Fateh et al. BMC Nutrition (2024) 10:131
https://doi.org/10.1186/s40795-024-00940-z

BMC Nutrition

RESEARCH Open Access

Healthy beverage index is associated with metabolic syndrome: insights from the Ravansar non-communicable disease (RaNCD) cohort study

Hawal Lateef Fateh[1], Neda Izadi[2], Shahab Rezaeian[3], Farid Najafi[4], Ebrahim Shakiba[5], Mitra Darbandi[4,6] and Yahya Pasdar[4,7*]

Abstract

Background Dietary patterns play a crucial role in the development and management of metabolic syndrome (MetS). The Healthy Beverage Index (HBI) is a novel tool that assesses the quality of beverage choices in the diet and provides insights into their potential impact on metabolic health. The aim of this study was to investigate the association between the HBI and the MetS.

Methods This cross-sectional study was conducted using data collected at baseline from the Ravansar Noncommunicable Disease Cohort Study. A total of 9,025 participants aged 35 to 65 years were included in the analysis. HBI was calculated using food items from the Food Frequency Questionnaire (FFQ). MetS status was defined according to established criteria, and logistic regression analysis was performed to assess the association between HBI scores and MetS, adjusting for potential confounding variables.

Results In our study, 41.13% of the population was found to have MetS, with a significant association between MetS and tertiles of HBI. Furthermore, the logistic regression model showed a significant inverse association between HBI scores and the odds of developing a MetS (OR = 0.90; 95% CI: 0.86, 0.94), even after adjusting for confounding factors, emphasizing the potential protective effect of higher HBI scores.

Conclusion Increased HBI scores were associated with lower risk of MetS, emphasizing the importance of choosing health-promoting beverages in controlling MetS. These findings support the association between dietary habits and metabolic health and provide practical guidance for individuals and public health initiatives aimed at improving metabolic outcomes.

Keywords Healthy Beverage Index, Food frequency questionnaire, Metabolic syndrome

*Correspondence:
Yahya Pasdar
Yahya.pasdar@kums.ac.ir

Full list of author information is available at the end of the article

Introduction

Metabolic syndrome (MetS) refers to a group of risk factors that include insulin resistance, dyslipidaemia, obesity, and hypertension [1–3]. When these factors come together, the likelihood of developing potentially fatal diseases such as heart disease, type 2 diabetes, and stroke increases [4–6]. As metabolic syndrome becomes more prevalent worldwide, it is essential for public health to understand the various factors that contribute to its onset and development. A recent study conducted in Iran found that MetS is highly prevalent in the country, affecting approximately 28–41% of the Iranian population. The prevalence varied depending on the specific region, age, and gender of the individuals studied. These findings underscore the need for effective public health strategies to address this growing health issue in Iran [7, 8].

The scientific community has recently made remarkable progress in recognising the fact that nutrition plays an important role in the development of metabolic syndrome [9]. Dietary patterns—including food and beverages choices has emerged as critical factor in the fight against and management this disease [10–12]. However, while much attention has been paid to dietary habits in relation to food, beverages have often received less attention in this research [13].

A person's propensity for obesity is influenced by a number of variables. This factors include older age, low levels of physical activity, limited education levels, lack of awareness, living in cities, and adopting unhealthy eating habits characterized by the consumption of high-calorie foods and sugary beverages, including sugar-sweetened beverages (SSBs) [14]. A recent study found that genetic and environmental factors may have a considerable impact on both the kind and quantity of drinks consumed [15].

Drinking water has several health benefits for the body [16]. Increased water consumption can be an important technique in the treatment and prevention of obesity [17, 18]. Other fluids, such as milk, tea, coffee, and unsweetened beverages, are also important for the overall well-being of the body [19, 20]. Fluid consumption is important for the efficient functioning of the genitourinary system and gastrointestinal tract [21, 22], which leads to a reduction in mortality [22, 23].

It should be noted that SSBs are recognized as an important factor to weight gain and obesity. Reduced consumption of SSBs, on the other hand, is associated with a lower risk of obesity and cardiovascular disease [22, 23].

The Healthy Beverage Index (HBI) thus proves to be a groundbreaking tool which the nutritional quality of beverages can be comprehensively assessed [24]. The HBI goes beyond just calorie count and takes into account the nutrient content, sugar levels, and other critical components of beverages that determine their potential impact on health [25]. Because the HBI provides a unique perspective on beverage choices, it opens up new possibilities for studying metabolic health and dietary interventions [26]. The aim of the study was to investigate the association between the HBI and MetS.

Methods

Study design and population

This cross-sectional study was based on the RaNCD prospective cohort study, which is a subset of the larger PERSIAN (Prospective Epidemiological Research Studies in Iran) project. Ravansar is located in the Kermanshah region of western Iran and has a population of around 50,000 people living in both urban and rural areas. The RaNCD cohort study began in 2014, with the enrollment of 10,047 people aged 35 to 65 years and it is still ongoing. The complete methodology of the RaNCD study has previously been published [27]. In this study, the exclusion criteria apply to patients with a specific medical history and individuals with a history of cancer, individuals diagnosed with thyroid disease, participants with abnormal daily energy intake (less than 800 or more than 4200 kcal/day), individuals suffering from end-stage renal disease (ESRD), and pregnant womenwere excluded from data. After exclusions, data from 9,025 participants were available for analysis.

