INFANT FEEDING AND NUTRITIONAL STATUS OF PRE-SCHOOL AGE CHILDREN

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Abstract. Malnutrition in the midst of overnutrition occurs as a current worldwide phenomenon. Proper nutrition in the early stages of life is essential for appropriate nutritional status later in life. The study retrospectively collected data on infant nutrition and pre-school (three to four years of age) growth and eating pattern to explore how infant nutrition affected nutritional status of Thai children. The subjects were divided into 2 groups according to their feeding practice - the breastfeeding group (BF), n = 30, and the non-breastfeeding group (NBF), n = 132. Prevalence of underweight, stunting, wasting, and overweight/obesity of BF infants at pre-school age was 0, 0, 6.7, and 0%, respectively, while that of NBF infants was 3.8, 3.0, 4.5, and 4.5%, respectively. Compared to BF infants, NBF group had a significantly higher pre-school weight-for-age Z score, weight-for-height Z-score and body mass index (p-value = 0.002, 0.006 and 0.005, respectively), but prevalence of under- and over-nutrition were not significantly different between the two groups, and, in addition, BF infants consumed less sweetened drinks (p-value = 0.016). A longer duration of breastfeeding and subsequent inclusion of complementary feeding correlated with favorable pre-school eating habits, such as less consumption of non-nutritious snacks and sweetened drinks, and more fruit and cereal consumption. In conclusion, breastfeeding and appropriate complementary feeding were among the most important factors promoting healthy pre-school nutritional status and appropriate eating habits.

Keywords: breastfeeding, complementary feeding, infant feeding, infant nutrition, pre-school nutritional status

INTRODUCTION

Overnutrition causes overweight and obesity, the prevalence of which in childhood has been increasing dramatically worldwide. In 2016, 41 million children under five years of age worldwide were overweight or obese compared with 30 million in 2000; during this 16-year period prevalence of overweight or obesity in Asian children increased by 40% (WHO, 2017). Thailand is one of the countries facing this problem of overnutrition while it still has prevalent undernutrition; according to Thailand's multiple indicator cluster survey (THMICS) 2015-2016 final report, prevalence of overweight, moderate-to-severe underweight, moderate-to-severe stunting, and moderate-to-severe wasting in Thai children under five years of age

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was 8.2, 6.7, 10.5, and 5.4%, respectively (NSO and UNICEF, 2016). A double burden of undernutrition (underweight, stunting or wasting) together with overnutrition (overweight or obesity) occurs at population, household and even individual levels. At the individual level, obese children, although having excess energy intake are known to have micronutrient deficiencies, scurvy, and thiamin deficiency and iron deficiency anemia (Densupsoontorn *et al*, 2013; Densupsoontorn *et al*, 2019).

Nutrition during early life, from conception to late infancy or toddlerhood, is associated with later nutritional status. Undernutrition early in life may predispose to overweight and related diseases later in life (WHO, 2019a), while rapid weight gain in infancy is associated with overweight or obesity in childhood (Wang *et al*, 2016). These findings highlight the importance of appropriate growth and nutrition during infancy in maintaining normal nutritional status later in life. Breastfeeding is among the best measures to prevent childhood obesity (Plagemann and Harder, 2005) and there exists a strong dose-dependent association between longer duration of breastfeeding and decrease in risk of overweight in later childhood (Harder *et al*, 2005). Another crucial feeding practice is appropriate complementary feeding, which leads to appropriate feeding habit and reduces risk of poor nutrition, either undernutrition or overnutrition (Grote *et al*, 2018). Quantity, quality and timing of the introduction of complementary food impact growth and nutritional status; intake of solids before four months of age increases risk of overweight and obesity, especially in formula-fed infants (Grote *et al*, 2018). Studies conducted in Europe showed high protein intake during infancy have increased obesity risk, but this relationship is not consistently observed (Hörnell *et al*, 2013). No specific type of food during the complementary feeding period is linked to childhood obesity (Grote and Theurich, 2014). Non-responsive parental feeding practices (for example, using overly restrictive, controlling, rewarding, or pressure feeding) and unhealthy child eating behaviors appear to be associated with childhood obesity risk in Southeast Asia but the findings are not conclusive (Lindsay *et al*, 2017).

In order to determine whether and how infant nutrition and feeding practices affect nutritional status of Thai children at pre-school age (three to four years old), a retrospective evaluation was conducted on infant nutrition (especially breastfeeding and complementary feeding) and pre-school growth and eating patterns. The findings should be useful in the development of preventive measures of malnutrition in children in Thailand.

