Mungbean	Mungbean	2	75	75	75
4 Vegetables					
Carrot	Carrot	56	17	2	60
Potato (inside the soup)	Potato (inside the soup)	24	10	3	55
Spinach	Spinach	20	21	5	44
Sweet corn	Sweet corn	16	28	8	75
String bean	String bean	15	27	5	20
Broccoli	Broccoli	9	30	3	90
Gourd	Gourd	7	22	10	50
Cabbage	Cabbage	5	11	1	20
Yardlong bean	Yardlong bean	4	15	15	15
Tomato	Tomato	4	2	2	2
Mushroom	Mushroom	2	10	10	10
5 Fruits					
Orange	Orange	16	45	6	125
Papaya	Papaya	12	75	42	100
Banana	Banana	9	50	25	50
Lansium	Lansium	8	40	10	50
Watermelon	Watermelon	7	63	50	75
Avocado	Avocado	5	142	40	208
Apple	Apple	4	50	50	50
Rambutan	Rambutan	4	70	70	70
6 Snacks					
Biscuit		48	17	4	60
Wafer		24	14	8	60
Extruded snacks		22	10	4	35
Cake	Cake (from small vendor)	15	40	16	50
Seaweed	Seaweed	9	45	30	45
Fried banana	Fried banana	5	50	20	60
Doughnut	Doughnut	8	19	15	36
Other flour base local/ traditional snack	Roasted fish cake, flour based traditional cake	8	33	15	58

Table 7. Food group and portion size (cont.)

Food group/sub group		Food item	n	Portion (g/day)		
				Median	Min	Max
	Gruel	Gruel	8	84	53	100
	Jelly	Jelly	6	42	39	97
7	Breast milk and dairy product					
	Breast milk	Breast milk	33	549		
	Follow on formula		43	114	12	411
	Evaporated milk		25	194	63	400
	Ice cream		12	35	8	95
	Cheese	Cheddar cheese	8	33	3	88
	Fermented milk		5	49	33	65
8	Miscellaneous					
	Vegetable oil	Vegetable oil	37	4	0.2	25
	Soya sauce	Soya sauce	33	5	4	30
	Chips	Chips	18	5	2	25
	Sugar	Sugar	15	5	1	16
	Coconut milk	Coconut milk	14	33	20	109
	Palm sugar	Palm sugar	9	24	2.5	27
	Margarine	Margarine	5	7	2	8

intake levels in both groups could fulfill the minimum dietary diversity requirement; however, the contribution of each food item to energy intake was determined according to the corresponding portion size. The accessibility and affordability of food engendered no significant difference in dietary diversity between the normal and overweight and obese; socioeconomic status may also be an influencing factor.[29] In addition, our results reveal a significant difference in the dietary diversity score between the groups in relation between children who breastfed without consuming follow-on formula, breastfed with consuming follow-on formula and non-breastfed but consuming follow-on fulfilled the minimum dietary diversity requirement. We concur with the observation of a previous study that dietary diversity is strongly correlated with breastfeeding status because non-breastfed children require complementary food as energy and nutrient sources.[29]

Dietary recommendations for the obese group were developed using food patterns in the normal-weight group, because the food patterns of overweight and obese children shifted from healthy to overconsumption. Nevertheless, we included the food types in the recommendation after considering the food consumed by both groups; this is because we could not compel the obese children to eat what they usually did not eat. The Indonesian Paediatric Doctor Association also underlined that dietary recommendations for obese children cannot compel the obese children to eat certain foods.[27,30] In addition, the design of this optimised diet is consistent with the suggestion by the Indonesian Paediatric Doctor Association for daily eating time, which is limited to three times a day. Consumption of follow-on formula was also restricted. Excess dairy milk consumption (more than 480-720ml a day), particularly follow-on formula, may lead to additional energy contribution.[27]

In data collection processes for dietary assessment, we used food recall as our assessment method, we also verified the portion sub size of food by weighing some food items to ensure that the portion size of food consumed by the children was closest to that of the actual intake. To minimise the selection bias, sampling criteria and procedure were applied to representative children. In addition, to minimise anticipated nonresponse and interviewer bias, the enumerators were trained and the questionnaire was simplified and pretested. Moreover, the study was monitored meticulously to ensure adherence to the planned protocol. To facilitate data analysis, data entry was conducted under close supervision. Double data entry was conducted for 10% of the total participants, and this process revealed no errors.

