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A Rapid Beverage Intake Questionnaire Can Detect Changes in Beverage Intake

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Abstract

Attention on beverage intake, specifically sugar-sweetened beverages (SSB), has increased in recent years. A brief valid, reliable and sensitive assessment tool for quantifying beverage consumption and determining its influence on weight status could help to advance research on this topic. The valid and reliable 15-item beverage questionnaire (BEVQ-15) estimates mean daily intake of water, SSB and total beverages (g, kcal) across multiple beverage categories. Objective: to determine the ability of the BEVQ-15 to detect changes in beverage intake over time. Participants ($n=70$; age= 37 ± 2 yrs; BMI= 24.5 ± 0.4 kg/m²) underwent two randomly assigned 30-day periods (Intervention, increased water and fruit juice consumption; Control, increased solid fruit consumption), with a 30-day washout phase between feeding periods. The BEVQ-15 was administered at the beginning and end of each period. Reliability was assessed by Pearson's correlations, paired sample *t* tests and Cronbach's Alpha. Paired sample *t* tests and repeated measures ANOVA were used to evaluate sensitivity to change. Sixty-nine participants completed all study sessions. Reliability was acceptable for most beverages (range: $R^2=0.52-0.95$, $P<0.001$), but not for energy drinks. Increases in water (g), juice (kcal, g) and total beverage (g) were detected during the intervention period ($P<0.001$); no changes in these variables were detected in the control period. The BEVQ-15 demonstrates the ability to detect changes in beverage intake over time. This brief (~ 2 min), self-administered, valid, reliable and sensitive beverage intake

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Conflict of Interest All authors declare that they have no conflicts of interest to disclose.

assessment tool may be used by researchers and practitioners who evaluate and intervene upon beverage intake patterns in adults.

Keywords

sugar-sweetened beverages; weight management; questionnaire; validity; reliability

1. Introduction

Obesity has become a major public health issue in the United States (U.S.), with 68.3% of adults overweight (Body Mass Index [BMI] 25–29.9 kg/m²) or obese (BMI ≥ 30 kg/m²) (Flegal et al., 2010). A BMI >25 is associated with health conditions such as hypertension, diabetes, cardiovascular disease, some forms of cancer, sleep apnea and overall mortality (Hensrud & Klein, 2006). Increased body weight, as well as an increased risk of type 2 diabetes, cardiovascular disease and hypertension, has been associated with sugar-sweetened beverage (SSB) intake, specifically soft drinks (Brown et al., 2011; de Koning et al., 2011; Malik et al., 2010; Vartanian et al., 2007). Attention has been directed at intake of energy (calorie) containing beverages and developing strategies to facilitate weight loss through changes in beverage intake (de Graaf, 2011).

Shifts in beverage intake patterns may have, in part, contributed to rising obesity rates (Duffey & Popkin, 2007). Total daily energy consumed from beverages has increased from 11.8% (1965) to 21.0% (2002), with beverages providing approximately 458 kcals daily per person (Duffey & Popkin, 2007). According to a recent Scientific Statement from the American Heart Association, the majority of added sugars in American's diets (~50%) come from SSB (Johnson et al., 2009). Furthermore, Block (Block, 2004) reported that energy-containing soda is the number one contributor to total daily energy (from all food and beverages) at 7.1%. The 2010 U.S. Dietary Guidelines recommends decreasing the consumption of solid fats and added sugars from a current intake of 33% to less than 15% of total energy intake (U.S. Department of Health and Human Services, 2010; Van Horn, 2010). To achieve this goal, it is advised that SSB be replaced with non-caloric beverages such as water or healthier alternatives such as milk (Malik et al., 2010; Van Horn, 2010).

Food frequency questionnaires (FFQ) can be as sensitive as multiple food intake records when measuring changes in dietary intake over time (Kristal et al., 1994); furthermore, they can provide habitual intake patterns versus only recent dietary intake. However, FFQ must be valid, reliable, reproducible (Willett, 1998) and sensitive to change (i.e., detect changes in consumption over time), however, the topic of sensitivity has not been considered or studied extensively (Guyatt et al., 1987; Kristal et al., 1994).