MATERIALS AND METHODS

Study site and recruitment of subjects

With permission of the Director of Phramongkutklao Hospital, Bangkok, Thailand, the electronic medical records (EMR) was screened for records of children visiting the outpatient clinic (OPD) of the Department of Pediatrics, from 1 June 2018 to 21 September 2019 to identify potential subjects. Inclusion criteria were (i) children 36-48 months of age on day of visit, (ii) born full-term (37-42 weeks of gestational age) and (iii) birthweight of 2.5-4.0 kg. Exclusion criteria were (i) having been hospitalized longer than seven days in the first month following birth, (ii) having disease or condition affecting growth (*eg* congenital heart disease, chronic lung disease,

chronic kidney failure, chronic diarrhea, and genetic syndrome), (iii) having acute moderate to severe disease interfering with anthropometric measurements on day of visit, and (iv) having no contact information of the child's parent.

The study protocol was approved by the Royal Thai Army Medical Department Institutional Review Board (no. R072q/61) and conducted in accordance with the Helsinki Declaration. Prior written consent was obtained from parents or legal guardian of each participating child.

Study design

Upon receiving parent's consent, a questionnaire was sent and an interview arranged, both of which were to ascertain the child's type of feeding (mother's milk, formula and complementary feeding), feeding patterns, history of illness from one year of age, and current weight and height; health and socioeconomic data of the family were also recorded. Anthropometric measurements on the day of visit retrieved from EMR represented pre-school growth of the subject.

Infant feeding is defined as feeding in the first year of life. Subjects were allocated into the breastfeeding (BF) group (subjects who were breastfed until at least 6 months of age and formula feeding if introduced after four months of age but limited to <50% of daily milk intake) and non-breastfeeding (NBF) group (subjects who did not fulfill the criteria of the BF group). Complementary feeding is defined as feeding of food other than breast milk or formula milk. Growth data from the WHO child growth standards were used to determine growth and nutritional status of the subject (WHO, 2019b).

The sample size was calculated using G*power software, version 3.0.5 (provided by Franz Faul, University Kiel, Germany). Based on THMICS 2015-2016 data it was assumed 10% of Thai infants living in Bangkok in 2016 were exclusive breastfed up to at least 4 months of age (NSO and UNICEF, 2016) and median weight of 42-month-old Thai boys was 15.4 kg. In order to detect 10% of weight difference at 36-48 months of age with a p-value ≤0.05 and a power of 0.95, a sample size of 30 subjects in the BF group and 260 in the NBF group was required. Subjects were enrolled until the sample size was achieved or until the end of the enrollment period, 30 September 2019.

Statistical analysis

Statistical analysis was performed using SPSS for Windows version 16.0 (SPSS Inc, Chicago, IL). Descriptive data are presented as mean ± SD, median with 25th and 75th percentile values or percentage. Fisher's exact test was used to compare categorical parameters and either Student's t-test or median to compare numerical parameters as appropriate. Correlation was tested using either Pearson's correlation or Spearman's rho test as appropriate. A p-value < 0.05 is considered significant.

RESULTS

One hundred and sixty-two children (80 boys and 82 girls) attending the outpatient clinic, Department of Pediatrics Phramongkutklao Hospital, Bangkok, Thailand were enrolled according to the criteria described above and allocated to either in BF group (n = 30) or in the NBF group (n = 132). The number of children recruited in NBF group was only 50% of that required due to time limit. Children in the BF compared to NBF group had significantly lower birthweight, weight at day of visit to the out-patient clinic, weight-for-age Z score (WAZ), weight-for-height

Z score (WHZ), and BMI (Table 1). There were no statistical differences in prevalence of underweight, stunting, wasting, and overweight/obesity between the two groups. Body mass index of parents, father's education and family income were not different between BF and NBF children group, but mothers in former group had significant higher level of education.

Majority of children (59%) were breastfed for <4 months, and 68% had their first formula feeding before 4 months

Table 1
Demographic profile of pre-school children attending outpatient clinic, Department of Pediatrics, Phramongkutklao Hospital, Bangkok, Thailand (1 June 2018 to 21 September 2019).

