

Is Beverage Consumption Related to Specific Dietary Pattern Intakes?

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Abstract Evaluating dietary patterns, rather than the consumption of single food items or nutrients, can provide a greater understanding of diet and health relationships. Dietary pattern research has been specifically identified as a research gap by the US Dietary Guidelines Committees. The purpose of this review was to determine if associations exist between the intake of commonly consumed beverages and specific dietary patterns. This review provides strong evidence that the consumption of water, unsweetened tea/coffee, low-fat milk, artificially sweetened beverages, and fruit/vegetable juice closely align with a Prudent dietary pattern; and conversely, the consumption of high-fat milk, alcohol, and sugar-sweetened beverages are strongly associated with a Western dietary pattern. Future directions include: 1) continuing to examine beverage intake patterns and define their relationship to dietary patterns, 2) developing a measure of overall beverage intake quality to assess beverage patterns, and 3) identifying beverage patterns that are associated with health and disease outcomes.

Keywords Beverage · Dietary pattern · Systematic review · Sugar-sweetened beverages · Dietary assessment · Non-nutritive sweeteners · Artificial sweeteners · Dietary quality · Pattern analysis

Introduction

The dramatic recent changes in the United States (US) population's beverage consumption habits, particularly with sugar-sweetened beverages (SSB) [1], have generated much interest in the role beverages play in overall health. The health benefits of water consumption include a reduced risk of coronary heart disease and gallstones [2] and possibly weight control [3, 4], whereas SSB consumption is associated with adverse health outcomes including weight gain and obesity [5, 6]. The consumption of low-fat milk and unsweetened tea and coffee is also generally associated with health benefits [7, 8]. Recommendations to replace SSB consumption with artificially sweetened beverages (non-nutritive sweeteners, NNS) for the purpose of reducing caloric intake, and consequently body weight, is controversial, as the evidence for effects of NNS intake on health and weight status is limited and show mixed results [7, 9, 10]. Although a great deal of attention has focused upon SSB intake, with considerable controversy over health effects, taxation, and policy recommendations [11, 12], some have suggested that a "broader focus" is needed [13].

Recognition that interactions between single foods or nutrients exist which impact health and disease outcomes has led to investigations of dietary patterns, which may better predict health or disease risk [14, 15]. As with foods, individuals consume different types of beverages throughout the day. Thus, investigations focused upon a single type of beverage could be confounded by an individual's overall food and beverage consumption pattern. A growing body of literature has investigated associations between dietary patterns (e.g.,

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Western/Prudent [16], Mediterranean [17], and the Healthy Eating Index [18]) and health outcomes such as obesity [19•], coronary heart disease [14], metabolic syndrome [19•, 20], hypertension [21], diabetes [22, 23], and cancer [24]. Recently, it has been suggested that rather than targeting a specific food product (e.g., SSB), that pricing policies including a combination of taxes and subsidies be adopted to promote healthier dietary patterns [25•]. Research identifying healthier overall dietary consumption patterns could be used to develop dietary recommendations that are more easily translated into optimal diets by the public [14], and to inform public policy.

Although dietary pattern research has shown important associations with disease outcomes in diverse populations [20, 26], dietary pattern research has been specifically identified as a research gap by US Dietary Guidelines Committees [27••]. To date, no systematic reviews have examined the body of literature addressing associations between beverage consumption and specific dietary patterns. Thus, the objective of this review was to determine if associations exist between the intake of commonly consumed beverages and specific dietary patterns.

Methods

A literature search was conducted for relevant articles published between June 2004 and September 2014. The identification stage consisted of an electronic search of the following keywords: “dietary pattern AND beverage” and additional searches replacing beverage with “water”, “tea”, “coffee”, “dairy”, “milk”, “diet soda”, “non-nutritive sweetened soda”, “artificially sweetened beverage”, “fruit juice”, “vegetable juice”, “alcohol”, “beer”, “wine”, “liquor”, “sugar-sweetened beverage”, “soft drink”, “soda”, “pop”, “sports drinks”, “juice drinks”, “energy drinks”, “fruit-ades”, “milkshake”, “yogurt drinks”, and “kefir”. Three databases were utilized: PubMed (MEDLINE), CINAHL, and COCHRANE. The present review was limited to clinical trials, meta-analyses, randomized control trials, journal articles, and reviews published within the past decade (June 2004–September 2014). This initial search identified 1,451 articles. The following process was used to screen the identified articles: step 1) we identified and removed duplicates ($n=723$) using Endnote X5 reference management software (Thomson Reuters 2011), step 2) we reviewed each article’s title and abstract ($n=728$) using the inclusion criteria below and excluded an additional 660 articles, and step 3) we downloaded and reviewed full-text articles ($n=68$) for inclusion/exclusion criteria.