Data collection

Face-to-face interviews were conducted with experienced individuals to collect the data from the questionnaires.

Socioeconomic status index

The Socioeconomic Status (SES) index was created by combining 18 socioeconomic factors using Principal Component Analysis (PCA) to capture the overall socioeconomic standing of participants. The factors included: education level, employment status, occupation type, income level, household wealth, access to health services, access to clean water, sanitation facilities, place of residence (urban or rural), housing quality (e.g., type of roofing and flooring), ownership of household assets (e.g., TV, car), land ownership, access to electricity, access to the internet or communication technologies, household size, type of fuel used for cooking, dietary quality and food security, and transportation access.

PCA was employed to reduce the dimensionality of the data and generate a composite SES score. The first component, explaining the largest variance in the data, was retained and used as the SES index. This index was then categorized into five distinct levels, ranging from the lowest (quintile 1) to the highest (quintile 5) SES, representing the overall socioeconomic distribution of the study population [27].

The PERSIAN cohort questionnaire was used to determine the level of physical activity [28]. This includes 22 questions divided into three categories: low (24-36.5 MET/hour per day), moderate (36.6–44.4 MET/hour per day) and high (44.5 MET/hour per day). In addition, current smokers were the participants those reported smoking at least 100 cigarettes.

In the RaNCD cohort, 25 cubic centimeters of blood were taken from each eligible study participant after a 12-hour break from eating in order to determine various biochemical markers. These markers included total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and fasting blood sugar (FBS). The blood samples were separated into whole blood and serum components and then stored at -80 °C in the RaNCD laboratory of the cohort center until analysis. Enzyme kits from Pars Azmun, Iran, were used to measure the concentrations of TC, HDL-C, TG, and LDL-C. The glucose oxidase technique was used to measure the serum FBS [27].

The BSM 370 device from Biospace Co. of Seoul, Korea. was used to measure body height. A bio-impedance analyzer, namely the InBody 770 from Biospace in Korea, was used to measure body weight. The body mass index (BMI) was calculated using the formula weight (kg)/height^2 (m). The waist circumference (WC) was divided by the hip circumference (HP) to obtain the waist-to-hip ratio (WHR). After the participants had rested for at least ten minutes, blood pressure was measured in a sitting position using a Reister sphygmomanometer with a cuff and stethoscope.

Dietary assessment

Dietary information was collected through in-person interviews using a nationally validated semi-quantitative Food Frequency Questionnaire (FFQ) consisting of 118 items [29]. Participants answered questions about the frequency and portion sizes of foods they consumed, including bread and cereals, dairy products, red and white meats, legumes, fruits and vegetables, sweets and desserts, tea and coffee, nuts, oils, and fats. A booklet with standard portion sizes was provided to assist in estimating the amounts consumed. The English translation of the FFQ has been included as an online supplement/appendix for reference [29].

Healthy beverage index score

The Healthy Beverage Index (HBI) score was calculated using the Duffey and Davy approach [30]. Beverages were divided into eight categories, and participants were scored based on their intake of each beverage type. The categories and scoring system were as follows:

1. Water: 0–15 points.
2. Tea and unsweetened coffee: 0–5 points.
3. Diet drinks (artificially sweetened beverages and calorie-free drinks): 0–5 points.
4. Natural fruit juices: 0–5 points.
5. alcohol: 0–5 points.
6. Low-fat milk: 0–15 points.
7. Total beverage energy: 0–20 points.
8. Meeting fluid requirements: 0–20 points.

These categories were based on the total amount of beverages. A higher cumulative HBI indicates better adherence to a healthier HBI pattern. The HBI score ranges from 0 to 100 and as no information on alcohol content and diet beverages was available for this study, the highest possible HBI score was 95 [31]. Finally, participants were categorized into tertiles based on their HBI scores, with the lowest group serving as the reference category.

Metabolic syndrome and its components

Metabolic syndrome was defined as the presence of three or more of the following criteria (component) based on the American Heart Association/National Heart definition:

1) Hypertension: Systolic blood pressure (SBP) ≥ 130 mmHg or diastolic blood pressure (DBP) ≥ 85 mmHg, or the use of antihypertensive medication. 2) Increased waist circumference: ≥102 cm (40 inches) in men and ≥88 cm (35 inches) in women. 3) High triglycerides: TG levels ≥ 150 mg/dL or the use of medication to treat high triglycerides. 4) Low HDL cholesterol: HDL-C < 40 mg/dL in men and < 50 mg/dL in women, or the use of medication to treat low HDL. 5) High fasting blood sugar: FBS ≥ 100 mg/dL (5.6 mmol/L) or a known diagnosis of diabetes [32].

Statistical analysis

Quantitative variables were presented as mean ± standard deviation, while qualitative variables were reported as frequency (percentage). The normality of the data was tested using the Kolmogorov-Smirnov test.

