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Alternative Indices for the Assessment of Nutritional Quality of Balanced Diet of Indonesian Children 4-6 Years Old

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Abstract: The objective of this study was to develop alternative indices for the assessment of nutritional quality of the diet of Indonesian children aged 4-6 years old. This study used the food consumption data of the Basic Health Research 2010. The food consumption data were collected using 24-h food recall method through a cross-sectional study. Total subject of this study after data screening was 10221 children 4-6 years. The nutritional quality (NQ) of 15 nutrients was used as a gold standard in the validity testing of the indices. The results showed that the most valid index (r = 0.6) was the index with a continue scoring system of six food groups (carbohydrate foods, vegetables, fruits, animal protein foods, plant protein foods, and milks) without considering fat, saturated fat, added sugar, and sodium intakes. The simplest and valid (r = 0.58) index was the index with a three levels discrete scoring system of the same six food groups.

Key words: Balanced diet index, dietary quality, food groups, Indonesian children

INTRODUCTION

Many developing countries now face the double burden of malnutrition, defined as the coexistence of underweight, stunted and overweight children (Muhammad and Saleem 2010). Besides, the prevalence of noncommunicable diseases (NCDs) is getting higher. Excess consumption of fat, sugar, and sodium are associated with increased risk of NCDs, such as diabetes, hypertension, cardiovascular disease. According to WHO, a nutritious balanced diet is important to prevent the rising burden of malnutrition and NCDs (WHO 2003; 2014).

In Indonesia, amount 19.6 % of children under five years are underweight, and 37.2% are stunted. On the other hand, 11.9% of children are overweight (MOHI, 2014a). Child malnutrition is associated with an increased risk of childhood mortality, poor cognition, physical and psychological health (Victoria *et al*., 2008; Koletzko *et al*., 2011; Amjad *et al*., 2015), and may result in an increased risk of NCDs and obesity in adulthood (Sawaya *et al*., 2009).

Currently, the Ministry of Health of Indonesia has developed a current balanced diet portion size for each aged group, as a healthy dietary guidelines for all age groups, including children, so that nutritional problems can be prevented (MOHI, 2014b). In some countries such as USA (Guenther *et al*., 2008; 2013), and Thailand (Taechangam *et al*., 2008) had developed an index to assess the nutritional quality of food consumption that is based on each country balanced diet, called the Healthy Eating Index. In Indonesia, Amrin *et al*. (2013) and Perdana *et al*. (2014) developed a Balanced Diet Index (BDI) to simply assess the nutritional quality of the diet of male and female adults respectively.

Until now, there is no index used to simply assess the nutritional quality of the diet based on the portion size of the current balanced diet of Indonesian children. Therefore, there is a need to develop an index to simply assess the nutritional quality of the diet based on a nation wide food consumption data. This research aim is to develop alternative indices for the assessment of nutritional quality of the diet based on the balanced diet portion size of Indonesian children 4-6 years old from the national data.

MATERIALS AND METHODS

Design and subjects: This study used the food consumption data of the Basic Health Research (Riskesdas) by applying a cross-sectional study design. Subjects were healthy children aged 4-6 years. Subjects with Z-Score height for age <-6 or > 6, weight for age <-6 or> 5, weight for height <-5 or >5, body mass index for age <-5 or> 5 were excluded (WHO, 2009). Subjects who consumed very low (<30% of basal metabolic energy) or very high (>300% basal metabolic energy) energy, consumed more than 400% nutrient adequacy, and consumed food in unusual condition (illness, fasting, feasts) were excluded. The final subjects after the data cleaning as much as 10221 children.

Data collection and analysis: The data gained by permission from Health Research and Development Agency of MOHI. The data used in this study were subject characteristics data, anthropometric data (body

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weight and body height), and food consumption data. The food consumption data were collected using 24-hour recall method from May to August 2010 by trained enumerators manage by the Ministry of Health of Indonesia. The data analysis was held in the Department of Community Nutrition, Faculty of Human Ecology, Bogor Agricultural University from September 2014 to May 2015

Food consumption and nutritional quality: The food consumption of the subjects was analyzed based on the participation rate and the quantity of food consumed for each of the food groups. The participation rate is the percentage of subjects who consume certain food groups compared to the total number of subjects. The quantity of food consumed is the mean quantity (g) of food consumed by each subject.

