The Relationship between Nutritional Status and Anthropometric Indices among 2-5-Year Old Children in Tehran

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ARTICLE INFO

ORIGINAL ARTICLE

ABSTRACT

Background: Malnutrition in children including lower nutrient intakes or high density food intakes is of recent world concerns; therefore, determining a simple index that reveals the diet adequacy might be an advantage. **Methods**: This cross-sectional study was done among 233 children aged 2-5 years old. A 24-hour dietary questionnaire was used to calculate mean adequacy ratio (MAR), naturally nutrient rich (NNR) and energy density (ED) via related formula. **Results**: A significant negative trend was observed for the relationship between the MAR and the Z-score of height for age. Significant positive relations were observed between the Z-score of body mass index (BMI) for age and the Z-score of weight for height as well as the Z-score of weight for age and the Z-score of height for age. In contrast, a significant negative correlation was between the energy density and MAR (all $P < 0.05$). **Conclusion**: According to the Z-score based on the NNR, MAR and ED, these three indices might be widely used to determine the adequacy of food intakes especially among children.

Keywords: *Mean adequacy ratio; Naturally nutrient; Energy density*

Introduction

The prevalence of childhood malnutrition is still of important concern in the world. Although the incidence is decreasing, the loss of about 3 million young lives a year is till due to malnutrition (Bryce *et al.*, 2008, Caulfield *et al.*, 2004). Moreover, 3.5 million children are at risk of death because of malnutrition. 11% of malnourished children face serious diseases and sickness in their adulthood (de Onis and Blossner, 2003). On the other hand, malnutrition might include the over intake of high calorie and high density food with less nutrients which results in obesity and overweight in later life. The prevalence of obesity among children in 2010 was estimated to be 11.7% in developed countries and 6.1% in developing countries; the related prevalence was less in Asia and was reported to be 4.9% (Ogden *et al.*, 2007). There are factors affecting the malnutrition or obesity among children including breastfeeding, low birth weight or late onset of food intakes in newborns (Anderson and Butcher, 2006); meanwhile, diet

plan and nutrient intakes are of important factors affecting health and preventing diseases in children. Thus, the precise screening of diet intakes via dietary indexes among children is necessary.

Hence the present study sought to assess the mean adequacy ratio (MAR), naturally nutrient rich (NNR) and energy density (ED) via related formula. For estimating the NNR, determined nutrients will be assessed and the energy factor will be omitted; the mean measures of the MAR will be estimated by dividing the sum of the MAR by their numbers and the ED will be calculated by dividing the sum of food intakes in gram by their estimations in kilocalorie. The confounding effect of energy will also be adjusted for the NNR and MAR.

Materials and Methods

Study design and participants: This cross-sectional study was conducted among 233 children aged 2 to 5 years old, including 100 girls and 133 boys, who were selected by multistage cluster sampling from 27 kindergartens in Tehran, Iran, in 2014. The 22 districts of Tehran were divided into 5 zones (North, South, East, West and Center) based on economic, social, and geographical conditions and 2 regions were randomly selected from each zone and finally these 12 kindergartens were randomly selected from the ten different regions of Tehran.

The inclusion criteria were 2 to 5-year old healthy children whose parents agreed for their participations and the exclusion criterion was having any diseases or disorders before or during the study.

Sample size of the study was estimated to be 233 numbers by considering $\alpha=0.05$ and $\beta=0.1$ and ED of 0.72 according to the previous study (Vernarelli *et al.*, 2013), as well as considering the correlation coefficient between the ED and diversity of foods.

The main researcher described the study protocol and procedures to children's parents; necessary information including the parents' educational status and informed consent forms were obtained from every family who agreed for joining their children to the study.

Measurements: Children were weighed without shoes and heavy clothing using a digital scale (HBF-214-EBW Omron Co) with a precision of 0.1 kg. Their height was also measured in a standing position without their shoes to the nearest 0.1 cm using a portable stadiometer (Seca, model 207 Germany). Parents were given a list of food record forms and they were trained to record the time, place, frequency, and the amount of each food that was taken by their children for 3-7 days. The 3-7-day food records have been done to give reliable estimates of food intakes for computing the macro- and micro-nutrients. Records were then converted to gram and analyzed by Nutritionist 4 software to calculate the calorie density and macronutrients including carbohydrates, proteins, and fats as well as micronutrients and minerals including vitamin A, thiamine, riboflavin, niacin, folate, cobalamin, vitamin C, vitamin D, vitamin E, calcium, zinc, iron, phosphorus, magnesium, potassium and fatty acids.

