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ORIGINAL ARTICLE

Food insecurity, dietary acid load, dietary energy density and anthropometric indices among Iranian children

Elnaz Daneshzad[1] · Ahmadreza Dorosty-Motlagh[1] · Nick Bellissimo[2] · Katherine Suitor[2] · Leila Azadbakht[1,3]

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Abstract
Objectives Food insecurity significantly influences diet quality which in turn has an impact on individual health. This study aimed to determine the association of food insecurity, dietary energy density (DED), dietary acid load (DAL), and the anthropometric status of children.
Study design A cross-sectional study.
Methods This study was conducted in 788 6-year-old girls who were referred to health care centers affiliated with Tehran University of Medical Sciences in the south of Tehran from October 2017 to March 2018. Food frequency questionnaires (168 food items) were assessed to calculate DAL and DED. Food insecurity was assessed using the 18-item United States Department of Agriculture questionnaire. Weight and height of children were measured as anthropometric indices.
Results Protein and energy intake were higher in participants with a higher DAL and DED, respectively. Energy, fat, carbohydrate, fiber, potassium, phosphorus, calcium, iron, folate, vitamin B12, mono- and poly-unsaturated fatty acid intake was inversely related to DAL. Children characterized as food insecure were more likely to be defined as thin (OR 5.36; 95% CI 3.41–8.40) than overweight (OR 0.18; 95% CI 0.12–027) and obese (OR 0.28; 95% CI 0.08–0.98, respectively). There was no significant association between DED, potential renal acid load (PRAL), and food security status. Moreover, there was no significant association between anthropometric measure and PRAL.
Conclusion Findings from our study revealed that there was no association between DAL and food insecurity. However, food insecure children were more likely to be characterized as thin than children categorized as food secure. More studies need to be performed in both genders to confirm our findings.
Level of evidence Level V cross-sectional descriptive study.

Keywords Food insecurity · Dietary acid load · Dietary energy density · Anthropometric · Children

Introduction

Periods of childhood growth are sensitive, yet there are critical windows that are widely influenced by nutritional status. They require more energy and nutrients such as iron and zinc to support adequate growth [1]. It has been previously reported in Iranian children aged 2–5 years old that the prevalence of stunted childhood growth was 7.5%, rates of underweight and overweight 6.9% and 17.8% in boys and 4.7% and 11.7% in girls, respectively [2]. It is well understood that weight and height development at an early age can critically impact health quality in later life. While childhood overweight or obesity has been associated with comorbidities such as asthma, diabetes, metabolic disease, hypertension and cardiovascular diseases (CVD) later in life [3], children and adolescents who fall

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✉ Leila Azadbakht
azadbakhtleila@gmail.com

1 Department of Community Nutrition, School of Nutritional Science and Dietetics, Tehran University of Medical Sciences, Tehran, Iran

2 School of Nutrition, Ryerson University, Toronto, Canada

3 Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

below recommended weight categories are associated with severe anemia and heart failure [4]. The rising demand for adequate food in childhood and adolescence requires adequate income and food availability and accessibility. The imbalance between cost of living and income has resulted in rapidly increasing levels of food insecurity among households all over the world specifically in developing countries [5]. Lack of money to preparing food is a blockade for having a healthy weight [6]. Previous research reported that household food insecurity among Iranian adolescents was 41% and 67% in children [7, 8].

Food insecurity is the unavailability of nutritious, sufficient and quality food and has been linked to both malnutrition and obesity [9, 10]. Ultimately, food insecurity can lead to negative health outcomes such as nutrient deficiency, anxiety, depression, decreased physical function, academic performance and chronic disease [7, 11]. Childhood nutritional status such as underweight, overweight or stunted growth is largely impacted by food insecurity, it has an influence on food quantity, quality, accessibility and availability [12]. As such, previous literature indicates food insecurity is widely associated with dietary patterns. However, these results are inconsistent in different study populations [13]. A healthy diet is an essential factor for not only physical development but cognitive growth [7]. Dietary acid load (DAL) is an index that determines the balance of acid-inducing foods such as meat and eggs and base-inducing foods such as fruits and vegetables [14]. DAL can be estimated with three commonly used scores: net endogenous acid production (NEAP) that is calculated as the ratio of ingested protein and potassium, potential renal acid load (PRAL) calculated by calcium, phosphorus, magnesium, potassium and protein, or using the ratio of animal protein-to-potassium [15, 16]. Acid–base imbalance is recognized as a risk factor for metabolic disorder, previous research among German children has demonstrated a higher dietary acid load was associated with higher blood pressure and loss of bone mineral contents [17].

