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The association between Healthy Beverage Index and anthropometric measures among children: a cross-sectional study

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Abstract

Purpose Several studies evaluated the associations between specific beverages and cardio-metabolic risks among children. However, the evidence on the association between patterns of the beverage consumption and children's anthropometric indices is rare. Therefore, this study was conducted to examine the association between Healthy Beverage Index (HBI) and anthropometric measures among 6-year-old girl children.

Methods In this cross-sectional study, 788 children selected from health centers in Tehran, Iran. Data on beverage intake, socio-demographic, physical activity, and anthropometric characteristics were evaluated using reliable and validated standard protocols. The predefined HBI was calculated based on the previous research.

Results After controlling for several confounders [mother age, mother body mass index, mother physical activity, socioeconomic status, children physical activity and energy intake, total oils (all kinds of oils like animal and plant oils), and total sweet foods (sweet foods except sweetened beverages)], being in the third compared to the first tertile of HBI among children was associated with increased odds of wasting (OR: 5.16; 95% CI 1.5–17.79) and underweight/wasting (OR: 1.81; 95% CI 1.07–3.07). Among the HBI components, just being in the third compared to the first tertile of high-fat milk was inversely associated with decreased odds of wasting (OR: 0.18; 95% CI 0.04–0.73).

Conclusions The HBI among children was associated with higher odds of wasting and underweight/wasting. In addition, high-fat milk consumption decreased the odds of wasting among children. Further prospective studies need to confirm these results.

Level of evidence Level V, descriptive cross-sectional study.

Keywords Healthy beverage index · Children · Obesity · Underweight · Wasting

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Introduction

The World Health Organization (WHO) reported that childhood overweight and obesity are becoming more prevalent across the world and the worldwide prevalence of overweight/obesity in children living in developing countries is 12.9% for boys and 13.4% for girls [1]. According to a national study, in 2014, about 5.1 and 10.8 of Iranian children had overweight and obesity, respectively [2]. Childhood obesity has been shown to be a precursor to adult obesity, and subsequent adverse health outcomes (such as diabetes, cardiovascular diseases, dyslipidemia), disability, and even mortality [3, 4]. Therefore, this vital health issue requires immediate intervention. A combination of genetic, metabolic, and lifestyle factors are contributing to the etiology of obesity [5, 6]. Studies conducted in the Middle East regions reported that among all of the behavioral components, childhood obesity exhibited

significant associations with physical inactivity, consumption of breakfast, vegetables and sugar-sweetened beverage (SSB) [7].

To date, extensive research has been done on the association between individual beverage consumption, particularly sugar-sweetened beverages, with overweight/obesity [8–10]. However, few publications have examined the overall quality of daily beverage consumption within a broader context of evaluating all consumed beverages as a pattern [11, 12]. Therefore, the HBI has been introduced as a holistic concept to evaluate the quality of overall beverage intake and its association with health-related outcomes in nutritional epidemiological studies [13]. This index included eight beverage categories, total beverage energy, and fluid consumption [14]. The cumulative effects of multiple beverages included in a holistic dietary index may provide better identification as the effect of a single beverage may be too small to be detectable [15]. Moreover, the HBI may have important public health implications since it can be implemented as a counseling tool to improve healthy beverage selection [15].

Some of the previous reviews showed that SSB consumption was associated with weight gain, overweight, and obesity [16, 17]; however, evidence from well-conducted meta-analyses provided inconsistent results regarding the association between SSB and weight status [18–20]. Data on the association between milk intake and children's weight status are scarce and conflicting. While some studies have shown no association between milk intake with weight status and body fat mass [21], others have provided either an inverse [22, 23] or a positive association [24] in this regard. Some studies have shown a positive association between fruit juice consumption with adiposity gain [25] and short stature [26]. However, others have failed to provide an association between fruit juice consumption with over-weight [27], weight change [28], height [29] and anthropometric indices [26] among children. A previous publication has shown that both the amount and the types of beverages consumed can be influenced by heredity and environmental factors [30]. Beverages in Iran are commonly sweetened with sucrose, not high-fructose maize syrup as is the case in most western countries [31]. As high-fructose syrup in most beverages has been supposed to be a vital factor which might affect adiposity [32], findings from western studies might not be generalizable to other countries. Therefore, due to this geographical variation, our objective was to evaluate the association of the HBI with anthropometric measures among Iranian children.

