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CARDIOVASCULAR DISEASE (JHY WU, SECTION EDITOR)

The Use of Healthy Eating Index 2015 and Healthy Beverage Index for Predicting and Modifying Cardiovascular and Renal Outcomes

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Abstract

Purpose of Review With the wide recognition of the importance of dietary patterns rather than isolated nutrient groups on health outcomes, numerous diet quality indices have been designed to evaluate the overall food intake quality in the last two decades.

Recent Findings The newest version of the Healthy Eating Index (HEI), HEI-2015, is a diet quality index that measures adherence to the recommendations of the 2015–2020 Dietary Guidelines for Americans. While the key nutrient groups are included in most diet quality indices, differences in other components and the scoring system differentiate HEI. The Healthy Beverage Index (HBI) was recently introduced. Previous literature has confirmed the association of the older versions of HEI with metabolic syndrome, inflammatory markers, and negative health outcomes including cardiovascular disease, type 2 diabetes mellitus, chronic kidney disease, and all-cause mortality.

Summary This review presents the existing evidence on the association of HEI-2015 and HBI with health markers and long-term outcome, provides guidance on their use, and identifies persisting challenges such as the development of simple, unified, and objective tools to characterize healthy diets in routine clinical practice.

Keywords Healthy eating index · Healthy beverage index · Chronic kidney disease · Cardiovascular disease

Introduction

The intriguing relationship between nutrition and long-term health outcomes has been a topic of interest for decades. Traditionally, such investigation focused on the impact of specific elements of nutrients, although food and beverages are consumed in numerous complex combinations in daily life. For this reason, nutrition patterns that reflect the combination of nutrients are being increasingly recognized and embraced in nutrition research.

The Healthy Eating Index (HEI) is a measure of the diet quality based on the Dietary Guidelines for Americans (DGA). The HEI is updated with each new edition of DGA and the latest release, which is HEI-2015, reflects the 2015–2020 DGA [1]. HEI-2015, as the previous HEI versions, assesses diet quality in two major components: nine adequacy components (which should be included in a healthy diet) and four moderation components (whose consumption should be limited to a minimum). An increase in the intake of adequacy components corresponds to an increase in scores, while an increase in the intake of moderation components corresponds to a decrease in the scores. The total HEI-2015 scores range from 0 to 100 and higher scores indicate greater adherence to dietary guidelines [1]. HEI is used for various research purposes, including dietary interventions, food assistance programs, and epidemiology [2]. Among numerous diet indexes, the Alternate Healthy Eating Index (AHEI) [3], the alternate Mediterranean (aMed) diet [4], the Dietary Approaches to Stop Hypertension Trial

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(DASH) score [5], and Dietary Inflammatory Index (DII) [6] are other scoring methods of diet quality used commonly in nutrition research.

For scoring, HEI uses the density approach which calculates each component amount per 1000 kilocalories (kcal). Such system allows the separation of food quality from quantity. The adequacy components include whole fruits, total fruits, whole grains, dairy, total vegetables, greens and beans, total protein foods, seafood and plant proteins, and fatty acids. The moderation components include refined grains, added sugar, saturated fats, and sodium [1] (Table 1).

Although HEI-2015 is quite comprehensive, it neglects the role of beverages as a major nutritional component. However, caloric beverages provide as much as 20% of the daily total energy intake, according to the reports of United States Department of Agriculture [7]. Furthermore, beverages are known to have strong associations with negative health outcomes. For instance, health consequences associated with excessive sugar sweetened beverages, including increased risk of obesity, cardiovascular disease (CVD), and type 2 diabetes mellitus (T2DM) [8, 9], have been extensively studied. Surprisingly, the assessment of overall quality of beverage consumption has been mostly overlooked until recently. To fill the gap, the Healthy Beverage Index (HBI) has been introduced.

