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Association of healthy eating index and anthropometric indices among primary school girls in southeast of Iran: a cross-sectional study

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Abstract

Background The school-age period is marked by substantial advancements in physical and cognitive development, highlighting the importance of assessing the diet quality and its impact on body weight and height. The main objective of this study was to evaluate the association between diet quality and selected anthropometric indices of primary school girls in southeast of Iran using the healthy eating index-2015 (HEI-2015).

Methods This cross-sectional study involved 330 students aged 6–12 years from 10 primary schools in Kerman City. Standard protocols and a dish-based food frequency questionnaire were employed to evaluate anthropometric indices and dietary intake. The HEI-2015 was utilized to assess the quality of participants' diets, with a total score ranging from zero to 100, based on thirteen food score components.

Results In the present study, older participants had higher HEI scores ($p = 0.02$). Additionally, participants in the highest tertile of HEI score had greaterodds of being overweight (OR: 2.13; CI = 1.17–3.85, $P = 0.011$) and had higher intakes of whole fruits, total fruits including fruit juice, whole grains, total protein foods, seafood and plant proteins, greens, and beans ($p < 0.05$). However, no significant association was found between HEI score and other anthropometric indices, obesity, and thinness.

Conclusions The study found no significant association between HEI scores and the likelihood of being thin or obese. However, children with the highest HEI scores were more likely to beoverweight. Therefore, it is recommended to implement health programs for primary school girls in Kerman to improve their eating habits and reduce the risk of overweight and obesity.

Keywords Anthropometric indices, Healthy eating index, Kerman, Overweight, Obesity, Thinness

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Background

Childhood is a critical period for the development of the mind and body. Assessing child growth is crucial for community health and nutritional well-being [1]. Approxiamtely 33% of children worldwide suffer from malnutrition [2]. In Iran, the prevalence of malnutrition, as measured by weight-for-age, height-for-age, and weight-for-height indices, was found to be 46.6%, 36.9%, and 53.3%, respectively [3]. Malnutrition in children can lead to growth failure, death, and disease due to inadequate or unsuitable food consumption [4, 5]. Therefore, evaluating children's dietary intake is essential.

Assessing the quality of dietary intake, rather than just quantity, is important for a comprehensive evaluation of an individual's food and beverage consumption. Poor diet quality can significantly affect mental and physical well-being, leading to conditions such as stunting, obesity, and cardiovascular disease [6]. Diet quality assessment is complex, as determining the quality based on just one nutrient or a single day's food consumption is not a reliable indicator of the overall diet quality.

Various dietary indices have been developed to assess diet quality. The healthy eating index (HEI) is designed to evaluate diet quality by comparing it to the recommendations of Dietary Guidelines for Americans [7, 8]. It comprises 13 components representing different food groups for individuals aged two years and older and can predict the risk of various health consequences [9].

Recent evidence shows that food insecurity rates among healthy individuals in Iran are higher than the global average [10]. Those who experience food insecurity tend to have lower diet quality compared to those who do not face food insecurity [11].Additionally, Kerman, a province in southeast of Iran,is among the seven provinces facing food insecurity [12].Therefore, evaluating the diet quality of children is of great importance. The current study aimed to determine the overall diet quality using HEI scores and investigate the association between HEI scores and anthropometric measures among female students in Kerman. This research is crucial for understanding and addressing the dietary needs of children in this region.

Method

Study design and population

This cross-sectional study collected data from 330 female primary school students aged 6 to 12, from ten girls-only schools in Kerman, Iran, between January and March 2022. Data were collected by a trained nutritionist. Quality control procedures, including regular checks for data completeness and accuracy, were implemented to minimize errors in data collection. Kerman, the capital of Kerman province, has a population of approximately 3 million. The necessary sample size was determined using the mean and standard deviation of BMI from a previous study on Iranian children aged 7–11 (Mean (±SD) = 16.0 ± 2.9 kg/m^2) [13]. Using the formula: n= [(z1 -α/2) ^{2} ×s^2] / d^2 with d = 2% and alpha = 0.05, a sample size of 323 was calculated and subsequently increased to 330 for added reliability. The study was designed with 80% power. We used the cluster random sampling method to select the cases. The study protocol received approval from the Ethical Committee of the Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1400.603). All methods were carried out in accordance with relevant guidelines and regulations or declaration of Helsinki.

