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Development and validation of a quantitative snack and beverage food frequency questionnaire for adolescents

N. De Cock,[1] J. Van Camp,[1] P. Kolsteren,[1] C. Lachat,[1] L. Huybregts,[1,2] L. Maes,[3] B. Deforche,[3,4] R. Verstraeten,[5] J. Vangeel,[6] K. Beullens,[6,7] S. Eggermont[6] & W. Van Lippevelde[4]

[1]Department of Food Safety and Food Quality, Ghent University, Ghent, Belgium
[2]Poverty, Health and Nutrition Division International Food Policy Research Institute, Washington, DC, USA
[3]Department of Public Health, Ghent University, Ghent, Belgium
[4]Physical Activity, Nutrition and Health Research Unit, Faculty of Physical Education and Physical Therapy, Vrije Universiteit Brussel, Brussels, Belgium
[5]Institute of Tropical Medicine, Antwerp, Belgium
[6]Leuven School for Mass Communication Research, KU Leuven, Leuven, Belgium
[7]Research Foundation Flanders (FWO), Brussel, Belgium

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Correspondence
N. De Cock, Department of Food Safety and Food Quality, Ghent University, Coupure Links 653, 9000, Ghent, Belgium.
Tel.: +32 9 264 93 77
Fax: +32 9 264 62 15
E-mail: nathaliel.decock@ugent.be

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Abstract

Background: A short, reliable and valid tool to measure snack and beverage consumption in adolescents, taking into account the correct definitions, would benefit both epidemiological and intervention research. The present study aimed to develop a short quantitative beverage and snack food frequency questionnaire (FFQ) and to assess the reliability and validity of this FFQ against three 24-h recalls.
Methods: Reliability was assessed by comparing estimates of the FFQ administered 14 days apart (FFQ1 and FFQ2) in a convenience sample of 179 adolescents [60.3% male; mean (SD) 14.7 (0.9) years]. Validity was assessed by comparing FFQ1 with three telephone-administered 24-h recalls in a convenience sample of 99 adolescents [52.5% male, mean (SD) 14.8 (0.9) years]. Reliability and validity were assessed using Bland–Altman plots, classification agreements and correlation coefficients for the amount and frequency of consumption of unhealthy snacks, healthy snacks, unhealthy beverages, healthy beverages, and for the healthy snack and beverage ratios.
Results: Small mean differences (FFQ1 versus FFQ2) were observed for reliability, ranking ability ranged from fair to substantial, and Spearman coefficients fell within normal ranges. For the validity, mean differences (FFQ1 versus recalls) were small for beverage intake but large for snack intake, except for the healthy snack ratio. Ranking ability ranged from slightly to moderate, and Spearman coefficients fell within normal ranges.
Conclusions: Reliability and validity of the FFQ for all outcomes were found to be acceptable at a group level for epidemiological purposes, whereas for intervention purposes only the healthy snack and beverage ratios were found to be acceptable at a group level.

Introduction

Adolescents typically adopt unhealthy eating habits, such as snacking, low consumption of dairy products, fruit, vegetables, and high intake of energy-dense snacks, sugar-sweetened beverages (SSBs) and other high-caloric beverages [1,2]. The overconsumption of high energy-dense beverages, such as sodas, sweetened milk beverages, fruit-based drinks and alcohol, has already been associated with excess sugar and energy intake and obesity in

adolescence and adulthood [3–5]. However, snacking, or eating in between meals, has been associated with both excess energy intake and being overweight and also an improved diet quality and reduced obesity [6–10]. The consequences are dependent on snacking frequency, food types eaten as snacks and portion sizes consumed [6–10]. If mainly energy-dense foods such as cookies, chocolate, chips or fast-food are consumed, energy, sugar and fat intakes from snacks are substantial and nutrient intakes are lower [7,8]. When more healthy foods, such as fruits and milk products, are eaten, energy intakes from snacks are lower and the overall nutritional quality of the diet is higher [7,8]. Not only do unhealthy snack and beverage intake both contribute independently to excess energy intake, but also their intakes are also related [11,12]. High SSB drinking children and adolescents were found to consume more sweet and salty snack foods than non SSB drinkers [11,12]. Effective evaluation of both habitual snack and beverage consumption is needed to determine important correlates of snack and beverage consumption, as well as to analyse interventions aimed at improving snack and/or beverage consumption.