The dietary energy density (DED) is the amount of available energy per unit of weight in the diet (kJ/g). DED is a marker of diet quality [18] which has been previously demonstrated to be related to overeating, overweight, weight gain, childhood obesity and changes in body composition [19, 20]. In contrast, lower DED is associated with better nutritional quality and a higher intake of fiber [21]. A study conducted in American children aged 2–8 years old found children with a lower DED similarly had a lower energy intake of fat and consumed more fruit and vegetables [22]. Moreover, energy-dense foods are less expensive and more available to buy for lower socioeconomic households [23, 24].

To our best knowledge, there is no study that has evaluated the association of food insecurity and dietary acid load with anthropometric status of children. The impact of food insecurity and food quality indicators on the growth of children highlights the importance of the present study aimed to explore the association of food insecurity and dietary acid load with anthropometric status of children.

Methods

This cross-sectional study observed 788 six-year-old girls referred to health centers affiliated to Tehran University of Medical Sciences who referred to health care centers affiliated to Tehran University of Medical Sciences for vaccination in south of Tehran from October 2017 to March 2018. Multi-stage cluster sampling was conducted. Inclusion criteria included Iranian children with obtained parental consent while children with diagnosed cardiovascular, liver and kidney diseases and cancer were excluded. General information, the food frequency questionnaire, and the United States Department of Agriculture (USDA) 18-item food security questionnaire were filled by the mother or maternal figures of participants.

Food security score was calculated by the total of responses score of USDA 18-item food security questionnaire previously validated [25]. Each item was rated from "0" to "2" points. Families which receive a total score of 0–2 are characterized as food secure, while a score of "3" to "7" and "8" to "12" indicate food insecurity without hunger and food insecurity with moderate hunger, respectively, and a score of "13" or higher indicates food insecurity with severe hunger. Finally, food security status has been divided into food secure and food insecure individuals.

Children supplement consumption was assessed in the general questionnaire, and their physical activity score was calculated based on metabolic equivalent by a reported weekly timetable [26].

Socioeconomic status (SES) was evaluated using a comprehensive questionnaire which included several items such as parent's occupation and education, number of children under 18 years old, number of family members, income level, health care insurance, food assistance, being the owner or tenant of a house, neighbourhood, vehicle ownership, number of cars and number of rooms in the house.

Anthropometric measurements including height, weight, and body mass index (BMI) were evaluated. Weight was measured by a digital scale (0.1 kg accuracy) with minimum clothing and no shoes. Height was measured using a fixed plastic meter to the wall in standard standing position. BMI was calculated by dividing the weight (kg) to the square of height (m). Parameters outlined by the World Health Organization (WHO) and Anthroplus software (version 1.0.4) were used to calculate the z-scores for BMI-for-age (BAZ), height-for-age (HAZ), and weight-for-age (WAZ). Therefore, BAZ ≥ 1 standard deviation (SD) was considered as overweight, BAZ ≥ 2 SD as obesity, − 3 ≤ BAZ ≤ − 1 as thin and BAZ ≤ − 2 SD was considered as severely thin. Children with HAZ ≤ − 2 SD and ≤ − 3 SD was defined as stunted and severely stunted, respectively. However, there were no participants in the present study characterized as stunted [27].

A validated food frequency questionnaire (FFQ 168 items) was used to evaluate participant's dietary intake [28]. Frequency of food item consumption was considered by the day, week, month and year. USDA household consumption values were used for computing grams per day for each food item. NUTRITIONIST-IV software modified for Iranian foods (version 7.0; NSquared Computing, Salem, OR) was used to estimate nutrient and energy intake [29].

Dietary acid load calculated based on the PRAL method outlined below [30].

$$\text{PRAL (mEq/day)} = \left(\text{protein}\left[\text{g/day}\right] \times 0.49\right) + \left(\text{P}\left[\text{mg/day}\right] \times 0.037\right) - \left(\text{K}\left[\text{mg/day}\right] \times 0.021\right) - \left(\text{Ca}\left[\text{mg/day}\right] \times 0.013\right) - \left(\text{mg}\left[\text{Mg/day}\right] \times 0.026\right).$$

Dietary energy density was calculated by dividing daily energy intake (kcal/day) into the total weight of food consumed (g/day) [31]. Only food intake was considered, drinks and beverages were excluded from analysis. Therefore, the effect of DED on body weight is related to only changes in food intake consumed, not drinks [32].