Inclusion and exclusion criteria

The present study recruited participants based on the following inclusion criteria:

(1) Voluntary participation, as indicated by the completion of a consent form, (2) Age eligibility within 6 to 12 years, (3) No chronic diseases such as diabetes, congenital metabolic disorders including maple syrup urine disease, phenylketonuria, thyroid gland anomalies, epilepsy, and asthma, and (4) Absence of corticosteroids, thyroid medications, diabetes medications, epilepsy medications, or allergy medications usage.

The study sample was limited to exclude children whose parents refrained from completing the informed consent.

Assessment of dietary intake

A dish-based food-frequency questionnaire (FFQ) designed for the Kerman population, along with standardized serving portions, was used to assess dietary consumption patterns over a year. This assessment was conducted by the participant's parents. The FFQ comprised 185 individual food items. The validity and reliability of this FFQ are reported in section "Reliability and reproducibility of food frequency questionnaire". Under standardized methodology, the frequency and portion size of all food items were converted into grams per day (g/day). NUTRITIONIST-IV software, adapted for Iranian food composition, quantified energy and nutrient content.

Healthy eating index 2015

Evaluating of the diet quality of participants was conducted using the HEI scores. The HEI comprises 13 components divided into two subgroups: adequacy and moderation. Nine factors for nutritional adequacy included consumption of fruits (total and whole), vegetables (greens and beans), whole grains, dairy products, protein-rich foods (animal and vegetable-based), seafood, and healthy fatty acids. Moderation elements included processed grains, salt, added sugars, and saturated fats. In terms of adequacy components, the highest possible score for various food groups, such as fruits (both the total and whole), vegetables (both total and greens/beans), and protein (both total and subdivided categories of seafood and plant-based), was five points. Non-consumption of any of these food items resulted in a score of zero.

Similarly, a score of up to 10 points was attainable for whole grains, dairy, and fatty acids. The score for consuming fatty acids (consisting of polyunsaturated and monounsaturated fatty acids compared to saturated fatty acids) is zero if not consumed. A rating of 10 was assigned to moderation elements when refined grains, sodium, added sugars, and saturated fats were consumed within the recommended limits, while reaching the upper consumption limit was attributed a score of zero. The overall HEI-2015 score was determined by adding scores of these components, resulting in a score range of zero to 100 [9].

Anthropometric measurements

Anthropometric measurements comprising height, body weight, and mid-arm circumference were measured for all children. Measurements are carried out to ensure reliability and validity by using standardized protocols and tools (CDC protocol attached as supplementary file). The person who did the measurements underwent training to ensure consistency in measurement techniques. Height was measured following established protocols, utilizing a stationary measuring instrument and positioned against a wall, with measurements taken to the nearest 0.1 cm. Participants' body weight was assessed through a digital scale providing a precision of 0.1 kg. Participants wore minimal clothing without shoes during their body weight measurement. We evaluated mid-arm circumference via the precise measurement of the circumferential extent at the midpoint between the elbow and the shoulder, with a degree of precision of 0.1 mm. The body mass index (BMI) was computed through the division of the individual's body weight in kilograms (kg) by the square of their height in meters (m), represented as kg/m^2.

The criteria established by the World Health Organization [20] applied for calculating z-scores for BMI-for-age (BAZ), height-for-age (HAZ), and weight-for-age (WAZ). BAZ were classified according to their weight status, which included obese ($BAZ \geq 2$ SD), overweight ($1\ SD \leq BAZ < 2\ SD$), thin ($-3\ SD < BAZ \leq -2\ SD$), and severely thin ($BAZ \leq -3$ SD). HAZ categories can be classified as stunted ($-3\ SD < HAZ \leq -2\ SD$) and severely stunted ($HAZ \leq -3$ SD) [14].