Materials and methods

Study population

A total sample of 788 healthy children was recruited from those who attended public health centers in Southern Tehran, Iran. A cluster random sampling method was applied to select subjects who referred to ten health and treatment centers. Girls who were 6 years old who did not have the previous diagnosis of chronic or malignant diseases were eligible for inclusion in our study.

Dietary assessment and definition of HBI

Children's usual dietary intakes were gathered via a face-to-face interview with their mothers using a 168-item semi-quantitative food frequency questionnaire (FFQ). The reliability and validity of the FFQ have been documented in previous research. Mothers were asked to report children's portion sizes of consumed foods based on predefined categories (based on daily, weekly, or monthly frequency) during the preceding year. Household measures were then translated to grams. To compute average energy and nutrients intake, an adapted version of NUTRITIONIST IV that makes corrections for Iranian foods (version 7.0; N-Squared Computing, Salem, OR, USA) was used.

The HBI was calculated based on a method developed by Duffey and Davy [13]. Consumed beverages were grouped into eight categories including water, unsweetened coffee and tea, low-fat milk (< 1.5% fat, fat-free, and/or soy milk), diet drinks (including non-calorically sweetened coffee and tea and other artificially sweetened beverages), 100% fruit juice, alcohol (including beer, wine, and liquor), full-fat milk (1.5% fat), and sugar-sweetened beverages (including fruit drinks, sweetened coffee, and tea, soda) [13].

The final HBI score ranges between 0 and 100, with a higher value demonstrating better adherence to beverage guidelines and healthier beverage intake pattern [13]. However, as in the current study, diet drinks (ranging from 0 to 5 score) and alcohol (ranging from 0 to 5 score) were not consumed by our target population, the maximum final HBI score was 90. As the aim of the present study was to investigate adherence to healthy beverage intake guidelines, not total fluid consumption, liquids consumed as part of a food (such as soup) were not taken into account.

Anthropometric measurements

Anthropometric measures (body weight and height) were assessed and recorded by a trained assistant. Children's weight was measured using a portable digital scale (SECA

753E; Seca, Hamburg, Germany) while they were in light and minimal clothing. To record height, children were instructed to stand comfortably against a wall and to keep their shoulders in a normal position. The measurement precision of weight and height were 0.1 kg, and 0.5 cm, respectively. BMI was computed as the participant's body mass (kg) divided by stature squared (m2). Children were categorized into five groups based on their BMI for age (BAZ) using WHO cut-off point as follows: obese [BAZ ≥ 2 standard deviation (SD)], over-weight (BAZ ≥ 1SD), normal nutritional status (BAZ ≥ -1SD and < 1SD), underweight (BAZ < -1SD), and wasting (BAZ < -2SD) [33].

Socio-demographic and lifestyle variables

Applying a valid and reliable questionnaire, the socioeconomic status (SES) of each participant was estimated [34]. This scale allowed us to categorize participants according to answers they provided to several questions regarding occupation, academic attainment, vehicle ownership, owner occupancy, trendy household appliances, the number of people living in a single home, the number of rooms in the house, and domestic and international trips during the previous year. A demographic questionnaire with questions regarding mothers' age and weight was completed for each participant. Both children and their mothers were asked to provide the average amount of time they spent on various inside- and outside-home activities during a day. Then to determine the level of physical activity (PA) for each participant, the registered amount of time for different activities was multiplied by their corresponding metabolic equivalent task value (MET-h/wk), and the final values were summed [35].

Statistical analysis

Statistical analyses were performed using SPSS software (version 23, SPSS Inc., Chicago, IL, USA) and $p < 0.05$ was set as statistically significant. Kolmogorov–Smirnov test was used for checking the normality of the data. A comparison of the continuous variables across tertiles of the Healthy Beverage Index was performed using analysis of variance (ANOVA) test. The analysis of covariance (ANCOVA) was used for estimating energy-adjusted children's dietary intakes across tertiles of a Healthy Beverage Index. Multivariate logistic regression test was performed for assessing the associations between Healthy Beverage Index and its components and children anthropometric measures in three different models: crude model; model 1, adjusted for children's energy intake, children's physical activity, socioeconomic status; mother's age, mother's BMI and mother's physical activity; model 2, adjusted for model 1 plus total oils (all kinds of oils like animal and plant oils) and total sweet foods (sweet foods except sweetened beverages).