Although many intervention studies have used fish oil supplements to demonstrate significant reductions in body weight,[11-16,31] only a few studies have employed the dietary intervention approach; however, they have not specifically reported its effect in body weight reduction or the information of the confirmed ratio of these fatty acid. Hence, the optimised diet developed in our study applied a cut off value of <10 for the omega-6/omega-3 ratio, which was obtained by calculating the omega-6 and omega-3 RDA requirements for Indonesian children aged 1–3 years.

In some optimised diet alternatives, a lower omega-6/omega-3 ratio could be achieved with lower food expenditure depending on the type of omega-3 and omega-6 food sources used in the optimised diet. In fact, omega-6 food sources had a higher cost than did omega-3 food sources in the optimised diet. Thus, to ensure the acceptance of a diet plan, a lower omega-6/omega-3 ratio with a lower cost is essential. Nevertheless, formula milk and other fortified food significantly contribute to lowering the omega-6/omega-3 ratio, but with an increase in price.

In children who were still breastfed, the omega-3 and omega-6 intake requirements were easily to be fulfilled because breast milk highly contributes to the required omega-6 and omega-3 intake. Plant proteins such as tempeh and tofu had a slightly higher contribution to omega-3 intake than did animal proteins in the optimised diet. Moreover, plant proteins were the highest contributor to omega-6 intake. In addition to the affordable price, these foods are usually consumed by children and are

Table 8. Daily optimized diet for overweight and obese children

Meal time	Food and portion size					
	A. Breastfed with consuming follow-on formula		B. Breastfed without consuming follow-on formula		C. Non breastfed but consuming follow-on formula	
	Breastmilk on demand		Breastmilk on demand			
Breakfast	Plain bread	10 g (0.33 slices)	Mashed potato:		Follow on formula[†]	16 g (0.5 glasses)
	Cheese (shredded)	3 g (1 teaspoon)	- potato	14 g (3 dices)	Cooked rice with coconut milk	26 g (2.5 tablespoons)
			- chicken liver	3 g (0.33 small pieces)	Chicken liver	3 g (0.33small pieces)
			- kidney bean	2 g (4 pieces)	Fried tempeh	15 g (1.5 table spoons)
			- carrot	2 g (2 small slices)	Soya sauce	4 g (1 teaspoon)
Snack	Tofu broccoli cake	5 g (1 small piece)	Biscuit[§]	20 g (2 pieces)	Cake with cheese inside	50 g (1 piece)
	- tofu (0.7 g)				Biscuit[¶]	11 g (2 pieces)
	- broccoli (8.8 g)					
	- egg (1 gr)					
	- UHT milk (1.5 ml)					
	- cheese (0.2 g)					
	Follow-on formula[†]	22 g (1 glass)				
Lunch	Cooked rice	30 g (3 tablespoons)	Cooked rice	10 g (1 tablespoon)	Cooked rice	20 g (2 tablespoons)
	Fried pomfred fish		Catfish (*mangut lele*)	55 g (0.5 tails)	Spinach *(sayur bening)*	5 g (0.5 tablespoons)
	- pomfred fish	28 g (0.5 pieces)	Tempeh *(oreg tempe)*		Fried chicken	5 g (0.5 tablespoons)
	- vegetable oil (as absorbed)	3.5g (1 teaspoon)	- tempeh	11 g (1 tablespoon)	Watermelon	75 g (1 regular piece)
	Spinach (fresh)	5 g (0.5tablespoons)	- vegetable oil	2 g (0.5 teaspoons)		
			- soya souce	4 g (1 teaspoon)		
			Spinach *(sayur bening)*	5 g (0.5 table spoons)		
			Orange	25 g (0.25 pieces)		
Snack	Biscuit[‡]	21 g (3 pieces)	Biscuit[‡]	15 g (2.5 pieces)	Gruel	100 g (1 bowl)
			Biscuit[¶]	18 g (3 pieces)	UHT milk	214 g (1 glass)
Dinner	Cooked rice	22 g (2 tablespoons)	Cooked rice	10 g (1 tablespoon)	Tuna fish (yellow spice)	40 g (1 small piece)
	Sauted mushroom		Sauted mix vegetable:		Sauted vegetable:	
	- mushroom	10 g (2 tablespoons)	- broccoli	38 g (12 small slices)	- mushroom	10 g (1 tablespoon)
	- sweet corn	10 g (1 tablespoon)	- string bean	5 g (3 slices)	- string bean	5 g (1.5 tablespoons)
	- chicken sausage	13 g (13 small slices)	- quail egg	10 g (1 piece)	- margarine	2 g (0.5 teaspoons)
	- vegetable oil (as absorbed)	1.5 g (0.5 teaspoons)	- tomato	2 g (2 small slices)		
			- margarine	2 g (0.5 teaspoons)		
Price (IDR)[††]	7,336		11,760		22,767	