Demographic and socio-economic status

A valid and reliable questionnaire was applied to evaluate demographic and socioeconomic status (SES) among the Iranian participants to examine correlation between SES and health outcomes [15]. Questions of the education and employment status of parents, household size, property ownership or rental status, possession of vehicles including the number of cars, the number of bedrooms in the dwelling, and ownership of various appliances such as washing machine, dishwasher, LCD TV, side-by-side refrigerator, air conditioner, vacuum cleaner, computer, laptop, and advanced heating system were incorporated into the survey instrument [15]. The scoring method was employed to evaluate socioeconomic status. Finally, the codes were summated and classified into three categories based on the qualitative description: weak, moderate, and rich.

Supplement intake and age of participants were recorded in a general questionnaire. The short form of the International Physical Activity Questionnaire (IPAQ) evaluated participants' physical activity (PA) [16]. The scores were computed based on the frequency and duration of light, moderate, and vigorous physical activities and sedentary episodes over the preceding seven-day period. The quantification of PA is typically conveyed through the expression of metabolic equivalent hours per week. The PA level stratified according to three categories: low physical activity, defined as less than 600 METs-minutes per week; moderate physical activity, ranging between 600 and 3,000 METs-minutes per week; and high physical activity, exceeding 3,000 METs-minutes per week [17].

Reliability and reproducibility of food frequency questionnaire

In this study, we assessed the reproducibility of the questionnaire by having 56 parents complete it twice, 12 weeks apart. The intra-class correlation coefficient was applied to measure the reproducibility. Additionally, three 24-hour recalls were collected during the study to assess validity. Pearson correlations and the Wilcoxon signed-rank test evaluated the validity. The strength of the relationship for data validity was interpreted using specific correlation rating interpretations. For Pearson statistics, a correlation of 0.10 to 0.30 was considered weak, 0.30 to 0.50 was moderate, and above 0.50 was strong. An ICC value of 0.00 to 0.10 indicated virtually no relationship, 0.11 to 0.40, 0.41 to 0.60, 0.61 to 0.80, and 0.81 to 1.0 indicated a slight, fair, moderate, and substantial relationship, respectively.

Statistical analysis

Histogram curves and Kolmogorov-Smirnov test examined the normal distribution of variables. In order to compare qualitative variables across tertiles of the Healthy Eating Index (HEI), the chi-square analysis was employed. Similarly, an analysis of variance (ANOVA) test was applied to compare quantitative variables across the HEI tertiles. An analysis of covariance (ANCOVA) evaluated the relationship between dietary consumption and anthropometric measurements across the Healthy Eating Index (HEI) tertiles. Three statistical models were applied in the study, namely: Model 1 (a crude model), Model 2 (adjusted for age and energy), and Model 3 (adjusted for age, energy, supplement use, parent smoking, physical activity, and socioeconomic status). A multiple logistic regression was applied to investigate the potential relationship between diet quality and various anthropometric indicators, including obesity, overweight, and underweight. The variance inflation factor (VIF) values for all independent variables in our regression model are below 5, indicating no significant multicollinearity concerns. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 24. A p-value of less than 0.05 was considered significant.

Results

Sociodemographic characteristics of study participants

Table 1 presents the demographic characteristics of the participants. The average age of participants was 9.02±1.81 years. A significant association was found between age and HEI tertile (p=0.02). However, no association was observed between other demographic characteristics and HEI. The rate of supplement use was 18.2%. 91.2% of participants have a low level of physical activity.

HEI scores and dietary intake

Dietary intake of the children is shown in Table 2. Participants in the higher tertile of HEI scores had a greater intake of fiber (P<0.001), PUFA (P=0.012), vitamin K (P=0.008), vitamin B3 (P=0.014), vitamin B9 (P=0.042), iron (P<0.001), whole fruit (P<0.001), total fruit (P<0.001), whole grain (P<0.001), total protein food (P=0.005), seafood and plant protein (P<0.001), greens and beans (P=0.003) and a significantly lower intake of SFA (P<0.001) and added sugar (P=0.021).

Association between HEI and anthropometric indices

Table 3 shows the reported mean±SD (SE) for the association between HEI and anthropometric indices. No significant association was found between HEI score and anthropometric indices.