To be included in the review, the article had to 1) assess an adult population (greater than 18 years old), 2) be published between June 2004 and September 2014, and 3) contain at least one beverage in the dietary pattern analysis or

demonstrate differences in dietary intake between beverage consumers versus non-consumers (e.g., a population that consumes SSB versus no consumption). Exclusion criteria included the following: 1) descriptive dietary data only (no patterns determined), 2) beverages grouped together into broad categories (e.g., hot drinks), 3) lack of association between a beverage and a dietary pattern, 4) food purchasing patterns instead of dietary intake patterns, and 5) a focus on special populations (i.e., pregnant women, children, and specific disease states). Figure 1 presents an overview of the search and screening process, based upon the PRISMA approach [28].

Results

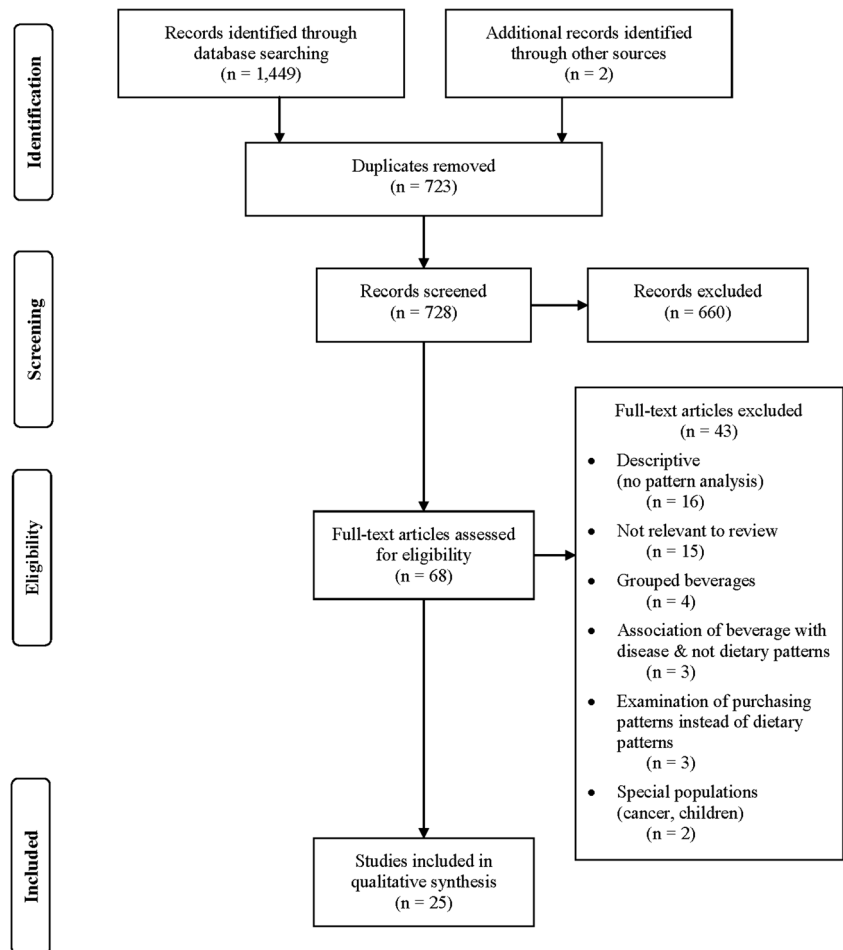
Twenty-five articles were identified for inclusion. Research findings are summarized in the text according to specific beverage categories, which were derived from existing beverage intake recommendations [8, 29]. Articles included in this review are summarized in Table 1, and distinguished by studies conducted in the US or in non-US populations. The results of the beverage intake studies were categorized by their association with two validated dietary patterns [14], which are presented in Table 2. The Prudent-type pattern has been associated with a higher consumption of fruits, vegetables, whole grains, and fish; the Western-type dietary pattern has been associated with a higher consumption of processed and red meat, butter, high-fat dairy products, and refined grains [14]. Importantly, these patterns have been associated with risk of coronary heart disease, obesity, and metabolic syndrome [14, 19•, 20].

