ASSOCIATION BETWEEN ENERGY AND MACRONUTRIENTS INTAKE WITH ANTHROPOMETRIC INDICATORS IN CHILDREN

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ABSTRACT

Antropometric indicator is the most widely used measurement of children's nutritional status. The three main indicators that use to deûne undernutrition are underweight, stunting, and wasting, will represent different histories of nutritional insult to children. Adequate nutrition is a prerequisite to good health and one important determinant of growth and development. The objective of this study was to investigate possible association between energy and macronutrients intake with anthropometric indicators. A cross-sectional study held at Jempiring Pediatric Wards Sanglah Hospital Denpasar from October until December 2013. Chi square and logistic regression test were used for detecting associations between energy and macronutrients intake with anthropometric indicators. A P-value less than 0.05 was considered statistical significant. A total of 152 children were analyzed. Underweight was associated with inadequate intake of total energy, carbohydrate, and protein with PR 5.47 (95% CI 1.20 to 24.96), 4.29 (95% CI 1.03 to 117.86), 3.40 (95% CI 1.04 to 11.13), respectively. Stunting was associated with inadequate intake of total energy and protein with PR 4.76 (95% CI 1.56 to 14.57) and 13.41 (95% CI 4.42 to 40.68), respectively. Wasting was associated only with inadequate intake of total energy with PR 4.14 (95% CI 1.74 to 9.83). It can be concluded that underweight, stunting, and wasting showed association with inadequate energy and macronutrients intake. **[MEDICINA 2014;45:3-8]**

Keywords**:** *energy, macronutrient, underweight, stunting, wasting, children*

HUBUNGAN ANTARA ASUPAN ENERGI DAN MAKRONUTRIEN DENGAN INDIKATOR ANTROPOMETRIK PADA ANAK

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ABSTRAK

Indikator antropometrik merupakan penilaian status nutrisi yang paling sering digunakan pada anak. Tiga indikator yang digunakan untuk menentukan adanya kekurangan nutrisi adalah *underweight*, *stunting*, dan *wasting*, yang akan menunjukkan perbedaan durasi waktu. Nutrisi yang adekuat diperlukan untuk mencapai kesehatan yang baik dan merupakan salah satu faktor pertumbuhan dan perkembangan yang penting. Tujuan penelitian ini adalah untuk mencari hubungan antara asupan energi dan makronutrien dengan indikator antropometrik. Penelitian potong lintang dilakukan di ruang rawat anak Jempiring RSUP Sanglah dari bulan Oktober sampai Desember 2013. Analisis Kai-kuadrat dan regresi logistik digunakan untuk mencari hubungan antara asupan energi dan makronutrien dengan indikator antropometrik. Nilai P kurang dari 0,05 dianggap bermakna. Sebanyak 152 anak dianalisis. *Underweight* berhubungan dengan ketidakdekuatan asupan energi, karbohidrat, dan protein dengan RP masing-masing 5,47 (IK 95% 1,20 sampai 24,96), 4,29 (IK 95% 1,03 sampai 117,86), 3,40 (IK 95% CI 1,04 sampai 11,13). *Stunting* berhubungan dengan ketidakadekuatan asupan energi dan protein dengan RP 4,76 (IK 95% 1,56 sampai 14,57) dan 13,41 (IK 95% 4,42 sampai 40,68). *Wasting* berhubungan hanya dengan ketidakadekuatan asupan energi total dengan RP 4,14 (IK 95% 1,74 sampai 9,83). Dapat disimpulkan bahwa *underweight*, *stunting*, dan *wasting* menunjukkan hubungan dengan ketidakadekuatan asupan energi dan makronutrien. **[MEDICINA 2014;45:3-8]**

Kata kunci: *energi, makronutrien, underweight, stunting, wasting, anak*

INTRODUCTION

Malnutrition in under-five children is one of the most serious health problem in developing countries. The term malnutrition includes both, undernutrition and overnutrition, but normally malnutrition is synonymous with undernutrition.[1] It is defined as failure to consume adequate energy, protein, and micronutrients to meet basic body requirements for maintenance, growth and development.[2] Malnutrition is one of the most important underlying causes of child mortality in developing countries, particularly during the ûrst 5 years of life.[3,4] It has been estimated that 6.3 million or 54% of young child mortality were associated with malnutrition.[5]

