*European Journal of Nutrition & Food Safety*
*4(4): 577-591, 2014*

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# Comparison of a Web-Based Frequency Questionnaire for Assessment of Beverage Intake with a Validated 7-Day Web-Diary from Danish Teenagers

**Anja Biltoft-Jensen[1*], Jeppe Decker Iversen[1], Lene Møller Christensen[1] and Jeppe Matthiessen[1]**

*[1]Department of Nutrition, National Food Institute, Technical University of Denmark, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark.*

***Author's contribution***

*This work was carried out in collaboration between all authors. Author ABJ planned and designed the study, performed the statistical analysis, wrote the protocol, developed the BFQ prepared the web diary, and wrote the first draft of the manuscript. Authors JDI, LMC and JM took part in design discussions. All authors contributed to the critical revision of the manuscript and the statistical analyses. All authors read and approved the final manuscript.*

***Method Article***

***Received 12th February 2014***
***Accepted 28th April 2014***
***Published 25th August 2014***

## ABSTRACT

**Aims:** To compare beverage intake measured using a web-based quantitative beverage frequency questionnaire (BFQ) with a 7-day estimated beverage diary (WebDAS), and to evaluate the BFQ's feasibility.
**Study Design:** Cross-sectional comparison of the BFQ, which contained 37 beverage types including energy drinks and caffeinated beverages, with the WebDAS.
**Place and Duration of Study:** Sample: Three 9th grade local authority school classes totalling 73 14-16-year-old students from a suburban area in Copenhagen were recruited. The study was carried out between September 2013 and November 2013.
**Methodology:** First respondents completed the WebDAS at home, and after 2 weeks they completed the BFQ at school. McNemar's test, the Wilcoxon signed rank test, Spearman's rank correlation coefficients, a Bland-Altman plot, weighted Kappa statistics and percentages of exact agreement were used to compare the results of the two methods.

**Corresponding author: Email: apbj@food.dtu.dk;*

**Results:** 49 (29 boys; 20 girls) had acceptable data from both the WebDAS, and the BFQ. The mean total beverage intake measured by the two methods differed significantly (BFQ: 1566 vs. WebDAS: 1231g/day, *P*<.01). The Spearman rank correlations were positive (*r*=.41-75) for all beverages including energy drinks, and significant for most beverages. Significant agreement for the numbers of consumers was observed between methods, except for soft drinks and chocolate. The mean (SD) difference was 335 (769)g/day, primarily due to an intake of water measured with BFQ almost twice as high as that measured with WebDAS. This was reflected in the Bland-Altman plot and in the percentages of exact agreement, which were lower for water than for other beverages (29% vs. 39-46%).
**Conclusion:** The BFQ gave results comparable to a 7-day beverage diary (WebDAS) in 14-16-year-olds. With a few adjustments, especially with regard to portion sizes and entries for water, we believe the BFQ will be useful in large population-based studies for assessment of beverage intake.

*Keywords: Beverage assessment; dietary assessment; energy drink; food frequency questionnaire; reporting accuracy; relative validation.*

## 1. INTRODUCTION

Energy drinks contain high amounts of caffeine as well as other stimulating ingredients such as taurine and guarana that enhance the effect of caffeine, and sometimes alcohol, and there is recent evidence of substantial health hazards for teenagers who consume energy drinks [1-3]. Generally, energy drinks also contain high amounts of added sugars, and sugar sweetened beverages are key contributors to the epidemic of overweight and obesity, as well as to dental problems [1]. Energy drinks are a relatively new beverage in Denmark. In 2009, it became legal to sell energy drinks in Denmark containing 320mg caffeine per litre; previously, the maximum had been 150mg per litre. Sales have increased by more than 100% since 2009 (personal communication Andreas Kadi, Energy Drinks Europe), which implies that the beverage habits of young Danes are changing. A recent survey conducted by the European Food Safety Authority (EFSA) showed that teenagers had the highest consumption of energy drinks [4], and most energy drinks are developed for and advertised to teenagers and young adults [5]. So it is relevant to examine teenagers' beverage consumption with special focus on energy drinks.

We assumed that there is great variation in the intake of energy drinks from day to day and probably also from week to week, which would mean that dietary assessment methods with short reference periods might not be well suited for studying the intake of energy drinks at the individual level. So we decided to develop a web-based quantitative Beverage Frequency Questionnaire (BFQ) to ask about the respondents' intake of beverages including energy drinks over the last month. Chocolate was the only solid food in the BFQ, but was included to make it possible to estimate the total caffeine intake. The BFQ was made for use in the Danish Beverage Study, which will include energy drinks. This national study is under way and is as yet unpublished.