Existing tools such as dietary records, 24-h recalls or large food frequency questionnaires (FFQs) assessing the total diet of adolescents are time-consuming, burdensome for the respondents and provide unnecessary details [13–16]. Especially when evaluating dietary intake in adolescents, rapidly administrable tools are necessary because adolescents are less interested in giving accurate reports [14]. Short assessments tools, focusing on specific behaviours, have been used before in adolescent populations to assess nutrient or food group intakes and were found to be easy to administer, reliable and valid [13–15,17,18]. To date, only a brief questionnaire exists that measures snack and beverage intake in adolescents [15]; however, this questionnaire was developed specifically for evaluating school policies and does not contain all possible snack foods or high-calorie beverages. Nor does it contain portion size estimation or evaluate the intake of snack foods at snack times. The latter is of crucial importance because the effects of snacking are determined by the type and portion size of snacks. Snack intake should be measured as the consumption of typical snack foods, both healthy and unhealthy, at snack times (e.g. any food eaten in between the main meals) [19,20].

The aim of the present study was to develop and validate a short quantitative FFQ to measure both habitual snack and beverage intake, using the correct definition of snacking (e.g. snack foods eaten at snack times) [21]. The reliability and validity of this FFQ was assessed in a sample of Flemish adolescents aged 14–16 years for both epidemiological and intervention purposes. Reliability and validity were assessed for the variables: frequency and quantity (g or mL) of unhealthy snacks, healthy snacks, unhealthy beverages and healthy beverages, and the healthy snack and beverage ratios.

Materials and methods

The present study is part of the REWARD project (www.rewardstudy.be), a multidisciplinary project that aims to increase healthy food choices in children and adolescents using reward-based mechanisms. In adolescents, the overall goal was to study and/or improve adolescents' snack and beverage choices. The first step was the development of a quantitative snack and beverage FFQ for adolescents, of which the present study reports the development and the validation and reliability analyses. This FFQ will be used in a subsequent cross-sectional study to research adolescents' snacking and drinking behaviours, and a smartphone-based intervention study to increase adolescents' healthy snack choices.

Development of the quantitative snack and beverage food frequency questionnaire

The selection of surveyed food and beverages items consisted of two steps. In step 1, a review of survey items from existing research examining food intake in children and adolescents was conducted [22–25]. From this review, one FFQ was selected to be used as the basis for our FFQ [22,25]. Step 2 assessed whether the items from this FFQ were commonly consumed as snacks or beverages by adolescents in Flanders. The frequent consumption of a food as snack or beverage was assessed based on the 24-h recall data of Flemish adolescents from the HELENA study [26]. The latter study evaluated the food intake and eating patterns of European adolescents aged 12.5–17.5 years from 10 European countries, including Belgium (Flanders) [26]. Items that were not commonly consumed as snacks or beverages by adolescents in the HELENA study were removed; and snacks or beverages that were commonly consumed, but were not present, were added. In total, the FFQ consists of 14 beverage items and 28 snack items. The FFQ is provided as Supporting information (Appendix S1).

Frequencies of consumption, portion sizes and examples of typical portions were adapted from the same quantitative FFQ that was used as basis for the selection of the items [22,25].

The snack and beverage FFQ was pretested by 40 adolescents (±2 classes) on clearness and appropriateness of the items and examples. Wording of the items and examples were revised based on their feedback.

Validation and reliability study

Design

Reliability and validity of the FFQ were examined in a convenience sample of Flemish adolescents. Reliability was assessed by comparing measurement agreement of a repeated administration [FFQ at time 1 (FFQ1) versus FFQ at time 2 (FFQ2)]. Validity was evaluated by comparing measurement agreement between the FFQ1 and the average of three 24-h dietary recalls. Executing the 24-h dietary recall three times is considered sufficient to obtain an estimation of the habitual intake of adolescents for the purpose of validation studies in adolescents [24,27,28]. Administering the 24-h dietary recalls by telephone is common and convenient in research with adolescents [27,29–31]. Main outcomes were the consumption frequency of unhealthy snacks, healthy snacks, unhealthy beverages and healthy beverages; the intake of unhealthy snacks (g), healthy snacks (g), unhealthy beverages (mL) and healthy beverages (mL); and the healthy snack and beverage ratios.