Results

Participants' characteristics across HBI are shown in Table 1. There was a significant association between BMI-for-age ($p = 0.04$) and HBI intake. The results for other variables were not significant.

Dietary intake of participants in each tertile of HBI are shown in Table 2. The dietary fat ($p < 0.001$), carbohydrate ($p < 0.001$), SFA ($p < 0.001$), total fiber ($p = 0.001$), some vitamins (A ($p < 0.001$), D ($p < 0.001$), K ($p = 0.001$), C ($p < 0.001$), B3 ($p < 0.001$), B9 ($p < 0.001$), and B12 ($p < 0.001$)), iron ($p < 0.001$), calcium ($p < 0.001$), magnesium ($p < 0.001$), and zinc ($p < 0.001$) decreased significantly across tertiles of HBI. In addition, participants in the highest tertile of HBI had significantly higher energy intake ($p < 0.001$).

Odds ratios (OR) and 95% confidence intervals (CI) for childhood wasting, underweight/wasting, obesity, and overweight/obesity are provided in Tables 3 and 4, respectively. After adjusting for several confounders in different models, participants in the highest compared to the lowest tertile of HBI had a higher risk of wasting (OR: 5.16; 95% CI

Table 1 Participants' characteristics according to different tertiles of healthy beverage index

| Variables | Tertiles of healthy beverage index | | | |
	Tertile 1 ($n = 277$)	Tertile 2 ($n = 249$)	Tertile 3 ($n = 262$)	P^a
Physical activity (MET/h)	9.47 (0.34)	9.51 (0.356)	9.50 (0.36)	0.32
Body mass index-for-age	0.44 (1.04)	0.44 (1.08)	0.22 (1.15)	0.04
Height-for-age	− 0.56 (0.43)	− 0.53 (0.42)	− 0.57 (0.42)	0.66
Socioeconomic status	32.32 (6.67)	31.82 (6.59)	31.44 (7.16)	0.31

Healthy Beverage Index consists of water, unsweetened coffee and tea, low-fat milk (< 1.5% fat, fat free, and/or soymilk), 100% fruit juice, full-fat milk (1.5% fat), and sugar-sweetened beverages (including fruit drinks, sweetened coffee, and tea, soda)

Data were presented as mean (SD)

[a]P values are from one-way analysis of variance (ANOVA)

Table 2 Energy-adjusted dietary intakes and tertiles of Healthy Beverage Index

Dietary intakes	Tertiles of Healthy Beverage Index			
	Tertile 1 ($n = 277$)	Tertile 2 ($n = 249$)	Tertile 3 ($n = 262$)	P^a
Total energy (Kcal/day)	970.36 (261.16)	1006.04 (260.32)	1069.95 (264.56)	< 0.001
Protein (g/day)	41.96 (3.07)	35.67 (3.21)	40.28 (3.16)	0.34
Fat (g/day)	38.32 (0.72)	32.23 (0.76)	30.59 (0.74)	< 0.001
Carbohydrate (g/day)	164.26 (2.92)	147.68 (3.06)	148.02 (3.00)	< 0.001
Saturated fatty acid (mg/day)	27.09 (0.51)	20.86 (0.54)	19.20 (0.53)	< 0.001
Total dietary fiber (mg/day)	19.76 (0.50)	17.49 (0.52)	17.33 (0.52)	0.001
Vitamin A (RAE/day)	1584.18 (56.20)	1257.01 (58.97)	1270.82 (57.92)	< 0.001
Vitamin D (µg/day)	2.30 (0.86)	1.46 (0.90)	1.14 (0.90)	< 0.001
Vitamin E (mg/day)	12.30 (0.35)	11.40 (0.37)	11.14 (0.36)	0.06
Vitamin K (µg/day)	155.73 (5.12)	130.90 (5.38)	132.95 (5.28)	0.001
Vitamin C (mg/day)	18.65 (0.32)	16.67 (0.34)	16.41 (0.33)	< 0.001
Vitamin B1 (µg/day)	0.78 (0.01)	0.78 (0.01)	0.79 (0.01)	0.21
Vitamin B2 (mg/day)	0.95 (0.01)	0.94 (0.01)	0.94 (0.01)	0.29
Vitamin B3 (mg/day)	25.21 (0.45)	21.86 (0.47)	22.38 (0.46)	< 0.001
Vitamin B6 (µg/day)	1.08 (0.14)	1.09 (0.15)	1.12 (0.15)	0.11
Vitamin B9 (µg/day)	367.78 (9.40)	299.30 (9.86)	296.57 (9.69)	< 0.001
Vitamin B12 (µg/day)	4.27 (0.09)	3.70 (0.09)	3.33 (0.09)	< 0.001
Iron (mg/day)	17.16 (0.21)	15.86 (0.22)	16.64 (0.22)	< 0.001
Magnesium (mg/day)	311.99 (5.71)	260.47 (5.99)	253.48 (5.90)	< 0.001
Zinc (mg/day)	8.99 (0.11)	8.20 (0.12)	8.11 (0.12)	< 0.001
Calcium (mg/day)	573.837 (8.91)	480.16 (9.35)	436.34 (9.19)	< 0.001