The BEVQ-15 is the only known validated beverage intake assessment tool that can determine the habitual beverage intake patterns of adults, including those with lower literacy levels (Hedrick et al., 2010; Hedrick et al., 2012). However, it is not known if the BEVQ-15 can detect changes in beverage intake over time. Without a sensitive beverage FFQ, extensive longitudinal data must be collected to examine habitual beverage intake; consequently, it is challenging to overcome weaknesses in the current body of literature on this topic (Allison & Mattes, 2009). To our knowledge, no prior investigations using feeding studies to evaluate the sensitivity to change of a validated FFQ have been conducted. The limited available literature focuses on comparing changes between multiple tools (i.e., which tool produces a higher index of change) (Kristal et al., 1994; Osler & Heitmann, 1996; Peterson et al., 2008; Thomson et al., 2003). A sensitive beverage intake tool could enhance nutrition intervention research targeting habitual beverage intake patterns in adults. Thus,

our objective is to determine the ability of the BEVQ-15 to detect changes in total beverage consumption, as well as specific beverage categories.

2. Materials and Methods

2.1. Participants

Healthy adults (n = 70) aged 21 years were recruited from a university community between August and December 2010. The Virginia Tech Institutional Review Board approved the study protocol. Participants provided written informed consent before enrollment; however, they were not aware of the specific purpose of the study. They were informed that the study's purpose was to evaluate a dietary questionnaire.

2.2. Design and Methods

This investigation utilized a randomized, within-subject crossover design, to examine the sensitivity to change of the BEVQ-15. Participants completed three 30-day periods: 1) beverage consumption (intervention), 2) whole fruit consumption (control), and 3) a washout period between feeding periods (See Figure). Several dietary intake assessment methods were utilized to mask the specific study purpose: fruit and vegetable screener (FVS) (Block et al., 2000), BEVQ-15 and 24-hour dietary recalls (DR). The FVS measures servings of fruits, vegetables and juice. The rationale for choosing 30-day periods is primarily based on the time frame measured by the BEVQ-15 and FVS (i.e., intake within the last month), which is consistent with suggested methods for FFQ development (Cade et al., 2002).

Beverage consumption guidelines recommend a daily intake of 50 fl oz of water and 8 fl oz of 100% fruit juice (Popkin et al., 2006); therefore, individuals consuming more than 48 fl oz of water and 16 fl oz of fruit juice per day were excluded from the study.

2.3. Initial/Screening Visit

Assessments included height, measured in meters without shoes using a wall mounted stadiometer, and body weight, measured in light clothing without shoes, to the nearest 0.1 kg using a digital scale (Scale-Tronix, Inc., Model 5002, Wheaton, IL). Urinary specific gravity (SG), an objective indicator of total fluid intake (hydration status and compliance), was determined using a refractometer (ATAGO 4410 Digital Urine Specific Gravity Refractometer, Bellevue, WA). SG functioned as a “bogus pipeline,” which may enhance validity of participant's responses by leading them to believe an objective measure of their intake was being examined (Willett, 1998).

Three DR were conducted and baseline dietary intake was established by using nutritional analysis software (Nutrition Data System for Research, 2009, University of Minnesota, Minneapolis [NDS-R]).

2.4. Feeding and Washout Periods

Individuals assigned to sequence 1 were instructed to consume two 8 fl oz bottles of *Deer Park* water (Nestlé Waters North America Inc., Stamford, CT) and two 4.23 fl oz boxes of *Juicy Juice* 100% juice (assorted flavors) (Nestlé, Glendale, CA) per day, in addition to their usual intake. Participants in sequence 2 were instructed to consume two servings of fruit (apples, oranges or 4 oz canned fruit in juice) per day, in addition to their usual intake. Water, juice and fruit were provided to participants during their weekly visits. In order to assess dietary compliance, daily tracking sheets for water, juice and fruit intake were provided and recorded by the research staff weekly.

At the end of the first feeding period, participants were instructed to return to their usual dietary habits for a 30-day washout period. During this time, no food or beverages were provided. At the end of the washout period instructions for completing the second feeding period were given. At the final visit, the specific aims of the study were revealed and \$45 compensation was provided.