[†]Follow-on formula which contain 0.19 g of omega-3 and 1.90 g of omega-6 per 100 g edible portion; biscuit which contain : [‡]0.02 g of omega-3 per 100 g edible portion; [€]0.01 g of omega-3 and 0.01 g of omega-6 per 100 g edible portion; [¥]5.48 g of omega-3 and 14.08 g of omega-6 per 100 g edible portion.
[§]1 USD=IDR 13,086, 2015.

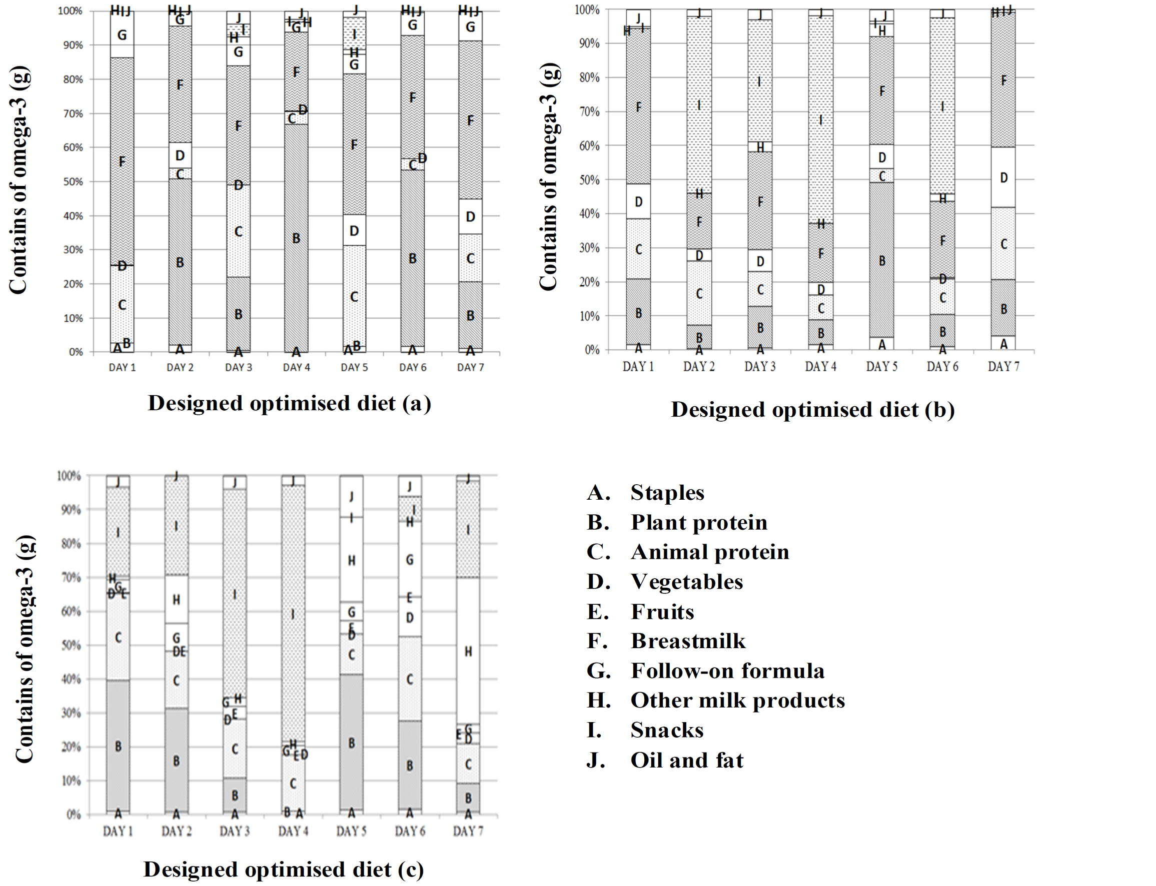

Figure 3. Food contribution on omega-3 intake of optimized diet for overweight and obese children who (a) Breastfed with consuming follow-on formula; (b) Breastfed without consuming follow-on formula; (c) Non breastfed but consuming follow-on formula.