Healthy Beverage Index consist of water, unsweetened coffee and tea, low-fat milk (< 1.5% fat, fat free, and/or soymilk), 100% fruit juice, full-fat milk (1.5% fat), and sugar-sweetened beverages (including fruit drinks, sweetened coffee, and tea, soda)

Data are presented as mean (SE)

[a] P values are from the analysis of covariance (ANCOVA) (all the variables except energy were adjusted for energy intake)

1.50–17.79) and underweight/wasting (OR: 1.81; 95% CI 1.07–3.07). Besides, compared to the lowest tertile, being in the highest tertile of high-fat dairy was associated with a lower risk of wasting (OR: 0.18; 95% CI 0.04–0.73).

Discussion

In the present study, a positive association was observed between The HBI and wasting and underweight/wasting. Further analysis showed that high-fat milk consumption was inversely associated with wasting.

The HBI was designed to evaluate overall beverage intake quality and to determine whether improvements in healthy beverage selection are associated with improvements in health-related outcomes [13]. It included eight beverage categories, total beverage energy, and fluid consumption [14]. The cumulative effects of multiple beverages included in a holistic dietary index may provide better identification as the effect of a single beverage may be too small to be detectable [15]. To date, few studies evaluated the association between

the HBI and different outcomes [13]. In this study that was conducted to evaluate the association of HBI with cardiometabolic risk among US adults, a positive association was seen between higher the HBI scores and more favorable lipid profiles and hypertension risk [13]. In the present study, a positive association was observed between HBI and the risk of wasting and underweight/wasting. Decreased intake of macronutrients was observed at the highest level of adherence to the HBI in our study which might explain the casualty of these findings. Besides, high-fat milk consumption was inversely associated with wasting. These findings are consistent with a prospective study conducted by Braun et al. [36]. This study found that higher total dairy protein intake was associated with an increase in weight during 8-year follow-up among children in Netherlands [36]. In another study, Dubois et al. after a 5-year follow-up showed that milk consumption at 9 years was positively associated with positive BMI change from 9 to 14 years [37]. In contrast, DeBoer et al. did not see an association between milk consumption and BMI z score or weight-for-height z score [38]. It has been demonstrated that an increase in dietary calcium via

Table 3 Multivariate adjusted odds ratios and 95% confidence intervals for childhood wasting and underweight/wasting across tertiles of healthy beverage intake