2.5. Data Analysis

Statistical analyses were performed using SPSS statistical analysis software (version 19.0 for Windows, 2010, International Business Machines Corporation, Pittsburgh, PA). Descriptive statistics (mean±standard error of the mean and frequencies) are reported for demographic characteristics. To assess test-retest reliability of the BEVQ-15, Pearson's correlations and paired sample *t* tests compared BEVQ at visit 1 responses to BEVQ at visit 2; Cronbach's Alpha was used to evaluate internal consistency. Condition by time differences (i.e., sensitivity to change), and possible sequence effects, were assessed by Repeated Measures Analysis of Variance (RM-ANOVA). When significant condition by time differences were found, paired sample *t* tests were used as post hoc analyses to compare mean differences between pre/post beverage variables for each feeding condition. The effectiveness of the washout period was evaluated by comparing visits 2 and 10 BEVQ (see Figure) using paired sample *t*-tests. The alpha level was set *a priori* at *P* 0.05.

3. Results

3.1. Demographics

Participants were reasonably balanced with regard to gender (60% female) and were primarily Caucasian (79%), with remaining participants African American (13%), Asian (6%), Hispanic (1%), or “other” (1%). Age ranged 21–82 yr (mean = 37±2 yr) and BMI ranged 17.7–33.2 kg/m² (mean = 24.5±0.4 kg/m²). Household income was uniformly distributed among five income levels, ranging \$14,999 to \$100,000. Most participants reported being college educated (84%). Baseline dietary intake from the DR showed a mean daily intake of 2,072±82 kcal and 66±4 g of added sugars. The BEVQ-15 reported a mean daily intake of water (722±51 g), fruit juice (51±8 kcal, 90±14 g), total SSB (135±21 kcal, 382±56 g), and total beverage (350±39 kcal, 1,688±106 g).

3.2. Reliability of the BEVQ-15

Test-retest Pearson bivariate correlations between the visit 1 and 2 BEVQ responses for the fifteen beverage items and four beverage outcomes (g, kcal) were all significant (range: $R^2=0.52-0.95$, $P<0.001$) with the exception of energy drink kcal and g ($R^2=0.22$, $P=0.08$); however, the absolute difference was minimal (4±7 kcal, 9±16 g). Absolute differences in outcomes between the visit 1 and 2 BEVQ were minimal (data not shown). Cronbach's Alpha ranged 0.71–0.94 for all outcomes.

3.3. Sensitivity to Change of the BEVQ-15

No significant differences were found between BEVQ2 and BEVQ10 (i.e., baseline assessments for each feeding period) water, juice and total beverages; thus, the washout period was successful in returning participants to baseline status. Mean differences between baseline and day 30, as well as between the intervention and control feeding periods for water, juice and total beverages are presented (Table 1). Significant differences in intake of all beverage variables during the intervention phase were detected (all *P* 0.001); and significant differences over time between feeding conditions were noted (all *P* 0.001), with the exception of total beverage kcals (mean difference = 66±65 kcal). No significant differences were found from baseline to day 30 during the control feeding period for any of

the beverage variables. Daily tracking sheets indicated high reported compliance to increased water and fruit juice consumption (mean percent = 94.3 ± 0.9 , 94 ± 0.9 , respectively). No significant changes were detected in urinary SG (mean pre = 1.0155, mean post = 1.0156; mean difference = 0.00013 ± 0.001 SG) or weight status (mean difference = 0.3 ± 0.2 kg) across the intervention phase.

3.4. Sensitivity to Change of the FVS

Although the major aim of this study was to evaluate the sensitivity to change of the BEVQ-15, to our knowledge, the sensitivity of the FVS has not been evaluated. There was a significant increase in fruit score during the control phase (mean scores = 2.5 ± 0.2 baseline, 4.8 ± 0.1 day 30; mean difference = 2.3 ± 0.2 , $P < 0.001$), which indicates that participants increased their fruit intake from approximately 2–6 servings per week to 1–2 servings per day. A significant difference over time between the feeding conditions ($P = 0.0001$) in fruit intake was detected (mean difference in score = 2.1 ± 0.3). During the intervention the fruit score did not change ($P = 0.117$).