Although many of the included articles investigated the associations of particular beverages with specific dietary patterns (i.e., Prudent versus Western), others explicitly defined dietary patterns based on the consumption of a particular beverage (e.g., description of dietary patterns for consumers versus non-consumers of NNS beverages). Results of both types of articles are collectively described within the following beverage categories.

Water

Four studies included dietary patterns associated with water consumption [30–33]. Using a nationally representative sample of US adults, Duffey et al., [30] identified food and beverage clusters to examine the association between them. Six independent beverage and food clusters (12 total) were identified. Being a member of a beverage cluster dominated by non-caloric beverages (e.g., “water and tea”) was associated with being in a healthier food cluster (e.g., “vegetable and fruit”). Additionally, the authors reported that participants in the “water and tea” and “coffee, tea, and water” clusters

Fig. 1 Flow diagram of the structured review of beverage associations with dietary patterns



consumed lower amounts of energy from other types of beverages, as compared to other beverage clusters (“sweetened coffee and soda”, “nutrients and soda”, and “soda”) [30].

Popkin et al., [32] compared the dietary characteristics of US water consumers to non-consumers. Water consumers reported significantly less sweetened coffee and tea, regular soda, fast food, and overall energy intake (194 kcal difference) and significantly more fruit juice and vegetable consumption than water non-consumers [32]. Within dietary patterns derived from cluster analysis, water was found to be associated with a cluster characterized by high fruit, vegetable, and low-fat dairy consumption [32].

A dietary pattern analysis completed in a population from the United Kingdom reported that water intake was associated with a healthier dietary pattern, which was high in fruit, vegetables, and dairy, and low in bacon, ham, and meat products [31]. A study comparing a Spanish population’s adherence to either a Western or Mediterranean dietary pattern showed lower overall water consumption [total water difference -107 g] with higher Western adherence and higher bottled water intake (total water difference +207 g) with higher Mediterranean adherence [33].

Tea/Coffee (Unsweetened)

Ten studies, a majority of these in international populations, included dietary patterns associated with unsweetened tea and/or coffee intake [30, 33–41], with mixed results. Total tea consumption among French adults [35] and Belgian military men [38] was positively associated with a Prudent-type dietary pattern. On the other hand, oolong and black tea (Japanese adults [40]) and coffee (Japanese [39, 40] and Korean [36] adults) were all associated with a Western-type pattern. Green tea consumption was positively associated with a Prudent-type pattern among Japanese adults [39] and a Western-type pattern among Korean men [37]. In a Spanish population, regular and decaffeinated coffee was negatively associated with Western-type patterns, and decaffeinated coffee was positively associated with the Mediterranean pattern [33]. Among Norwegian women, lower coffee consumption was related to the “healthy eaters” pattern (skim milk, yogurt, chicken, and fruit) [34]. In the US, increased tea and coffee consumption was associated with higher adherence to a Mediterranean diet [41]. Unsweetened tea and coffee were clustered with