Normality of data was checked by histogram curve and Kolmogorov–Smirnov test. Food security status was reported as "food secure" and "food insecure". Qualitative and quantitative variables across dietary scores were assessed using a Chi-square and independent sample t test and one-way ANOVA test, respectively. Food intake of children was classified into the median of dietary scores. Dietary intakes were compared using the analysis of covariance by adjusting the effect of energy intake among the median of dietary scores. To determine the relationship between food security status and anthropometric growth in children, binary logistic regression was used in the crude and adjusted model (Model 1). Physical activity, energy intake, SES, and supplement consumption were adjusted for in model 1. To determine the relationship between DAL and anthropometric growth in children, binary logistic regression was used in the crude and adjusted model. In the adjusted model, further adjusting was performed for food security status. SPSS software was used to perform analyses and $p < 0.05$ was considered as statistically significant.

Results

In the present study, 526 families were food secure. Mean weight of all children was 20.85 ± 2.35 kg. Table 1 shows the characteristics of participants across DAL and DED scores. There was no significant association between demographic

Table 1 Demographic and anthropometric characteristics of children according to dietary acid load and dietary energy density (n = 788)

Variables	All	PRAL		p value	DED		p value
		Low (n = 394)	High (n = 394)		Low (n = 394)	High (n = 394)	
Weight (kg)	20.85 ± 2.35	20.76 ± 2.40	20.94 ± 2.30	0.286	20.96 ± 2.48	20.77 ± 2.21	0.270
Height (cm)	113.75 ± 2.01	113.62 ± 2.05	113.88 ± 1.94	0.065	113.65 ± 2.11	113.85 ± 1.89	0.178
BMI (kg/m^2)	16.12 ± 1.84	16.08 ± 1.87	16.15 ± 1.81	0.634	16.23 ± 1.95	16.02 ± 1.71	0.125
PA (MET h/week)	9.49 ± 0.35	9.49 ± 0.36	9.49 ± 0.35	0.981	9.50 ± 0.36	9.49 ± 0.35	0.764
SES	31.87 ± 6.81	31.45 ± 7.04	32.28 ± 6.55	0.088	31.94 ± 6.97	31.80 ± 6.66	0.769
WAZ	− 0.02 ± 0.79	− 0.05 ± 0.81	0.01 ± 0.78	0.357	0.01 ± 0.83	− 0.49 ± 0.75	0.301
HAZ	− 0.55 ± 0.42	− 0.57 ± 0.43	− 0.53 ± 0.41	0.284	− 0.56 ± 0.43	− 0.54 ± 0.42	0.570
BAZ	0.36 ± 1.09	0.34 ± 1.11	0.38 ± 1.07	0.552	0.41 ± 1.15	0.32 ± 1.02	0.260
Supplements n (%)							
Yes	334 (42.4)	179 (53.6)	155 (46.4)	0.084	181 (54.1)	154 (45.9)	0.051
No	454 (57.6)	215 (47.4)	239 (52.6)		213 (47.0)	239 (53.0)	
FSS n (%)							
Secure	526 (66.8)	257 (48.9)	269 (51.1)	0.364	260 (49.5)	265 (50.5)	0.704
Insecure	262 (33.2)	137 (52.3)	125 (47.7)		132 (51.0)	127 (49.0)	

p value calculated using independent sample t test analysis (present as mean ± SD)

PRAL potential renal acid load, *DED* dietary energy density, *BMI* body mass index, *PA* physical activity, *SES* socio-economic status, *FSS* Food Security Status, *BAZ* z-score for BMI-for-age, *HAZ* z-score for height-for-age, *WAZ* z-score for weight-for-age

Table 2 Dietary intakes of children according to dietary acid load and dietary energy density ($n = 788$)