The recommendations included in the HBI are based on the Beverage Guidance System and Dietary Guidelines for Americans, similar to HEI. HBI consists of 10 components, which include water, unsweetened coffee and tea, low-fat milk, diet drinks, 100% fruit juice, alcohol, full-fat milk, sugar-sweetened beverages, the total beverage energy, and metabolic fluid requirement (Table 2). According to the percentage of fluid intake of each component, and the percentage of total energy gained via beverages, the score may range from 0 to 100. While the "healthy" beverage pattern would make a score of 100, the average HBI score for typical beverage consumption of an adult has been reported as 56 in the USA [10].

Over the years, HEI and other indexes have been vastly used in various research and were found to predict different health outcomes. However, the newest update of HEI, HEI-2015, is yet to be assessed for its associations with cardiorenal outcomes. Moreover, HBI, as a measure of overall beverage quality, has a considerable potential to be used in nutrition research and whether it is predictive of health outcomes is to be found. The purpose of this article is to review the latest HEI and newly introduced HBI, summarize existing evidence on metabolic risk factors and the long-term health outcomes associated with these indexes, and guide their use in future studies and clinical setting.

HEI, How Different Is It from Other Indexes?

The updated HEI-2015 preserved most components and scoring system of HEI-2010; only minor changes were done. HEI-2015 has included saturated fats and added sugars as separate components instead of placing them in the "empty calories" component, as done by HEI-2010. Meanwhile, excess calories from alcohol, which was included in the empty calories, were omitted from components.

HEI-2015 has several key differences from other eating indexes. For instance, while AHEI shares most components of HEI-2015, it also assesses for the fat quality (saturated

Table 1 Healthy Eating Index-2015 components and scoring [1]

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
Adequacy			
Total fruits	5	≥ 0.8 c equivalents/1000 kcal	No fruit
Whole fruits	5	≥ 0.4 c equivalents/1000 kcal	No whole fruit
Total vegetables	5	≥ 1.1 c equivalents/1000 kcal	No vegetables
Greens and Beans	5	≥ 0.2 c equivalents/1000 kcal	No dark green vegetables or beans and peas
Whole grains	10	≥ 1.5 oz equivalents/1000 kcal	No whole grains
Dairy	10	≥ 1.3 c equivalents/1000 kcal	No dairy
Total protein foods	5	≥ 2.5 oz equivalents/1000 kcal	No protein foods
Seafood and Plant Proteins	5	≥ 0.8 c equivalents/1000 kcal	No seafood or plant proteins
Fatty acids	10	(PUFAs + MUFAs)/SFAs ≥ 2.5	(PUFAs + MUFAs)/SFAs ≤ 1.2
Moderation			
Refined grains	10	≤ 1.8 oz equivalents/1000 kcal	≥ 4.3 oz equivalents/1,000 kcal
Sodium	10	≤ 1.1 g/1000 kcal	≥ 2.0 g/1000 kcal
Added sugars	10	≤ 6.5% of energy	≥ 26% of energy
Saturated fats	10	≤ 8% of energy	≥ 16% of energy

PUFAs polyunsaturated fatty acids, *MUFAs* monounsaturated fatty acids, *SFAs* saturated fatty acids, *c* cup (0.24 L), *oz* ounce (28.35 g)

Table 2 Healthy Beverage Index (HBI) components and scoring [10]