The three main indicators that use to deûne undernutrition, are underweight, stunting, and wasting, will represent different histories of nutritional insult to children.[4,6] Nutritional management among many environmental factors is the most crucial factor because it plays a key role in maintaining and synthesizing body tissues during the growth period.[7] Adequate nutrition is a prerequisite to good health and one important determinant of growth and development.[3] Among the food groups, protein and fat play an important role not only in providing required energy, but also in the normally growth process.[8] Several studies indicate that protein or calorie deficient diet may results in underweight, wasting and lowered resistance to infection, stunted growth and impaired cognitive development and learning.[9,10] However, study by Pourhaeshemi et al shows that there is no significant association between macronutrients intake and anthropometric indices.[7] The objective of this study was to investigate possible association between energy and macronutrients intake with anthropometric indicators.

MATERIALS AND METHODS

This study was a cross-sectional study, held at Nutrition and Metabolic Disease Division, Department of Child Health, Udayana University Medical School, Sanglah Hospital, Denpasar. This study was performed at Jempiring Pediatric Ward Sanglah Hospital from October until December 2013. Eligible patients were chosen by consecutive sampling method. The inclusion criteria were children 6 months until 12 years old and admitted to Jempiring Pediatric Ward Sanglah Hospital from October to December 2013. The exclusion criteria were patients with chronic disease, history of low birth weight, or incomplete medical record. Sample size was counted by 2-tailed 2 proportion hypothesis with a 0.05, power 80%, and effect size 10%. Based on previous study by Poushashemi, et al[7] the proportion of malnutrition in children with normal energy and macronutrients intake is 5.4%, this will lead to minimum estimated sample size obtained was 145 subjects. This study was performed after obtaining permission from Ethic Committee of Medical School, Sanglah Hospital, Denpasar.

Age was determined by the time since birth until the time of admission (months). Sex was determined based on phenotype appearance and divided to male and female. Chronic disease was defined as infection, inflammation, or neoplastic disease that persists more than 2 months, such as human immunodeficiency virus infection, chronic renal disease, chronic liver disease, congenital heart disease, diabetes mellitus, neoplasm, etc which was diagnosed by doctor and collected from medical record. Low birth weight was defined as birth weight below 2500 grams. Exclusive breastfeeding as defined by the World Health Organisation (WHO) implied that the infant received only breast milk and no other liquids or solids, except for drops or syrups consisting of vitamins, mineral supplements, or medicines. Introduction complementary feeding was defined as the age at which all solid food and liquid foods other than breast milk or infant formula and follow-on formula first introduced, divided into three groups, less than 4 months, 4-6 months, and equal or more than 6 months.

Data that met the inclusion criteria of the medical record were written in the research form. Data included age, sex, exclusive breastfeeding, initiation of complementary feeding, birth weight, diagnosis, body weight, body length/height, 24-hour-dietary recall, and anthropometry indices (weight for age, length/height for age, weight for length/height, and body mass index for age if necessary). Data would not be included if the exclusion criteria existed.

Weight was measured with baby weight scale for children under 2 years old and with standing scale for children above 2 years old. Children were weighed with light underclothes or naked and without a diaper for infants (kilograms). Length was measured by horizontal wooden stadiometer for children under 2 years old, in recumbent position (centimeters). Height was measured with plastic mistar that put on the wall for children above 2 years old that stood up close to the wall and didn't use any shoes (centimeters).

Subsequently, information on the weight, height, and age of 6 to 59 month old children were entered into the WHO Anthro software (version 3.1.0). Similar information pertaining to above 60 month olds were fed into the WHO AnthroPlus software (version 1.0.3). These software determined the participants' weight for age z-scores (WAZ), length/height for age z-scores (HAZ), and weight for length/height z-scores (WHZ) or BMI for age z-score since the data of WHZ was not defined in the WHO AnthroPlus software. These data represented the prevalence of underweight, stunting, and wasting status, respectively. Weight for age z-scores below -2 was categorized as underweight, HAZ below -2 was categorized as stunting, and WHZ below -2 was categorized as wasting.