Variables	All	PRAL		*p* value	DED		*p* value
		Low ($n = 394$)	High ($n = 394$)		Low ($n = 394$)	High ($n = 394$)	
Energy (Kcal/day)	1014.74 (9.32)	1118.37 (11.09)	911.12 (12.78)	< 0.0001	889.12 (12.08)	1140.07 (10.81)	< 0.0001
Protein (g/day)	39.41 (1.83)	34.09 (2.70)	44.73 (2.70)	0.008	43.13 (2.79)	35.71 (2.79)	0.078
Fat (g/day)	33.82 (0.47)	36.31 (0.64)	31.33 (0.64)	< 0.0001	32.91 (0.67)	34.70 (0.67)	0.077
CHO (g/day)	153.62 (1.92)	164.30 (2.52)	142.94 (2.52)	< 0.0001	151.49 (2.54)	155.53 (2.64)	0.311
MUFA (g/day)	21.85 (0.33)	24.04 (0.42)	19.66 (0.42)	< 0.0001	21.42 (0.45)	22.27 (0.45)	0.211
PUFA (g/day)	16.60 (0.28)	17.41 (0.38)	15.79 (0.38)	0.005	16.45 (0.40)	16.73 (0.40)	0.642
Fiber (g/day)	18.23 (0.33)	22.70 (0.38)	13.77 (0.38)	< 0.0001	18.04 (0.45)	18.40 (0.45)	0.603
Vitamin K (mg/day)	3347.57 (51.05)	4132.18 (54.27)	2562.96 (54.27)	< 0.0001	3325.58 (68.26)	3368.06 (68.26)	0.679
Potassium (mg/day)	636.51 (9.07)	702.37 (11.22)	570.65 (11.22)	< 0.0001	631.35 (12.01)	640.67 (12.01)	0.607
Calcium (mg/day)	498.52 (6.56)	552.81 (7.92)	444.22 (7.92)	< 0.0001	490.40 (8.59)	506.23 (8.59)	0.221
Sodium (mg/day)	5113.38 (100.73)	5507.45 (142.34)	4719.31 (142.34)	< 0.0001	5026.92 (147.86)	5204.38 (147.86)	0.425
Iron (mg/day)	16.24 (0.17)	17.65 (0.17)	14.83 (0.17)	< 0.0001	15.99 (0.19)	16.46 (0.19)	0.104
Folate (Ug/day)	322.46 (6.19)	386.39 (7.79)	258.54 (7.79)	< 0.0001	318.14 (8.64)	326.45 (8.64)	0.523
Vitamin B12 (Ug/day)	3.77 (0.05)	4.06 (0.07)	3.49 (0.07)	< 0.0001	3.72 (0.08)	3.82 (0.08)	0.432

Data is presented as mean and standard errors, and calculated by analysis of covariance which adjusted for energy intake. Energy intake was compared using an ANOVA according to DAL and DED scores

PRAL potential renal acid load, *DED* dietary energy density, *CHO* carbohydrate, *MUFA and PUFA* mono- and poly-unsaturated fatty acids, *K* potassium, *P* phosphorus

and anthropometric variables and dietary scores. Table 2 presents the dietary intakes according to DAL and DED scores. Protein intake was positively associated with a high DAL score, while energy intake was positively associated with DED. Intake of energy, fat, carbohydrate, fiber, potassium, phosphorus, calcium, iron, folate, vitamin B12, mono- and poly-unsaturated fatty acids was inversely associated with DAL.

The multivariable-adjusted odds ratio for anthropometric disorders and dietary scores across the food security status is indicated in Table 3. Our findings suggest food insecure participants are more likely to be classified as thin (OR 5.36; 95% CI 3.41–8.40) than overweight (OR 0.18; 95% CI 0.12–027) or obese (OR 0.28; 95% CI 0.08–0.98). There was no significant association between DED, PRAL, and food security status. Supplemental Table 1 presents the *Z* scores of anthropometric variables according to food security status which confirms the results of Table 3. Also, there was no significant association between the mid-arm circumference and food security status. Table 4 shows that there was no significant association between anthropometric measure and PRAL.

Discussion

In this cross-sectional study, we examined the association between food insecurity, dietary acid load, dietary energy density and anthropometric indices among 788 6-year-old Iranian children. Our findings dictate that there was no correlation between DAL, DED and food insecurity. However, food insecure children were more likely to be classified as thin compared to children categorized as food secure. Finally, there was no association between DAL and anthropometric measures.

A study which assessed 300 healthy mother-infant pairs revealed no significant associations between DED quartiles among lactating mothers and infant growth between 2 and 4 months of age [33]. In contrast, a previous study demonstrated that DED was positively associated with BMI, fat mass index, body fat percentage and abdominal fat in 8–12-year-old children. It should be noted that Gomez-Burton et al. looked at both genders in addition to an older age category [34]. While previous evidence has suggested that DED is positively associated with cardiometabolic risk in children, our findings indicate a lack of association between these two variables. However, this may be indicative of a homogeneous group of children who were participated in our study sample. Moreover, overweight or obese children with different age (8–12 years old) can be another cause of diverse results which in this age, children have various dietary habits regarding to hormonal changes, puberty and independency feeling. Therefore, children in this age may eat fast foods, sugar sweetened beverage, snacks and other high energy dense foods which are related to overweight and obesity. Also, differences anthropometric evaluation should be considered. In the present study, weight and height were assessed, however,

Table 3 Multivariable-adjusted odds ratio for anthropometric disorders and adherence to dietary scores according to food security status (*n* = 788)