4. Discussion

This investigation determined that the BEVQ-15 can detect changes in beverage intake, both total and within individual beverage categories. Strengths of this investigation include: a randomized cross-over design, blinding participants to the study's purpose to reduce potential for bias in self-reported measures, a semi-controlled feeding approach/food provision, in combination with objective biomarkers of fluid intake, which may have contributed to the high compliance rate. Participant retention was also very high, with attrition $< 0.01\%$ of sample, and the sample was fairly diverse (age, gender, BMI). In effort to overcome the limited monitoring of free-living individuals, urinary specific gravity samples were obtained, weekly visits that provided necessary beverages and fruits were conducted, and beverage and fruit daily tracking sheets were recorded. Finally, FFQ are not often evaluated for their ability to detect changes in dietary intake, and no other investigations have examined the sensitivity to change in validated FFQ using a semi-controlled feeding design.

The BEVQ-15 was developed to rapidly assess water intake, total beverage intake, and SSB intake, across multiple populations, including those with low-literacy levels. The BEVQ-15 demonstrates an acceptable ability to detect changes in beverage intake over time. Thus, the BEVQ-15 can be used to assess changes in beverage intake in intervention studies which target changes in beverage intake behaviors; furthermore, the BEVQ-15 may help determine possible relationships between beverage consumption and health-related outcomes, such as those related to diabetes, hypertension and obesity. Future work is needed to evaluate the validity and reliability of the BEVQ-15 in children.

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References

- Allison DB, Mattes RD. Nutritively sweetened beverage consumption and obesity. *J Am Med Assoc.* 2009; 301(3):318–320. doi: 10.1001/jama.2008.974.
- Block G. Foods contributing to energy intake in the U.S.: data from NHANES III and NHANES 1999–2000. *J Food Compos Anal.* 2004; (17):439–447.

- Block G, Gillespie C, Rosenbaum EH, Jenson C. A rapid food screener to assess fat and fruit and vegetable intake. *Am J Prev Med.* 2000; 18(4):284–288. [PubMed: 10788730]
- Brown I, Stamler J, Van Horn L, Robertson C, Chan Q, Dyer A, Huang C, Rodriguez B, Zhao L, Daviglus M, Ueshima H, Elliott P. Sugar-sweetened beverage, sugar intake of individuals, and their blood pressure: international study of macro/micronutrients and blood pressure. *Hypertension.* 2011; 57(4):695–701. doi: 10.1161/hypertensionaha.110.165456. [PubMed: 21357284]
- Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires - a review. *Public Health Nutr.* 2002; 5(04):567–587. doi: doi:10.1079/PHN2001318. [PubMed: 12186666]
- de Graaf C. Why liquid energy results in overconsumption. *Proc Nutr Soc.* 2011; 70(2):162–170. [PubMed: 21356139]
- de Koning L, Malik VS, Rimm EB, Willett WC, Hu FB. Sugar-sweetened and artificially sweetened beverage consumption and risk of type 2 diabetes in men. *Am J Clin Nutr.* 2011; 93(6):1321–1327. doi: 10.3945/ajcn.110.007922. [PubMed: 21430119]
- Duffey KJ, Popkin BM. Shifts in patterns and consumption of beverages between 1965 and 2002. *Obesity.* 2007; 15(11):2739–2747. [PubMed: 18070765]
- Flegal K, Carroll M, Ogden C, Curtin L. Prevalence and trends in obesity among U.S. adults, 1999–2008. *J Am Med Assoc.* 2010; 303(3):235–241.
- Guyatt G, Walter S, Norman G. Measuring change over time: assessing the usefulness of evaluation instruments. *J Chronic Dis.* 1987; (40):171–178. [PubMed: 3818871]
- Hedrick V, Comber D, Estabrooks P, Savla J, Davy B. The beverage intake questionnaire: initial validity and reliability. *J Am Diet Assoc.* 2010; 110:1227–1232. [PubMed: 20656099]
- Hedrick V, Savla J, Comber D, Flack K, Estabrooks P, Nsiah-Kumi P, Ortmeier S, Davy B. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. *J Acad Nutr Diet.* 2012; 112(6):840–849. [PubMed: 22709811]
- Hensrud DD, Klein S. Extreme obesity: a new medical crisis in the United States. *Mayo Clin Proc.* 2006; 81(10):S5–S10. [PubMed: 17036573]
- Johnson R, Appel L, Brands M, Howard B, Lefevre M, Lustig R, Sacks F, Steffen L, Wylie-Rosett J. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation.* 2009; 120(11):1011–1020. [PubMed: 19704096]
- Kristal A, Beresford S, Lazovich D. Assessing change in diet-intervention research. *Am J Clin Nutr.* 1994; 59(1 Suppl):185S–189S. [PubMed: 8279421]
- Malik V, Popkin B, Bray G, Despres J, Hu F. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation.* 2010; 121:1356–1364. [PubMed: 20308626]
- Osler M, Heitmann BL. The validity of a short food frequency questionnaire and its ability to measure changes in food intake: a longitudinal study. *Int J Epidemiol.* 1996; 25(5):1023–1029. doi: 10.1093/ije/25.5.1023. [PubMed: 8921490]
- Peterson KE, Hebert JR, Hurley TG, Resnicow K, Thompson FE, Greene GW, Shaikh AR, Yaroch AL, Williams GC, Salkeld J, Toobert DJ, Dumas A, Elliot DL, Hardin J, Nebeling L. Accuracy and precision of two short screeners to assess change in fruit and vegetable consumption among diverse populations participating in health promotion intervention trials. *J Nutr.* 2008; 138(1): 218S–225. [PubMed: 18156428]
- 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):529–542. [PubMed: 16522898]
- Thomson C, Giuliano A, Rock C, Ritenbaugh C, Flatt S, Faerber S, Newman V, Caan B, Graver E, Hartz V, Whitacre R, Parker F, Pierce J, Marshall J. Measuring dietary change in a diet intervention trial: comparing food frequency questionnaire and dietary recalls. *Am J Epidemiol.* 2003; 157(8):754–762. [PubMed: 12697580]
- U.S. Department of Health and Human Services. U.S. Department of Agriculture. U.S. Department of Health and Human Services, and U.S. Department of Agriculture (HHS, USDA) Dietary Guidelines for Americans. 7th Edition. US Government Printing Office; Washington, DC: 2010.