Recruitment of participants

Data were collected from February to March 2014 using a convenience sample of 14–16-year-old Flemish adolescents. These adolescents were recruited from three secondary schools, in each school three classes (±60 students per school) were selected by the principals to participate in the study. Adolescents were asked separately if they also wanted to participate in the validation study, because this required more effort. Incentives were raffled among adolescents that participated in both studies. Parents or legal guardians of the selected adolescents received a letter explaining the study purpose and were asked for passive consent for the participation of their adolescent. Adolescents were also informed that they could withdraw from the study at any time without explanations. No inclusion or exclusion criteria were applied. The study protocol was approved by the Ethics Committees of the Ghent University Hospital.

Study procedure

A team of researchers visited the schools on a previously agreed time during school hours. Adolescents completed the FFQ (FFQ1) in the presence of a research assistant. Adolescents were instructed to carefully read the instructions (see Supporting information, Appendix S1) given with the FFQ and were informed that they could ask questions at any time. Adolescents also completed a short demographic questionnaire at the same time. Completing the FFQ took the adolescents approximately 20 min. Adolescents who agreed to participate in the validation study also provided a telephone number and the hours they were available for the 24-h recalls at this time point.

For the purpose of the reliability study, the FFQ was administered a second time (FFQ2), 14 days after the first administration (FFQ1) following the same procedures.

For the purpose of the validation study, three 24-h recalls were administered between FFQ1 and FFQ2 in such a way that all participants provided data for two weekdays and one weekend day. At a group level, a balanced representation of each week day was obtained. Participants were called in between the agreed hours and were asked about food consumption of the previous day. Participants were unaware at which days they would be called. The administration of the 24-h recall took approximately 15 min each time. The 24-h recalls were conducted by dieticians, who were trained to administer these recalls in a standardised way [22,25]. No specific automatised procedure, such as the multiple-pass method [32], was used. Adolescents were called three times on different days before being regarded as having dropped out.

Instruments

The quantitative beverage and snack food frequency questionnaire

The FFQ assessed usual food intake with a reference period of 1 month. The six frequency categories used were: never or seldom; 1–3 days month^{-1}; 1 day week^{-1}; 2–4 days week^{-1}; 5–6 days week^{-1}; every day. Depending on the item, four to six portion size categories were provided together with a list of common standard portion measures as examples.

The FFQ comprised of two sections: beverages (14 items) and snacks (28 items). The intake of beverages was evaluated over the whole day because beverages such as soft and fruit drinks provide additional calories and sugars throughout the whole day and not only at snack times [33]. The intake of snacks was evaluated in terms of all food items consumed outside (>30 min) of breakfast, lunch and dinner, in accordance with Rodriguez and Moreno's definition of snacking [21]. Items in both sections were presented in such a way that closely related items were presented on the same page with the more specific items presented before the general ones [13].

Snacks and beverages were classified as either healthy or unhealthy using the UK Ofcom Nutrient Profiling model [34]. This model provides a score as a proxy for 'unhealthiness' of a beverage or food product. Food items that scored 4 points or more and beverage items that scored 1 point or more were considered to be unhealthy [34]. Following this scoring system, the snack and beverage items, sport drinks, energy drinks, soft drinks, sweetened milk drinks, cocktails, aperitif drinks, liquor, crisps, other salty snacks, sausage/cheese rolls and pizza, other fried snacks, fries, hamburgers, cheese or meat cubes, sandwich

with sweet or savoury spread, ice-cream, popsicles, breakfast cereals, pudding, mousses, chocolate, candy bars, candy, dry cookies, other cookies, breakfast rolls and pastries were considered to be unhealthy. The items water, fruit juice, coffee, milk substitutes, milk, beer, wine, fruit, dried fruit, nuts, raw vegetables, pitta, pasta cups, unsweetened and sweetened yoghurt were considered healthy.