Table 1 Summary of included articles

Reference	Population	Dietary Assessment Method	Beverages with Associations to Dietary Patterns ^d						
			Water	Tea/ coffee	LF milk	NNS	Juice	HF milk	Alcohol
United States (US) Population									
Anderson 2012 [43]	n=1,751 older US adults	FFQ ^a			✓		✓	✓	✓
Duffey 2012 [49]	n=4,161 young US adults	FFQ				✓			
Nettleton 2008 [22]	n=5,011 US adults	FFQ							✓
Steffen 2014 [41]	n=4,713 young US adults	FFQ		✓		✓			✓
Deshmukh-Taskar 2009 [44]	n=995 young US adults	Semiquantitative FFQ			✓		✓	✓	✓
Gao 2007 [45]	n=131,368 US adults	Semiquantitative FFQ			✓			✓	✓
Duffey 2006 [30]	n=9,491 US adults	1 24-hr dietary recall ^b	✓	✓	✓	✓	✓	✓	✓
Popkin 2005 [32]	n=4,755 US adults	1 24-hr dietary recall ^b	✓						
Ledikwe 2004 [50]	n=179 older US adults	5 24-hr dietary recalls					✓		
Newby 2004 [47]	n=449 US adults	7 day food diary			✓		✓	✓	✓
Non-US Populations									
Centritto 2008 [52]	n=7,646 Italian adults	FFQ					✓	✓	
Engeset 2005 [34]	n=35,554 Norwegian women	FFQ		✓	✓	✓	✓	✓	✓
Lee 2011 [37]	n=3,581 Korean male adults	FFQ		✓			✓		✓
Maruapula 2007 [53]	n=1,079 older Batswana adults	FFQ					✓	✓	✓
Mishra 2010 [42]	n=17,521 Australian women	FFQ			✓		✓	✓	
Nanri 2013 [39]	n=101,630 Japanese adults	FFQ		✓			✓	✓	✓
Shi 2011 [51]	n=1,231 Chinese adults	FFQ					✓	✓	
Shimazu 2007 [40]	n=40,547 Japanese adults	FFQ		✓				✓	
Mullie 2009 [38]	n=1,852 Belgian military males	Semiquantitative FFQ		✓	✓		✓	✓	✓
Naja 2011 [46]	n=2,048 Lebanese adults	Semiquantitative FFQ			✓	✓	✓	✓	✓
Sanchez-Villegas 2009 [33]	n=15,073 young Spanish adults	Semiquantitative FFQ	✓	✓	✓	✓	✓	✓	✓
Kim 2012 [36]	n=10,089 Korean adults	1 24-hr dietary recall ^c		✓				✓	
Batis 2014 [48]	n=9,253 Chinese adults	3 24-hr dietary recalls			✓				
Kesse-Guyot 2009 [35]	n=5,194 French adults	6 24-hr dietary recalls		✓				✓	✓
Mishra 2006 [31]	n=1,265 United Kingdom adults	3, 5-day food diaries	✓	✓	✓		✓	✓	

^a FFQ: Food-frequency questionnaire

^b 24-hr dietary recall from NHANES: National Health and Nutrition Examination Survey 1999-2001

^c 24-hr dietary recall from KNHANES: Korean National Health and Nutrition Examination Survey 2001-2005

^d Tea/coffee: unsweetened; LF milk: low-fat/soy milk; NNS: non-nutritive sweeteners (artificially sweetened beverages); Juice: 100 % fruit/vegetable juice; HF milk: high-fat milk; Alcohol: beer, wine, liquor; SSB: sugar-sweetened beverages (soda, fruit drinks, sweetened tea/coffee)

water in the beverage results for Duffey et al., and are presented in the water section [30].

For the remaining articles, the identified dietary patterns were not considered Western or Prudent: in a Japanese population, green tea was associated with a traditional Japanese diet (high fish and soybean) [40]; in the United Kingdom, coffee loaded heavily with “ethnic foods and alcohol” (high intake of fried Indian and Chinese foods) [31]; and in Norwegian women, the highest coffee consumption was with the “traditional fish eaters” pattern (characterized by high intake of fish, sour cream, and potatoes) [34].

Low-Fat/Skim Milk and Soy Beverages

Only four of the eleven articles studied low-fat dairy beverages solely [31, 33, 34, 42], while the remaining seven articles examined low-fat dairy products as a whole (including low-fat milks, cheeses, and yogurts) [30, 38, 43–47].