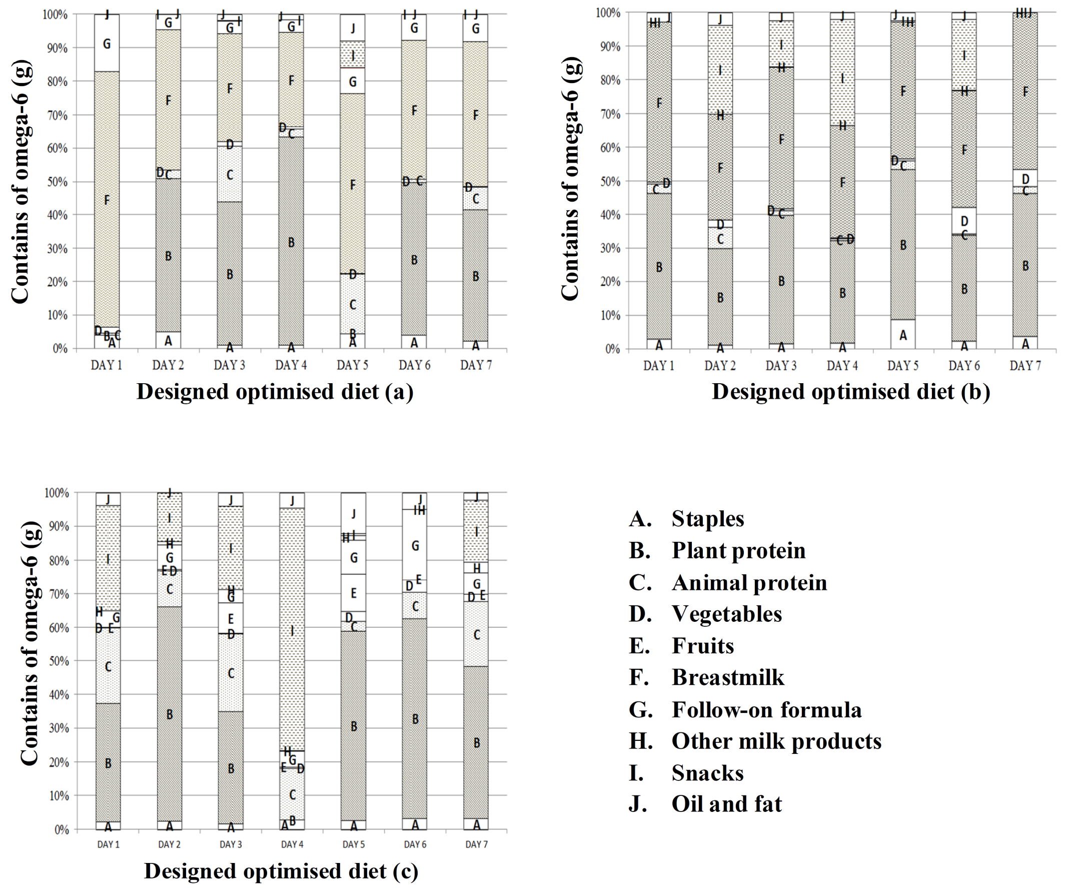

Figure 4. Food contribution on omega-6 intake of optimized diet for overweight and obese children who (a) Breastfed with consuming follow-on formula ; (b) Breastfed without consuming follow-on formula; (c) Non breastfed but consuming follow-on formula.

Table 9. Percentage of fulfillment of nutrient requirement from optimized diet according to Indonesian Recommended Dietary Allowance for children age 12-23 months

Nutrient†	Nutrient fulfillment of optimised diet (%)																				
	7-days type 1 optimisation‡							7-days type 2 optimisation§							7-days type 3 optimisation¶						
	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-1	D-2	D-3	D-4	D-5	D-6	D-7
Energy	94	107	97	91	91	85	111	95	94	113	112	112	85	111	91	101	85	94	100	98	93
Macronutrient																					
Protein	154	91	133	107	116	98	141	123	127	201	169	107	98	141	140	173	118	146	159	169	191
Total fat	102	101	102	103	103	91	102	103	103	103	103	102	91	102	95	94	88	103	89	102	97
Omega 3	145	184	178	180	152	174	135	137	382	217	360	196	174	130	233	378	358	301	224	120	425
Omega 6	125	136	177	139	106	138	133	120	181	137	170	141	138	124	180	181	214	181	112	104	158
Ratio n6: n3	9	8	10	8	7	8	10	9	5	7	5	8	8	10	8	5	6	6	5	9	4
Carbohydrate	98	113	86	80	80	80	145	83	82	81	107	116	80	145	81	88	81	80	116	83	80
Micronutrient																					
Fat soluble Vitamin																					
Vitamin A	207	265	150	313	238	328	177	323	301	281	307	335	328	177	151	151	149	150	134	150	202
Vitamin D	101	100	100	158	102	101	87	133	107	113	80	100	101	87	227	153	160	160	100	247	100