Variables	Food security status		*p* value
	Food secure (*n* = 526)	Food insecure (*n* = 262)	
Overweight (*n* = 262)			
Crude	1	0.18 (0.12–0.28)	< 0.0001
Model 1	1	0.18 (0.12–0.27)	< 0.0001
Obesity (*n* = 23)			
Crude	1	0.29 (0.08–0.99)	0.049
Model 1	1	0.28 (0.08–0.98)	0.048
Thinness (*n* = 20)			
Crude	1	5.11 (3.29–7.93)	< 0.0001
Model 1	1	5.36 (3.41–8.40)	< 0.0001
Severe thinness (*n* = 105)			
Crude	1	2.04 (0.84–4.98)	0.114
Model 1	1	2.44 (0.97–2.51)	0.057
DED			
Crude	1	0.94 (0.70–1.27)	0.704
Model 1	1	0.79 (0.56–1.12)	0.202
PRAL			
Crude	1	0.87 (0.64–1.17)	0.364
Model 1	1	0.95 (0.68–1.32)	0.764

p value was calculated using binary logistic regression

Data is presented as odds ratio and 95% confidence interval

Model 1 adjusted for energy intake, physical activity, supplements consumption, and socioeconomic status

PRAL potential renal acid load, *DED* dietary energy density

Table 4 Multivariable-adjusted odds ratio for anthropometric disorders according to dietary acid load (*n* = 788)

Variables	PRAL		*p* value
	Low	High	
Overweight (*n* = 262)			
Crude	1	0.85 (0.63–1.14)	0.290
Model 1	1	0.78 (0.55–1.10)	0.170
Obesity (*n* = 23)			
Crude	1	1.31 (0.56–3.02)	0.520
Model 1	1	1.13 (0.44–2.85)	0.795
Thinness (*n* = 20)			
Crude	1	0.68 (0.45–1.04)	0.076
Model 1	1	0.76 (0.47–1.24)	0.283
Severe thinness (*n* = 105)			
Crude	1	1.22 (0.50–2.99)	0.651
Model 1	1	0.98 (0.36–2.70)	0.983

p was calculated using binary logistic regression

Data is presented as odds ratio and 95% confidence interval

Model 1 adjusted for energy intake, physical activity, supplements consumption, socioeconomic status and food security status

PRAL potential renal acid load

Gomez-Buurton et al. assessed the body composition [34, 35].

There is a limited body of research which identifies the association of DAL or DED with food security status among children. A cross-sectional study among 525 Iranian girls aged 14–18 years old demonstrated a positive association between dietary inflammatory index (DII) and food insecurity; DII is a dietary score which can be used to assess diet quality [36]. Further, a cross-sectional study which evaluated 218 children aged 10 years old using a healthy eating index concluded that children from insecure households reported reduced energy intake and reduced intake of whole fruits compared with children characterized as food secure [28].

The present study suggests that participants who were food insecure were more likely to be classified as thin and less likely to be classified as overweight or obese. Anthropometric measurements such as weight and height are reflective of nutritional status, and as such can be indicative of household social and economic status [37, 38]. Indeed, previous research determined that food insecurity was associated with low economic status [39]. Further, previous research has identified the relationship between food insecurity and poor health outcomes in children including emotional, behavioral, and academic performance, blood pressure, and increased hospitalization during early childhood [7, 40, 41]. A cross-sectional study in 150 Iranian households with 1–1.5-year-old infants revealed that infant height was significantly lower socioeconomic households [42]. Moreover, recently a study has revealed that adults who experience food insecurity report intentional dietary restraint. Also, this dietary restraint was associated with eating disorders in food insecure families which can effect on anthropometric indices by itself [43]. Also, one a cross-sectional study has indicated that food insecurity was associated with self-reported bulimia nervosa as well as greater binge-eating frequency [44]. Since food intake is an important factor in optimal growth, it is critical to develop proactive food policies and increase public awareness to the importance and accessibility of proper nutrition from a young age. Several approaches such as diet quality indices like as DAL, DED, and assessments of food insecurity can be used to evaluate the association between food intake and health outcomes. Despite this, Joe et al. established a very weak correlation between poor anthropometric measures and food intake suggesting that deficient anthropometric measures were not positively associated with food intake in Indian children. This effect was observed following statistical adjustments for socioeconomic and maternal health status [45]. South et al. indicated that 2.1% of food insecure children aged 8–17 years were underweight, while 44.2% of them were overweight or obese; food insecurity was further associated with increased blood pressure in participants [40].