Variables	Tertiles of Healthy Beverage Index			P trend[a]
	Tertile 1	Tertile 2	Tertile 3	
Wasting (body mass index for age z score < − 2 standard deviation)				
Healthy Beverage Index				
Crude	1.00	1.40 (0.37–5.27)[b]	2.99 (0.94–9.51)	0.49
Model 1	1.00	1.53 (0.41–5.81)	3.59 (1.10–11.66)	0.03
Model 2	1.00	1.93 (0.50–7.47)	5.16 (1.50–17.79)	0.01
Low-fat dairy				
Crude	1.00	0.29 (0.08–1.07)	0.69 (0.26–1.84)	0.40
Model 1	1.00	0.30 (0.08–1.12)	0.68 (0.25–1.85)	0.40
Model 2	1.00	0.29 (0.07–1.04)	0.59 (0.21–1.64)	0.28
High-fat dairy				
Crude	1.00	0.70 (0.26–1.88)	0.29 (0.08–1.07)	0.06
Model 1	1.00	0.34 (0.94–1.21)	0.19 (0.05–0.79)	0.02
Model 2	1.00	0.41 (0.12–1.43)	0.18 (0.04–0.73)	0.02
Natural juices				
Crude	1.00	1.17 (0.39–3.52)	1.17 (0.39–3.52)	0.80
Model 1	1.00	0.97 (0.31–3.08)	1.08 (0.34–3.34)	0.90
Model 2	1.00	0.93 (0.29–2.98)	0.97 (0.31–3.05)	0.90
Artificial juices				
Crude	1.00	1.00 (0.37–2.71)	0.49 (0.15–1.64)	0.27
Model 1	1.00	0.80 (0.28–2.30)	0.45 (0.13–1.56)	0.21
Model 2	1.00	0.69 (0.23–2.01)	0.33 (0.09–1.23)	0.10
Sweetened beverages				
Crude	1.00	0.87 (0.31–2.43)	0.62 (0.20–1.91)	0.40
Model 1	1.00	0.69 (0.24–2.05)	0.56 (0.18–1.80)	0.32
Model 2	1.00	0.64 (0.21–1.90)	0.45 (0.14–1.50)	0.19
Tea–coffee				
Crude	1.00	1.81 (0.52–6.24)	2.29 (0.70–7.51)	0.17
Model 1	1.00	1.95 (0.55–6.84)	2.42 (0.72–8.11)	0.15
Model 2	1.00	2.13 (0.60–7.56)	2.40 (0.72–8.07)	0.16
Underweight and wasting (body mass index for age z-score < − 1 standard deviation)				
Healthy beverage index				
Crude	1.00	1.17 (0.68–2.01)	1.82 (1.11–3.00)	0.02
Model 1	1.00	1.09 (0.63–1.89)	1.70 (1.02–2.83)	0.04
Model 2	1.00	1.14 (0.65–1.98)	1.81 (1.07–3.07)	0.02
Low-fat dairy				
Crude	1.00	0.85 (0.51–1.40)	0.88 (0.53–1.44)	0.57
Model 1	1.00	0.80 (0.48–1.33)	0.86 (0.52–1.43)	0.56
Model 2	1.00	0.79 (0.48–1.32)	0.85 (0.51–1.41)	0.53
High-fat dairy				
Crude	1.00	0.55 (0.33–0.91)	0.65 (0.40–1.06)	0.00
Model 1	1.00	0.64 (0.36–1.13)	0.73 (0.44–1.21)	0.23
Model 2	1.00	0.64 (0.36–1.13)	0.73 (0.44–1.22)	0.23
Natural juices				
Crude	1.00	0.73 (0.44–1.23)	1.00 (0.61–1.62)	0.99
Model 1	1.00	0.79 (0.47–1.34)	1.04 (0.63–1.71)	0.87
Model 2	1.00	0.81 (0.47–1.37)	1.04 (0.62–1.72)	0.88
Table 3 (continued)				
Artificial juices				
Crude	1.00	0.57 (0.34–0.97)	0.93 (0.58–1.50)	0.77
Model 1	1.00	0.62 (0.36–1.08)	1.00 (0.61–1.62)	0.98
Model 2	1.00	0.61 (0.36–1.07)	1.00 (0.61–1.64)	0.98
Sweetened beverages				
Crude	1.00	0.50 (0.29–0.85)	0.81 (0.51–1.30)	0.36
Model 1	1.00	0.54 (0.32–0.94)	0.88 (0.54–1.43)	0.57
Model 2	1.00	0.54 (0.31–0.94)	0.88 (0.53–1.45)	0.57
Tea–coffee				
Crude	1.00	0.85 (0.50–1.45)	1.27 (0.78–2.08)	0.32
Model 1	1.00	0.83 (0.49–1.43)	1.30 (0.79–2.14)	0.28
Model 2	1.00	0.83 (0.48–1.43)	1.30 (0.79–2.15)	0.28