It was important to calibrate the BFQ against a thoroughly validated tool since the BFQ was to be used in a large study to assess the beverage intake of Danish children and young adults, and later will be used to estimate their caffeine intake. It was also important to examine whether the proposed response categories were relevant and used by the

respondents. Finally, it was important to examine whether the questions were clear and understandable for the respondents, because the BFQ is a self-administered questionnaire. Teenagers are high consumers [4] and a target group for energy drinks [5], so it is natural to include teenagers in a comparability study of the BFQ.

Few validation studies have examined the intake of energy drinks. While a number of studies have been conducted on the consumption of energy drinks by young people, most studies have examined the proportion of consumers of energy drinks among young people [4,6-8], and none of these quantified or validated the intake. EFSA has recently conducted a survey of children's, adolescents' and adults' consumption of energy drinks in 16 EU Member States [4]. Denmark was not part of this study. The questionnaires for the three age groups were tested in pilot studies in three Member States. In these pilot studies school children completed the questionnaires and gave feedback, but no validation study was carried out.

In two studies, the usual beverage intake in adults, measured using a food frequency questionnaire (FFQ), was validated using Urine Specific Gravity (USG) as a hydration biomarker [9,10]. The study by Malisova et al. [9] found no correlation between the biomarker and the total beverage intake measured with a Water Balance Questionnaire (WBQ), while other urine biomarkers such as urine volume and osmolarity showed good correlations. In the study by Hedrick et al. [10], they used a Beverage Intake Questionnaire (BEVQ) and found a significant negative correlation between the total beverage intake and the USG biomarker. However, in a recent review of Nissensohn et al. [11], the authors conclude that there is not enough available data in the literature to set robust biomarker proxies for fluid intake. With the age group of respondents being teenagers, who may find urine sample collection "off-putting", we decided to conduct a comparability study with a web-based 7-day beverage diary as reference method. The web-based 7-day beverage diary has previously been used in the Danish OPUS school meal study [12]. A relative validation using a 3-4-day food diary or 24-hour recalls as reference method has previously been used to validate beverage FFQs [10,13-15]. A relative validation would also be suitable for calibrating the portion sizes and response categories for the Danish Beverage Study.

The aim of this study was to evaluate the web-based BFQ that collects intake data of beverage and chocolate in children and young adults. The estimated intake of 14-16-year-olds from the web-based BFQ was compared with estimated intakes from a web-based 7-day beverage diary. Furthermore, we examined whether the questions and response categories were understandable, stimulated recall, and motivated the respondent to reply.

## 2. MATERIALS AND METHODS

After acceptance from school heads, three 9$^{th}$ grade school classes (14-16-year-olds) were recruited through school teachers from local authority schools in a middle-to-low income suburban area in Copenhagen. A total of 73 students (33 girls and 40 boys) were invited to participate. The comparison study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki, and verbal informed consent was obtained from all participants.

### 2.1 Study Design

First, respondents completed a 7-day web-based beverage diary (WebDAS) after receiving instruction in their classes from two project assistants. The WebDAS has been extensively

validated by several objective methods [16-18]. Two weeks after completing the WebDAS, respondents answered the BFQ – also on the Web. The user interface of the BFQ was set up in collaboration with a market research institute (YouGov). To determine whether students understood the questions, the beverage categories, and the frequencies and portion sizes given, cognitive testing of the BFQ was included during completion. Respondents were asked to "think out loud" when they were in doubt, and any lack of clarity was noted. The respondents received cinema tickets and a lecture on energy drinks as an incentive, when the survey was finished.

## 2.2 Beverage Frequency Questionnaire (BFQ)

The BFQ contained questions about the frequency and quantity of their consumption of 37 beverages. There were also two sets of general questions. The first set of general questions addressed the consumption pattern for energy drinks and was targeted at consumers only. The second part was directed to all respondents and included the consumption of chocolate as well as background factors.

The beverage questionnaire was designed to make it possible to estimate the usual daily intake of 37 generic types of beverages and energy drinks in g/day. Some beverages, such as coffee and tea, were asked about in specific types, such as espresso, filter coffee, black tea, green tea, depending on the caffeine content. Similarly, the consumption of cola was asked about specifically for the later estimation of caffeine intake. Finally, there was a distinction between beverages with added sugars and those with no added sugars or light versions, to make it possible to estimate the total intake of sugar-sweetened beverages.

The 37 generic types of beverages were: water (one category including both tap and bottled water), water with caffeine, milk, chocolate milk, drinking yoghurt, soy milk, juice, smoothies, cola beverages, diet coke beverages, soft drinks, light soft drinks, lemonade, lemonade light, coffee, instant coffee, espresso, coffee drinks, decaffeinated coffee, herbal tea, green tea, black tea, chai latte, iced tea, protein drinks, sports drinks, sports gel, beer, wine, alcohol pops, cider, cocktails, liqueurs, spirits, energy drinks, light energy drinks, and energy drinks with alcohol. Furthermore, three questions on the intake of chocolate were included to make it possible to estimate caffeine intake; the three categories were: dark chocolate with normal cocoa content (43-55%), dark chocolate with high cocoa content (>55%), and milk chocolate.