The current study was conducted to assess the association between DAL, DED, food security and anthropometric measures in Iran, however several limitations should be addressed. This study included a heterogeneous sample of 6-year-old children which included thin, overweight and obese participants. A future study should be conducted in a more exclusionary population to delineate further if any associations occur. This study evaluated the physical activity level of participants, however future studies should assess body composition with more accurate methods such as Dual Energy X-ray Absorptiometry Scan (DXA) or BodPod. For the correct determination of food consumption, it was better if food consumption had been determined by a different method in addition to the food frequency questionnaire. Finally, confounding variables may have had an unknown impact on results, but future studies are needed.

Finding from our study revealed that there was no association between DAL with food insecurity. However, the likelihood of being classified as thin was higher in food insecure children. Overall, food policies and educational programs should be provided to prevent growth abnormalities in Iranian children. More well-designed studies such as cohort designs need to be performed in different countries and in both genders to confirm findings presented in this study.

What is already known on this subject?

No study has evaluated the association of food insecurity and dietary acid load with anthropometric status of children. The impact of food insecurity and food quality indicators on the growth of children highlights the importance of the present study aimed to explore the association of food insecurity and dietary acid load with anthropometric status of children.

What does this study add?

The findings from our study revealed that there was no association between DAL with food insecurity. In the present study, protein and energy intakes were higher in children with a higher dietary acid load (DAL) and dietary energy density (DED) score, respectively. Energy, fat, carbohydrate, fiber, potassium, phosphorus, calcium, iron, folate, vitamin B12, mono- and poly-unsaturated fatty acid intake was inversely related to DAL. Children characterized as food insecure were more likely to defined as thin (OR 5.36; 95% CI 3.41–8.40) than overweight (OR 0.18; 95% CI 0.12–027) and obese (OR 0.28; 95% CI 0.08–0.98, respectively). There was no significant association between DED, potential renal acid load (PRAL), and food security status. Moreover, there was no significant association between anthropometric measure and PRAL. Overall, food policies and educational programs should be provided to prevent growth abnormalities in Iranian children.

Author contributions LA and AD designed the study. ED prepared the first draft and performed statistical analysis. NB and KS contributed to drafting the manuscript and data interpretation. LA supervised the study.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical approval The present study was approved by the ethical committee of Tehran University of Medical Sciences.

Informed consent All participants filled out informed consent at the beginning of the study.

References

1. Mahan L, Kathleen Raymond LJ (2017) Krause's food & the nutrition care process, 14th edn. Chap 17
2. Jalali AK, Motlagh AD, Abdollahi Z, Movahedi A, Minaie M, Abbasi B (2019) A report of health related anthropometric indices in 2–5 years old children of golestan Province of Iran in 2015. Clin Nutr Res 8(2):119–128. https://doi.org/10.7762/cnr.2019.8.2.119
3. Antonisamy B, Vasan SK, Geethanjali FS, Gowri M, Hepsy YS, Richard J et al (2017) Weight gain and height growth during infancy, childhood, and adolescence as predictors of adult cardiovascular risk. J Pediatr 180(53–61):e3. https://doi.org/10.1016/j.jpeds.2016.09.059
4. Batte A, Lwabi P, Lubega S, Kiguli S, Otwombe K, Chimoyi L et al (2017) Wasting, underweight and stunting among children with congenital heart disease presenting at Mulago hospital, Uganda. BMC Pediatr 17(1):10. https://doi.org/10.1186/s12887-017-0779-y
5. Coleman-Jensen A, Nord M, Andrews M (2012) S. C. Household Food Security in the United States in 2011. Economic Research Service, US Department of Agriculture, Washington, DC
6. Taylor E, Foster J, Mobley A (2019) A qualitative investigation of body weight and weight loss-related attitudes of mothers and fathers in the context of food insecurity. Eat Weight Disord. https://doi.org/10.1007/s40519-019-00804-7
7. Daneshzad E, Yavari P, Rahimi-Foroshani A, Dorosty-Motlagh A, Nadjarzadeh A (2015) L. Y. Food insecurity, socio-economic status, and educational achievement: a cross-sectional study in high school girls, Noshahr, Iran. J Nutr Sci Diet 1(3):141–148
8. Behzadifar M, Behzadifar M, Abdi S, Malekzadeh R, Arab Salmani M, Ghoreishinia G et al (2016) Prevalence of food insecurity in iran: a systematic review and meta-analysis. Arch Iran Med 19(4):288–294
9. FAO (1996) The state of food and agriculture. Food and Agriculture Organization of the United Nations, Rome
10. Kaur J, Lamb MM, Ogden CL (2015) The Association between Food insecurity and obesity in children-the national health and