The 24-hour-dietary recall data were obtained from asking the parent or caregiver by nutritionist about the type and quantity of all foods and beverages consumed by the children during the previous 24 hours when healthy state. The dietary recalls were then reviewed by *daftar komposisi bahan makanan* (DKBM) to derive the mean energy (kcal/day) and macronutrients intake (included

carbohydrate, protein, and fat (gram/day)) and compared with *angka kecukupan gizi* (AKG) by age groups and sex. Two broad categories for energy and each macronutrient were defined in comparison to AKG. According to this, children who consumed equal or more than 80% AKG were defined having adequate intake and children who consumed less than 80% AKG were defined having inadequate intake.

Chi square test was used for detecting associations between energy and macronutrients intake and the anthropometric indicators (underweight, stunting, and wasting). Multivariate analysis was performed with logistic regression test. A P-value less than 0.05 was considered statistically significant. The statistical analyzes were performed using software computer program.

Table 1. Subject characteristics

Variables	N (152)	Percentage (%)
Sex, male	85	55.9
Age		
>6-59 months	86	56.6
≥60 months	66	43.4
Exclussive breastfeeding 6 months	35	23
Introduction complementary feeding		
<4 months	12	7.9
4-6 months	113	74.3
>6 months	27	17.8
Inadequate energy intake	44	28.9
Inadequate carbohydrate intake	41	27
Inadequate protein intake	32	21.1
Inadequate fat intake	106	69.7
WAZ <-2SD	24	15.8
HAZ <-2SD	26	17.1
WHZ <-2SD	27	17.8

RESULTS

A total of 164 children were studied from October to December 2013. Twelve (7.3%) children were excluded from the analysis due to chronic disease (8), low birth weight (2), and both (2). The remaining 152 children, 85 (55.9%) were males and 67 (44.1%) were females, giving a male: female ratio of 1.27: 1. The subject of this study consisted of 86 (56.6%) children aged 6 months until 59 months and 66 (43.4%) children equal or more than 60 months. Exclusive breastfeeding was given only to 35 (23%) children. Complementary feeding was introduced by mother earlier than 4 months (12 (7.9%)), at 4 to 6 months of age (113 (74.3%)), and above 6 months of age (27 (17.8%)). The total energy and macronutrients intake were reviewed by DKBM and compared to AKG for each age group and sex of children. We found inadequate intake of energy, carbohydrate, protein, and fat were 44 (28.9%), 41 (27%), 32 (21.1%), and 106 (69.7%), respectively. The prevalence of underweight, stunting, and wasting were 24 (15.8%), 26 (17.1%), and 27 (17.8%), respectively (**Table 1**).

Bivariate analysis using Chi-square test of energy or each macronutrients intake with the anthropometric indicators shown in **Table 2**. Underweight associated with inadequate intake of total energy, carbohydrate, and protein with PR 21.67 (95% CI 6.78 to 69.23), 18.31 (95% CI 6.17 to 54.29), 10.88 (95% CI 4.12 to 28.75), respectively. Stunting associated with inadequate intake of total energy, carbohydrate, and protein with PR 10.97 (95% CI 4.15 to 28.95), 8.03 (95% CI 3.19 to 20.19), and 23.59 (95% CI 8.34 to 66.71), respectively. Wasting associated only with inadequate intake of total energy with PR 4.14 (95% CI 1.74 to 9.83).

From multivariate analysis (**Table 3**), underweight associated with inadequate intake of total energy, carbohydrate, and protein

Table 2. Association between energy and macronutrients intake with underweight, stunting, and wasting

Variables	Underweight		Stunting		Wasting	
	P	PR (95% CI)	P	PR (95% CI)	P	PR (95% CI)
Inadequate energy	<0.001	21.67 (6.78 to 69.23)	<0.001	10.97 (4.15 to 28.95)	0.001	4.14 (1.74 to 9.83)
Inadequate carbohydrate	<0.001	18.31 (6.17 to 54.29)	<0.001	8.03 (3.19 to 20.19)	0.076	2.18 (0.91 to 5.20)
Inadequate protein	<0.001	10.88 (4.12 to 28.75)	<0.001	23.59 (8.34 to 66.71)	0.228	1.77 (0.69 to 4.52)
Inadequate fat	0.541	1.36 (0.50 to 3.69)	0.381	1.55 (0.58 to 4.16)	0.143	2.15 (0.76 to 6.08)