The beverage list was generated from the Danish National Survey of Diet and Physical Activity (DANSDA) [19], supplemented with the beverage intake in children from the Danish OPUS school meal study [12], and further supplemented with market information from Coop Denmark (large Danish and Nordic retail chain), the Danish Brewers Association, and individual Danish coffee firms. DANSDA reflected the intake of beverages in the population at a generic level, while OPUS reflected the intake of children (8-11-year-olds) at a more detailed level. The frequencies and mean volumes of intake of the different beverages from the above studies were investigated, and the beverages selected for the questionnaire were chosen on the basis of a combination of these parameters. The exceptions were sports gel and oat and soy milk. Sports gel was included because it is a caffeinated beverage and oat and soy milk to offer a response alternative for vegans and people who cannot tolerate milk. Information on sales data from Coop Denmark, the Danish Brewers' Association, and the coffee firms contributed to our knowledge of the sales of energy drinks, sports drinks, ciders, alcopops and different types of coffee, which is poorly covered in the DANSDA and OPUS studies.

First, participants were asked if they consumed a certain beverage the last month (yes/no). Secondly they were asked to indicate frequency of consumption. The frequencies in the BFQ were adapted from the EFSA study [4], and were divided in order to make this classification, and 8 frequency response options were provided as illustrated in Table 1.

**Table 1. The eight frequency options in the BFQ**

| Response option | Frequency |
|---|---|
| 1 | 4 or more times per day |
| 2 | 2-3 times per day |
| 3 | Almost daily |
| 4 | 4-5 times per week |
| 5 | 2-3 times per week |
| 6 | 1 time per week |
| 7 | 2-3 times the past month |
| 8 | 1 time the past month |

The amount of beverages and chocolate consumed was estimated by selecting the portion size from 2-4 different digital images from 16 different photo series illustrating common beverage portion sizes (Fig. 1). A "more than the largest portion" and a "do not know" response category was also included. The "More than" portion was estimated to be 50% higher than the largest portion, and the "do not know" portion used standard weights from DANSDA [20]. To score the BFQ, the frequency was converted into units of times per day, and then multiplied by the amount consumed to provide average daily beverage consumption in g/day.