Characteristics	Breastfed group (n = 30)	Non-breastfed group (n = 132)	p-value*
Male, %	40	51	0.313[a]
Birthweight, kg (Mean ± SD)	2.9 ± 0.2	3.2 ± 0.3	<0.001[b]
Age on day of visit, months (Mean ± SD)	42 ± 3	41 ± 4	0.241[b]
Weight on day of visit, kg (Mean ± SD)	14 ± 1	15 ± 2	0.003[b]
Height on day of visit, cm (Mean ± SD)	98 ± 2	98 ± 4	0.838[b]
Pre-school weight-for-age Z-score[b] (Mean ± SD)	-0.52 ± 0.75	0.02 ± 1.09	0.002[b]
Weight-for-age Z-score -2 to +2, %	100	92	0.2103[b]
Prevalence of underweight, %	0	4	0.585[a]
Pre-school height-for-age Z-score (Mean ± SD)	-0.28 ± 0.70	-0.16 ± 0.91	0.512[b]
Height-for-age Z-score -2 to +2, %	100	96	0.585[a]
Prevalence of stunting, %	0	3	1.000[a]
Pre-school weight-for-height Z-score (Mean ± SD)	-0.52 ± 0.91	0.17 ± 1.27	0.006[b]
Weight-for-height Z-score -2 to +2, %	93	91	1.000[a]
Prevalence of wasting, %	7	4	0.648[a]
Prevalence of overweight/obesity[c], %	0	4	0.594[a]
Pre-school BMI, kg/m^2 (Mean ± SD)	15 ± 1	16 ± 2	0.005[d]
Father's BMI, kg/m^2 (Mean ± SD)	25 ± 2	25 ± 4	0.579[d]
Mother's BMI, kg/m^2 (Mean ± SD)	21.8 ± 2.1	22.2 ± 2.8	0.610[d]
Father's education (at least college level), %	93	83	0.171[a]
Mother's education (at least college level), %	100	85	0.026[a]
Monthly household income (>THB30,000 or approximately USD1,000), %	93	87	0.531[a]

*Statistical significance at p-value < 0.05; [a]Fisher's exact test; [b]Student's t-test; [c]Weight-for-height Z-score ≥2; [d]Median test; BMI: body mass index; SD: standard deviation; kg: kilogram; cm: centimeter; kg/m^2: kilogram per square meter.

of age. Complementary feeding was introduced at 6-7 months of age in 73% of the children and 86% received three meals of semisolid food at 8-9 months of age. Age (mean ± SD) at introduction of UHT milk was 23 ± 7 months (median = 24 months).

Among the pre-school parameters measured, namely, weight, height, WHZ, height-for-age Z score (HAZ), WHZ, and BMI, only birthweight was positively correlated with pre-school height and HAZ, and duration of breastfeeding negatively correlated with HAZ; otherwise these two factors together with age at introduction of complementary feeding and age at introduction of three meals daily of solid food were not correlated with the abovementioned parameters (Table 2).

Some 97% of children of pre-school age had three meals daily of solid food; 96% consumed high-iron food, 99% poultry or fish and 60% vegetables; 92% had no more than one serving daily of non-nutritious snacks; 38% did not drink any sweetened beverages; 66% ate one serving daily of fruits or cereals; 81% drank 2-4 servings of milk daily; 85% did not have any night-time feeding. BF and the NBF groups were comparable in terms of number of daily consumption of meals of solid food, high-iron food and vegetable intake, amounts of fruits and cereals and non-nutritious snacks consumed, daily number of milk servings, and number of night-time feeding, but BF group drank less sweetened drinks. In BF group 63% of children did not consume sweetened drinks at all compared to 33% in NBF group, while 17% of the latter had at least one serving of sweetened drink every day. When pre-school eating habits (daily number of solid meals, high-iron food intake, vegetables intake, amounts

Table 2

Association of birthweight and types of infant feeding with pre-school growth of children (n = 162) attending outpatient clinic, Department of Pediatrics, Phramongkutklao Hospital, Bangkok, Thailand (1 June 2018 to 21 September 2019).

Factor	Pre-school weight	Pre-school height	Pre-school weight-for-height Z-score	Pre-school height-for-age Z-score	Pre-school weight-for-height Z-score	Pre-school body mass index
Birthweight[a] (r, p-value)	0.149, 0.059	0.243, 0.002*	0.149, 0.059	0.234, 0.003*	0.049, 0.537	0.018, 0.818
Duration of breastfeeding[b] (r, p-value)	-0.079, 0.318	-0.069, 0.385	-0.132, 0.1093	-0.186, 0.018*	-0.071, 0.367	-0.070, 0.379
Age at introduction of complementary feeding[b] (r, p-value)	-0.123, 0.119	-0.096, 0.226	-0.095, 0.228	-0.011, 0.886	-0.109, 0.166	-0.103, 0.190
Age at introduction of three meals of semisolid food[b] (r, p-value)	0.071, 0.366	0.005, 0.951	0.077, 0.327	0.016, 0.838	0.113, 0.151	0.111, 0.159