For articles that examined low-fat milk separately from other sources of low-fat dairy, the following associations were observed: in a Spanish population, higher intakes of low-fat milk were associated with high adherence to a Mediterranean dietary pattern, and lower intakes with a Western-type dietary

Table 2 Association of beverages to Prudent-type and Western-type dietary patterns

Beverage	Prudent-Type Dietary Patterns *		Western-Type Dietary Patterns **	
	Positively Associated	Negatively Associated	Positively Associated	Negatively Associated
Water				
Water	Duffey 2006 ^a [30] Mishra 2006 ^c [31] Popkin 2005 ^a [32] Sanchez-Villegas 2009 [33]			Duffey 2006 ^a [30] Sanchez-Villegas 2009 [33]
Tea/coffee (unsweetened)				
Tea	Duffey 2006 ^a [30] Kesse-Guyot 2009 [35] Mullie 2009 [38] Nanri 2013 [39] Steffen 2014 ^a [41]		Lee 2011 ^b [37] Nanri 2013 [39]	Duffey 2006 ^a [30]
Coffee	Duffey 2006 ^a [30] Sanchez-Villegas 2009 [33] Steffen 2014 ^a [41]	Engeset 2005 ^c [34]	Kim 2012 [36] Nanri 2013 [39] Shimazu 2007 [40]	Duffey 2006 ^a [30] Sanchez-Villegas 2009 [33]
Low-Fat/skim milk and soy beverages				
Low fat/skim milk and soy milk	Anderson 2012 ^{ad} [43] Deshukh-Taskar 2009 ^{ad} [44] Duffey 2006 ^{ad} [30] Engeset 2005 ^c [34] Gao 2007 ^{acd} [45] Mishra 2010 ^c [42] Mullie 2009 ^d [38] Naja 2011 ^d [46] Newby 2004 ^{ad} [47] Sanchez-Villegas 2009 [33]			Anderson 2012 ^{ad} [43] Mishra 2006 ^c [31] Sanchez-Villegas 2009 [33]
Soy milk	Mishra 2006 ^c [31]		Batis 2014 [48]	Mishra 2010 ^c [42]
Non-calorically sweetened beverages [artificially sweetened or non-nutritive sweeteners (NNS)]				
Non-calorically sweetened beverages	Duffey 2012 ^a [49•] Sanchez-Villegas 2009 [33]	Steffen 2014 ^a [41]		Duffey 2006 ^a [30] Sanchez-Villegas 2009 [33]
Diet soda	Naja 2011 [46]			
Caloric beverages with some nutrients				
Fruit/vegetable juice	Deshukh-Taskar 2009 ^a [44] Engeset 2005 ^c [34] Ledikwe 2004 ^a [50] Mishra 2006 ^c [31] Mullie 2009 [38] Newby 2004 ^a [47] Sanchez-Villegas 2009 [33]		Centritto 2008 [52] Maruapula 2007 [53] Naja 2011 [46] Nanri 2013 [39] Shi 2011 [51]	Sanchez-Villegas 2009 [33]
High-fat/whole milk		Anderson 2012 ^{ae} [43] Engeset 2005 ^c [34] Mishra 2010 ^c [42] Sanchez-Villegas 2009 [33]	Anderson 2012 ^{ae} [43] Deshukh-Taskar 2009 ^{ae} [44] Duffey 2006 ^{ae} [30] Gao 2007 ^{abe} [45] Gao 2007 ^{acc} [45] Lee 2011 ^{be} [37] Mullie 2009 ^c [38] Sanchez-Villegas 2009 [33]	
Alcoholic beverages				
-Beer		Shimazu 2007 [40]	Kesse-Guyot 2009 [35] Kim 2012 [36] Newby 2004 ^a [47] Shi 2011 [51] Shimazu 2007 [40] Anderson 2012 ^a [43] Centritto 2008 [52] Kesse-Guyot 2009 [35] Mullie 2009 [38] Nanri 2013 [39] Shi 2011 [51]	Sanchez-Villegas 2009 [33]
-Wine	Mishra 2010 ^c [42]	Sanchez-Villegas 2009 [33]	Centritto 2008 [52]	Sanchez-Villegas 2009 [33]

Table 2 (continued)