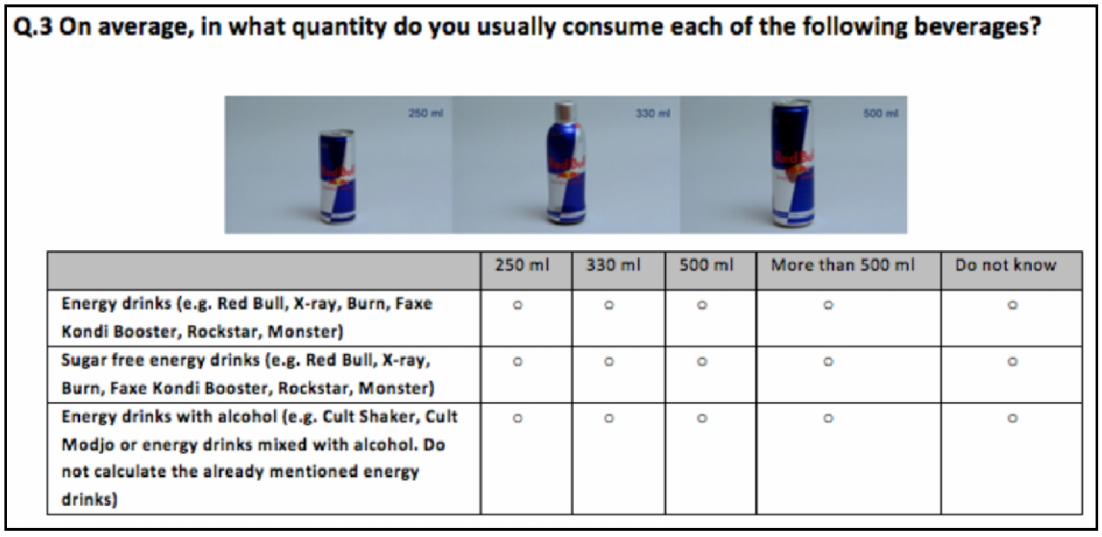


**Fig. 1. Screen shot of portion size estimation of energy drinks**

### 2.2.1 General questions

The BFQ included ten questions solely for consumers of energy drinks. These questions concerned the age at which the respondent started drinking energy drinks, situations in which energy drinks were consumed, in whose company energy drinks were consumed, binge intake (defined as 1 litre or more), frequency of consumption of 1 litre or more, and self-experienced side effects of consuming energy drinks. Moreover, six questions about caffeine and energy drinks were included for all respondents. These addressed the respondents' intake of caffeine pills, their evaluation of the stimulating effect and health effect of the different beverages, and their knowledge about the side effects of drinking energy drinks. Finally, the BFQ included questions about height, weight, intake of dietary supplements and lifestyle factors, such as smoking, physical activity, sleep and screen time. The web-based BFQ used various screening questions and filters to target questions to each respondent's beverage consumption. Detailed questions about energy drinks were only asked of those who replied that they had drunk an energy drink at least once in the past month.

## 2.3 Reference Method: Web-Based 7-Day Beverage Assessment (WebDAS)

In the WebDAS, an animated skunk guides respondents through six daily beverage situations (breakfast, morning, lunch, afternoon, dinner, evening) and helps respondents to remember the beverages and chocolate they have consumed during the day. For the beverage and chocolate recording, a database of 119 beverages and 31 chocolate types was available via category browsing or free text search. It was also possible to type in beverages and chocolate not found by the search facilities. The amount consumed was estimated by selecting the portion size from 2-4 digital images from 24 photo series.

Furthermore, participants recorded whether a recording day represented the usual or an unusual intake, and any reasons for unusual intakes, such as illness. To enhance memory, WebDAS shows pictures of beverages at a given meal and also has internal checks for capturing the intake of chocolate and beverages.

To create motivation, the WebDAS includes the following: a food-meter that displays the total amount of beverages recorded so far, a most-popular-beverage ranking, and a computer game with a high score list. If a participant failed to report beverage intake one day they were reminded the next day by e-mail. If a participant failed to record daily beverage intake within 48hours, the recording day was automatically closed for further registration, and the next recording day was opened. For respondents to be included in the analysis, the WebDAS had to be completed for at least three weekdays and one weekend day, to take variation between weekdays and weekend days into account.

## 2.4 Statistical Analysis

The statistical analyses were performed with IBM SPSS (v. 20.0 for Windows, 2011, SPSS). McNemar's test was used to analyse the categorical agreement between the numbers of consumers of different beverages between the two methods. Total mean beverage intake reported by the two methods was compared using a paired-sample *t*-test. The intake of the individual beverages were not normally distributed, so the Wilcoxon signed rank test was used to compare the median intake of the different beverages in the results from the BFQ with those from the 7-day WebDAS. In the present study, it was important to assess how well the BFQ ranked respondents according to beverage intake compared to WebDAS. This

was assessed by a Bland-Altman plot illustrating visual agreement between the BFQ and the WebDAS, and by Spearman's rank Correlation Coefficients. In addition, for the intake of total beverages, water, milk, juice, soft drinks and chocolate, weighted Kappa statistics were used to incorporate counts for subjects with exact quartile agreement, plus two-third counts for subjects with quartiles differing by one level, and one-third counts for subjects with quartiles differing by two levels. Percentages of agreement were used to determine the percentage of subjects placed in the same or the same and adjacent quartiles by the tools. P-values<0.05 were considered as significant.

## 3. RESULTS AND DISCUSSION

Of the 73 students in the three school classes, 49 (20 girls, 29 boys) had acceptable 7-day records from the WebDAS, and 65 (29 girls, 36 boys) had acceptable BFQ leaving 49 (20 girls, 29 boys) with acceptable recordings for both methods. Mean (SD) age of the 49 respondents was 14.9 (0.5) years. It took on average approx. 10 minutes to complete the BFQ (min: 4; max: 17min).

As seen in Table 2, there was, as expected, a tendency to attain a higher proportion of consumers for the different beverage types with the BFQ. However, this tendency did not apply to soft drinks, for which the proportion of consumers was higher in WebDAS (WebDAS: 84% vs. BFQ: 63%. *P*=.031). Overall, there was good agreement between the two assessment methods with regard to the proportion of consumers for the different types of beverage. However, the BFQ found a significantly higher proportion of consumers eating chocolate than the WebDAS (BFQ: 92% vs. WebDAS: 69%. *P*<.001).