Odds ratio and 95% confidence interval for weight disorders in tertiles of HEI

The findings from the multiple logistic regression analysis are presented in Table 4. Initially, a crude model indicated that individuals in the highest tertile of HEI score were more likely to be classified as overweight compared to those in the lowest tertile (OR: 2.13; CI=1.17–3.85, P=0.011). This association remained significant after adjustment for age and energy (OR:2.08; CI=1.13–3.84, p=0.022), parent education, parent occupation, supplement use, parent smoking, physical activity, and SES (OR:1.95; CI=0.91–4.20, p=0.019).

Validity and reliability of food frequency questionnaire

Table 5 represents the results concerning the reliability and reproducibility of the food frequency questionnaire. The findings indicated that the newly developed FFQ is both reliable and valid. The correlation coefficients between dietary intake estimates obtained from the FFQ and 24-hour dietary recalls were 0.52 for carbohydrates, 0.54 for proteins, and 0.51 for fat. Additionally, the Wilcoxon signed-rank test showed no significant differences between the FFQ and 3-day dietary records for most nutrients (p>0.05). The intra-class correlation coefficients, used to measure the consistency of the FFQ, ranged from 0.54 to 0.77. Overall, this FFQ is considered a suitable tool for assessing dietary intake in specific age groups.

Discussion

The current study was conducted to evaluate the association between HEI and anthropometric status in primary school girls in Kerman. The results showed that children with higher HEI scores were more likely to be overweight than those with lower HEI scores. However, there were no significant associations between overall diet quality and other anthropometric indices. To the best of our knowledge, this is the first study to evaluate HEI in children aged 6–12 years old in Kerman.

Our study indicates a significant association between HEI score and the odds of being overweight. Similar findings were reported by Askari et al., who found that HEI was positively associated with the odds of being overweight in a cross-sectional study of 788 six-year-old Iranian children [6]. Also, in another cross-sectional study on Turkish adults, a positive association was found between HEI and BMI [18]. However, in contrast with our findings, Sundararajan et al. reported an inverse association between HEI and BMI in Canadian adults [19]. A systematic review indicated an inverse association between HEI and weight gain [20]. On the other hand, Azadbakht et al. found no significant association between HEI score and BMI of female students (n 265) aged 11–13 years [21]. Hurley et al. conducted a cross-sectional study and found no correlation between weight status in school-aged children and their adherence to the youth healthy eating index [22]. Moreover, Manios et al. demonstrated in a cohort study on 2,518 children aged 1 to 5 years that BMI status was not associated with HEI score [23].

Table 1 Characteristics of participants (primary school girls in Kerman) in tertiles of Healthy Eating Index-2015