nutrition examination survey. J Acad Nutr Diet 115(5):751–758. https://doi.org/10.1016/j.jand.2015.01.003
11. (2009) M N. Food Insecurity in Households with Children: Prevalence, Severity, and Household Characteristics. Economic Research Service, US Department of Agriculture, Washington, DC
12. Ali Naser I, Jalil R, Wan Muda WM, Wan Nik WS, Mohd Shariff Z, Abdullah MR (2014) Association between household food insecurity and nutritional outcomes among children in Northeastern of Peninsular Malaysia. Nutr Res Pract 8(3):304–311. https://doi.org/10.4162/nrp.2014.8.3.304
13. UNICEF (1990) Strategy for improved nutrition of children and women in developing countries. UNICEF, New York
14. Garcia AH, Franco OH, Voortman T, de Jonge EA, Gordillo NG, Jaddoe VW et al (2015) Dietary acid load in early life and bone health in childhood: the Generation R Study. Am J Clin Nutr 102(6):1595–1603. https://doi.org/10.3945/ajcn.115.112821
15. Han E, Kim G, Hong N, Lee YH, Kim DW, Shin HJ et al (2016) Association between dietary acid load and the risk of cardiovascular disease: nationwide surveys (KNHANES 2008–2011). Cardiovasc Diabetol 15(1):122. https://doi.org/10.1186/s12933-016-0436-z
16. Kiefte-de Jong JC, Li Y, Chen M, Curhan GC, Mattei J, Malik VS et al (2017) Diet-dependent acid load and type 2 diabetes: pooled results from three prospective cohort studies. Diabetologia 60(2):270–279. https://doi.org/10.1007/s00125-016-4153-7
17. Krupp D, Shi L, Maser-Gluth C, Pietzarka M, Remer T (2013) 11beta Hydroxysteroid dehydrogenase type 2 and dietary acid load are independently associated with blood pressure in healthy children and adolescents. Am J Clin Nutr 97(3):612–620. https://doi.org/10.3945/ajcn.112.047829
18. Zhou X, Xue H, Duan R, Liu Y, Zhang L, Harvey L et al (2015) The cross-sectional association of energy intake and dietary energy density with body composition of children in Southwest China. Nutrients 7(7):5396–5412. https://doi.org/10.3390/nu7075228
19. Howarth NC, Murphy SP, Wilkens LR, Hankin JH, Kolonel LN (2006) Dietary energy density is associated with overweight status among 5 ethnic groups in the multiethnic cohort study. J Nutr 136(8):2243–2248. https://doi.org/10.1093/jn/136.8.2243
20. Ledikwe JH, Blanck HM, Kettel Khan L, Serdula MK, Seymour JD, Tohill BC et al (2006) Dietary energy density is associated with energy intake and weight status in US adults. Am J Clin Nutr 83(6):1362–1368. https://doi.org/10.1093/ajcn/83.6.1362
21. O'Connor L, Walton J, Flynn A (2013) Dietary energy density and its association with the nutritional quality of the diet of children and teenagers. J Nutr Sci 2:e10. https://doi.org/10.1017/jns.2013.8
22. Vernarelli JA, Mitchell DC, Hartman TJ, Rolls BJ (2011) Dietary energy density is associated with body weight status and vegetable intake in U.S. children. J Nutr 141(12):2204–2210. https://doi.org/10.3945/jn.111.146092
23. Darmon N, Briend A, Drewnowski A (2004) Energy-dense diets are associated with lower diet costs: a community study of French adults. Public Health Nutr 7(1):21–27. https://doi.org/10.1079/phn2003512
24. Drewnowski A, Specter SE (2004) Poverty and obesity: the role of energy density and energy costs. Am J Clin Nutr 79(1):6–16. https://doi.org/10.1093/ajcn/79.1.6
25. Hakim S, Dorosty AR, Eshraghian M (2010) Association of food insecurity and household socio-economic status with the body mass index among urban women in Dezful. SJSPH 8(2):55–66
26. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ et al (2000) Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 32(9 Suppl):S498–504. https://doi.org/10.1097/00005768-200009001-00009
27. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J (2007) Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 85(9):660–667. https://doi.org/10.2471/blt.07.043497
28. Azadbakht L, Esmaillzadeh A (2009) Red meat intake is associated with metabolic syndrome and the plasma C-reactive protein concentration in women. J Nutr 139(2):335–339. https://doi.org/10.3945/jn.108.096297