The daily intake of each snack and beverage item of the FFQ was obtained by multiplying frequency of consumption with quantity of consumption per week (g) divided by 7. These daily estimates were then summed to obtain the daily intake of healthy snacks (g), unhealthy snacks (g) unhealthy beverages (mL) and healthy beverages (mL). The consumption frequency of unhealthy and healthy snacks or beverages was calculated by summing the frequencies of the different food or beverage items and dividing this sum by 7. Finally, healthy snack and beverage ratios were calculated. These ratios represent how much percentage of the total snack or beverage intake was healthy. The higher these ratios, the more healthy the snack or beverage intake of the adolescents.

$$\text{Healthy snack ratio} = \left(\frac{\text{daily intake of healthy snacks}}{\text{daily intake healthy and unhealthy snacks}}\right) \times 100$$

$$\text{Healthy beverage ratio} = \left(\frac{\text{daily intake of healthy beverages}}{\text{daily intake healthy and unhealthy beverages}}\right) \times 100$$

The 24-h recalls

All information obtained during the telephone administered 24-h recalls was noted in a document subdivided into six eating occasions: breakfast, morning snacks, lunch, afternoon snacks, dinner and evening snacks. For each of these occasions, detailed information was requested from the adolescent by the researcher concerning the type of food consumed, the brand (with description) and the quantity consumed. For each of these occasions, product categories were also provided depending on the type of meal; for example, for breakfast, these are: cereal, bread, spreads/meat/cheese/etc., margarine/butter/etc., drinks and others.

Because the focus of our FFQ was only on snacks (all food items consumed outside the three main meals) and beverages (evaluated over the whole day), only the 24-h recall data regarding food items obtained in the sections morning, afternoon and evening snacks and beverage items from all sections were used and imported into LUCILLE, version 0.1 [35]. Lucille is a software package designed to process food intake developed by our own research group [35]. The present study opted to question all eating occasions and not only snack occasions because beverage intake was evaluated over the whole day. This would also not interfere with the normal way of performing a telephone-administered 24-h recall.

All foods and beverages consumed by the adolescents in the 24-h recalls were summed to obtain the intakes per snack and beverage item from the FFQ and per recall day. These intakes per item were then summed to obtain again the daily intake of healthy snacks (g), unhealthy snacks (g) unhealthy beverages (mL) and healthy beverages (mL) per recall day. The latter were then averaged to obtain an average of the three recall days to represent the habitual intake of healthy snacks (g), unhealthy snacks (g), unhealthy beverages (mL) and healthy beverages (mL) comparable with the data obtained via the FFQ. Also, the consumption frequencies of unhealthy or healthy beverage or snack items were calculated by summing the different snack or beverage items consumed each recall day and then again averaging these numbers over the three recall days to obtain the usual consumption frequencies of unhealthy or healthy snack and beverage items consumed per day. Finally, the healthy snack and beverage ratios were calculated in the same manner as stated above.

Statistical analysis

All analyses were performed in STATA, version 13.1 (StataCorp, College Station, TX, USA). Although correlation coefficients are a poor estimate of measurement agreement, they are provided in the present paper to allow comparison with other studies [36,37].

Reliability analysis

Only participants who completed both FFQ1 and FFQ2 were retained for the reliability analysis. Descriptive analyses were used to evaluate the characteristics of the participants (mean age and sex) in the reliability study and to describe the mean intakes and frequencies obtained via FFQ1 and FFQ2.

Reliability was assessed first by determining the correlation coefficients, Spearman's rho, between the outcomes derived from FFQ1 and FFQ2. Second, agreement between the repeated administration for each of the outcomes was evaluated using Bland–Altman plots [38]. The same procedure to determine mean difference, its confidence interval (CI) and the 95% limits of agreement (LOA) was followed as previously proposed by Ambrosini *et al.* [39], including the transformation of all outcomes to their natural logarithms before analyses because of the usual skewness in intake distributions. Mean differences (FFQ1 – FFQ2) and LOAs were thus back transformed

by taking the antilog, and values are presented as percentages. For example, a mean agreement of 100% for energy intake would suggest exact agreement, whereas a mean agreement of 120% indicates that the FFQ1 overestimated unhealthy snack intake by 20% compared to FFQ2, on average. Furthermore, 95% LOAs of 55–184% for unhealthy snack intake would suggest that 95% of all subjects' FFQ1 estimates are between 55% and 184% of their FFQ2 unhealthy snack intake estimate [38,39]. Third, the classification agreement between FFQ1 and FFQ2 was assessed using weighted kappa statistics and its SD by comparing classifications of the outcomes into low, medium and high tertiles [40] using the standards as proposed by Landis and Koch (1977) [41]. These standards are less than 0 'less than chance agreement', 0.01–0.20 'slight agreement', 0.21–0.40 'fair agreement', 0.41–0.60 'moderate agreement', 0.61–0.80 'substantial agreement' and 0.81–0.99 'almost perfect agreement'. To account for prevalence and bias effects, the prevalence-adjusted and bias-adjusted kappa (PABAK) was presented alongside the kappa statistics [42].