Healthy Eating Index-2015 tertiles						
Variable		**All** *N* = 330	**Tertile 1** ≤ 57 *N* = 133	**Tertile 2** > 57 < 60 *N* = 69	**Tertile 3** ≥60 *N* = 128	***P* value**
		Quantitative variables*/ mean ± SD				
Age (year)		9.02(1.81)	8.85(1.85)	8.74(1.72)	9.35(1.77)	0.028
Weight (kg)		33.81(13.03)	32.96(13.31)	31.55(10.67)	35.90(13.68)	0.051
Height (cm)		136.68(13.56)	136.10(14.21)	134.05(12.64)	138.69(13.15)	0.059
BMI (kg/m2)		17.49(3.93)	17.15(3.94)	17.11(3.38)	18.03(4.15)	0.132
MUAC (cm)		21.97(3.72)	21.75(3.70)	21.36(3.51)	22.53(3.80)	0.075
Physical activity (met/min/week)		193.87(428.30)	160.79(327.49)	240.56(513.30)	203.07(469.32)	0.435
		Qualitative variables† /N (%)				
Grade	1st	17.6%	28(8.5%)	13(3.9%)	17(5.2%)	0.233
	2nd	15.5%	22(6.7%)	12(3.6%)	17(5.2%)	
	3rd	16.7%	24(7.3%)	13(3.9%)	18(5.5%)	
	4th	16.1%	17(5.2%)	11(3.3%)	25(7.6%)	
	5th	17.3%	24(7.3%)	13(3.9%)	20(6.1%)	
	6th	17.0%	18(5.5%)	7(2.1%)	31(9.4%)	
Socioeconomic status	Low	56.4%	67(20.3%)	48(14.5%)	71(21.5%)	0.087
	Medium	41.5%	64(19.4%)	19(5.8%)	54(16.4%)	
	High	2.1%	2(0.6%)	2(0.6%)	3(0.9%)	
Supplement	Yes	18.2%	27(8.2%)	10(3.0%)	23(7.0%)	0.596
	No	81.8%	106(32.1%)	59(17.9%)	105(31.8%)	
Parents smoking	Yes	11.5%	18(5.5%)	6(1.8%)	14(4.2%)	0.573
	No	88.5%	115(34.8%)	63(19.1%)	114(34.5%)	
Physical activity	Low	91.2%	124(37.6%)	60(18.2%)	117(35.5%)	0.407
	Medium	8.5%	9(2.7%)	9(2.7%)	10(3.0%)	
	High	0.3%	0(0.0%)	0(0.0%)	1(0.3%)	
Father's education	High school	17.9%	25(7.6%)	13(3.9%)	21(6.4%)	0.889
	Diploma	49.1%	64(19.4%)	31(9.4%)	67(20.3%)	
	College	33.0%	44(13.3%)	25(7.6%)	40(12.1%)	
Mother's education	High school	13.0%	18(5.5%)	10(3.0%)	15(4.5%)	0.639
	Diploma	53.3%	68(20.6%)	33(10.0%)	75(22.7%)	
	College	33.6%	47(14.2%)	26(7.9%)	38(11.5%)	
Family member	4 or less	69.1%	92(27.9%)	54(16.4%)	82(24.8%)	0.072
	5 to 7	29.1%	41(12.4%)	13(3.9%)	42(12.7%)	
	More than 7	1.8%	0(0.0%)	2(0.6%)	4(1.2%)	
Father's occupation	Manager	2.4%	1(0.3%)	1(0.3%)	6(1.8%)	0.106
	Employee	28.2%	38(11.5%)	23(7.0%)	32(9.7%)	
	Worker	9.1%	7(2.1%)	10(3.0%)	13(3.9%)	
	Housewife	0.3%	0(0.0%)	0(0.0%)	1(0.3%)	
	Retired	0.9%	1(0.3%)	0(0.0%)	2(0.6%)	
	Self-employment	57.3%	82(24.8%)	33(10.0%)	74(22.4%)	
	Others	1.8%	4(1.2%)	2(0.6%)	0(0.0%)	
Mother's occupation	Manager	0.6%	0(0.0%)	1(0.3%)	1(0.3%)	0.724
	Employee	9.4%	12(3.6%)	8(2.4%)	11(3.3%)	
	Worker	0.3%	1(0.3%)	0(0.0%)	0(0.0%)	
	Housewife	80.3%	104(31.5%)	54(16.4%)	107(32.4%)	
	Retired	0.3%	0(0.0%)	0(0.0%)	1(0.3%)	
	Self-employment	7.3%	13(3.9%)	4(1.2%)	7(2.1%)	
	Others	1.8%	3(0.9%)	2(0.6%)	1(0.3%)	

*The *P* value reported for the quantitative variables was resulted from one-way ANOVA, and the numbers are reported as mean ± SD. †The *P* value for the qualitative variables was calculated by the chi-square test, and the results are based on N (%). *P* value < 0.05 shows a significant level of association

The contradictory results might be attributed to variations in study design, populations, and dietary intake assessment tools. The age of participants significantly affects the results, as children in this particular age range have different eating habits and more control over their food choices. They might consume sugar-sweetened beverages, snacks, fast food, or other energy-dense food items related to weight gain but not considered in the HEI. The different eating habits in diverse populations should also be considered, especially since most diet

Table 2 Dietary intake of participants (primary school girls in Kerman) in tertiles of Healthy Eating Index