Beverage	Prudent-Type Dietary Patterns *		Western-Type Dietary Patterns **	
	Positively Associated	Negatively Associated	Positively Associated	Negatively Associated
-Liquor		Sanchez-Villegas 2009 [33]	Kesse-Guyot 2009 [35] Mullie 2009 [38] Anderson 2012 ^a [43] Mullie 2009 [38]	
Calorically sweetened beverages				
Sugar-sweetened beverages (SSB)		Anderson 2012 ^a [43] Steffen 2014 ^a [41]	Anderson 2012 ^a [43] Deshukh-Taskar 2009 ^a [44] Gao 2007 ^{ab} [45] Gao 2007 ^{ac} [45] Kesse-Guyot 2009 [35] Lee 2011 ^c [37] Mullie 2009 [38]	
Regular soda		Duffey 2006 ^a [30] Engeset 2005 ^c [34] Naja 2011 [46] Newby 2004 ^a [47] Sanchez-Villegas 2009 [33]	Engeset 2005 ^c [34] Maruapula 2007 [53] Naja 2011 [46] Nanri 2013 [39] Nettleton 2008 ^a [22] Sanchez-Villegas 2009 [33]	
Fruit drinks				
Sweetened tea			Maruapula 2007 [53]	
Sweetened coffee		Naja 2011 [46]		

* Prudent-type dietary patterns: represents dietary patterns that closely align with the Prudent dietary pattern. Typically contains vegetables, fruits, legumes, whole grains, fish, and poultry

** Western-type dietary patterns: represents dietary patterns that closely align with the Western dietary pattern. Typically contains red meat, processed meat, refined grains, sweets and dessert, French fries, and high-fat dairy products

^a US Population

^b Male

^c Female

^d Low-fat dairy products: skim/1 % milk and milk products

^e High-fat dairy products: whole/2 % milk and milk products

pattern [33]; in a population of women in the United Kingdom, low-fat milk intake was negatively associated with a “meat, potatoes, and sweet foods” pattern [31]; in a population of Norwegian women, low-fat milk intake was associated with the “healthy eaters” pattern [34]; and in a population of Australian women, low-fat milk intake was associated with high intakes of other low-fat dairy products and negatively associated with high-fat milk intake [42].

The remaining articles define low-fat dairy as a combination of low-fat dairy products, which included milk (i.e., milk, cheese, and yogurt). For studies conducted in US populations, low-fat dairy products were overwhelmingly associated with healthy/Prudent-type dietary patterns [30, 43–45, 47]; similar patterns were found for Lebanese adults [46] and Belgian males [38].

Three studies examined the intake of soy milk [31, 42, 48]. In a Chinese population, soy milk was positively associated with a “modern high-wheat” pattern (high intake of wheat, cakes, cookies, deep-fried wheat, eggs, soy milk, and animal-based milk) [48], but negatively associated with a dietary pattern of “processed meat, meat, and takeaway” in a

population of Australian women [42]. In the United Kingdom, women that consumed a diet high in fruits and vegetables also consumed higher amounts of soy milk, and soy milk was positively associated with intake of a “mixed” pattern (high intake of fruit, vegetables, skim milk, desserts, and low intake of meat dishes) among men [31].

Non-Calorically Sweetened Beverages

Six articles discussed the associations of NNS beverage intake with dietary patterns [30, 33, 34, 41, 46, 49]. Duffey et al., identified Prudent and Western dietary patterns within a sample of US adults and assessed differences between NNS consumers and non-consumers [49]. The authors report that 66 % of NNS consumers were in the Prudent pattern and that NNS non-consumers, regardless of dietary pattern, had higher total energy intake [49]. In this same population, lower intake of diet beverages was associated with higher adherence to a Mediterranean dietary pattern [41]. Another study using a nationally representative sample of US adults found that

individuals who were in a “fast food” or “snack and high-fat food” pattern were less likely to be in a “diet” beverage group [30].

Among international populations, results between NNS and dietary pattern were also mixed. Within a Norwegian female population, increased intake of diet soda was positively associated with an “alcohol” pattern (high intake of alcohol and red meat, and lower intake of desserts) [34]. In Lebanese participants, diet soda was associated with a Prudent-type dietary pattern [46], and similarly, in a Spanish population, increased consumption of NNS beverages were associated with a Mediterranean dietary pattern, and decreased consumption was associated with a Western dietary pattern [33].