Validation analysis

Only participants who completed at least two 24-h recalls and FFQ1 were retained for the validation analysis. Descriptive analyses were used to evaluate the characteristics of the participants (mean age and sex) in the validation study and to describe their mean intakes and frequencies obtained via FFQ1 and the 24-h recalls (average of the three evaluated days).

Validity was assessed by first determining correlation coefficients (Spearman's rho) between the outcomes derived from FFQ1 and the average of the three 24-h recalls. Second, this was followed by a comparison of the agreement for all outcomes between FFQ1 and the average of the recalls by means of Bland–Altman plots, in the same manner as explained above for the reliability study. The third and final assessment determined the classification agreement for all outcomes between FFQ1 and the recalls by means of kappa statistics, as explained above.

Results

Reliability study

Participants and descriptives

In total, 179 adolescents [60.3% male; mean (SD) age 14.7 (0.9) years], or 97% of 184 adolescents sampled in the reliability study, provided valid data for both administrations of the FFQ.

Table 1 shows the estimates for the outcomes obtained from FFQ1 and FFQ2. FFQ1 had higher estimates for all outcomes except for the healthy snack ratio.

Reliability

Mean differences for all outcomes were small (less than 30% difference). The largest mean difference observed was +28.8% for the quantity of healthy beverages consumed. The smallest difference observed was +3.8% for the healthy beverage ratio (Table 2). FFQ1 thus overestimated the quantity of healthy beverages by 28.8% or FFQ1 measured 128.8 mL and FFQ2 100 mL. Except for the healthy snack ratio, all mean differences were positive and different from 100%, indicating that FFQ1 overestimated intakes compared to FFQ2. The 95% CIs included 100% agreement except for the frequency of unhealthy and healthy snacks, the quantity of unhealthy and healthy snacks and the quantity of unhealthy beverages, indicating nonsignificant differences between FFQ1 and FFQ2. LOAs were wide for all outcomes (Table 2).

Table 1 Mean snack and beverage intakes for the reliability (n = 179) and validation study (n = 99)

	Reliability (n = 179)				Validity (n = 99)			
	FFQ1		FFQ2		FFQ1		Average of the recalls	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Frequency of unhealthy snacks per day	2.8	(1.9)	2.4	(1.8)	2.4	(1.5)	0.8	(0.7)
Frequency of healthy snacks per day	1.1	(0.7)	0.9	(0.7)	1.1	(0.7)	0.5	(0.7)
Quantity of unhealthy snacks consumed per day (g)	225.8	(237.1)	220.9	(308.9)	180.0	(154.4)	44.7	(41.5)
Quantity of healthy snacks consumed per day (g)	195.6	(173.0)	181.0	(190.8)	201.6	(160.7)	65.0	(104.3)
Healthy snack ratio (%)	45.5	(27.8)	46.3	(27.7)	51.5	(26.8)	26.6	(32.7)
Frequency of unhealthy beverages per day	0.8	(0.7)	0.7	(0.7)	0.7	(0.7)	0.8	(0.8)
Frequency of healthy beverages per day	2.0	(0.8)	1.8	(0.8)	2.0	0.8)	2.7	(1.1)
Quantity of unhealthy beverages consumed per day (mL)	295.2	(390.2)	269.3	(388.1)	286.0	(436.9)	185.2	(260.6)
Quantity of healthy beverages consumed per day (mL)	987.0	(542.5)	841.2	(559.8)	988.9	(504.3)	921.8	(481.2)
Healthy beverage ratio (%)	77.3	(24.0)	76.5	(24.3)	79.1	(24.1)	76.7	(24.3)

FFQ, food frequency questionnaire.