[a]Pearson's correlation test; [b]Spearman's rho test; *Statistically significant at p-value < 0.05.

of fruits and cereals consumed, amount of non-nutritious snacks consumed, amount of sweetened drinks consumed, daily number of milk servings, and night-time feeding) were evaluated, the following were noted: (i) breastfeeding was correlated with less amount of sweetened drinks consumed, (ii) duration of breastfeeding negatively correlated with amounts of sweetened drinks and non-nutritious snacks consumed, and (iii) age at introduction of complementary feeding positively correlated with amounts of fruits and cereals consumed but negatively with amounts of sweetened drinks and non-nutritious snacks consumed, and daily number of milk servings (Table 3). Age at introduction of three meals daily of solid food was not correlated, positively or negatively, with any of the abovementioned pre-school eating habits.

Among the fathers, 85% had at least a college education and 88% of the mothers. Some 60% of the families reported monthly household income of THB30,000-50,000 per month and 28% reported having income >THB50,000. All mothers in BF group had at least college education compared to 85% in NBF group. There was no significant difference in fathers' education and household income between both groups (Table 1). The children barely had respiratory or gastrointestinal tract or other common infections during the previous year, with 96% reporting to have ≤1 episode of respiratory tract infection per year, 93% ≤1 episode of gastrointestinal tract infection per year, and none with urinary or skin infection.

DISCUSSION

The study shows relatively good pre-school nutritional status among the majority of the children with acceptable pre-school HAZ, WAZ and WHZ and prevalence <5% of underweight, stunting, wasting, and overweight/obesity compared to data from THMICS 2015-2016 that reported prevalence of underweight, stunting, wasting, and overweight in Thai children under 5 years of age ranging from 5.4 to 10.5% (NSO and UNICEF, 2016). This might be due to difference in age group (3 to 4 years in the present study compared with >1-5 years in THMICS survey), area of residence of subjects (children living in Bangkok metropolitan area versus country-wide), education of parents (at least college level versus all levels of education), and socio-economic status of families (more affluent versus general population). The inclusion and exclusion criteria of the present study might have led a selection bias as children with small or large birthweight, two established risks for both forms of childhood malnutrition, were not included (Kitsantas and Gaffney, 2010). The study cohort was also seemingly healthy from perinatal stage up to time of survey. Interestingly, both forms of malnutrition were equally prevalent in BF and NBF groups, although the former appeared to have lower prevalence of underweight, stunting, and overweight/obesity but higher prevalence of wasting. The lower than expected NBF sample size precluded more rigorous statistical analysis.

Although pre-school growth parameters, namely, weight, WAZ, WHZ, and BMI, were significantly different between BF and NBF groups, the parameters of both groups were within healthy ranges for pre-school age children (WHO, 2020), the differences might be related to certain factors during infancy. Lower birthweight has been long

Table 3

Association of infant feeding factors with pre-school eating habit of children (n = 162) attending outpatient clinic, Department of Pediatrics, Phramongkutklao Hospital, Bangkok, Thailand (1 June 2018 to 21 September 2019).

Infant feeding related factor	Eating habit of pre-school children							
	Daily number of solid meals	High-iron food intake	Vegetable intake	Amount of fruits and cereals consumed	Amount of non-nutritious snack consumed	Amount of sweetened drink consumed	Daily number of milk servings	Night-time feeding
Breastfeeding	0.633[a]	1.00[b]	0.4188[b]	0.256[a]	0.615[a]	0.016[a]*	0.095[a]	0.800[a]
Duration of breastfeeding	0.056, 0.479[c]	0.661[a]	0.021[a]	0.152, 0.053[c]	-0.274, 0.000[c]*	-0.300, <0.001[c]*	-0.127, 0.106[c]	-0.022, 0.780[c]
Age at introduction of complementary feeding	-0.046, 0.560[c]	0.545[a]	0.786[a]	0.182, 0.020[c]*	-0.188, 0.017[c]*	-0.218, 0.005[c]*	-0.178, 0.024[c]*	-0.112, 0.156[c]
Age at introduction of three meals of semisolid food	-0.141, 0.074[c]	0.844[a]	0.220[a]	0.139, 0.078[c]	-0.108, 0.172[c]	-0.102, 0.199[c]	-0.038, 0.629[c]	-0.046, 0.564[c]

[a]Median test presented as p-value; [b]Fischer's exact test presented as p-value; [c]Spearman's rho test presented in r, p-value; *Statistically significant at p-value < 0.05.

known to be a predictor of subsequent growth retardation (Binkin *et al*, 1988; Lourenco *et al*, 2012; Araújo de França *et al*, 2016). Among the study children birthweight demonstrated small correlation with only pre-school height and HAZ. Even though birthweight is an important predictor of pre-school growth, it may not be a significant among the test children for the following reasons: (i) both BF and NBF groups had birthweight within normal range (2.5-3.5 kg) owing to the inclusion criterion, and (ii) pre-school height and HAZ were not different between both groups despite their statistical correlations with birthweight, albeit with a low differentiating power.