Fruit and Vegetable Juice

There is a consistently positive association between fruit and/or vegetable juice consumption with a Prudent or high nutrient dense dietary pattern within US populations [44, 47, 50]. Outside the US, however results are equivocal. Fruit/vegetable juice was associated with Mediterranean/healthy dietary patterns in Norwegian [34] and British [31] women and Belgian men [38]; conversely, among Chinese [51], Lebanese [46], Italian [52], Japanese [39], and Batswana [53] adults, fruit/vegetable juice consumption was associated with a Western-type or high meat/sweet dietary pattern. Within a Spanish population, lower juice intake was associated with both Mediterranean and Western dietary patterns [33]. In the United Kingdom, two dietary patterns were observed that were not associated with Prudent-type or Western-type dietary patterns. Fruit juice intake loaded positively for British men that consumed a “mixed” dietary pattern and both men and women in an “ethnic foods and alcohol” pattern [31].

High-Fat Milk

A majority of the studies examining high-fat milk consumption reported positive associations with a Western-type dietary pattern within the US [30, 43–45] and other countries [33, 37, 38] or negative associations with Prudent-type patterns both in the US [43] and abroad [33, 34, 42]. Three additional studies produced dietary patterns that did not fall specifically into a Prudent or Western-type dietary pattern: high-fat milk was positively associated with the “bread eaters” pattern in Norwegian women [34] and the “traditional Lebanese” pattern in Lebanese adults [46], and negatively associated with a “sweets” pattern in US adults [47].

Alcoholic Beverages

Beer Intake of beer was negatively associated with Prudent-type dietary patterns in US [43] and Chinese adults [51]. Furthermore, beer consumption was positively associated with

Western-type patterns in US [43], Japanese [39], Chinese [51], French [35], and Italian adults [52], and Belgian males [38].

Wine Results of studies investigating wine consumption were mixed. Red wine was positively associated with a Mediterranean style dietary pattern in Australian women [42], but positively associated with a Western dietary pattern in Italian [52] and French adults [35] and Belgian men [38].

Liquor In a Spanish population, liquor intake decreased as adherence to a Mediterranean dietary pattern increased [33], and it was also positively associated with a Western-type pattern in US adults [43] and Belgian males [38].

Total Alcohol Total alcohol intake was associated with less healthy dietary patterns in all populations studied. Total alcohol consumption was negatively associated with a Prudent-type diet in Japanese adults [40] and positively associated with a Western-type diet in French [35], Chinese [51], Japanese [40], Korean [36], and US adults [47]. However, within a Spanish adult population, lower intake of beer and wine was associated with higher adherence to both a Western and a Prudent dietary pattern [33].

Additional studies identified dietary patterns that did not fall into a Prudent or Western-type dietary pattern: intake of beer, wine, and liquor was positively associated with the “alcohol users” pattern in Norwegian women [34]; beer was positively associated with the “beer” pattern in older Batswana adults [53]; saké was associated with a “traditional” pattern in Japanese adults [39]; and alcohol was associated with a “fish and alcohol” pattern in Lebanese adults [46], a “sweets” pattern in US adults [47], and negatively associated with a “sweet tooth” pattern in Chinese adults [51]. In the United Kingdom, beer, wine, and liquor (in women) and wine and liquor (in men) were positively associated with the “ethnic foods and alcohol” pattern [31].

Sugar-Sweetened Beverages (SSB)

SSB Two studies in US adults negatively associated SSB intake with a Prudent-type diet [41, 43], and six US and international studies positively associated SSB consumption with a Western-type diet [35, 37, 38, 43–45]. An additional study with US adults reported that individuals who fell into a caloric beverage group (e.g., sweetened coffee and soda) were more likely to fall in a less healthy diet cluster (e.g., “snacks and high-fat foods”) [30].

Regular Soda Five studies found regular soda consumption negatively associated with a Prudent-type pattern [30, 33, 34, 46, 47], and six studies found regular soda consumption was positively associated with a Western-type pattern [22, 33, 34, 39, 46, 53].