Beverage component	Description	Points
Water	Water comprises at least 20% of fluid requirements	15
	Water < 20% of fluid requirements	Proportional points for intake > 0 to < 20%
	No water consumption	0
Coffee and tea	Unsweetened coffee and tea comprise 0–40% of fluid requirements	5
Low-fat milk	< 1.5%, fat-free, and/or soy milk comprises 0–16% of fluid Requirements	5
Diet drinks	Artificially sweetened beverages, including coffee and tea, comprise 0–16% of fluid requirements	5
100% Fruit juice	100% fruit juice comprises 0–8% of fluid requirements	5
Alcohol	Between 0–1 drinks for women, 0–2 drinks for men	5
Full-fat milk	0% of fluid requirements come from 2% or full-fat milk	5
Sugar-sweetened beverages	0%-8% of fluid requirements come from sugar-sweetened carbonated beverages, fruit drinks, sweetened coffee or tea, other sweetened beverages, other beverages	15
Total beverage energy	Energy from beverages < 10% of total energy	20
	Energy from beverages ≥ 10% but < 15% of total energy	Proportional points based on reported intake
	Energy from beverages ≥ 15% of total energy	0
Met fluid requirement	Amount of beverages (mL) consumed was greater than or equal to fluid requirements	20
	Amount of beverages (mL) consumed was less than fluid requirements	Proportional points based on reported intake

versus polyunsaturated fats), consumption of nuts, and red and processed meat as separate components. Additionally, AHEI awards moderate alcohol intake separately [3]. Unlike HEI-2015, AHEI does not account for seafood and plant proteins. Distinctively, AHEI-2010 includes foods and nutrients shown to be associated with chronic diseases such as CVD and type 2 diabetes mellitus [3].

The aMED index was adapted from the traditional Mediterranean diet outlined by previous studies [11]. Its 9 separate components are vegetables, legumes, fruit, fish, nuts, whole grains, moderate alcohol intake, and ratios of monounsaturated to saturated fat while processed meats is the only moderation component. The aMED does not assess the intake of sugar-added food and is the only index that does not account for sodium intake among the 4 indexes [4].

DASH index is based on the DASH diet used in hypertension management and includes red and processed meat, sugar sweetened beverages, and sodium in addition to five healthy components, which contain low-fat dairy and nuts [5]. Like HEI-2015, alcohol use is excluded. However, fat quality is not included.

The scoring systems of HEI-2015 and AHEI are similar with slight variations. The maximum score for each component is 10 and the maximum total score is 110 in AHEI, and 100 in HEI-2015. The aMED index has a different scoring system and awards points to a component depending on its consumption amount compared to that of the median. Each component can get 1 point and the total scores range from 0 to 9. DASH is scored by quintiles in the dataset. Patients in quintile one receive one point, while patients in five are awarded five points. Total score ranges from 8 to 40 [5].

Although each diet index has some differences both in components and scoring systems, researchers continue to use these indices interchangeably in the lack of consensus on the optimal index. Despite the efforts of comparing the predictive values of many diet indices [12–16], no conclusive evidence has been gathered (Fig. 1).

Association of HEI and HBI with Metabolic Risk Factors

Healthy dietary patterns associated with traditional cardiometabolic risk factors. Healthy diet has been proposed as the key preventive measure against the epidemic of metabolic syndrome, a major risk factor for the development of diabetes mellitus, CVD, and mortality [17, 18]. Previous studies have shown significant associations between HEI scores and components of metabolic syndrome. Higher scores in older and new versions of HEI are correlated with lower body mass index consistently in cross-sectional [12, 19] and prospective cohort studies[20], as well as with abdominal adiposity, blood pressure, and favorable serum lipid levels [19]. In healthy obese adults, low adherence to HEI-2015 was an independent predictor of metabolic syndrome. Using structural equation modeling, adherence to HEI-2015 mediated