**Table 2. Numbers of consumers of beverages and chocolate measured with the web-based beverage frequency questionnaire (BFQ) and a web-based 7-day beverage diary (WebDAS), and agreement of consumers and non-consumers between methods**

| | BFQ proportion of consumers % (n=49) | WebDAS proportion of consumers % (n=49) | Agreement between proportion of consumers P-value* |
|---|---|---|---|
| Water | 100 | 92 | .125 |
| Milk | 90 | 86 | .687 |
| Juice/smoothies | 62 | 59 | 1.000 |
| Soft drinks | 63 | 84 | .031 |
| Cordials | 37 | 35 | 1.000 |
| Coffee | 18 | 16 | 1.000 |
| Tea | 47 | 49 | 1.000 |
| Sports- and protein drinks | 10 | 6 | .625 |
| Energy drinks | 25 | 22 | 1.000 |
| Wine, spirits, liqueurs, | 12 | 10 | 1.000 |
| Beer, alcopops, ciders | 14 | 14 | 1.000 |
| Chocolate | 92 | 69 | <.001 |

**The categorical agreement between numbers of consumers was analysed using McNemar's test*

The total mean beverage intake measured by the two methods differed significantly (BFQ: 1566 vs. WebDAS: 1231g/day, *P*=.02). The mean (SD) difference was 335 (769)g/day. This was primarily due to an intake of water measured with BFQ almost twice as high as that measured by WebDAS. Consumption of milk was higher with the BFQ than with WebDAS (median: 230g/day vs. 187g/day *P*= 0.05), and the WebDAS found a higher alcohol intake (wine, spirits, liqueurs) than the BFQ (median: 49g/day vs. 8g/day *P*=0.04) (Table 3). Positive Spearman rank correlations were found for all beverages, but the number of consumers was small for coffee, energy drinks and alcohol.

**Table 3. Beverage and chocolate intake by consumers (means (standard deviations); medians (interquartile range) and correlation coefficients) measured with a web-based beverage frequency questionnaire (BFQ) and a web-based 7-day beverage diary (WebDAS)[¶]**

| Beverage (number of consumers with both methods) | BFQ g/day consumers | | WebDAS g/day consumers | | *P*-value[§] | Correlation coefficient[†] |
|---|---|---|---|---|---|---|
| | Mean (SD) | Median (P25;P75) | Mean (SD) | Median (P25;P75) | | |
| Total beverages (n=49) | 1566 (841) | 1294 (993;2072) | 1231 (414) | 1150 (914;1469) | .02 | 0.42** |
| Water (n=45) | 787 (586) | 750 (375;1000) | 496 (324) | 483 (233;671) | <.001 | 0.41** |
| Milk (n=40) | 349 (329) | 230 (114;500) | 267 (209) | 187 (120;393) | .05 | 0.51** |
| Juice/smoothies (n=20) | 168 (209) | 91 (41;200) | 121 (92) | 86 (54;193) | .24 | 0.53* |
| Soft drinks (n=27) | 255 (344) | 165 (72;238) | 279 (281) | 194 (102;375) | .11 | 0.61** |
| Cordials (n=12) | 128 (199) | 32 (16;200) | 159 (199) | 86 (36;200) | .48 | 0.68* |
| Coffee (n=7) | 115 (109) | 100 (23;180) | 100 (72) | 71 (36;174) | .24 | 0.69 |
| Tea (n=17) | 155 (200) | 54 (16;247) | 202 (149) | 193 (61;293) | .14 | 0.75** |
| Energy drinks (n=9) | 134 (129) | 104 (51;176) | 145 (99) | 125 (71;214) | .68 | 0.53 |
| Wine, spirits, liqueurs (n=5) | 15 (15) | 8 (6;26) | 45 (30) | 49 (14;66) | .04 | 0.70 |
| Chocolate (n=34) | 16 (24) | 7 (4;20) | 17 (22) | 11 (7;18) | .84 | 0.29 |

** Significant at 0.05 level*
*** Significant at 0.01 level*
*[¶] Beverage groups with less than 5 respondents with both methods are not shown*
*[§] Wilcoxon signed rank test*
*[†] Spearman rank correlation*

The Bland-Altman plot of the total beverage intake showed a proportional bias for positive differences between BBQ and WebDAS at higher values of the beverage intake and negative differences at lower values (Fig. 2). The 95% limits of agreement were -1085 and 1929g/day.