Healthy Beverage Index consist of water, unsweetened coffee and tea, low-fat milk (< 1.5% fat, fat free, and/or soymilk), 100% fruit juice, full-fat milk (1.5% fat), and sugar-sweetened beverages (including fruit drinks, sweetened coffee, and tea, soda)

Model 1: Adjusted for mother age, mother body mass index, mother physical activity, socioeconomic status, children physical activity, and energy intake

Model 2: Adjusted for model 1 + total oils (all kinds of oils like animal and plant oils), total sweet foods (other sweet foods except sweetened beverages)

[a]Obtained from Mantel–Haenszel extension Chi square test

[b]Odd ratio (95% confidence interval)

its influence on circulating calcitropic hormones can lead to a decrease in the concentration of intracellular ionized calcium in human adipocytes. Following this decrement, the lipolysis and fat oxidation is stimulated [39]. On the other hand, high protein intake can stimulate insulin-like growth factor 1 (IGF-1) release and other growth hormones, which in turn enhances muscle and fat mass [40].

No association emerged between HBI and overweight and overweight/obesity. By contrast, a cross-sectional study on children and adolescents revealed that Canadian boys aged 6–11 years whose beverage pattern (included fruit drinks, regular soft drinks, sweetened coffees, and sweetened teas) was positively associated with odds of overweight and obesity [41]. A prospective study by Libuda et al. which was conducted on German children and adolescents (aged 9–18 years old) reported a positive association between energetic beverages with BMI standard deviation scores in girls, but not boys [11]. Moreover, a cross-sectional study which identified three beverage patterns among 19,800 Korean adults showed a negative relationship between alcoholic beverage pattern (included a high intake of alcoholic beverages and low intake of unsweetened coffee and tea, dairy products, and 100% fruit and vegetable juices) with both obesity and abdominal obesity. This study also showed a

Table 4 Multivariate adjusted odds ratios and 95% confidence intervals for children obesity and overweight/obesity across tertiles of Healthy Beverage Index

Variables	Tertiles of Healthy Beverage Index			P trend
	Tertile 1	Tertile 2	Tertile 3	
Obesity (body mass index for age z-score ≥ 2 standard deviation)				
Healthy Beverage Index				
Crude	1.00	1.78 (0.68–4.67)	0.75 (0.24–2.40)	0.69
Model 1	1.00	1.80 (0.68–4.75)	0.78 (0.24–2.52)	0.74
Model 2	1.00	2.10 (0.77–5.73)	0.95 (0.28–3.21)	0.99
Low-fat dairy				
Crude	1.00	3.08 (0.98–9.69)	1.76 (0.51–6.10)	0.44
Model 1	1.00	3.38 (1.06–10.78)	1.98 (0.57–6.93)	0.33
Model 2	1.00	3.26 (1.02–10.41)	1.81 (0.51–6.42)	0.42
High-fat dairy				
Crude	1.00	2.29 (0.78–6.68)	1.41 (0.44–4.50)	0.61
Model 1	1.00	2.08 (0.63–6.89)	1.39 (0.42–4.60)	0.71
Model 2	1.00	2.17 (0.66–7.07)	1.28 (0.38–4.27)	0.81
Natural juices				
Crude	1.00	1.34 (0.46–3.91)	1.51 (0.53–4.31)	0.44
Model 1	1.00	1.23 (0.41–3.70)	1.49 (0.51–4.36)	0.46
Model 2	1.00	1.20 (0.39–3.68)	1.40 (0.47–4.13)	0.55
Artificial juice				
Crude	1.00	2.04 (0.69–6.05)	1.60 (0.52–4.98)	0.45
Model 1	1.00	1.78 (0.58–5.54)	1.47 (0.46–4.66)	0.56
Model 2	1.00	1.70 (0.54–5.27)	1.31 (0.40–4.31)	0.71
Sweetened beverages				
Crude	1.00	2.24 (0.77–6.55)	1.41 (0.44–4.49)	0.61
Model 1	1.00	2.01 (0.66–6.08)	1.29 (0.39–4.22)	0.74
Model 2	1.00	1.93 (0.63–5.87)	1.14 (0.34–3.85)	0.91
Tea–coffee				
Crude	1.00	0.79 (0.29–2.15)	0.77 (0.28–2.10)	0.60
Model 1	1.00	0.82 (0.29–2.27)	0.81 (0.29–2.25)	0.68
Model 2	1.00	0.86 (0.31–2.40)	0.80 (0.29–2.22)	0.66
Overweight/obesity (body mass index for age z score ≥ 1 standard deviation)				
Healthy Beverage Index				
Crude	1.00	1.05 (0.73–1.50)	0.80 (0.55–1.15)	0.23
Model 1	1.00	1.07 (0.74–1.54)	0.80 (0.55–1.16)	0.25
Model 2	1.00	1.10 (0.76–1.59)	0.83 (0.57–1.22)	0.35
Low-fat dairy				
Crude	1.00	1.29 (0.89–1.85)	1.03 (0.71–1.49)	0.88
Model 1	1.00	1.34 (0.93–1.95)	1.07 (0.73–1.55)	0.74
Model 2	1.00	1.33 (0.92–1.93)	1.04 (0.71–1.52)	0.84
High-fat dairy				
Crude	1.00	0.84 (0.59–1.22)	0.97 (0.67–1.39)	0.85
Model 1	1.00	0.72 (0.47–1.09)	0.89 (0.61–1.30)	0.62
Model 2	1.00	0.73 (0.48–1.11)	0.87 (0.60–1.27)	0.53
Natural juices				
Crude	1.00	0.99 (0.69–1.43)	0.84 (0.58–1.21)	0.34
Model 1	1.00	0.97 (0.67–1.41)	0.83 (0.57–1.21)	0.34
Model 2	1.00	0.96 (0.66–1.39)	0.81 (0.55–1.18)	0.27