29. Ghaffarpour M, Houshiar-Rad AHK (1999) The manual for household measures, cooking yields factors and edible portion of food. Keshaverzi Press, Tehran
30. Remer T, Manz F (1994) Estimation of the renal net acid excretion by adults consuming diets containing variable amounts of protein. Am J Clin Nutr 59(6):1356–1361. https://doi.org/10.1093/ajcn/59.6.1356
31. Kant AK, Graubard BI (2005) Energy density of diets reported by American adults: association with food group intake, nutrient intake, and body weight. Int J Obes (Lond) 29(8):950–956. https://doi.org/10.1038/sj.ijo.0802980
32. Ledikwe JH, Blanck HM, Khan LK, Serdula MK, Seymour JD, Tohill BC et al (2005) Dietary energy density determined by eight calculation methods in a nationally representative United States population. J Nutr 135(2):273–278. https://doi.org/10.1093/jn/135.2.273
33. Moradi M, Maracy MR, Esmaillzadeh A, Surkan PJ, Azadbakht L (2018) Associations between dietary energy density in mothers and growth of breastfeeding infants during the first 4 months of life. J Am Coll Nutr 31:1–7. https://doi.org/10.1080/07315724.2018.1465486
34. Gomez-Bruton A, Arenaza L, Medrano M, Mora-Gonzalez J, Cadenas-Sanchez C, Migueles JH et al (2019) Associations of dietary energy density with body composition and cardiometabolic risk in children with overweight and obesity: role of energy density calculations, under-reporting energy intake and physical activity. Br J Nutr 121(9):1057–1068. https://doi.org/10.1017/S0007114519000278
35. Donin AS, Nightingale CM, Owen CG, Rudnicka AR, Jebb SA, Ambrosini GL et al (2014) Dietary energy intake is associated with type 2 diabetes risk markers in children. Diabetes Care 37(1):116–123. https://doi.org/10.2337/dc13-1263
36. Daneshzad E, Ghorabi S, Hasani H, Omidian M, Jane Pritzl T, Yavari P (2019) Food insecurity is positively related to dietary inflammatory index in Iranian high school girls. Int J Vitam Nutr Res 16:1–7. https://doi.org/10.1024/0300-9831/a000572
37. Gurzkowska B, Kulaga Z, Litwin M, Grajda A, Swiader A, Kulaga K et al (2014) The relationship between selected socioeconomic factors and basic anthropometric parameters of school-aged children and adolescents in Poland. Eur J Pediatr 173(1):45–52. https://doi.org/10.1007/s00431-013-2109-1
38. Di Cesare M, Bhatti Z, Soofi SB, Fortunato L, Ezzati M, Bhutta ZA (2015) Geographical and socioeconomic inequalities in women and children's nutritional status in Pakistan in 2011: an analysis of data from a nationally representative survey. Lancet Glob Health 3(4):e229–e239. https://doi.org/10.1016/S2214-109X(15)70001-X
39. Milad D-M, Ahmad RDM, Seyyed MH, Kazem Z, Arvin K, Mahjoubeh S et al (2013) Food insecurity and some associated socioeconomic factors among upper gastrointestinal cancer patients. Int Res J Appl Basic Sci 4(2):482–486
40. South AM, Palakshappa D, Brown CL (2019) Relationship between food insecurity and high blood pressure in a national sample of children and adolescents. Pediatr Nephrol. https://doi.org/10.1007/s00467-019-04253-3
41. Shankar P, Chung R, Frank DA (2017) Association of food insecurity with children's behavioral, emotional, and academic outcomes: a systematic review. J Dev Behav Pediatr

38(2):135–150. https://doi.org/10.1097/DBP.0000000000000383
42. Ajami M, Abdollahi M, Salehi F, Oldewage-Theron W, Jamshidi-Naeini Y (2018) The association between household socioeconomic status, breastfeeding, and infants' anthropometric indices. Int J Prev Med 9:89. https://doi.org/10.4103/ijpvm.IJPVM_52_17
43. Middlemass KM, Cruz J, Gamboa A, Johnson C, Taylor B, Gomez F et al (2020) Food insecurity and dietary restraint in a diverse urban population. Eat Disord. https://doi.org/10.1080/10640266.2020.1723343
44. Lydecker J, Grilo C (2019) Food insecurity and bulimia nervosa in the United States. Int J Eat Disord. https://doi.org/10.1002/eat.23074
45. Joe W, Rajpal S, Kim R, Laxmaiah A, Harikumar R, Arlappa N et al (2019) Association between anthropometric-based and food-based nutritional failure among children: evidence from NNMB urban nutrition study 2015. India Matern child Nutr 15:e12830. https://doi.org/10.1111/mcn.12830