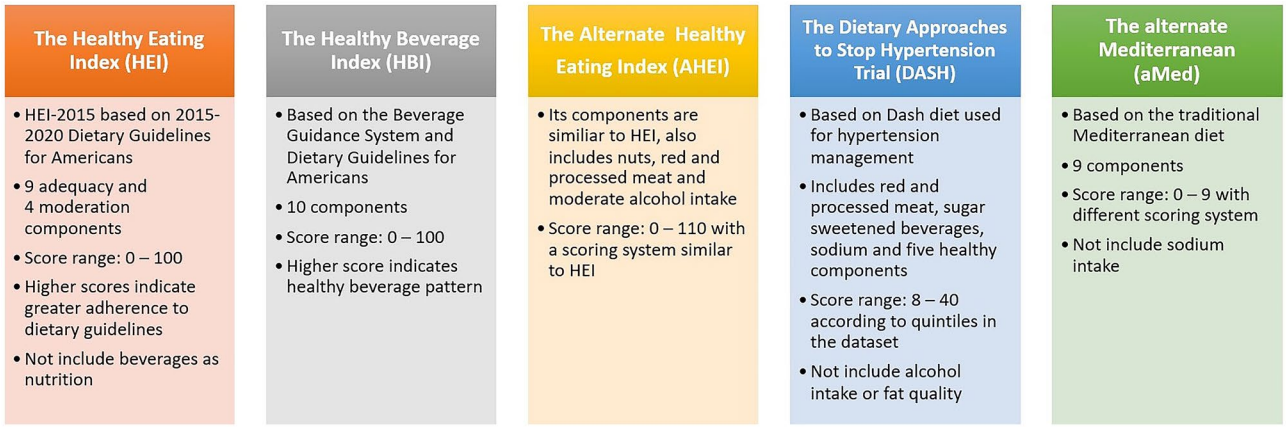

Fig. 1 The comparison of healthy eating and healthy beverage indexes. The comparison between five main healthy eating and healthy beverage indexes are provided in the figure with their number of components, scoring systems, ranges, and important included and excluded components for each index

the association between age and several cardio-metabolic risk factors of metabolic syndrome, including fat mass, fat free mass, systolic blood pressure (SBP), and high-density lipoprotein cholesterol (HDL-C). HEI-2015 scores also mediated the association between gender and waist circumference, systolic blood pressure (SBP), HDL-C, and triglyceride [21].

It should be noted that patients with higher index scores are also more likely to exercise and less likely to smoke [12], implying a healthier lifestyle preference overall.

Association of HEI and HBI with Inflammatory Markers

Meat-based or "Western" diet patterns have been associated with chronic low grade inflammation, which is linked with type 2 diabetes mellitus, CVD, and cancer [22]. Indeed, several cross-sectional studies have reported an inverse relationship between serum C reactive protein (CRP) levels and scores in the old HEI versions [23–26], AHEI [4, 27, 28], DASH [29], and aMED [4]. The DII scoring algorithm has been based on the effect of diet on inflammation by assessment of pro- and anti-inflammatory food parameters [6]. High adherence to the AHEI and HEI was correlated with higher serum levels of the anti-inflammatory marker adiponectin [27, 30]. However, the association of the updated HEI with inflammatory markers is yet to be verified. Additionally, information is needed on the association of diet scores with molecules of special interest for inflammation, aging and renal and CV disease, such as Klotho. Klotho is a protein with anti-aging and anti-inflammatory properties, which is downregulated by inflammation and other insults and is a key regulator of phosphate balance, adapting phosphate excretion to phosphate intake [31]. Importantly, worse DII score has been shown to correlate with lower eGFR levels, suggesting an association between pro-inflammatory diet and declining kidney function [32, 33].

HEI, HBI, and Cardiovascular Outcome

There is strong evidence that healthy diet may decrease the incidences of many chronic diseases including T2DM [34], CVD [35], cancer [36], and overall mortality [37]. As a validated measure of diet quality, HEI has been used extensively to elucidate the associations between diet quality and disease risk. According to a report in 2017, 185 papers that used HEI-2005 and over 100 papers that used HEI-2010 had been published [38]. Higher scores in HEI-2005 and HEI-2010 have been associated with lower risk of CVD, T2DM [3], and cardiovascular, cancer,and all-cause mortalities [39].

These findings have been corroborated by a meta-analysis of 15 cohort studies including more than 1 million participants in 2015. Diets of highest quality, as assessed by HEI 2005 and HEI 2010, AHEI, and DASH scores, were associated with significant risk reduction for all-cause mortality by 22%. Mortalities due to CVD, cancer, and T2DM were reduced by 22%, 15%, and 22%, respectively [14].