- Van Horn L. Development of the 2010 U.S. dietary guidelines advisory committee report: perspectives from a registered dietitian. *J Am Diet Assoc.* 2010; 110(11):1638–1645. doi: 10.1016/j.jada.2010.08.018. [PubMed: 21034875]
- Vartanian L, Schwartz M, Brownell K. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health.* 2007; 97(4):667–675. [PubMed: 17329656]
- Willett, WC. *Nutritional Epidemiology*. 2nd ed.. Oxford University Press; 1998.

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Highlights

- The BEVQ-15 estimates mean daily intake (g, kcal) of multiple beverage categories
- The BEVQ-15 is a brief, self-administered, valid and reliable questionnaire
- The BEVQ-15 demonstrates the ability to detect changes in beverage intake over time
- It may be used by those who evaluate and intervene upon beverage intake patterns

Figure.
 Study Procedures: A Brief Beverage Intake Questionnaire Can Detect Changes in Beverage Intake

Table 1

Ability of the Brief Beverage Intake Questionnaire (BEVQ-15) to Detect Changes in Beverage Intake: Differences in Water, Juice and Total Beverage Intake During Intervention and Control Feeding Conditions

Beverage Variable ^a	Baseline	Day 30	Change ^{bc}
Water, <i>g</i>			
Intervention	719±55	905±45	186±42 *
Control	755±84	645±49	110±71
Sensitivity to Change			296±78 *
Juice, <i>g</i>			
Intervention	100±14	410±33	310±33 *
Control	101±16	106±15	5±14
Sensitivity to Change			305±38 **
Juice, <i>kcal</i>			
Intervention	62±9	235±19	173±21 **
Control	55±9	61±9	6±8
Sensitivity to Change			167±23 **
Total Beverage, <i>g</i>			
Intervention	1,700±109	2,158±97	458±85 *
Control	1,794±137	1,740±129	55±115
Sensitivity to Change			513±133 *
Total Beverage, <i>kcal</i>			
Intervention	360±40	505±37	145±35 *
Control	356±39	435±66	79±49
Sensitivity to Change			66±65

^aExpressed as Mean±Standard Error of the Mean (SEM).

^bMean difference within condition over time, according to a paired sample *t* test. Slight differences may be noted from the preceding rows due to rounding; whole numbers are presented in the Table.

^cSensitivity to change is reported as the condition by time difference assessed by Repeated Measures Analysis of Variance (RM-ANOVA).

* P<0.001.

** P<0.0001.