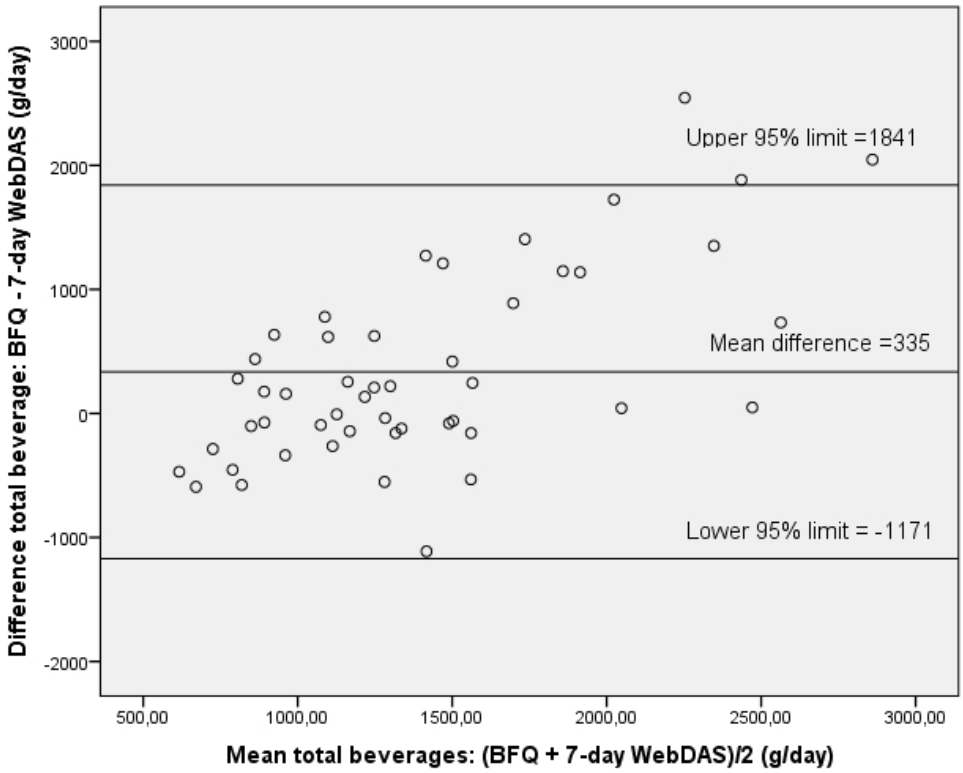


**Fig. 2. A Bland-Altman plot of the differences between the total beverage intake derived from the web-based beverage frequency questionnaire (BFQ) and the web-based 7-day beverage diary (WebDAS) plotted against the mean of total beverages from BFQ and WebDAS (n=49)**

The proportion of respondents appearing in the same or adjacent quartile for the total beverage intake measured with BFQ and WebDAS was 83%; 12% were misclassified in the 3rd quartile and 4% were misclassified in the 4th opposite quartile. For chocolate, 86% were classified in the correct or adjacent quartiles, 12% were misclassified and 1% were classified in the opposite quartile. Weighted Kappa statistics and percentages of exact agreement were lowest for water. Chocolate had the highest weighted Kappa statistic, and juice had the highest percentage of exact agreement (Table 4).

All frequency response options were used, but there were large differences dependent on the type of beverage. The category "≥ 4 times a day" was primarily used for water and milk. 1 time a month was especially used for liqueurs. There were no respondents who had intakes of sports gel or soy milk.

All quantity options were used for water, chocolate milk, cola and energy drinks. For the remaining beverages the smallest and in some cases the two smallest response categories were not used except for wine, where the largest response category was not used.

**Table 4. Associations between quartile placement for selected beverages groups and chocolate using the web-based beverage frequency questionnaire (BFQ) and the web-based 7-day beverage diary (WebDAS) (n=49)**

| | Exact agreement (%) | Adjacent quartile classification (%) | 3rd quartile classification (%) | Opposite quartile classification (%) | Weighted Kappa statistic |
|---|---|---|---|---|---|
| Total beverages | 39 | 45 | 12 | 4 | 0.29 |
| Water | 29 | 41 | 14 | 16 | 0.10 |
| Milk | 41 | 45 | 10 | 4 | 0.38 |
| Juice/smoothies | 46 | 29 | 18 | 6 | 0.33 |
| Soft drinks | 39 | 43 | 14 | 4 | 0.31 |
| Chocolate | 33 | 53 | 12 | 2 | 0.39 |

## 3.1 Results from the Feasibility Testing

During the completion of the BFQ it was observed that various issues needed to be clarified. These included:

- Emphasising that respondents should select all the beverages they have drunk in the past month, even if it was only a glass.
- Defining terms such as a “drinking situation”; “stimulating effect”; “in your opinion” (own experiences or what respondents believed), and “computer screen time” (includes homework, tablets, mobile phones, etc.?)
- Expanding answer categories e.g. for screen time, and including teen situations and expressions such as LAN party, super fresh, etc.
- Changing one question about the health value of energy drinks to asking about the relative health value of various beverages, including energy drinks.
- Changing of the filter on alcoholic beverages from 15 to 13 years.

## 3.2 Discussion and Comparison of Results with Those from Similar Studies

Table 5 presents an overview of validation studies of frequency questionnaires used to assess beverage intake only, or beverage and food intake in children and adolescents.