Mounting evidence implies similar associations for HEI-2015 as well. In the prospective analysis of Atherosclerosis Risk in Communities (ARIC) cohort, participants in the highest quintile of HEI-2015 had a 16% lower risk of incident CVD, 32% lower risk of cardiovascular mortality, and 18% lower risk of all-cause mortality among several ethnic groups ($p < 0.001$ for all). Similar results were found for the AHEI-2010, aMed, and DASH scores [13]. The same trend was seen with incident chronic kidney disease (CKD) [40]; however, no association was found between initial diet scores and incident diabetes mellitus [20]. Another very

recent cohort study of initially healthy health professionals, observed lower risk of CVD and stroke in the highest quintiles of HEI-2015, AHEI, aMed, and Healthful Plant-Based Diet Index (HPDI). The associations were stronger in the HEI-2015 and AHEI indexes and were similar across ethnic groups [41]. Findings from the Multiethnic cohort confirmed the validity of the HEI-2015 for predicting mortality from all-cause, CVD, and cancer in the general population whereas its validity was not assessed in CKD patients [42].

In an updated 2020 version of the meta-analysis by Schwingshackl et al., the HEI-2015 was inversely associated with all-cause mortality, CVD, and cancer, but not with T2DM and CKD [16].

All mentioned scoring systems have been associated with long term health outcomes; however, some indexes were reported to be more effective than others in several studies. HEI-2010, AHEI-2010, aMED, and DASH scoring were compared regarding their association with mortality from all-causes, CVD, and cancer [43], as well as type 2 diabetes mellitus risk [15] in the Multiethnic Cohort. Higher scores for all indexes were associated with decreased all-cause, cardiovascular, and cancer mortality. Nevertheless, HEI-2010 had a larger impact on risk reduction in all three categories for men. In women, AHEI showed greater reductions for all-cause and CVD mortality and aMed showed larger reduction for all-cause and cancer mortality [43]. Higher scores of AHEI-2010, aMED, and DASH were significantly associated with lower diabetes mellitus risk, while no association was found for the HEI-2010 index. Among the indexes, DASH index had the greatest association with diabetes and was the only index whose association remained significant in different ethnicities [15].

Changes in healthy diet scores can also predict positive health outcomes. In three healthy cohorts, improvement in diet quality over a 4-year period, as assessed by AHEI score, was associated with decreased risk of T2DM in a subsequent 4-year follow-up period. It is noteworthy that only 32% of the association was explained by changes in body weight [44].

Previous evidence has shown the association of soft drink consumption with the development of obesity and increased risk of CVD and type 2 diabetes mellitus [8, 45, 46]. Whether the recently published HBI is associated with long-term outcomes is yet to be elucidated. Nevertheless, Duffey et al. found positive associations between higher HBI scores and lower hyperlipidemia and hypertension risk; and, among men, CRP levels [10]. Moreover, Hu et al. showed a correlation between long term outcome and Healthy Beverage Score (HBS), a beverage index similar to HBI. While HBS has a different scoring system and excludes water consumption, it otherwise includes the same beverage components in the HBI. The results showed that among a cohort of people with CKD, participants in the highest tertile had a 17% lower risk of all-cause mortality compared with participants in the lowest tertile of the HBS. No association was found with incident CVS. When each beverage component was analyzed separately, unsweetened coffee and tea were inversely associated with all-cause mortality, while fruit juice was directly associated with incident CVD (Fig. 2) [47].