A one-way ANOVA was performed to compare the mean ± standard deviation of the anthropometric and biochemical characteristics between the three study groups. Frequency comparisons were performed using the Chi-square test. Crude and adjusted logistic and linear regression models were used to determine the association between HBI score and MetS and its components, with estimates reported along with 95% confidence intervals (CIs). Potential confounding variables such as age, sex, total energy intake, SES, physical activity, smoking, and BMI were controlled for in the adjusted model [33, 34]. For statistical analyses, significance was defined as a $P < 0.05$, and results were reported with 95% confidence intervals. All analyses were performed using STATA software, version 14.2 (Stata Corp, College Station, Tex).

Results

The mean age of the study population (9,025 participants) was 47.22±8.28 years, with no significant difference between the three tertiles (p=0.437). The study population was evenly distributed between men and women, with no statistically significant differences in gender distribution between the tertiles (p=0.064).

Marital status differed significantly between tertiles, with a higher proportion of married individuals in the higher HBI tertile (p=0.008). The level of physical activity also varied significantly, with a higher percentage of participants in the "high physical activity" category in the lower HBI tertile (p=0.044). Current smoking status also showed significant differences between tertiles (p<0.001). There was no difference between alcohol consumption and HBI tertiles (p=0.451). Anthropometric measures such as BMI, WC, hip circumference, waist-to-hip ratio, body fat mass and visceral fat area were significantly lower in the higher HBI tertile group (p<0.001 for all). Cardiometabolic risk factors, including TG, FBS, SBP and DBP, were also significantly lower in the higher HBI tertiles (p<0.001 for all). In contrast, HDL-C was higher in the highest HBI tertile (47.55±11.40) than in the lowest tertile (45.25±10.98). The prevalence of MetS was significantly higher in the lower HBI tertile than in the higher tertiles (p<0.001). These results suggest that individuals with higher HBI levels have a more favorable anthropometric and cardiometabolic profile (Table 1).

Water intake increased significantly across HBI tertiles, with the highest tertile (T3) consuming an average of 3367±1779 ml/day compared to 1582±1023 ml/day in the lowest tertile (T1) (p<0.001). The consumption of unsweetened coffee and tea was also significantly higher in the higher HBI tertiles: T3 consumed an average of 455.23±26.35 ml/day compared to 248.04±25.32 ml/day in T1 (p<0.001). The consumption of low-fat milk and 100% fruit juice also increased slightly across the HBI

Table 1 Characteristics of the study population by tertiles of healthy Beverage Index

Characteristics	All (n=9,025)	T1 (<45) (n=3,060)	T2 (45–70) (n=2,930)	T3 (71–80) (n=3,035)	*P*-value
Age (year)	47.22±8.28	47.75±8.38	46.90±8.23	46.99±8.20	0.437
Gender, *n* (%)					
Male	4596 (50.93)	1584 (51.76)	1440 (49.15)	1572 (51.80)	0.064
Female	4429 (49.07)	1476 (48.24)	1490 (50.85)	1463 (48.20)	
Marital status, *n* (%)					
Single	401 (4.44)	135 (4.41)	138 (4.78)	128 (4.22)	**0.008**
Married	8138 (90.17)	2717 (88.79)	2656 (90.65)	2765 (91.10)	
Divorced and other	486 (5.39)	208 (6.79)	136 (4.64)	142 (4.68)	
Physical activity (Met h/day)					
Low	2707 (29.99)	889 (29.05)	888 (30.31)	930 (30.64)	**0.044**
Moderate	4211 (46.66)	1400 (45.75)	1397 (47.68)	1414 (46.59)	
High	2107 (23.35)	771 (25.20)	645 (22.01)	692 (22.77)	
Current smoker, *n* (%)	1100 (12.33)	408 (13.49)	362 (12.51)	330 (10.99)	**<0.001**
Alcohol use, *n* (%)	485 (5.37)	152 (4.97)	161 (5.49)	172 (5.67)	0.451
Body Mass Index, kg/m^2	27.91±4.51	28.01±4.33	27.92±4.66	26.55±4.61	**<0.001**
Waist Circumference, cm	97.30±10.62	98.34±10.70	97.14±10.52	96.36±10.54	**<0.001**
Hip Circumference, cm	102.63±9.02	103.38±9.40	102.57±8.83	101.91±8.73	**<0.001**
Waist-to-Hip Ratio	0.94±0.06	0.94±0.06	0.92±0.06	0.91±0.61	**<0.001**
Body Fat Mass	25.13±9.57	25.86±9.69	24.92±9.46	24.59±9.50	**<0.001**
Percent Body Fat	33.90±9.48	34.43±9.47	33.64±9.36	33.60±9.61	**0.003**
Visceral Fat Area	122.54±51.63	126.36±52.03	121.13±50.90	119.94±51.72	**<0.001**
TC, mg/dL	185.56±37.93	186.71±38.77	185.54±31.22	184.35±37.86	**0.037**
TG, mg/dL	122.47±87.80	129.77±88.99	123.46±90.87	113.70±82.41	**<0.001**
LDL-C, mg/dL	111.66±31.39	112.26±32.16	11.37±31.34	111.31±30.63	0.382
HDL-C, mg/dL	46.63±11.35	45.25±10.98	46.68±11.49	47.55±11.40	**<0.001**
FBS, mg/dL	97.06±30.17	100.45±35.17	96.16±29.50	94.37±24.16	**<0.001**
SBP, mm Hg	108.21±17.03	108.94±17.32	104.14±16.98	101.49±14.74	**0.002**
DBP, mm Hg	68.82±9.93	71.12±10.03	69.82±9.98	65.51±9.75	**0.003**
Metabolic Syndromes, *n* (%)	3702 (41.13)	1355 (44.46)	1205 (39.78)	1142 (39.06)	**<0.001**