Naturally nutrient rich (NNR) score estimation: The NNR score, which is a nutrients-to-calories ratio, is based on mean percentage daily values (DVs) for 14 nutrients in 2000 kcal food. These 14 nutrients included protein, calcium, iron, vitamin A, vitamin C, thiamine, riboflavin, vitamin B12, folate, vitamin D, vitamin E, monounsaturated fat, potassium, and zinc. **Formula 1** indicates the estimation of the NNR.

Formula 1: NNR= Σ%DV2000 kcal/14

Mean adequacy ratio (MAR) estimation: The MAR is a member of indicators that estimate the individual intake of nutrients. The nutrient adequacy ratio (NAR) was measured at first to estimate the MAR. The NAR is equal to the ratio of an individual's nutrient intake to the recommended dietary allowance (RDA) of the nutrient based on individual's age and sex; the MAR is then calculated by averaging all the NAR values together; formula 2 shows the related MAR estimation.

Formula 2: MAR = ΣNAR / Number of Nutrients

Food density estimation: The density of food is calculated by dividing the amount of calories that serving contains by the weight of a serving of the food in grams (**Formula 3**).

Formula 3: ED of food = Number of calories/ weight (g)

The mean Z-score of weight and height for age as well as the Z-score of weight for age of individuals were compared between participants based on the MAR and NAR values. The correlation of anthropometric measurements including food density and adequacy of nutrients with the nutrition status of children were assessed as well as the correlation of parental educational status and the anthropometric measurements with the nutrition status of individuals.

Data analysis: SPSS software (version 16; SPSS Inc., Chicago, IL) was used to analyze the data and the results were expressed as mean ± standard deviation (SD). Shapiro-Wilk test was used to determine the normality of the distribution of variables. The background characteristics of participants were compared using independent sample *t-test* and chi-squared test. The differences between the 2 groups were determined by independent *t-test*; differences in anthropometric measurements and nutrients were compared by paired sample *t-test* and Wilcoxon signed ranks test between in each group. One-way ANOVA test was also used to determine the differences between the four groups. Differences with P-value < 0.05 were considered to be statistically significant.

Results

The average number of children in every family was about 2 (1.9); 233 children including 100 girls and 133 boys were included for the final analysis. According to **Table 1**, the mean age of children was 3.5±0.93 year. The mean weight and height of participants were estimated to be 15.07 ± 3.03 kg and 97.83 ± 10.16 cm, respectively. The mean measures of birth weight and height were 3.16 ± 0.48 kg and 50.43 ± 3.58 cm, respectively. The mean time of breastfeeding was estimated to be 18.32 months.

The mean and standard deviation of Z-score for anthropometric measurements based on food and ED quartiles are presented in **Tables 2** and **Tables 3**, respectively. No significant differences were observed for any of the factors. Furthermore, the mean and standard deviation of Z-score for anthropometric measurements based on the MAR quartiles are presented in **Table 4**. A significant negative trend was observed for the relation between the MAR and the Z-score of height for age. Moreover, correlation coefficient between nutrient factors and anthropometric measures among children are presented in **Table 5**; as it is shown, there is a significant positive correlation between the Z-score of BMI for age and the Z-score of weight for height. A significant positive relation is also observed between the Z-score of weight for age and the Z-score of height for age. In contrast, a significant negative correlation is between the ED and MAR.