Nutritional Quality (NQ) of the diet of each of the subjects were calculated based on the mean adequacy level of 15 nutrients, namely energy, protein, fat, carbohydrate, water, vitamin A, vitamin B1, vitamin B9 (folate), vitamin B12, vitamin C, sodium, calcium, iron, phosphorus, and zinc. The adequacy level of each nutrient is truncated at 100 in order to prevent the occurrence of compensation between the values of the adequacy of nutrients (Gibson, 2005). Nutrient intake was obtained from the conversion of the weight of the food intake into nutrient by using food composition tables of Indonesia and USDA, and nutrition fact of labeled foods. The nutrient requirement of each of the subjects was calculated individually. The Classification of the macro nutrients adequacy are (1) very deficit (<70%); (2) medium deficit (70-79%); (3) mild deficit (80-89%); (4) normal (90-119%); and (5) excess (≥120%) (Department of Health 1996 in Hardinsyah *et al*., 2012). The classification of vitamins and minerals adequacy are (1) less (<77%); and (2) enough (≥77%).

Balanced diet index (BDI): The concept of food grouping in the development of BDI was divided into two groups, namely the consumption of food groups that should be fulfilled the nutrient requirement, and foods should be limited to NCDs (fat, salt/sodium, and added sugar). There are two types of food group in the present study, namely the five food group and the six food group. The five food group consists of 1) carbohydrate foods, 2) vegetables, 3) fruits, 4) animal foods (included milk), and 5) plant protein foods. The six food group is similar to the five food group, but the milk group is separated to be the sixth group.

A signing value to every component in the BDI was divided into three scoring systems, namely: (1) a discrete scoring system with three levels of assessment (BDI3); (2) a discrete scoring system with four levels of assessment (BDI4), and (3) a continuous scoring system of assessment (BDIC). BDI3, BDI4, BDIC was developed in a variety of alternatives (Table 1).

The serving size standard for each food group was adapted and validated from portion size of a balanced diet for Indonesian children 4-6 years old. The proportion of energy from fat and added sugars adapted from the WHO guidelines (FAO, 2008; WHO, 2015).

The Pearson correlation test was used to assess the correlation between BDI scores and Nutritional Quality (NQ) scores. Valid BDI was the BDI had a highest correlation coefficient to NQ. The index was considered to be a simple index if its apply a discrete scoring system.

RESULTS

Balanced diet indices: There were 12 balanced diet indices (BDI) developed in this study for Indonesian children aged 4-6 years old. As shown in Table 2, each of them has a significant positive correlation with the nutritional quality of the diet, NQ ($p<0.01$) with correlation coefficients range from 0.2 to 0.6. Among them, the two BDIs that have correlation coefficients equal or more than 0.6 were BDIC-60 (Table 3) and BDI3-60 (Table 4); and the BDI that has lowest correlation coefficient was BDI4-94. The BDI that highest correlation coefficient among index with included four foods be limited (total fat, saturated fat, sodium/salt, and added sugar) was BDIC-104 (Table 5)

There was a consistent result that BDIs with included four foods be limited (total fat, saturated fat, sodium/salt, and added sugar) always have lower correlation coefficients compared to BDIs without the four limited foods. Besides, there was also a consistent result that the BDIs calculated based on a discrete scoring system always have lower correlation coefficient compared to the BDIs calculated based on a continue scoring system.

Nutrients adequacy and food consumption: Overall, the mean of nutritional quality of the diet of the Indonesian children was 60.2 ± 16.3. The mean adequacy level of each of the nutrients consumed by the children varies from 29% (vitamin C) to 138% (protein). The nutrients categorized as deficit among Indonesian children were energy, fat, vitamin A, vitamin B1, folate, vitamin, calcium, and zinc (Fig. 1).