Abbreviations: HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; TG, Triglycerides; TC, total cholesterol; FBS, fasting blood sugar, SBP, systolic blood pressure; DBP, diastolic blood pressure. *Analysis of variance (ANOVA) and Chi square, P<0.05

Table 2 Daily healthy beverage intake per healthy Beverage Index tertiles

HBI Components	T1 (<45) (*n*=3,060)	T2 (45–70) (*n*=2,930)	T3 (71–80) (*n*=3,035)	*P*-value
Water intake (ml/day)	1582±1023	2006±815	3367±1779	**<0.001**
Unsweetened coffee and tea (ml/day)	248.04±25.32	359.52±27.67	455.23±26.35	**<0.001**
Low-fat milk (ml/day)	51.32±74.05	52.06±70.67	53.15±69.62	**0.001**
100% fruit juice (ml/day)	5.37±14.81	5.91±16.75	6.71±17.26	**<0.001**
Sugar-sweetened beverages (ml/day)	926.94±635±40	751.77±510.44	698.88±432.38	**<0.001**
% energy from beverages	6.19±2.70	7.51±1.17	14.13±5.19	**<0.001**
Meeting fluid requirement (ml/day)	2381.40±889.01	2801.27±937.19	2931.24±1005.12	**<0.001**

Data are presented as means±standard deviations for daily intake of beverages and percentage of energy from beverages, categorized by tertiles of the Healthy Beverage Index (HBI). Tertile 1 (T1) includes individuals with an HBI score less than 45, Tertile 2 (T2) includes individuals with an HBI score between 45 and 70, and Tertile 3 (T3) includes individuals with an HBI score between 71 and 80. *P*-values indicate the significance of differences between tertiles

Table 3 Associations of Healthy Beverage Index score with metabolic syndrome using logistic regression model

Model	OR (95%CI)			*P*-trend
	T1	T2	T3	
Crude model	1.00	0.90 (0.86–0.94)	0.89 (0.80–0.98)	**<0.001**
Adjusted model 1	1.00	0.90 (0.86–0.95)	0.82 (0.77–0.87)	**<0.001**
Adjusted model 2	1.00	0.94 (0.89–0.96)	0.73 (0.55–1.01)	**0.016**

Model 1. Adjusted for age, sex, total energy intake

Model 2. Adjusted for age, sex, total energy intake, SES, physical activity, smoking, and BMI

tertiles, although the differences were less pronounced ($p=0.001$ and $p<0.001$ respectively). In contrast, consumption of sugar-sweetened beverages decreased significantly from the lowest to the highest HBI tertile, with T1 consuming an average of 927 ml/day compared to 699 ml/day in T3 ($p<0.001$). Regarding the percentage of total energy intake from beverages, a significant increase was observed from the lowest to the highest HBI tertile, with T3 obtaining 14.13% of their energy from beverages compared to 6.19% at T1 ($p<0.001$). In addition, study participants in the higher HBI tertiles were more likely to meet the recommended fluid intake of 2,800-3,000 ml/day, with T3 consuming an average of 2,931 ml/day compared to 2,381 ml/day in T1 ($p<0.001$). These results suggest that individuals with higher HBI scores tended to have more favorable beverage consumption patterns, characterized by higher consumption of water and unsweetened coffee/tea, lower consumption of sugar-sweetened beverages, and a greater likelihood of achieving the recommended fluid intake (Table 2).

The association between HBI tertiles and risk of MetS showed that in the crude model, individuals in the highest HBI tertile (T3) had a significantly lower risk of MetS than individuals in the lowest tertile (T1), with an odds ratio (OR) of 0.89 (95% CI: 0.80–0.98). This inverse association remained statistically significant after adjusting for age, sex, and total energy intake in Model 1 (OR: 0.82, 95% CI: 0.77–0.87). When additional adjustments were made for SES, physical activity, smoking and BMI in model 2, the association between HBI and risk of MetS remained statistically significant (OR: 0.73, 95% CI: 0.55–1.01). However, the confidence interval became wider in the fully adjusted model, indicating a possible attenuation of the effect size due to the inclusion of these additional confounders. The p-trend values of all three models were statistically significant, indicating a dose-response relationship between higher HBI levels and a lower risk of MetS. These results suggest that adherence to a healthier lifestyle, as reflected by a higher HBI score, is associated with a lower risk of developing MetS, even after accounting for sociodemographic and lifestyle factors (Table 3).