Table 1. Baseline Data of Participants

Variables	Mean	Standard Deviation
Age (year)	3.50	0.93
Weight of birth (kg)	3.16	0.48
Height of birth (kg)	50.43	3.58
Current weigh (kg)	15.07	3.03
Current height (cm)	97.83	10.16

Table 2. Mean (±SD) of Z-score for anthropometric measurements based on naturally nutrient rich (NNR) quartiles

Quartiles (Number)	Z-score of weight for height	Z-score of height for age	Z-score of weight for age	Z-score of BMI[a] for age
First (59)	0.569 ± 0.69	-0.067 ± 1.45	-0.05 ± 1.02	0.012 ± 1.55
Second (58)	0.024 ± 0.62	-0.013 ± 1.36	0.117 ± 0.99	0.012 ± 1.34
Third (59)	-0.005 ± 0.75	-0.008 ± 1.41	-0.196 ± 0.99	0.383 ± 1.53
Forth (57)	0.077 ± 0.67	0.168 ± 1.41	0.012 ± 1.04	-0.079 ± 1.53
P -value [b]	0.29	0.82	0.29	0.3

[a] Body mass index; [b]: ANOVA test

Table 3. Mean (±SD) of the Z-score for anthropometric measurements based on energy density (ED) quartiles

Quartiles (Number)	Z-score of weight for height	Z-score of height for age	Z-score of weight for age	Z-score of BMI[a] for age
First (59)	0.051 ± 0.76	-0.054 ± 1.39	0.171 ± 1.00	0.156 ± 1.61
Second (58)	0.050 ± 0.68	-0.176 ± 1.36	-0.206 ± 0.98	0.186 ± 1.47
Third (59)	-0.084 ± 0.66	-0.216 ± 1.42	-0.129 ± 0.98	-0.015 ± 1.28
Forth (57)	0.147 ± 0.62	0.093 ± 1.44	0.148 ± 1.07	0.298 ± 1.64
P-value [b]	0.33	0.45	0.10	0.73

[a] Body mass index [b]: ANOVA test

Table 4. Mean (±SD) of the Z-score for anthropometricmeasurements based on the mean adequacy ratio (MAR) quartiles

Quartiles (Number)	Z-score of weight for height	Z-score of height for age	Z-score of weight for age	Z-score of BMI[a] for age
First Q[c] (59)	-0.075 ± 0.63	0.345 ± 1.25	0.017 ± 1.08	-0.199 ± 1.39
Second Q (58)	0.152 ± 0.70	0.105 ± 1.50	-0.139 ± 1.02	0.529 ± 1.57
Third Q (59)	0.005 ± 0.67	-0.457 ± 1.27	-0.240 ± 1.06	-0.009 ± 1.67
Forth Q (57)	0.048 ± 0.70	-0.090 ± 1.44	0.179 ± 0.91	0.189 ± 1.39
P- value [b]	0.33	0.04	0.14	0.05

[a] Body mass index [b]: ANOVA test

Table 5. Correlation coefficient between nutrient and anthropometric factors among 2-5 year old children

	Z-score of weight for age	Z-score of weight for height	Z-score of height for age	Z-score of BMI[a] for age	NNR[b]	MAR[c]	ED[d]
Z-score of weight for age	-	-0.064	-0.032	0.786[e]	0.09	-0.016	0.057
Z-score of weight for height	-	-	0.364[e]	-0.124	-0.127	0.072	-0.025
Z-score of weight for age	-	-	-	-0.117	0.048	0.037	0.004
Z-score of BMI for age	-	-	-	-	0.090	-0.073	0.027
NNR	-	-	-	-	-	-0.063	0.022
MAR	-	-	-	-	-	-	-0.028[e]

[a]: Body mass index; [b]: Naturally nutrient rich; [c]: Mean adequacy ratio; [d]: Energy density; [e]: P-value <0.05

Discussion

This study was performed to assess the relation of the means of food density, ED and MAR with anthropometric measurements including the Z-scores of weight for height, height for age and BMI for age among 233 children. As the mean time of breastfeeding was 18.32, it could be an effective factor in children's health which positively affects the mentioned correlation. A study by Arimond et al. showed that the duration of breastfeeding might predict the efficacy of nutrients and ED as well as various types of food intakes (Arimond and Ruel, 2004). The mean measures of the MAR, food and ED in the present study were 0.03 ± 0.012, 0.93 ± 0.25 and 1.06 ± 0.27, respectively.