Table 4 (continued)

Variables	Tertiles of Healthy Beverage Index			P trend
	Tertile 1	Tertile 2	Tertile 3	
Artificial juices				
Crude	1.00	1.39 (0.96–2.00)	1.06 (0.73–1.54)	0.76
Model 1	1.00	1.36 (0.93–1.99)	1.01 (0.69–1.48)	0.98
Model 2	1.00	1.34 (0.91–1.96)	0.97 (0.66–1.43)	0.86
Sweetened beverages				
Crude	1.00	1.40 (0.97–2.01)	1.0 (0.69–1.44)	0.98
Model 1	1.00	1.36 (0.93–1.99)	0.93 (0.63–1.36)	0.67
Model 2	1.00	1.35 (0.92–1.97)	0.88 (0.60–1.31)	0.53
Tea–coffee				
Crude	1.00	1.22 (0.85–1.76)	1.07 (0.74–1.54)	0.73
Model 1	1.00	1.24 (0.86–1.80)	1.07 (0.73–1.55)	0.75
Model 2	1.00	1.26 (0.87–1.83)	1.06 (0.73–1.54)	0.77

Healthy Beverage Index consist of water, unsweetened coffee and tea, low-fat milk (< 1.5% fat, fat-free, and/or soymilk), 100% fruit juice, full-fat milk (1.5% fat), and sugar-sweetened beverages (including fruit drinks, sweetened coffee, and tea, soda)

Model 1: Adjusted for mother age, mother body mass index, mother physical activity, socioeconomic status, children physical activity, and energy intake

Model 2: Adjusted for model 1 + total oils (all kinds of oils like animal and plant oils), total sweet foods (other sweet foods except sweetened beverages)

[a]Obtained from Mantel–Haenszel extension Chi square test

[b]Odd ratio (95% Confidence Interval)

positive association between SSB pattern (included a high intake of sodas, sweetened coffee and tea, fruit drinks and sports/energy drinks) with abdominal obesity [42]. In line with our results, in the mentioned study, no association was observed between unsweetened beverage pattern (included a high intake of unsweetened coffee) with anthropometric measures [42].