Table 3. Multivariate analysis risk factors of underweight, stunting, and wasting

Variables	Underweight		Stunting		Wasting	
	P	Adjusted PR PR(95% CI)	P	Adjusted PR (95% CI)	P	Adjusted PR PR(95% CI)
Inadequate energy	0.028	5.47 (1.20 to 24.96)	0.006	4.76 (1.56 to 14.57)	0.001	4.14 (1.74 to 9.83)
Inadequate carbohydrate	0.046	4.29 (1.03 to 117.86)	0.675	1.40 (0.29 to 6.77)	0.636	0.75 (0.22 to 2.49)
Inadequate protein	0.043	3.40 (1.04 to 11.13)	<0.001	13.41 (4.42 to 40.68)	0.807	0.87 (0.28 to 2.66)
Inadequate fat	0.462	0.60 (0.15 to 2.35)	0.512	0.64 (0.17 to 2.42)	0.380	1.62 (0.55 to 4.79)

with PR 5.47 (95% CI 1.20 to 24.96), 4.29 (95% CI 1.03 to 117.86), 3.40 (95% CI 1.04 to 11.13), respectively. Stunting associated with inadequate intake of total energy and protein with PR 4.76 (95% CI 1.56 to 14.57) and 13.41 (95% CI 4.42 to 40.68), respectively. Wasting associated only with inadequate intake of total energy with PR 4.14 (95% CI 1.74 to 9.83). Underweight, stunting, or wasting didn't associate with intake of fat.

DISCUSSION

Status of growth is the best indicator for health and nutritional status of children. Nutritional status can be assessed using clinical signs of malnutrition, biochemical, and anthropometric indicator. Anthropometric indicator thus has an important advantage over others, whereas biochemical and clinical indicators are useful only at the extremes condition of malnutrition, body measurement is sensitive over the full spectrum.[9] In Indonesia, World Health Statistics (2012) has reported the prevalence of stunting and underweight among children under 5 years between 2005-2011 are 40.1 percent and 19.6 percent.[6] In this study, we found prevalence of underweight, stunting, and wasting were 24 (15.8%), 26 (17.1%) and 27 (17.8%) respectively.

Malnutrition is usually the result of a combination of inadequate dietary intake and infection. Malnourished children are shorter and lighter in weight than they should be for their age.[11] Adequate nutrition is a prerequisite to good health and one important determinant of growth and development.[3] The RDA represents the establishment of a nutritional norm for planning and assessing dietary intake and are the levels of intake of essential nutrients considered to be adequate to meet the known needs of practically all healthy people. Indonesia used AKG term as a modification of RDA (Recommended Dietary Allowance).[7] Based on AKG, we found children with inadequate intake of energy, carbohydrate, protein, and fat were 44 (28.9%), 41 (27%), 32 (21.1%), and 106 (69.7%), respectively.

Dietary surveys are therefore one of the essential components of nutritional assessment. Assessing dietary adequacy in terms of quality and quantity is equally important. Children who took adequate energy had lower risk of being underweight than those who took inadequate energy.[12] In most situations, interpretation of association between energy (food) intake and linear growth is confounded by the fact that when food intake is low, the intake of many other nutrients will also be inadequate.[13] This low energy intake of the children reflects reduction of body weight and body fat.[14] Nutritional inadequacy also compromises immunological function and therefore increases susceptibility to disease and associated growth retardation.[15] Both bivariate and multivariate analysis in this study indicated all three indicators of malnutrition (underweight, stunting, and wasting) associated with inadequate energy intake.