Children in NBF group were breastfed for a shorter period than those in BF group. Mothers' education might play a role in determining the longer breastfeeding period as a higher proportion of mothers in BF group had at least college education, in agreement with several reports (Swenson *et al*, 1993; Davies-Adetugbo and Ojofeitimi, 1996; Zadka *et al*, 2019) but not all (Sencan *et al*, 2013). However, duration of breastfeeding had a small negative correlation with pre-school HAZ. Prolonged

breastfeeding has been reported to affect linear growth of children (Michaelsen *et al*, 2000), although a more recent study reported slow linear growth is limited only to the first year of life (Betoko *et al*, 2017). In the present study, no differences were observed in any pre-school growth parameters between children breastfed longer than 12 months compared to other children. In addition, duration of breastfeeding did not correlate with pre-school WHZ and BMI, findings at odds with previous reports of breastfeeding resulting in decreased prevalence of overweight/obesity in childhood (Harder *et al*, 2005; Plagemann and Harder, 2005). Several perinatal factors other than breastfeeding might be associated with childhood overweight/obesity, such as type of delivery, maternal BMI and diabetes mellitus during pregnancy (Notara *et al*, 2018). In the present study, parents' BMI did not correlate with pre-school WHZ and BMI of the test children. Interestingly, in NBF group, paternal but not maternal BMI correlated with pre-school WHZ and BMI. This could be a coincidence as this was not observed in BF group.

Children in NBF group started complementary feeding earlier compared to BF group, but no correlations were observed between age at introduction of complementary feeding and pre-school growth parameters. Formula-fed children in the prospective European Childhood Obesity Project (CHOP Study) who commenced complementary food two weeks earlier than breastfed counterparts, almost 40% at or before 4 months of age have increased risk of obesity in later childhood (Grote *et al*, 2018). These contrary findings might be due to the small number of the study children started complementary feeding before 4 months of age; even in NBF group, 91% of children were introduced complementary feeding at an appropriate age (4-7 months) (Agostoni *et al*, 2008).

The children had relatively favorable pre-school eating habits, majority eating three daily meals of solid food, high-iron and -protein food, and fruits and vegetables, drinking 2-4 daily servings of milk, and consuming non-nutritious snacks and sweetened drinks in moderate amounts. BF and NBF groups did not differ in most eating habits, with the exception NBF group drinking marginally but significantly more sweetened drinks (one drink per day compared to no drink in BF group). Longer duration of breastfeeding and later introduction of complementary feeding in BF group might have contribute to this, as shown by the negative correlations of both parameters with amount of sweetened drink consumed as well as non-nutritious snacks. Later introduction to complementary food correlated with more fruit and cereal consumption.

Breastfeeding and timely introduction of complementary food are crucial for appropriate food acceptance and eating behavior of children (Shim *et al*, 2011; Harris and Coulthard, 2016; de Barse *et al*, 2017). Proper nutrition in the early stages of children life, especially breastfeeding, has an important influence on subsequent proper neuro-biological mechanisms of children appetite (Boswell *et al*, 2018), as observed in the present study.

The study has several limitations. Firstly, the number of children enrolled in NBF was only 50% of the estimated sample size, resulting in a lower statistical power to detect the desired differences. *Post hoc* analyses revealed a power of 75% to detect difference in pre-school

body weight, 5% power in pre-school height, and 84% power in pre-school BMI. Secondly, the study was a retrospective data collection, which is prone to recall bias, with anthropometric measurements based on recorded data rather than using a standardized collection method. Thirdly, parents' anthropometric measurements were based on interview, and a number of potential confounders were not obtained (*eg* antenatal care history - serology, total pregnancy weight gain, and prenatal complications - and nutrition of breastfeeding mothers). Fourthly, the inclusion/exclusion criteria resulted in a selection bias.

In conclusion, the study reveals the influence of infant nutrition on pre-school growth and eating habits of a small cohort of Thai children. Breastfeeding and appropriate complementary feeding were among the most important factors in promote healthy pre-school nutrition and eating habits. These finding provide a baseline data for future development of improved guidelines for infant feeding by mothers to allow optimal growth and subsequent proper eating habits of their pre-school offspring.

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