In the current study, no association was observed between SSB and weight status. In line with our findings, a cross-sectional study did not show any association between SSB and weight status among U.S children of 2–5 years old [43]. A prospective study on 1203 children aged 5–7 years revealed no association between SSB at age 5–7 years and BMI at the age of 9 years [44]. Another cross-sectional study on Norwegian children (aged 8–14 years old) did not provide any association between sweetened soft drink and BMI [45]. Such associations were also replicated in studies conducted in other European countries [46, 47]. In this direction, several review studies have shown a weak association between SSB intake and weight outcomes [48, 49]. By contrast, a prospective study on U.S preschool children aged 3–5 years revealed that soda and all SSB intake were positively associated with BMI z scores at baseline of the study [50]. Moreover, in the mentioned study, fruit drinks, and all SSB intakes

were associated with higher odds of overweight after 2 years of follow-up [50].

We found no association between fruit juice and weight status. In the study by Skinner et al. no significant association was shown between fruit juice intake (100% juice only) and children's height and body mass index [29]. A prospective study which was conducted on children and adolescents showed that fruit and fruit juice intake (not determined) was not associated with significant changes in BMI z score during 3 years of follow-up [51]. It is noteworthy that a cross-sectional study by Faith et al. showed that higher fruit juice intake (not determined) was associated with increased adiposity among children (aged 1 to 4 years) who were initially overweight or at risk for overweight, but not normal-weight children [25]. Their findings were in line with recent evidence that the association between juice intake and weight gain is limited to overweight and obese children [52]. A reason why we failed to observe any association between fruit juice and weight status might be due to the overall normal weight of our participants.

The reason why we did not find any beverage-weight association contrary to previous studies might be attributable to several factors. Dietary fat intake has an important role as a dense source of energy and essential fatty acids like alpha-linolenic and linoleic acids, which have a critical role in growth and development [53]. Also, fat intake could facilitate the absorption of the fat-soluble vitamins needed in normal growth [54]. Dietary intake of protein is vital to the normal development of muscles and bones of children [55]. On the other side, carbohydrates function as an important and immediate source of daily activity energy and provide glucose needs for the brain [56]. As mentioned above, decreased intake of macronutrients was observed at the highest level of adherence to the HBI in our study, which might explain the casualty of this finding. Besides, it is well understood that the development of obesity and overweight or underweight weight status occurs because of a long-term energy imbalance. It is also well established that parents of overweight and obese children reported greater feeding restrictions than parents of healthy-weight children. Since many parents were employees, they do not have accurate information about their children's food intake during the day. An unavoidable limitation of the study is the natural reporting errors that occur using an FFQ such as misclassification of data and that information that relies on correct reports by the mother.

To our knowledge, this is the first study conducted in children that addresses the relationships between HBI and anthropometric measures. The limited available research on this subject especially among children, due to the high prevalence of SSB consumption, and large sample size outline a few principle strengths of our current findings. First, the cross-sectional design of the study prevents us to draw conclusive associations between HBI and anthropometric status. Therefore, prospective studies are needed to evaluate these associations over longer periods. Second, since our study only included girls, we were not able to extrapolate our findings to both sexes. Third, in this study, dietary intake was assessed by taking FFQ from parents, which might lead to under- or over-reporting of food intake.

In conclusion, the findings of this study showed that HBI was positively associated with wasting and underweight/wasting, however, was not associated with other anthropometric measures. Also, this study showed that high-fat milk consumption was inversely associated with wasting. Future prospective studies are required to evaluate the association between HBI and anthropometric status in both genders, to characterize gender differences in the long period.

What is already known on this subject?

To date, several studies investigated the associations between specific beverages intake and risk of cardiovascular diseases and abnormal growth status among children with inconclusive results. Also, few studies performed on the associations between healthy and unhealthy beverages pattern and risk of diseases in this population. However, there is no study investigating the associations between the HBI, as a more comprehensive beverage index including approximately all of the healthy beverages in a diet, and growth status and obesity among this vulnerable group.

What does this study add?

Based on the results of the studies in adult population, it seems that higher adherence to the HBI is associated with more favorable metabolic profiles. However, our results showed that higher adherence to this index might be harmful for the children population because of potential nutrient deficiency following adherence to index that might lead to abnormal growth status in children. Therefore, it seems that the application of this dietary recommendation should be encouraged with caution in this population.

Compliance with ethical standards

Conflict of interest None.

Ethical approval This study ethically approved by National Institute for Medical Research Development of Tehran University of medical science, Tehran, Iran (IR. TUMS. VCR.REC.94-04-161-31 112).

Informed consent Informed consent was obtained from each participant prior to the study.

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