Regarding the food consumption of the children, the results showed that the carbohydrate food group was the food group with the highest participation rate; while the fruit group was the lowest participation rate. In terms of quantity, the carbohydrate food group was the food group with the highest quantity be consumed; while the milk group was the lowest quantity be consumed by the children (Table 6).

DISCUSSION

The present study showed that the validity of BDI based on six food groups with a continue scoring system

Table 1: Alternative Balanced Diet Indices (BDI)

Index	Definition	Cumulative scores
BDI3-50	BDI with 3 levels scoring system, consisting of 5 components and 0 aspects related to NCDs	0-50
BDI3-60	BDI with 3 levels scoring system, consisting of 6 components and 0 aspects related to NCDs	0-60
BDI3-94	BDI with 3 levels scoring system, consisting of 9 components and 4 aspects related to NCDs	0-90
BDI3-104	BDI with 3 levels scoring system, consisting of 10 components and 4 aspects related to NCDs	0-100
BDI4-50	BDI with 4 levels scoring system, consisting of 5 components and 0 aspects related to NCDs	0-50
BDI4-60	BDI with 4 levels scoring system, consisting of 6 components and 0 aspects related to NCDs	0-60
BDI4-94	BDI with 4 levels scoring system, consisting of 9 components and 4 aspects related to NCDs	0-90
BDI4-104	BDI with 4 levels scoring system, consisting of 10 components and 4 aspects related to NCDs	0-100
BDIC-50	BDI with continue scoring system, consisting of 5 components and 0 aspects related to NCDs	0-50
BDIC-60	BDI with continue scoring system, consisting of 6 components and 0 aspects related to NCDs	0-60
BDIC-94	BDI with continue scoring system, consisting of 9 components and 4 aspects related to NCDs	0-100
BDIC-104	BDI with continue scoring system, consisting of 10 components and 4 aspects related to NCDs	0-100

Table 2: Correlation coefficients between BDIs to NQ

	NQ	BDI3 -50	BDI3 -60	BDI3 -94	BDI3 -104	BDI4 -50	BDI4 -60	BDI4 -94	BDI4 -104	BDIC -50	BDIC -60	BDIC -94	BDIC -104
NQ	1												
BDI3-50	0.52*	1											
BDI3-60	0.58*	0.89	1										
BDI3-94	0.27*	0.71*	0.67*	1									
BDI3-104	0.35*	0.69*	0.76*	0.93*	1								
BDI4-50	0.47*	0.86*	0.78*	0.64*	0.63*	1							
BDI4-60	0.53*	0.79*	0.91*	0.56*	0.71*	0.88*	1						
BDI4-94	0.20*	0.55*	0.48*	0.90*	0.84*	0.68*	0.57*	1					
BDI4-104	0.29*	0.58*	0.66*	0.85*	0.92*	0.68*	0.74*	0.93*	1				
BDIC-50	0.54*	0.88*	0.83*	0.65*	0.66*	0.94*	0.87*	0.63*	0.66*	1			
BDIC-60	0.60*	0.78*	0.90*	0.54*	0.69*	0.81*	0.94*	0.52*	0.69*	0.87*	1		
BDIC-94	0.33*	0.65*	0.59*	0.84*	0.81*	0.71*	0.63*	0.86*	0.83*	0.75*	0.62*	1	
BDIC-104	0.42*	0.63*	0.72*	0.77*	0.85*	0.68*	0.76*	0.78*	0.87*	0.72*	0.80*	0.91*	1