The associations between total HBI and the individual components of MetS were assessed using linear regression models. In the crude model, a higher HBI score was significantly associated with a lower WC (β = -0.62, $p<0.001$), lower TG levels (β = -2.92, $p<0.001$), lower FBS (β = -2.09, $p<0.001$) and a lower risk of hypertension (β = -1.90, $p=0.014$). However, the association with low HDL-C was not statistically significant ($p=0.546$). After adjustment for age, sex and total energy intake in model 1, the inverse associations for WC (β = -0.69, $p<0.001$) and FBS (β = -1.95, $p<0.001$) remained significant. The association with hypertension was attenuated and became non-significant ($p=0.082$), while the associations with TG and HDL cholesterol also lost statistical significance. In fully adjusted model 2, which included additional covariates such as SES, physical activity, smoking and BMI, the significant inverse association remained only for FBS (β = -1.76, $p<0.001$). The associations with WC, TG, HDL-C and hypertension were no longer statistically significant after adjusting for these confounders. These results suggest that higher HBI is primarily associated with lower FBS levels. The associations with other components of MetS appear to be partially explained by the influence of these confounders (Table 4).

Discussion

In this study, a significant association was found between HBI scores and the likelihood of developing metabolic syndrome. Individuals who consumed more HBI exhibited a significantly lower odd of developing MetS.

Table 4 Associations of total healthy Beverage Index score with the components of metabolic syndrome using linear regression model

MetS Components	Crude Model		Model 1		Model 2	
	β (95% CI)	*P*-value	β (95% CI)	*P*-value	β (95% CI)	*P*-value
Waist circumference	**-0.62 (-0.84, -0.39)**	**< 0.001**	**-0.69 (-0.93, -0.46)**	**< 0.001**	-0.01 (-0.15, 0.12)	0.812
Triglycerides	**-2.92 (-4.81, -1.03)**	**< 0.001**	1.43 (-0.45, 3.32)	0.136	1.69 (-0.15, 3.54)	0.073
Fasting blood sugar	**-2.09 (-2.74, -1.45)**	**< 0.001**	**-1.95 (-2.62, -1.29)**	**< 0.001**	**-1.76 (-2.42, -1.10)**	**< 0.001**
High-density lipoprotein	0.07 (-0.16, 0.31)	0.546	0.21 (-0.02, 0.45)	0.076	0.08 (-0.15, 0.32)	0.476
Hypertension	**-1.90 (-3.41, -0.38)**	**0.014**	-1.31 (-2.79, 0.16)	0.082	-0.31 (-1.73, 1.11)	0.669

Model 1. Adjusted for age, sex, total energy intake

Model 2. Adjusted for age, sex, total energy intake, SES, physical activity, smoking, and BMI

In the context of public health and nutrition, the Healthy HBI is an important tool for evaluating and advocating healthier beverage choices. It provides a thorough and consistent method to assess people's beverage consumption habits, taking into account a variety of beverages, from water to sugar-filled drinks [35]. The HBI is a useful tool for individuals, healthcare providers, and policymakers to make informed decisions about beverage consumption by rating different beverages according to their nutritional value [24]. This helps to identify and quantify healthier beverage options [24]. The importance of the HBI extends beyond personal health, as it can support public health campaigns that encourage people to adopt healthy drinking habits to reduce the incidence of chronic diseases related to diet, such as metabolic syndrome and obesity [3, 36]. The HBI plays a key role in improving our knowledge of how beverage choices affect overall health and in developing ways to change dietary habits and improve public health outcomes [37].

A notable addition to the study on diet and metabolic health is the observation that individuals with higher HBI scores are significantly less likely to develop MetS. The complicated and multidimensional disease known as metabolic syndrome is related to a number of risk factors, such as insulin resistance, high blood pressure, and obesity [38].

According to the results of the study, an important factor influencing metabolic health is the caliber of beverages selected, as indicated by higher HBI levels. This result supports the notion that a balanced and health-conscious choose of beverages can help reduce the risk of MetS. A more complex understanding of the function of drinks for metabolic health is enabled by the methodology of the study, which takes a comprehensive approach to beverages and uses a scoring system to assess their health.

It is helpful to compare these results with those relevant studies in order to put them in perspective. A study conducted by Appelhans et al. (2016) examined beverage consumption in a broad population and the risk of MetS [38]. The harmful effects of sugary beverages were highlighted by Appelhans et al.'s study that higher consumption of SSBs was associated with an increased risk of MetS [38]. Sugar-sweetened beverages contain high amounts of fructose [39]. The liver converts fructose into fatty acids, which are then stored as triglycerides. This process promotes the accumulation of fat in the liver (hepatic steatosis) and contributes to non-alcoholic fatty liver disease (NAFLD), a common component of MetS [40]. Excessive fructose leads to insulin resistance in the liver and muscle tissues. High fructose intake impairs the insulin receptor's ability to activate the signaling pathway (e.g., the PI3K-Akt pathway), reducing glucose uptake by muscle and fat cells [41]. The results of this study and the current publication are consistent with each other and emphasize the importance of beverage choice for the risk of MetS.