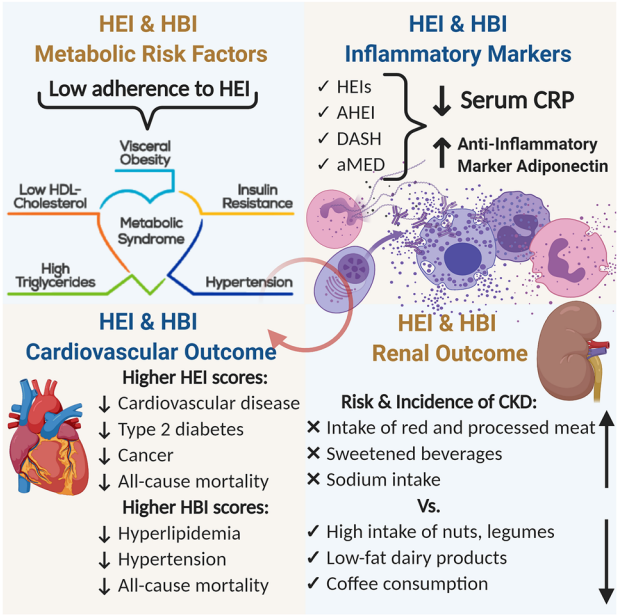

Fig. 2 The relationship between the healthy eating index (HEI), the healthy beverage index (HBI), metabolic risk factors, inflammatory markers, cardiovascular, and renal outcomes. The low adherence to the healthy eating index (HEI) is associated with significant risk factors for the development of metabolic syndrome. High score of HEI and the healthy beverage index (HBI) that indicates high adherence to healthy diet are associated with decreased CRP, increased anti-inflammatory marker adiponectin. Also, high adherence to healthy diet is associated with decreased disease burden such as decreased cardiovascular disease, diabetes mellitus, cancer, and chronic kidney disease. The Healthy Eating Index, HEI; The Healthy Beverage Index, HBI; The Alternate Healthy Eating Index, AHEI; The Dietary Approaches to Stop Hypertension Trial, DASH; The Alternate Mediterranean, aMed; C-Reactive Protein, CRP; Chronic Kidney Disease, CKD

HEI, HBI, and Renal Outcome

Generally speaking, risk of CKD has not been an outcome variable in most analyses on the relationship of healthy diet indexes and mortality, CVD, or diabetes risk. The only report on the association of HEI-2015 and renal outcome is ARIC, which found a risk reduction of 17% in incident CKD among participants in the highest quintile of HEI-2015 [40].

Analysis of the NIH-AARP cohort revealed significant association between diet quality assessed by HEI-2010, AHEI, aMed and DASH scores, and major renal outcomes during the mean follow-up time of 14 years. Regardless

of the index used, the highest quintiles of the scores had significantly lower risk of composite negative renal outcome, which was defined as initiation of dialysis and death due to renal causes. Diets with lower sodium and higher potassium intake were also associated with lower risk of the composite outcome [48–50].

A healthy diet, evaluated by the DASH score, may be effective in preventing the development of proteinuria [51, 52] and the decline in eGFR [51, 53, 54]. Importantly, among the individual components of the DASH score, high intake of red and processed meat, sweetened beverages, and sodium was directly associated with CKD, while high intake of nuts, legumes, and low-fat dairy products was inversely associated with CKD [53, 55]. Nevertheless, analysis of the NIH-AARP cohort data revealed no association between renal outcome and the Recommended Food Score, which includes only a narrow range of healthy nutrients, thus highlighting the importance of overall quality in diet rather than specific food groups [48].

It is proposed that a healthy diet may slow the progression of CKD through its benefits to blood pressure control, blood glucose, and lipid levels as well as its anti-oxidant and anti-inflammatory effects [56]. Additional dietary phosphate may also be important in CKD context. Thus, red and processed meat and at least some sweetened beverages share a high content in highly bioavailable phosphate from food additives or animal proteins [57, 58].