Two American studies by Hedrick et al. [10,13] validated two versions of the same quantitative beverage intake questionnaire (BEVQ) for adults. In both studies, the reference period was the previous month. The reference method in the first study was a 4-day diet diary and a Urinary Specific Gravity (USG) hydration biomarker, and in the second study the reference method was 3 x 24 hour intake recalls (FIRs). In the first study, the correlation of total beverage intake between BEVQ and the 4-day diet diary was 0.46 [10], and in the reduced BEVQ, it was 0.51 [13]. In the present study, the correlation was at similar level (0.42) for total beverage intake. The correlations between the individual beverages from the BFQ and reference instrument were similar to those in both studies by Hedrick et al. [10,13]. The present study is one of very few studies that compare beverage intake estimated with a beverage frequency questionnaire with intake estimated with beverage diaries in 14-16-year-old teenagers. A study by Neuhouser et al. [14] validated a Beverage and Snack Questionnaire (BSQ) in 13-year-olds using a 4-day food diary administered the week prior to the BSQ administration as reference method. The reference period for the BSQ was one week. Their study obtained good correlations for the different beverages (0.56-0.80 vs. 0.41-

0.75) in the present study. However, the reference period was very short and overlapped the food-recording period – making beverage intake easier to remember and report.

Other frequency questionnaires for children and adolescents have not targeted beverages specifically, but also foods and nutrients. The Iodine Fluoride Study and Bone Density Study validated two frequency questionnaires: The Targeted Nutrient Questionnaire (TNQ) for 9-year-old children and the Block Kids Food Questionnaire (BKFQ) for 8-year-old children [15]. Both questionnaires used the same 3-day diaries as reference method [15]. In both questionnaires, the reference period was the previous week. Marshall et al. reported results for 4-5 beverages, and correlations for milk, juice, soft drinks and water intake were lower than in the present study. Furthermore, they also assessed the agreement using percentage of exact agreement and weighed Kappa statistics for milk juice, soft drinks and water (only the TNQ). These results (Kappa: 0.13-0.43; % agreement: 33-48) were similar to those of the present study (Kappa: 0.10-0.39; % agreement: 29-46).

A study by Matthys et al. [21] validated a semi-quantitative Web-based FFQ using 3-day estimated food diaries for 12-18-year-olds as reference method. They reported correlation coefficients for 3 beverages of 0.47; 0.52; 0.53 for water, alcoholic beverages and soft drinks respectively. This was in agreement with the present study, and higher than for most of the measured foods, which suggests that beverage intake can be reasonably well measured with a FFQ.

The two studies by Hedrick et al. [10,13] and the study by Neuhouser et al. [14] also assessed the intake of energy drinks (Table 5). The results showed correlations of 0.42 [10] and 0.60 [13] between BEVQ and 4-day diet diary and 3-day FIRs, and 0.56 (consumed at school) and 0.65 (consumed away from school) between BSQ, and 4-day food diary [14]. In the present study the correlation was 0.53. Furthermore, a good agreement between the numbers of consumers of energy drinks was seen in the present study. This suggests that the consumption of energy drinks may be easy to remember and quantify. Coffee and tea intake also showed good correlations similar to the two studies of Hedrick et al. (Table 5).

In the present study, the amount of water recorded with the BFQ was almost twice as high as the intake measured with WebDAS. This might be explained by water being drunk in many different portion sizes, for example, straight from the tap, glass, bottle and water bottle, and the respondents were being asked to estimate the average for a beverage where the portion sizes vary significantly across drinking occasions, which might be difficult. At the same time, there may be a considerable unnoticed waste of tap water. Seen in this perspective, it cannot be ruled out that the large portion sizes of water were too large in the BFQ. The proportional bias seen in the Bland-Altman plot with large portions that were overestimated and small portions being underestimated may also be a result of bias in the water estimates since water is the beverage consumed in by far the highest amounts (BFQ: 50% of total beverage intake and WebDAS: 40%). This was also reflected in the quartile placement of water where approximately one third of all respondents were placed in the exact quartile, one third below and one third above (data not shown).

**Table 5. Overview of validation studies of frequency questionnaires used to assess beverage intake only or beverage and food intake in children and adolescents**