Regarding the results of correlation coefficient of the present study, Steyn et al. ~~also~~ found the similar relation between the MAR and the scores of types of food intakes (Steyn *et al.*, 2006). In contrast with the finding, Esmaillzadeh et al., who assessed the NAR and MAR among women, reported negative correlation between energy intakes and MAR (Esmaillzadeh and Azadbakht, 2011). Although the mentioned study was performed among older participants, it is inconsistent with the present findings. On the other hand, based on recent 11-region assessment, the food diversity index is significantly correlated with the Z-score of height for age, in which a positive correlation was observed for china, Kenya, and Mali, 4.42.43 (Arimond and Ruel, 2004).

Respecting the correlation of Z-score of height for age with food density in the present study, an ascending but insignificant relation was observed, likely due to the higher intake of high calorie foods that indeed, led to higher amounts of food density. Thus, it can be assumed that consuming the majority part of total calorie from protein rich vegetables and fruits, would prevent the incidence of obesity in childhood and adulthood (Bujnowski *et al.*, 2011).

No significant correlation was observed for the correlation of the Z-score for anthropometric measurements based on food and ED quartiles; The time of measuring the anthropometric indices could

be the reasons for not observing any alterations in their levels.

On the other hand, a significant negative trend was observed for the relation between the MAR and the Z-score of height for age in the present study, which is out of expectation. In a study by Styein et al., which was conducted among 2200 children, it was found that the MAR had a positive relationship with the Z-score of height for age (Steyn *et al.*, 2006, Steyn *et al.*, 2012); This discrepancy could be due to higher sample size of the mentioned study and/or higher intakes of dense food and not precisely due to the quality of foods.

A study by Onyan et al. reported that a strong relationship was observed between dietary diversity and anthropometric measurements among children which could even be a separate predictor of anthropometric status in children (Onyango, 2003). Rah et al. revealed that food diversity could be a strong predictor of stunning as it had a significant negative relationship with stunning among 6 to 59-month old children and as the diversity of food increased, the stunning would be 15% -31% lower in children. The relation between food diversity and anthropometric measurements was not assessed in this study (Rah *et al.*, 2010).

Hebestreit et al. estimated the density of solid and liquid foods among 16228 children and reported that those children who have had foods with lower density and lower calorie, had better food choices compared to those who have had higher dense foods with higher calories (Hebestreit *et al.*, 2014). Taren et al. also reported that the calorie of protein as well as zinc intakes from foods were strongly and positively associated with anthropometric indices especially the Z-score of height for weight and the nutrition quality score (Taren and Chen, 1993). Another study conducted among 2200 children showed that positive associations existed between food variety score, dietary diversity score and the MAR, and they also reported that the Z-score of height for age and the Z-score of weight for height had positive correlation with the mentioned

anthropometric indices (Millward and Jackson, 2004).

Although the most important anthropometric indices and its correlation with nutrition factors including NNR, MAR and ED were included approximately among an acceptable sample size, the limitations of the present study should also be noted. Measuring food records are not enough; thus, 24-hour recalls or food frequency questionnaires should be estimated in future investigations; the cross-sectional nature of such research studies cannot prove the exact causal relationship between anthropometric indices and food factors and as the present study was conducted in Tehran city and as we needed to expand the results to the whole country or other countries,. More researches are needed to perform in other cities or other countries.

Conclusions

In this study, according to the observed results based on the NNR, MAR and ED, which include significant positive relations between the Z-score of BMI for age and the Z-score of weight for height as well as a significant negative correlation between the energy density and the MAR, it was

tried to express that the NNR, MAR and ED indexes might be widely used to determine the adequacy of food intakes especially among children. As far as the authors know, limited studies have been done on this topic; since heavy business and advertisements do not permit such investigations to be performed in the world. However, more investigations with more sample size are needed to conduct similar meta-analysis and thus to prevent the intakes of disadvantageous foods among children to stop the non-stopping rate of obesity and its co-morbidities.

Acknowledgment

Thanks are owed to all individuals who participated in this study.

Authors' Contributions

Nadjarzadeh A designed and developed this article. Razmpoosh E conducted and wrote the manuscript and Khosravi H had participated in the data collection. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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