*Significant correlation at the 0.01 level

Table 3: Assessment criteria of BDIC-60 for children aged 4-6 years

Component	Score 0	Score 10	Equals
Carbohydrate foods*	0 or ≥ 10 servings	4-6 servings	a. Serv < 4; Score = 10/4 x servings b. Serv < 6; Score = 10 c. Serv ≥ 6; Score = -10/4 x servings + 25 d. Serv ≥ 10; Score = 0
Vegetables*	0 servings	≥ 2 servings	a. Serv < 2 ; Score = 5 x servings b. Serv ≥ 2; Score = 10
Fruits*	0 servings	≥ 3 servings	a. Serv < 3; Score = 10/3 x servings b. Serv ≥ 3; Score = 10
Animal proteins (non milks)*	0 servings	≥ 2 servings	a. Serv < 2; Score = 5 x servings b. Serv ≥ 2; Score = 10
Plant proteins*	0 servings	≥ 2 servings	a. Serv < 2; Score = 5 x servings b. Serv ≥ 2; Score = 10
Milks*	0 servings	≥ 1 servings	a. Serv < 1; Score = 10 x servings b. Serv ≥ 1; Score = 10

Table 4: Assessment criteria of BDI3-60 for children aged 4-6 years

Component	Score 0	Score 5	Score 10
Carbohydrate foods*	< 2 or ≥ 8 servings	≥ 2 - 4 or ≥ 6 - 8 servings	≥ 4-6 servings
Vegetables*	<1 servings	≥1-2 servings	≥ 2 servings
Fruits	<1½ servings	≥ 1½-3 servings	≥ 3 servings
Animal proteins (non milks)*	< 1 servings	≥1-2 servings	≥ 2 servings
Plant proteins*	< 1 servings	≥1-2 servings	≥ 2 servings
Milks*	<½ servings	≥½-1 servings	≥ 1 servings

(BDIC-60) is similar to BDI based on six food groups with three levels of scoring system (BDI3-60). Correlation coefficient BDIC-60 and BDI3-60 to the NQ were 0.60 and 0.58 respectively.

These correlation coefficients were higher compared to similar indices developed by previous studies. Taechangam *et al.* (2008) developed the Thailand Healthy Eating Index (THEI). THEI scores had a significant positive correlation with the nutritional quality of the diet with correlation coefficients 0.3-0.5 ($p < 0.01$). Amrin *et al.* (2013) developed balanced diet index (BDI) for Indonesian adult male in Indonesia, which also had a significant positive correlation with the nutritional quality of the diet with correlation coefficient 0.6 ($p<0.01$). Perdana *et al.* (2014) developed BDI alternative for Indonesian adult women, and that BDI had a

Tabel 5: Assessment criteria of BDIC-104 for children aged 4-6 years

Components	Score 0	Score 10	Equals
Carbohydrate foods*	0 atau ≥ 10 servings	4-6 servings	a. Serv < 4; Score = 10/4 x servings b. Serv <6; Score = 10 c. Serv ≥ 6; Score = -10/4 x servings + 25 d. Serv ≥ 10; Score = 0
Vegetables*	0 servings	≥ 2 servings	a. Serv < 2; Score = 5 x servings b. Serv ≥ 2; Score = 10
Fruits*	0 servings	≥ 3 servings	a. Serv < 3; Score = 10/3 x servings b. Serv ≥ 3; Score = 10
Animal proteins* (non milks)	0 servings	≥ 2 servings	a. Serv < 2; Score = 5 x servings b. Serv ≥ 2; Score = 10
Plant proteins*	0 servings	≥ 2 servings	a. Serv < 2; Score = 5 x servings b. Serv = 2; Score = 10
Milks*	0 servings	≥ 1 servings	a. Serv < 1; Score = 10 x servings b. Serv ≥ 1; Score = 10
Total fat	<15 or > 45 %-e	30%-e	a. T.fat < 15 or > 45%; Skor = 0 b. T.fat 15-30%; Score = 2/3 x (%e) - 10 c. T.fat 30-45%; Score = -2/3 x (%e)+ 30
Saturated fat	> 15%-e	≤ 8 %-e	a. Sat.fat ≤ 8%; Score = 10 b. Sat.fat > 8%; Score = -10/7 x(%e) + 150/7 c. Sat.fat > 15%; Score = 0
Added sugar	> 10%-e	≤ 6 %-e	a. Sugar ≤ 6%; Score = 10 b. Sugar > 6%; Score = - 10/4 x (%e) + 25 c. Sugar > 10%; Score = 0
Sodium	< 600 mg or > 1800 mg	1200mg	a. Sod < 600 atau > 1800 ; Score = 0 b. Sod 600-1200 ; Score= 1/60 x (mg) - 10 c. Sod 1200-1800; Score = -1/60 x (mg) + 30