In our study, an inverse association between HBI and MetS was demonstrated. According to a study by Liu et al. (2021) [42], higher HBI is negatively associated with MetS in US women. In addition, Shin et al. (2018) found a positive association between SSB consumption and the odds of MetS (OR: 1.61; 95% CI: 1.20–2.16) [43]. In addition, another study conducted by Denova-Gutiérrez et al., (2010) in adult Mexicans found that consumption of drinks with added sugar increased the odds of developing MetS [44]. According to a number of studies, those who consumed more sugar-sweetened beverages (SSBs) had a 0.5–2 times higher incidence of MetS [45, 46]. Independent of body weight, another study by Mirmiran et al. (2015) found that sugar-sweetened carbonated soft drinks were positively associated with MetS, hypertension, abdominal obesity, and a higher odds of unfavorable changes in cardiometabolic risk variables [47].

Compared to the groups with lower HBI scores, the study found that individuals with higher HBI scores had significantly lower waist circumference, lower triglyceride levels, improved FBS levels, and a lower prevalence of hypertension. These results suggest a favorable association between healthy beverages and cardiometabolic well-being.

According to a study by Duffey and Davy (2015) [30], there is a correlation between a higher HBI and a lower probability of having a large WC. Similarly, Collison et al. (2010) [48] discovered that larger WC in school children was related to increased consumption of carbonated, sugar -sweetened beverages. In addition, studies by Funtikova et al. (2015) on adults in Spain showed that replacing soft beverages with fruit juice and whole milk, both containing 100 kcal, reduced WC by 1.1 and 1.3 cm, respectively [49].

To fully understand the relationship between healthy beverages and cardiometabolic well-being, it is important to contrast these results with another study. We refer to a related study by Jahanbazi et al. (2023), which investigated how HBI scores affect cardiometabolic health [26]. Similar results were observed in the study by Kiyah et al. which used a larger sample size ($n=16{,}252$) and a longitudinal approach. According to the Kiyah et al. study, those with higher HBI scores had a significant decrease in their waist circumference, a significant improvement in their FBS levels, a significant decrease in their triglyceride levels, and a significant decrease in the prevalence of hypertension compared to those with lower HBI scores.

The comparable results of the two studies demonstrate the strength of the association between improved cardiometabolic health outcomes and healthy beverages as determined by HBI scores.

Strengths/limitations

The strength of this study lies in its large, well-defined cohort and robust methodology. This study provides a thorough and statistically significant examination of the association between metabolic syndrome and the HBI using data from a large population sample. The large cohort ensures better generalizability of the results to a broader population and also improves statistical power.

The limitations of the research under review, which include plausible confounding factors and cross-sectional methodology. Longer-term randomized controlled trials are needed to determine the relationship between healthy beverage intake and cardiometabolic health. It is also important to consider the extent to which these results are transferable to different demographics and cultural setting.

Conclusion

The results of study suggest that higher HBI scores are associated with a lower developing of MetS. This emphasizes the importance of choosing health-promoting drinks as a strategy - to control and prevent MetS. These findings add to the growing body of research demonstrating the association between dietary habits and metabolic health and provide practical advice for people and public health programs aimed at improving metabolic health outcomes.

Acknowledgements

The authors thank the PERSIAN cohort Study collaborators and of Kermanshah University of Medical Sciences.

Author contributions

HLF and YP generated the initial idea for the study, SHR and FN carried out all analyses and visualization of the results. HLF, MD NI and ESH, drafted the manuscript. All authors provided critical input into.

Funding

This study was supported by the Kermanshah University of Medical Sciences, Kermanshah, Iran (grant number 92472).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The Ethics Committee of Kermanshah University of Medical Sciences approved the study (code: KUMS.REC.1394.318). All methods were carried out in accordance with relevant guidelines and regulations. All the participants were provided oral and written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Nursing Department, Kalar Technical Institute, Garmian Polytechnic University, Kalar, Kurdistan Region, Iraq
[2]Research Center for Social Determinants of Health, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Infectious Diseases Research Center, Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran
[4]Research Center for Environmental Determinants of Health (RCEDH), Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran
[5]Social Development and Health Promotion Research Center, Kermanshah University of Medical Sciences, Kermanshah, Iran
[6]Student Research Committee, Kermanshah University of Medical Sciences, Kermanshah, Iran
[7]Department of Nutritional Sciences, School of Nutritional Sciences and Food Technology, Kermanshah University of Medical Sciences, Kermanshah, Iran

Received: 30 May 2024 / Accepted: 26 September 2024
Published online: 01 October 2024

References

1. Huang PL. A comprehensive definition for metabolic syndrome. Dis Model Mech. 2009;2(5–6):231–7.
2. Fateh HL, Mirzaei N, Gubari MIM, Darbandi M, Najafi F, Pasdar Y. Association between dietary total antioxidant capacity and hypertension in Iranian kurdish women. BMC Womens Health. 2022;22(1):255.
3. Fateh HL, Muhammad SS, Kamari N. Associations between adherence to MIND diet and general obesity and lipid profile: a cross-sectional study. Front Nutr. 2023;10.
4. Martín-Timón I, Sevillano-Collantes C, Segura-Galindo A, Del Cañizo-Gómez FJ. Type 2 diabetes and cardiovascular disease: have all risk factors the same strength? World J Diabetes. 2014;5(4):444–70.
5. Dal Canto E, Ceriello A, Rydén L, Ferrini M, Hansen TB, Schnell O, et al. Diabetes as a cardiovascular risk factor: an overview of global trends of macro and micro vascular complications. Eur J Prev Cardiol. 2020;26(2suppl):25–32.