Fruit Drinks, Sweetened Tea and Coffee In a sample of US adults, sweetened fruit drinks were positively associated with a “sweets” pattern [47]. In Batswana older adults, sweetened tea was positively associated with a Western-type pattern [53]. In Lebanese adults, sweetened coffee was negatively associated with a Prudent diet and positively associated with a “fish and alcohol” pattern [46].

Conclusion

There has been much interest in the past decade in assessing dietary patterns instead of consumption of single food items or nutrients, as patterns can help provide a greater understanding of diet and health relationships [14, 19, 54]. The Dietary Guidelines Committees have identified dietary pattern-related research as a significant research gap, and have urged reviews of the current literature [27••]. This article represents the first review paper addressing the associations of beverage intake with dietary patterns.

This review provides strong evidence that specific beverages are related to Prudent/healthy or Western/less healthy dietary patterns. The evidence from Table 2 suggests that water, unsweetened tea/coffee, low-fat milk, NNS beverages, and fruit/vegetable juice consumption closely align with a Prudent dietary pattern. Conversely, high-fat milk, alcohol, and SSB are strongly associated with a Western dietary pattern. The twenty-five articles included in this review encompassed study populations with a wide range of age and ethnicity, as well as large sample sizes (twelve articles had a sample size greater than 5,000).

There are several limitations of the data that were evaluated. First, eight of the twelve articles that evaluated dairy consumption grouped all dairy products into a single variable rather than evaluating milk consumption independently from other sources of dairy products [30, 37, 38, 43–47]. Additionally, nine articles did not distinguish between low-fat or high-fat dairy products in the analysis; thus associations with dairy products were not assessed for those articles [35, 37, 39, 40, 48, 50–53]. Second, there was a lack of consistency and specificity between beverage categories in some articles, with groups such as “hot drinks” [46], “other drinks/beverages” [36, 37], and “beverages” [51], which made it difficult to determine associations of specific beverages to dietary patterns.

Third, comparing beverage consumption patterns across thirteen different countries presented challenges for interpreting results [15]. Several articles produced dietary patterns specific to the respective culture (i.e., traditional dietary patterns) [31, 34, 40, 46, 47, 51, 53], which were not easily translatable to a healthy or unhealthy dietary pattern. As Tucker [15] demonstrated, intake of certain dietary items can

vary greatly among various cultures and may represent an integral part of many cultures. We theorize that this may, at least in part, explain why there was no distinct pattern observed between some beverages, specifically coffee and tea, with overall dietary intake patterns.

Fourth, all of the dietary pattern analysis was based on self-reported dietary intake data, which is subject to reporting error and subject recall bias [55]. A knowledge gap identified by the Institute of Medicine is the development of dietary biomarkers of food, beverage, and nutrient intake [56], which may help overcome this limitation and provide validity to self-reported dietary intake assessment methods [57, 58]. Furthermore, investigations of dietary pattern analysis would be strengthened by the inclusion of dietary biomarkers [14, 57].

We identified two important gaps in the existing literature. First, there was limited availability of pattern analyses that included non-caloric items such as water and NNS beverages. Most of the articles performed pattern analyses based on caloric content and not amount/weight consumed, consequently overlooking water (articles that assessed water: [30–33]) and NNS beverages (articles that assessed NNS: [30, 33, 34, 41, 46, 49•]). Second, while several articles addressed longitudinal changes in dietary patterns, no articles addressed consequential changes in dietary patterns with targeted changes in beverage consumption (e.g., changes in dietary intake that were the consequences of changes in SSB and NNS intake). More research is needed in this area, as the evidence for longitudinal effects of NNS intake on health and weight status is limited and shows mixed results [9, 10].

Future Directions

Future research areas should focus on: 1) examining beverage intake patterns (not just individual beverages) and defining their relationship to dietary patterns, 2) developing a measure of overall beverage quality intake based upon associations of beverage intake with health outcomes, similar to the Healthy Eating Index, which could be translated into consumer-friendly recommendations [59], and 3) identifying beverage patterns that are associated with specific health conditions. The ability to correlate habitual beverage intake patterns with overall health status may lead to the development of evidence-based public health recommendations for beverage consumption patterns.

Compliance with Ethics Guidelines

Conflict of Interest Valisa E. Hedrick, Brenda M. Davy, and Kiyah J. Duffey declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

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