The risk of CKD is significantly higher in regular consumers of sugar-sweetened beverages [59]. Higher prevalence and incidence of CKD were reported in patients consuming over four servings of sugar sweetened beverages per week [60]. Coffee consumption, on the contrary, has been associated with significantly lower risk of incident CKD, albuminuria, and mortality related to CKD [61]. Results from the ARIC study also showed decreased risk of CKD in low-fat dairy consumers [62]. To date, there has been only one study evaluating the relationship between overall beverage quality and CKD. CKD patients in the highest tertile of HBS had a 25% lower risk of CKD progression than patients in the lowest tertile of the HBS. No association was found with incident CVD. In alignment with the previous findings, low-fat milk was inversely associated with CKD progression [47]. However, it should be acknowledged that the use of beverage indexes introduces a challenge in severe CKD patients who have significantly limited fluid intake and its use in CKD may be restricted with mild to moderate stages of disease. Nevertheless, for this population, the relationship of HBI with renal outcome is yet to be established (Fig. 2).

Recommendations for the use of HEI and HBI

Both HEI-2015 and HBI were developed to be used for various purposes such as epidemiology of diet quality among different population subgroups, evaluating the relationships between diet quality and health consequences, and assessing the efficacy of diet interventions [63].

The components in HEI are expressed relative to the energy intake for calculation and may require unique computational methods. The specific score algorithms are beyond the scope of this review and can be found elsewhere [63]. However, it should be noted that in clinical scenarios where extensive dietary data and 24-h dietary records are not available or intense computational methods are not feasible, and simpler questionnaires such as HBI-Q may be utilized. HBI-Q assess HBI score via the beverage intake questionnaire 15 (BEVQ-15), which contains 15 questions and has been reported to have over 90% agreement with actual HBI scores [64].

HEI and HBI should be seen as complimentary rather than independent indexes in nutrition research as eating patterns are highly intertwined with beverage choices. Indeed, changes in HBI were found to correlate with changes in total HEI-2010 score [65] previously. Consequently, it may be advisable to measure them simultaneously in the research setting.

How to Change Diets in Accordance with HEI and HBI

Although healthy nutrition recommendations are widely available, healthy eating information is seldom communicated in clinical practice. Among various diets focused on weight management, none has been found superior to others. As such, HEI-2015 and other indexes do not focus on any specific diet but on dietary patterns regarding macronutrients. Nevertheless, the complexity of these indexes limits their usefulness in guiding patient's diet in the daily life. For both the clinical and research settings, diets like the DASH diet and the Mediterranean diet or tools like Choose My Plate (offered by US U.S. Department of Agriculture at https://www.myplate.gov/) and the Healthy Eating Plate (offered by Harvard University at https://www.hsph.harvard.edu/nutritionsource/healthy-eating-plate/) can be used to follow the recommendations of DGA [66] and provide high HEI-2015 scores. To simplify the complex guidelines, the Healthy Eating Plate recommends covering one-half of the plate with vegetables and fruits, one-fourth with whole grains, and one-fourth with healthy proteins, and drinking water as the primary beverage [67]. Minimizing the consumption of added sugars and saturated fats is another critical point emphasized. Such easy-to-follow tools may help patients achieve greater adherence to healthy eating patterns.

While many patients are aware of the health implications of diet, the impact of beverages is frequently overlooked. One crucial step to improving healthy beverage intake is increasing the intake of water. HBI places a strong emphasis on the consumption of water and advocates that water should

compromise at least 20% of fluid requirements [10]. While sugar-sweetened beverages have been consistently associated with obesity and related complications [8], water consumption remains below the daily recommended intake for most of the population in the USA. By using data from NHANES cohort, Duffey et al. calculated the impact of replacing sugar-sweetened beverages with water on HBI scores and obesity prevalence. Replacing one serving of sugar-sweetened beverages with water improved the HBI score by 9 to 21% a predicted weight loss of 0.4 to 1.99 kg among adults over a 6–8-month period [68]. Water replacement may be a simple but highly effective strategy to promote weight loss or encourage weight maintenance in general population. It should be noted that while replacement of other beverages with water is still a feasible suggestion for CKD patients, caution must be exerted not to advocate water intake above recommended in this sensitive population.