*1 serving of carbohydrate foods equivalent with 100 g (¾ cup) of rice, 1 serving of vegetables equivalent with 100g (1 cup) of spinach, 1 serving of fruits equivalent with 50g (1 piece) of banana or papaya, 1 serving of animal proteins equivalent with 50g (1/3 head) of fresh fish, 1 serving plant proteins equivalent with 50g (2 slices medium) of tempeh, 1 servings of milk equivalent with 20g of milk powder.

Table 6: Participation and quantity of food consumption of subjects

Food groups	Carbohydrate foods	Vegetables	Fruits	Animal proteins	Milks	Plant proteins
Participation rate (%)	99.9	55.9	13.4	84.3	25.8	33.3
Intake (g)	429±192	54±76	12±43	90±72	11±23	22±44

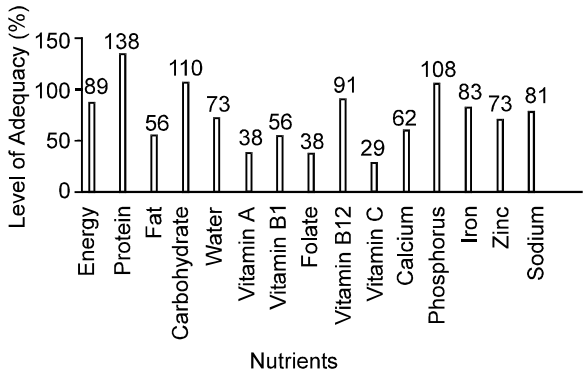

Fig. 1: Level of nutrients adequacy of subjects

significant positive correlation with the nutritional quality of the diet with correlation coefficient 0.2-0.7 (p <0.01). When compared to other type of balanced diet indices, the BDIs developed in the present study were similarly valid. Prasetyo *et al.* (2013) analyzed the correlation between Desirable Dietary Pattern Score (DDS) and nutritional quality of the diet of children aged 2-6 years in Indonesia. The DDS had a significant positive correlation with the nutritional quality of the diet (r = 0.60, p<0.05). Pertiwi *et al.* (2014) analyzed the correlation between DDS and nutritional quality of the diet of children aged 7-12 years in Indonesia. The DDS had a significant positive correlation with the nutritional quality of the diet (r = 0.59, p <0.05). However, the DDS is not practical since it required to calculate energy intake and adequacy prior to calculating the score. Similarly, THEI developed by Taechangam *et al.* (2008) used a continuous scoring system which is needed a complex computation.

Based on the above evidence, all of the DDS, BDIC-60, and BDI3-60 could validly use to describe the nutritional quality of children's diet. However, BDI3-60 was a simplest index to be applied because it is using a discrete scoring system. The balanced diet index which developed for Indonesian male and female adults also used three levels of a discrete scoring system (Amrin *et al.* 2013; Perdana *et al.* 2014). That index was simpler than DDS to assess the nutritional quality of the diet of Indonesian children, male and female.

The present study showed that the validity of BDI based on ten food groups with a continue scoring system

(BDIC-104) was the most complete index to assess the nutritional quality of the diet of subjects. BDIC-104 included four aspects (total fat, saturated fat, sodium, and added sugar) related to NCDs. The BDIC-104 was not simply and less validity (r = 0.42), but it was a useful index to assess diet quality in study related to diet and NCDs.

In conclusion, there were 12 BDIs had been developed in the present study. BDIC-60 was the most valid index for assessing the nutritional quality of the diet of Indonesian children aged 4-6 years; and BDI3-60 was the simplest and valid index. The BDIC-104 was the most complete index for assessing both nutritional quality of the diet and the quality of food intake in relation to the prevention NCDs.

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