Vitamin E	94	82	82	87	71	78	68	80	82	83	78	83	78	68	85	92	83	78	102	85	127
Vitamin K	95	104	100	103	102	96	103	373	333	800	773	273	96	103	133	167	100	140	287	193	100
Water soluble Vitamin																					
Vitamin B-1	99	147	103	102	86	94	90	88	127	103	133	92	94	90	120	98	133	117	133	120	87
Vitamin B-2	177	162	178	153	132	164	149	794	137	131	147	130	164	149	140	143	157	123	177	179	197
Niacin	107	100	129	98	87	95	118	105	123	155	100	105	95	118	125	82	135	150	95	167	117
Pantothenic acid	172	104	106	128	127	147	142	132	126	141	189	125	147	142	100	100	105	100	143	101	141
Vitamin B-6	172	136	156	112	113	132	155	100	108	162	142	88	132	155	112	112	148	140	174	180	190
Folic acid	124	123	94	144	115	146	123	129	115	121	160	139	146	123	126	101	109	105	100	141	99
Vitamin B-12	472	349	287	500	282	604	292	618	549	524	598	492	604	292	428	449	360	290	426	384	589
Vitamin C	380	215	147	209	167	220	183	185	225	258	433	245	220	183	103	130	110	118	133	103	83
Mineral																					
Calcium	101	104	111	121	103	111	99	80	92	97	92	105	111	99	128	149	107	100	115	131	151
Phosphorus	167	100	100	94	101	116	135	77	86	100	100	80	116	135	122	123	104	105	158	101	191
Magnesium	165	108	109	108	123	128	181	108	108	172	182	108	128	181	120	108	113	150	163	158	178
Iron	125	119	97	134	101	118	104	106	94	110	118	78	118	104	159	133	190	130	121	136	130
Zinc	146	101	101	109	105	128	129	100	80	150	93	113	128	129	130	165	115	100	140	83	145
Daily food cost, IDR (thousand) ††	7.5	7.3	11.4	8.4	7.3	6.2	7.7	7.5	11.8	17.5	17.1	9.7	12.7	11.9	13.9	22.6	9.8	10.1	11.0	15.5	22.8