Underweight is common and defined as low weight-for-age.[10,11] It is an important presentation of protein energy malnutrition, which is missed a lot of times.[16] It reflects both previous growth (chronic) and present (acute) nutritional conditions. Hence the high rate of underweight reflects the presence of both long term chronic malnutrition and recent food insecurity or illness. Underweight among pre-school children can reflect prenatal under nutrition, infection, and possibly inadequate attention by care givers. This can imply that these children are disadvantaged in terms of care and may have inadequate intake of energy nutrients in the past.[10,11] When a diet is insufficient in protein and/or energy there will be a slowing down of linear height and failure to gain weight or weight loss.[16]

In our study, we found similarity, underweight associated with inadequate intake of carbohydrate and protein. Carbohydrate is the main energy

source of the human diet that provides energy and can thus contributes to weight gain.[17] Protein is an organic compound which contains amino acid chains that involves in almost every biological process of human body. Adequate intake of protein is needed to maintain growth, development, and body biological process.[18] Decreased consumption of protein in the growing years may contribute to the decreased growth in height and weight.[13]

Stunting is defined as a low height-for-age for children and usually associated with long term chronic malnutrition and long term factors, such as frequent infection and poor feeding practices. Children stunted at school age are likely to have been exposed to poor nutrition since early childhood.[10,11] Our study found that stunting was not only associated with inadequate intake of energy, but inadequate intake of protein also took place. Protein is one of type II nutrients. The type II nutrients are the growth nutrients. They are the building blocks of tissue and are necessary for nearly all biochemical pathways. With deficient intake of any one of these nutrients the child will not grow. With a mild and chronic deficiency this leads to stunting.[19]

The nutrients required specifically for skeletal growth are those that are in high concentration in cartilage and bone. Cartilage is mainly composed of glycoseaminoglycans such as chondroitin sulphate. Most of the sulphate in the body is derived from catabolism of the amino acids methionine and cystine. Thus, there either needs to be adequate protein, relatively rich in sulphur amino acids in the diet, to permit height gain.[20]

In other hand, low protein intake is usually accompanied not only by low energy intake but also by inadequate amounts of important micronutrients that are contained in dietary protein sources. These include iron, zinc, copper, calcium, and vitamin A.[13] Nutrition plays a key role in the control of linear growth through a variety of mechanisms. Insulin-like growth factor I (IGF-I) receptors are found predominantly in proliferating bone chondrocytes, and IGF-I itself stimulates synthesis of collagen and proteoglycans. These physiological functions explain the role of IGF-I in linear growth. IGF-I is reduced during acute protein deûciency (kwashiorkor) and protein energy malnutrition in children. Some micronutrients also affect the IGF-I system.[21]

Wasting is defined as low weight-for-height for children. It is a measure of current or acute undernutrition, usually as a consequence of insufficient food intake or a high incidence of infectious diseases, especially diarrhoea. Wasting of children primarily reflects severe short term deprivation of food in his/her immediate nutritional history, for example during episodes of disease such as diarrhea or in times of food shortage. Wasting in turn impairs the functioning of the immune system and can lead to increased severity and duration of and susceptibility to infectious diseases and an increased risk for death.[10,11] Consistent with the explanation, our study found that wasting showed an association only with inadequate intake of total energy. While it didn't associate with each component of macronutrients. In an acute protein deficiency condition there would be clinical symptoms as kwasiorkhor that may not changed WHZ due to oedem.

In this study, it was shown that fat didn't associated with anthropometric indicators. One of the possible reason was high prevalence of inadequate fat intake in our study, 69.7%. Another explanation are, as theory, fatty acids are less efficiently used for energy production than carbohydrates, and are preferentially stored in the adipose tissue. In addition, oxidation of long chain fatty acids initially takes place in peroxisomes and is also not very efficient. For individuals eating high fat diets with excess calorie intake, much of the dietary fatty acids are readily stored in the adipose tissue.[22]

Limitations of this study included: (1) the use of the cross sectional design which limits the determination of the direction of cause and effect relationship between the studied variables, another study design is recommended, (2) calculations of nutrient intake from 24-hour dietary recall supplied by parent or caregiver could be less accurate than using weight records of foods consumed (3) in this study, several factors that affected result were not analysis, in example age, sex, history of breastfeeding, prevalence of previous illness, comorbid condition like anemic, genetic factor like parental height and weight.

CONCLUSIONS

This study confirmed that underweight, stunting, and wasting showed association with inadequate energy and macronutrients intake. Underweight was associated with inadequate intake of energy, carbohydrate, and protein. Stunting was associated with inadequate intake of energy and protein. Wasting was associated only with inadequate intake of energy. There was no association between fat intake and anthropometric indicators.

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