Healthy Eating Index-2015 tertiles				
Variable	**Tertile 1** **≤ 57** ***N* = 133**	**Tertile 2** **> 57** **< 60** ***N* = 69**	**Tertile 3** **≥60** ***N* = 128**	***P* value**
Energy (kcal/d)	1887.88(725.66)	1788.00(532.27)	1830.93(589.92)	0.545
Carbohydrate (g/d)	259.43(2.34)	263.07(3.26)	264.66(2.39)	0.285
Protein (g/d)	63.17(0.62)	62.79(0.87)	64.02(0.64)	0.461
Fat (g/d)	65.20(0.92)	64.17(1.27)	62.70(0.93)	0.163
fiber (g/d)	13.33(0.20)	14.32(0.28)	14.91(0.21)	0.0001
Cholesterol (mg/d)	262.37(5.61)	266.70(7.78)	258.12(5.71)	0.664
SFA (g/d)	23.34(0.53)	21.38(0.74)	19.76(0.54)	0.0001
MUFA (g/d)	19.68(0.27)	19.41(0.38)	19.07(0.28)	0.308
PUFA (g/d)	13.36(0.25)	14.41(0.35)	14.35(0.26)	0.012
Vitamin A	736.73(39.82)	731.64(55.29)	761.90(40.56)	0.872
Vitamin D (μg)	1.35(0.08)	1.36(0.12)	1.53(0.09)	0.298
Vitamin E (mg)	11.48(0.24)	11.71(0.34)	11.98(0.25)	0.365
Vitamin K (mg)	160.06(3.96)	159.39(5.49)	176.03(4.03)	0.008
Thiamine (mg)	1.61(0.02)	1.57(0.03)	1.66(0.02)	0.061
Riboflavin (mg)	1.50(0.02)	1.49(0.03)	1.47(0.02)	0.658
Niacin (mg)	16.00(0.16)	15.85(0.22)	16.57(0.16)	0.014
Vitamin B5 (mg)	5.01(0.06)	5.11(0.09)	5.04(0.06)	0.674
Vitamin B6 (mg)	1.46(0.03)	1.48(0.04)	1.53(0.03)	0.324
Folic acid (μg)	207.56(3.68)	211.22(5.11)	220.64(3.75)	0.042
Vitamin B12 (μg)	3.43(0.07)	3.28(0.09)	3.21(0.07)	0.085
Vitamin C (mg)	92.36(3.64)	98.91(5.06)	102.02(3.71)	0.172
Calcium (mg)	761.88(18.50)	749.45(25.69)	734.28(18.85)	0.579
Magnesium (mg)	215.90(2.64)	220.00(3.42)	220.45(2.51)	0.386
Potassium (mg)	2754.29(36.23)	2859.30(50.30)	2834.49(36.90)	0.155
Zinc (mg)	8.25(0.10)	8.12(0.14)	7.97(0.10)	0.147
Fe (mg)	13.05(0.15)	13.62(0.21)	14.29(0.16)	0.0001
Phosphorus (mg)	1068.00(14.73)	1084.78(20.45)	1069.82(15.01)	0.785
Selenium (mg)	0.10(0.002)	0.10(0.003)	0.10(0.002)	0.847
Whole fruits (cup/d)	1.66(0.06)	2.14(0.09)	2.00(0.06)	0.0001
Total fruits (cup/d)	1.82(0.07)	2.34(0.09)	2.22(0.07)	0.0001
Whole grains (ounce/d)	0.47(0.06)	0.70(0.09)	1.24(0.06)	0.0001
Dairy (cup/d)	1.65(0.06)	1.62(0.09)	1.63(0.06)	0.963
Total protein foods (ounce/d)	6.03(0.12)	6.22(0.17)	6.61(0.12)	0.005
Seafood & plant proteins (ounce/d)	1.78(0.05)	1.84(0.07)	2.10(0.05)	0.0001
Greens & beans (cup/d)	0.37(0.01)	0.39(0.02)	0.44(0.01)	0.003
Total vegetables (cup/d)	2.26(0.04)	2.33(0.06)	2.39(0.04)	0.150
Refined grains (ounce/d)	11.83(0.32)	10.86(0.43)	10.89(0.32)	0.072
Sodium (mg/d)	1149.44(20.52)	1154.89(28.49)	1135.23(20.90)	0.825
Added sugars (g/d)	22.96(1.01)	21.51(1.41)	18.94(1.03)	0.021

SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids. The *P* value is reported from covariance analysis, and the results are based on mean ± SD. All of the variables are adjusted for energy intake. *P* value < 0.05 shows a significant level of association

quality assessment tools like Healthy Eating Index (HEI), Diet Quality Index (DQI), and Dietary Guidelines for Americans Adherence Index (DGAI) are designed for the US population.