†% fulfillment based on recommendation: Energy requirement was calculated by 86.5*mean body weight, macronutrient: protein=2*mean body weight, fat=3.4*mean body weight, carbohydrate=11.9*mean body weight. Micronutrient recommendation based on RDA.

Type of diet optimization: ‡breastfed with consuming follow-on formula; §breastfed without consuming follow-on formula; and ¶non breastfed but consuming follow-on formula.

††1 USD=IDR 13,086, 2015.

available in almost all traditional and modern markets around the study area.

Biscuits were the most frequently consumed snacks by the children, which contribute to omega-6 and omega-3 intake, especially among children who are no longer being breastfed. Many biscuit products are available in the urban area, and such products have become one of the children's favourite snacks. Because of their considerably high contribution to children's food intake, the nutrient content of children complementary food from this item should be considered.

The developed optimised diet fulfilled all recommended nutrient amounts; by contrast, most optimised diets exceed the UL of total vitamin A and magnesium. This excess was still considered safe because the UL for vitamin A was applied only for preformed vitamin A,[32] which are mostly derived from animal food sources. In the menu, vitamin A was contributed by vegetables such as carrot and fruits, which are rich in beta-carotene. Beta-carotene can be converted into vitamin A in the body and hence classified as a provitamin A carotenoid. In addition, the UL for magnesium intake represented the intake from a pharmacological agent only and did not include the intake from food and water[32]; however, magnesium intake in the menu was mostly contributed by food sources. Thus, this optimised diet meets the requirements and is acceptable for children aged 12–23 months.

Dietary fibre intake is another concern, because it was not considered in the LP analysis. LP was difficult to execute when dietary fibre was considered; this is because the food type that is usually consumed is not very varied and has low fibre content. Nevertheless, the developed optimised diet fulfilled the minimum dietary diversity, because it contained four or more food groups such as grains, roots, and tubers; flesh foods (meat, fish, poultry, and liver); dairy products (milk and cheese); eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables.

The optimised diet developed in this study can be applied to overweight and obese children to improve their nutritional status, particularly for weight control management. In addition, the diet can be used by the government as a reference for formulating guidelines and regulations regarding interventions for obese children to combat the national obesity concern. However, the feasibility of applying the optimised diets should be considered. The optimised diet mainly incorporates omega-3 and omega-6 intake, and the major sources of omega-3 fatty acids are fish and fish products. Daily intake of these foods may not be suitable for some children who cannot tolerate fish and fish product. In general, a background diet which is biodiverse is necessary for the physiological effects of a particular nutrient to be realised,[35] the same principles might apply to a background of breastfeeding or even intergenerational diet.[36]

The willingness of mothers to provide the optimised diet to their children may be related to their feeding-related perceptions, knowledge, and behaviour, including food taboos and its feasibility. The present developed optimised diet offers specific recommendation for complementary food (portion size, prize) in addition to the recommendation provided by the Balanced Nutrition Recommendation from Ministry of Health of Republic of Indonesia,[33] in young children. Therefore, the optimised diet is beneficial for weight control management in overweight and obese children, if applied with high compliance.

Further study is required to determine whether children can sustainably apply the optimised diet with good compliance. Moreover, the impact of this optimised diet menu on the improvement of the nutritional status of overweight and obese children must be further investigated. Therefore, future study needs to include dietary fiber in developing LP based on diets for overweight and obese children.

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AUTHOR DISCLOSURES

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