Future Perspectives

Existing data enforce the importance of assessing the overall diet over isolated focus on particular food groups, which cannot depict the synergy between various nutrients.

While these indexes depict adherence to healthy diet patterns and have been shown to predict chronic diseases, they are invariably based on self-reported data and are prone to systemic bias (e.g., recall bias, social desirability bias) [69]. In addition, collecting 24-h diet data can be cumbersome in busy clinical settings. Identification of novel metabolomic biomarkers of nutrition intake that are easy to collect can provide more objectivity for nutrition research. Furthermore, proteomic profiling may reveal molecular biomarkers that reflect biologic pathways leading to chronic diseases. Recently, in a large multiethnic cohort, Kim et al. identified seventeen unique metabolites that were correlated with HEI-2015, AHEI, DASH, or aMED scores. Among these, six metabolites overlapped across multiple indexes and glycerate was associated with all 4 indices [70]. Using proteomic and metabolomic data, Walker et al. also identified 69 unique circulating proteins and 25 metabolites associated either with AHEI or DASH as well as 31 proteins and 29 metabolites associated with both indices. Importantly, some of the associated proteins were related to previously identified genetic loci in GWAS analyses, implying their linkage with various metabolic traits and increased susceptibility to CVD [71]. These data should be, however, considered preliminary, as kidney function was not taken into account and several of the metabolites identified are known to accumulate in CKD (e.g., hippurate, indoxyl sulfate) and some identified proteins, such as TWEAK, are also responsive to diverse disease conditions, including CKD [72]. Similar studies have also shown associations between various untargeted biomarkers and dietary patterns [73–76]. More comprehensive and confirmatory studies are needed to advance our understanding of metabolomic and proteomic signatures of nutrition patterns and employ these biomarkers in future research.

Currently, multiple comprehensive methods exist to assess diet quality and no consensus has yet been reached on which method is the most favorable. This situation leads to inconsistencies in the literature, as otherwise comparable studies use different diet indexes, diminishing reproducibility. One comprehensive eating index to encompass the need in both research and clinical settings should be sought in future studies. Existing evidence imply that many of the existing diet indices, including HEI-2015, have predictive values for negative health outcomes. More precise assessment of nutrition patterns and their relations with chronic diseases would allow for targeted preventive actions preceding the onset of chronic diseases. Lastly, evidence on the associations of HBI and the most recently developed eating index, HEI-2015 with biomarkers and long-term outcomes is needed.

Conclusion

In summary, HEI-2015 is a reliable index to measure overall diet quality while HBI assesses overall beverage intake and diet and can be used as a complementary index to the eating scores. These tools are valuable in clinical settings, in intervention trials to assess overall quality of diet and beverage intake and in epidemiologic studies. Although the scoring calculations are complex and may not be feasible to use in daily practice, their components should be used to guide patient treatment in the light of their association with health outcome. Easy steps to improve HEI-2015 and HBI scores include increasing vegetable, fruit, and whole grain consumption, while decreasing added sugar and saturated fat consumption and replacing sweetened beverages with water. In addition to verifying the predictive validity of HEI-2015 and HBI for cardiorenal outcomes in the general population and in CKD patients, future studies should seek solution to the need of one comprehensive eating index which is objective and simple to apply to routine clinical practice.

Practical application

- HEI-2015 is a reliable index to measure overall diet quality.
- HE-2015 and HBI may be valuable parameters to predict cardiovascular and renal outcome in general population as well as in CKD patients.
- HEI-2015 and HBI should be used in clinical practice and may help to improve the outcome of the patients.

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Data Availability Not applicable.

Code Availability Not applicable.

Declarations

Ethics Approval and Consent to Participate Not applicable.

Consent for Publication Not applicable.

Conflict of Interest The authors do not have any potential conflicts of interest to disclose.

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• Of importance
•• Of major importance

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