Our research shows no significant association between the HEI score and anthropometric indices. Similar to our study, several studies did not show significant association between HEI score and anthropometric status [21–23]. However, some studies found a significant relationship between HEI scores and anthropometric indicators [18, 19, 24]. The lack of significant association in our study could be due to various reasons. Firstly, it could be due to the study's cross-sectional design limited our ability to detect long-term energy imbalances. Secondly, the lack of association we observed may also be due to under or over-reporting of food intake by parents or guardians, who may need to be made aware of their child's total food intake or changes in eating behavior. Lastly, the HEI scoring method treats all adequately consumed foods equally, even though different food groups may have varying impacts on anthropometric indices. For instance, processed foods and full-fat dairy are categorized as adequate components in the HEI but could contribute to increased weight status.

Our findings indicated that participants with higher HEI scores tend to have a higher intake of protein foods,

Table 3 Association between anthropometric indices and Healthy Eating Index score among primary school girls in Kerman

Healthy Eating Index-2015 tertiles					
Variable		**Tertile 1** **≤ 57** ***N* = 133**	**Tertile 2** **> 57** **< 60** ***N* = 69**	**Tertile 3** **≥60** ***N* = 128**	***P* value**
MUAC (cm)	Model 1*	21.75(3.70)	21.36(3.51)	22.53(3.80)	0.075
	Model 2†	21.87(0.25)	21.74(0.35)	22.20(0.26)	0.534
	Model 3†	21.85(0.26)	21.74(0.36)	22.22(0.26)	0.470
BAZ	Model 1*	0.06(1.43)	0.15(1.44)	0.32(1.48)	0.369
	Model 2†	0.06(0.11)	0.23(0.16)	0.28(0.12)	0.400
	Model 3†	0.05(0.11)	0.24(0.16)	0.28(0.12)	0.351
HAZ	Model 1*	0.66(1.31)	0.45(1.18)	0.58(1.15)	0.489
	Model 2†	0.64(0.10)	0.47(0.14)	0.59(0.10)	0.613
	Model 3†	0.64(0.10)	0.45(0.14)	0.61(0.10)	0.568
WAZ	Model 1*	0.27(1.24)	-1.86(16.96)	0.45(1.47)	0.200
	Model 2†	0.17(0.81)	-1.87(1.09)	0.57(0.86)	0.188
	Model 3†	0.10(0.83)	-1.90(1.12)	0.68(0.88)	0.182

*The model 1 was resulted from one-way ANOVA, and the numbers are reported as mean ± SD. †Model 2 and 3 was resulted from covariance analysis, and the numbers are re-ported as mean ± SE. *P* value < 0.05 shows a significant level of association. Model 1: crude. Model 2: Adjusted for age and calorie. Model 3: Adjusted for age, calorie, supplement use, parents' smoking, physical activity and socio-economic status. MUAC: mid-upper arm circumference, BAZ: BMI-for-age z-score, HAZ: height-for-age z score, WAZ: weight-for-age z-score

Table 4 Odd ratios and 95% confidence intervals for being thin, overweight or obese among different tertiles of Healthy Eating Index

Healthy Eating Index-2015 tertiles					
Variable		**Tertile 1** **≤ 57** ***N* = 133**	**Tertile 2** **> 57** **< 60** ***N* = 69**	**Tertile 3** **≥60** ***N* = 128**	**P trend**
Thin	Model 1	1	1.16(0.27–5.02)	1.70(0.54–5.36)	0.354
	Model 2	1	1.24(0.28–5.46)	1.72(0.53–5.54)	0.310
	Model 3	1	0.884(0.11–7.09)	4.63(0.74–28.78)	0.271
Overweight	Model 1	1	0.95(0.43–2.10)	2.13(1.17–3.85)	0.011
	Model 2	1	0.96(0.43–2.15)	2.08(1.13–3.84)	0.022
	Model 3	1	1.18(0.44–3.09)	1.95(0.91–4.20)	0.019
Obese	Model 1	1	1.09(0.45–2.62)	0.68(0.30–1.54)	0.378
	Model 2	1	1.13(0.46–2.75)	0.61(0.27–1.41)	0.257
	Model 3	1	1.79(0.58–5.50)	0.74(0.25–2.18)	0.260