| Author | Questionnaire | Reference method/ period | Mean age (years) | Correlations between questionnaire and reference method | Exact agreement (%) and Kappa |
|---|---|---|---|---|---|
| Biltoft et al. The present study | 37-item beverage frequency questionnaire (BFQ) | • 7-day food diary<br>• 1 month | 14.9 | **Consumers only**<br>• Single beverages*: r=0.41-0.75<br>• Energy drinks: r =0.53<br>• Coffee/Tea: r =0.69/0.75 | Agreement %: 29-46<br>Kappa: 0.10-0.39 |
| Hedrick et al. 2012 [13] | 15-item beverage intake questionnaire (BEVQ) | • 3 x 24 hour recalls<br>• 1 month | 43 | • Single beverages*: r=0.13-0.76<br>• Energy drinks: r =0.60<br>• Coffee/Tea: r =.70 | Not published |
| Hedrick et al. 2010 [10] | 19-item beverage intake questionnaire (BEVQ) | • 4-day food diary and Urine Specific Gravity<br>• 1 month | 39 | • Single beverages*: r=0.28-0.81<br>• Energy drinks: r =0.42<br>• Coffee/Tea: r =0.55 | Not published |
| Neuhouser et al. 2009 [14] | 19-item beverage and snack questionnaire (BSQ) (9 beverages) | • 4-day food diary<br>• Previous week | 12.7 | • Single beverages¶: r=0.56-0.80<br>• Energy drinks: r =0.56/0.65 | Not published |
| Marshall et al. 2008 [15] | Two questionnaires:<br>• 22-item Targeted Nutrient Questionnaire (TNQ) (5 beverages)<br>• 75-question Block Kids Food Questionnaire (BKFQ) (4 beverages) | • 3-day food diary<br>• Previous week | TNQ: 9.0<br>BKFQ: 8.3 | Both questionnaires.<br>• Single beverages*: r=0.22-0.57 | Both questionnaires.<br>Agreement %: 33-48<br>Kappa: 0.13-0.43 |
| Matthys et al. 2007 [21] | 69-item food and beverage Web-based FFQ (3 beverages) | • 3-day food diary<br>• 1 month | 14 | • Single beverages*: r=0.49-0.53 | Not published |

**Spearman's rank correlations for individual beverages presented as a range, only specific for energy drinks and coffee/tea. ¶Pearson's correlation coefficients*

However, no overestimation of water was seen in the two studies by Hedrick et al. [10,13] or in the studies by Matthys et al. [21] and Marshall et al. [15]. Water may also be underestimated using WebDAS because it can be difficult to remember to register all water consumed over the course of a day. Water drinking also occurs between meals at leisure activities, etc. Beverages and foods consumed between meals are usually less remembered [22]. It has been suggested previously that beverage intake might be underestimated when food records are used [23]. However, the median intake of water in the present study estimated with 7-day WebDAS (483g/day) was similar to that found by Matthys in a similar age group using 3-day estimated food records (408g/day). The portion sizes and frequencies of water reported in the BFQ need further examination.

It is well known that the FFQ method tends to overestimate the intake of foods that are perceived as healthy [24]. This may also be the case in the present study, where water and milk were overestimated. In contrast, the proportion of soft-drink consumers was underestimated. This could be due to respondents answering on the basis of their own self-perception or giving socially acceptable answers in the BFQ, whereas in the WebDAS respondents recorded their current beverage intake.

### 3.3 Strengths and Limitations

The BFQ was set up professionally and the respondents were sent an e-mail with a link to reply in the same way as planned in the nationwide Danish Beverage Study. Moreover, the study population was not a convenience sample. Furthermore, the study population had a narrow age range, was relatively young, and the results showed that the BFQ was suitable for self-completion by teenagers. However, one major limitation of this study was the relatively small number of respondents, which resulted in limited coverage of coffee, energy drinks, alcoholic beverages, and sports and protein beverages, because of the low number of consumers. Furthermore, it would have been appropriate to extend the age group to 14-20-year-olds, because heavy consumption of energy drinks might be expected from 16-20-year-olds as well.

There were also differences in the number of respondents who completed the BFQ and the WebDAS. This may be due to respondents answering the BFQ at school and completing the WebDAS food diary at home during leisure time. Furthermore, the number of students that were at school when the instructions were given for completing the WebDAS differed due to illness from when respondents completed the BFQ.

The present study can be used to adjust and calibrate the method used in the nationwide Danish Beverage Study and for comparison of the overall results with this study.

## 4. CONCLUSION

The BFQ gave results comparable with those of a 7-day beverage web-diary (WebDAS) from 14-16-year-olds and seems to perform just as well as other beverage FFQs. With a few adjustments, especially with regard to portion sizes and entries for water, we believe the BFQ will be useful in large population-based studies for assessment of beverage intake.

## ACKNOWLEDGEMENTS

The authors wish to thank: Ronja Lill Krabbe and Mariah Juul Nielsen, students in Global Nutrition and Health at the Metropolitan University College, for helping with study materials, the conduct of “think out loud” testing and giving instructions; Karsten Kørup, for conducting the data processing of the Web-based 7-day beverage diary (WebDAS); Erling Saxholt for help in taking portion size images (both at the Department of Nutrition, National Food Institute, Technical University of Denmark). This study was internally funded.

## COMPETING INTERESTS

Authors declare that they have no competing interests.

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