6. Sharma A, Mittal S, Aggarwal R, Chauhan MK. Diabetes and cardiovascular disease: inter-relation of risk factors and treatment. Future J Pharm Sci. 2020;6(1):130.
7. Farmanfarma KK, Kaykhaei MA, Adineh HA, Mohammadi M, Dabiri S, Ansari-Moghaddam A. Prevalence of metabolic syndrome in Iran: A meta-analysis of 69 studies. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2019;13(1):792-9.
8. Hosseinpour-Niazi S, Mirmiran P, Hosseinpanah F, Fallah-Ghohroudy A, Azizi F. Association of marital status and marital transition with metabolic syndrome: tehran lipid and glucose study. Int J Endocrinol Metab. 2014;12(4):e18980.
9. Jha BK, Sherpa ML, Imran M, Mohammed Y, Jha LA, Paudel KR, et al. Progress in understanding metabolic syndrome and knowledge of its Complex Pathophysiology. Diabetology. 2023;4(2):134–59.
10. Chen P-J, Antonelli M. Conceptual Models of Food Choice: influential factors related to Foods, Individual Differences, and Society. Foods. 2020;9(12):1898.
11. Rahimlou M, Mirzaei K, Keshavarz SA, Hossein-Nezhad A. Association of circulating adipokines with metabolic dyslipidemia in obese versus non-obese individuals. Diabetes Metab Syndr. 2016;10(1 Suppl 1):S60–5.
12. Rahimlou M, Morshedzadeh N, Karimi S, Jafarirad S. Association between dietary glycemic index and glycemic load with depression: a systematic review. Eur J Nutr. 2018;57(7):2333–40.
13. Sogari G, Velez-Argumedo C, Gómez MI, Mora C. College Students and Eating habits: a study using an ecological model for Healthy Behavior. Nutrients. 2018;10(12).
14. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Alsulaiman NA, Musaiger AO. Prevalence of overweight, obesity, and abdominal obesity among urban Saudi adolescents: gender and regional variations. J Health Popul Nutr. 2014;32(4):634–45.
15. de Castro JM. A twin study of genetic and environmental influences on the intake of fluids and beverages. Physiol Behav. 1993;54(4):677–87.
16. Wenhold F, Faber M. Water in nutritional health of individuals and households: An overview Water SA. 2009;35.
17. Daniels MC, Popkin BM. Impact of water intake on energy intake and weight status: a systematic review. Nutr Rev. 2010;68(9):505–21.
18. Muckelbauer R, Sarganas G, Grüneis A, Müller-Nordhorn J. Association between water consumption and body weight outcomes: a systematic review. Am J Clin Nutr. 2013;98(2):282–99.
19. Dennis EA, Flack KD, Davy BM. Beverage consumption and adult weight management: a review. Eat Behav. 2009;10(4):237–46.
20. Popkin BM, Armstrong LE, Bray GM, Caballero B, Frei B, Willett WC. A new proposed guidance system for beverage consumption in the United States. Am J Clin Nutr. 2006;83(3):529–42.
21. Armstrong LE, Ganio MS, Casa DJ, Lee EC, McDermott BP, Klau JF, et al. Mild dehydration affects mood in healthy young women. J Nutr. 2012;142(2):382–8.
22. Ganio MS, Armstrong LE, Casa DJ, McDermott BP, Lee EC, Yamamoto LM, et al. Mild dehydration impairs cognitive performance and mood of men. Br J Nutr. 2011;106(10):1535–43.
23. Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. Am J Public Health. 2007;97(4):667–75.
24. Rasaei N, Ghaffarian-Ensaf R, Shiraseb F, Abaj F, Gholami F, Clark CCT, et al. The association between Healthy Beverage Index and psychological disorders among overweight and obese women: a cross-sectional study. BMC Womens Health. 2022;22(1):295.
25. Ferruzzi MG, Tanprasertsuk J, Kris-Etherton P, Weaver CM, Johnson EJ. Perspective: the role of beverages as a source of nutrients and phytonutrients. Adv Nutr. 2020;11(3):507–23.
26. Jahanbazi L, Abbasalizad Farhangi M, Tousi AZ, Nikrad N. The Association between Healthy Beverage Index (HBI) with metabolic risk factors among apparently metabolically healthy overweight and obese individuals. Clin Nutr Res. 2023;12(3):218–28.
27. Pasdar Y, Najafi F, Moradinazar M, Shakiba E, Karim H, Hamzeh B, et al. Cohort profile: Ravansar Non-communicable Disease cohort study: the first cohort study in a kurdish population. Int J Epidemiol. 2019;48(3):682–f3.
28. Aadahl M, Jørgensen T. Validation of a new self-report instrument for measuring physical activity. Med Sci Sports Exerc. 2003;35(7):1196–202.