Model 1: crude. Model 2: Adjusted for age and calorie. Model 3: Adjusted for age, calorie, supplement use, parents' smoking, physical activity and socio-economic status. *P* values were calculated using logistic regression. These values are odds ratios (95% CIs) by considering tertiles of HEI as ordinal variable

Table 5 Reproducibility and validation study: Correlation coefficient and Wilcoxon Signed Rank Test for validity and ICC for reproducibility

	FFQ	**3DR**	**Wilcoxon Signed Rank Test (p Value)**	**Correlation coefficient[2]**	**ICC[3]**
	Mean ± SD	**Mean ± SD**			
Carbohydrate	262.22(92.28)	235.75(84.97)	0.013	0.7	0.52
Protein	63.42(22.62)	58.75(20.94)	0.059	0.63	0.54
Fat	64.02(25.76)	60.28(24.58)	0.136	0.61	0.51
Calcium	748.58(335.10)	696.48(272.37)	0.434	0.54	0.59
Fe	13.65(5.01)	12.77(4.78)	0.016	0.75	0.74
Magnesium	218.52(76.82)	201.07(81.82)	0.013	0.65	0.6
Vitamin C	97.48(54.55)	95.75(62.34)	0.211	0.77	0.62
Vitamin A	777.25(503.65)	745.43(532.87)	0.915	0.68	0.7
Vegetables	170.65(87.34)	175.79(107.75)	0.866	0.59	0.75
Fruits	280.38(155.49)	284.13(170.27)	0.135	0.68	0.65
Meat and its products	89.56(41.06)	78.41(34.25)	0.124	0.68	0.75
Dairy products	394.29(224.29)	370.29(192.16)	0.541	0.89	0.62

[1] Wilcoxon signed-rank test were used to examine the difference between FFQ and 3DR with a significant p value < 0.001. [2]Pearson or Spearman correlation coefficient were used to assess the correlation between variables with a p-value < 0.05 considered as significant. [3]The intra-class coefficient for the comparison between FFQ1 and FFQ2. 3DR, dietary recall

fruits, vegetables, dairy, whole grains, and beans compared to participants with lower HEI scores. Previous studies indicates that consuming more whole grains, fruits, vegetables, and dairy products is associated with a decrease in anthropometric measurements [25, 26]. However, higher meat and beans intake have been associated with being overweight and obese [27, 28].

There are some strengths in the current study. First, the HEI-2015 was applied to investigate the association between diet quality and the odds of being overweight and obese in children in Iran for the first time. Second, a valid and reliable 185-item food frequency questionnaire was used in this study, which was specifically designed for participants that consumed local foods from Kerman City. Finally, the parents of the children were educated regarding healthy eating for eight weeks.

There are few limitations that should be described. The cross-sectional design of our study means that it cannot establish a definite cause-and-effect relationship. Also, it is critical to consider residual confounding variables that may impact the findings. Genetic diversity can serve as a potential source of residual confounding in epidemiological studies and is difficult to eliminate its effect entirely. While Iran has significant genetic diversity, Kerman has limited genetic heterogeneity. Finally, to address these few limitations, future studies should aim to investigate the relationship between HEI and anthropometric indices in primary school girls using a prospective design.

Conclusions

We conclude that HEI-2015 had a significant association with being overweight among6-12 years old primary school girls in Kerman, while no significant association was observed between HEI and other anthropometric indices. We recommend implementing health education and intervention programs in primary schools in Kerman to promote a healthier eating index and reduce the risk of overweight and obesity among girls aged 6–12. Further research should be conducted on other age and population groups with different dietary patterns to understand the association between HEI and anthropometric indices.

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Author contributions
NJ, LA, and MM designed the study; NJ collected and analyzed the data; NJ and LA interpreted the findings; NJ drafted the manuscript; and LA and MM revised the final manuscript. LA and MM supervised all the stage of study conduction. All authors read and approved the final manuscript.

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Data availability
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval and consent to participate
The Human Ethical Committee of Tehran University of Medical Science approved the study protocol (IR.TUMS.MEDICINE.REC.1400.603). Informed consent was obtained from all subjects' parents or their legal guardian(s).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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