29. Moradi S, Pasdar Y, Hamzeh B, Najafi F, Nachvak SM, Mostafai R, et al. Comparison of 3 nutritional questionnaires to determine energy intake accuracy in Iranian adults. Clin Nutr Res. 2018;7(3):213–22.
30. Duffey KJ, Davy BM. The healthy Beverage Index is Associated with reduced cardiometabolic risk in US adults: a preliminary analysis. J Acad Nutr Diet. 2015;115(10):1682–e92.
31. Jalilpiran Y, Mozaffari H, Askari M, Jafari A, Azadbakht L. The association between healthy Beverage Index and anthropometric measures among children: a cross-sectional study. Eat Weight Disord. 2021;26(5):1437–45.
32. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation. 2005;112(17):2735–52.
33. Shaikh RA, Siahpush M, Singh GK, Tibbits M, Socioeconomic Status. Smoking, Alcohol use, physical activity, and Dietary Behavior as determinants of obesity and body Mass Index in the United States: findings from the National Health interview survey. Int J MCH AIDS. 2015;4(1):22–34.
34. Specht IO, Heitmann BL, Larsen SC. Physical activity and subsequent change in Body Weight, composition and shape: Effect modification by familial overweight. Front Endocrinol (Lausanne). 2022;13:787827.
35. Jacobo Cejudo MG, Ochoa-Rosales C, Ahmadizar F, Kavousi M, Geleijnse JM, Voortman T. The healthy beverage index is not associated with insulin resistance, prediabetes and type 2 diabetes risk in the Rotterdam Study. Eur J Nutr. 2023;62(7):3021–31.
36. Walls HL, Peeters A, Proietto J, McNeil JJ. Public health campaigns and obesity - a critique. BMC Public Health. 2011;11(1):136.
37. Cleveland DA. What'rsquo;s to Eat and Drink on Campus? Public and Planetary Health, Public Higher Education, and the Public Good. Nutrients. 2023;15(1):196.
38. Nouri M, Shateri Z, Rezaei M, Zangene A, Homayounfar R, Keshani P. Healthy beverage index could decrease odds of metabolic syndrome: a cross-sectional study. Food Sci Nutr. 2023;11(8):4562–71.
39. Malik VS, Hu FB. Fructose and Cardiometabolic Health: what the evidence from Sugar-Sweetened beverages tells us. J Am Coll Cardiol. 2015;66(14):1615–24.
40. Coronati M, Baratta F, Pastori D, Ferro D, Angelico F, Del Ben M. Added Fructose in non-alcoholic fatty liver Disease and in metabolic syndrome: a narrative review. Nutrients. 2022;14(6).
41. Softic S, Stanhope KL, Boucher J, Divanovic S, Lanaspa MA, Johnson RJ, et al. Fructose and hepatic insulin resistance. Crit Rev Clin Lab Sci. 2020;57(5):308–22.
42. Liu J, Zhu Q, Dong Y, Yan Q, Li Y, Tang X, et al. Association of the healthy Beverage Index with metabolic syndrome and stroke in U.S. adults: the National Health and Nutrition Examination Survey 2013–2014. Research Square; 2021.
43. Shin S, Kim SA, Ha J, Lim K. Sugar-Sweetened Beverage Consumption in relation to obesity and metabolic syndrome among Korean adults: a cross-sectional study from the 2012‑2016 Korean National Health and Nutrition Examination Survey (KNHANES). Nutrients. 2018;10(10).
44. Denova-Gutiérrez E, Talavera JO, Huitrón-Bravo G, Méndez-Hernández P, Salmerón J. Sweetened beverage consumption and increased risk of metabolic syndrome in Mexican adults. Public Health Nutr. 2010;13(6):835–42.
45. Dhingra R, Sullivan L, Jacques PF, Wang TJ, Fox CS, Meigs JB, et al. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. Circulation. 2007;116(5):480–8.
46. Barrio-Lopez MT, Martinez-Gonzalez MA, Fernandez-Montero A, Beunza JJ, Zazpe I, Bes-Rastrollo M. Prospective study of changes in sugar-sweetened beverage consumption and the incidence of the metabolic syndrome and its components: the SUN cohort. Br J Nutr. 2013;110(9):1722–31.
47. Mirmiran P, Yuzbashian E, Asghari G, Hosseinpour-Niazi S, Azizi F. Consumption of sugar sweetened beverage is associated with incidence of metabolic syndrome in tehranian children and adolescents. Nutr Metab (Lond). 2015;12:25.
48. Collison KS, Zaidi MZ, Subhani SN, Al-Rubeaan K, Shoukri M, Al-Mohanna FA. Sugar-sweetened carbonated beverage consumption correlates with BMI, waist circumference, and poor dietary choices in school children. BMC Public Health. 2010;10:234.

49. Funtikova AN, Subirana I, Gomez SF, Fitó M, Elosua R, Benítez-Arciniega AA, et al. Soft drink consumption is positively associated with increased waist circumference and 10-year incidence of abdominal obesity in Spanish adults. J Nutr. 2015;145(2):328–34.

Publisher's note