Table 2 Mean differences and confidence intervals (CIs), as well as limit of agreement (LOA), kappa, prevalence-adjusted and bias-adjusted (PABAK) and Spearman's rho values, for the reliability study (n = 179)

	Mean agreement (%)*	95% CI (%)*	LOA (%)*	Kappa	PABAK	Spearman's rho
Frequency of unhealthy snacks per day	118.9	109.1, 129.4	37.7, 375.0	0.51	0.56	0.69
Frequency of healthy snacks per day	119.1	106.2, 133.4	26.4, 537.0	0.49	0.55	0.69
Quantity of unhealthy snacks consumed per day (g)	119.1	106.7, 133.1	16.0, 843.3	0.57	0.62	0.75
Quantity of healthy snacks consumed per day (g)	115.1	99.1, 133.4	16.3, 812.8	0.49	0.55	0.62
Healthy snack ratio (%)	95.3	85.1, 106.7	21.8, 415.9	0.54	0.59	0.73
Frequency of unhealthy beverages per day	107.4	93.3, 123.6	18.3, 629.5	0.56	0.61	0.68
Frequency of healthy beverages per day	113.2	105.7, 121.1	45.1, 283.8	1.00	1.00	0.71
Quantity of unhealthy beverages consumed per day (mL)	107.9	91.2, 127.7	13.2, 885.1	0.55	0.60	0.70
Quantity of healthy beverages consumed per day (mL)	128.8	117.2, 141.9	35.2, 472.1	0.53	0.59	0.67
Healthy beverage ratio (%)	103.8	96.8, 111.2	41.1, 261.8	0.52	0.58	0.69

*Antilogs in percentages: mean agreement of 100% for quantity of unhealthy snacks would suggest exact agreement, whereas mean agreement of 119.1% indicates that the FFQ1 overestimates the quantity of unhealthy snacks by 20%, on average. FFQ, food frequency questionnaire.

Moderate classification agreement (kappa in Table 2) was observed for all outcomes except for the frequency of healthy beverages, where substantial agreement was observed. The kappa coefficient improved for all outcomes when it was adjusted for prevalence and bias (PABAK) (Table 2).

Spearman's rho's (Table 2) ranged from 0.62 (healthy snacks g day^{-1}) to 0.75 (unhealthy snacks g day^{-1}).

Validation study

Participants and descriptives

In total, 99 adolescents [52.5% male, mean (SD) age 14.8 (0.9) years], or 82% of 121 adolescents sampled in the validation study, provided valid data for at least two 24-h recalls and FFQ1. Of these 99 participants, 88 (88.9%) completed three recalls and 11 (11.1%) complete only two.

Table 1 indicates that the FFQ provided higher estimates than the 24-h recalls for snack intake in terms of frequencies and quantities consumed and the healthy snack ratio. For beverage intake, the FFQ provided lower estimates for the frequencies of unhealthy and healthy beverages, although higher estimates for the quantities consumed and the healthy beverage ratio.

Validity

Small mean differences (less than 30%) were observed for unhealthy and healthy beverages (frequencies and quantities), ranging from −24.7% to +7.6% (Table 3). The FFQ overestimated the quantities consumed by 9 or 4 mL, whereas it underestimated the frequency of unhealthy and healthy beverages by 0.25- or 0.17-fold. The FFQ and the 24-h recalls showed almost perfect agreement for the healthy beverage ratio (mean difference=100.5%). Large mean differences, however, were observed (Table 3) for the intake of healthy and unhealthy snacks, especially the quantity and the frequency of unhealthy snacks was overestimated by the FFQ (+152.9% and 225.8%, respectively). The FFQ overestimated the frequency of eating unhealthy snacks by 1.5-fold and the quantity consumed by 226 g. For the healthy snack ratio, the difference between both methods was small (+11.2%). The 95% CIs did not include 100% agreement, except for the healthy snack ratio, the frequency of unhealthy beverages, the quantity of unhealthy and healthy beverages, and the healthy beverage ratio, indicating significant differences between both methods. LOAs were wide for all outcomes (Table 3). Figure 1 illustrates the differences in mean agreement and LOAs by presenting the Bland–Altman plots for the intake of unhealthy snacks, healthy snacks, unhealthy beverages and healthy beverages, and the healthy snack and beverage ratios.

Slight to moderate classification agreement was observed between the FFQ and the recalls. Classification agreement improved for all outcomes when adjusted for prevalence and bias (Table 3).

Spearman's rho's (Table 3) ranged from 0.17 (healthy beverages frequency day^{-1}) to 0.69 (unhealthy beverages g day^{-1}).

Discussion

The present study reports on the reliability and validity of a newly developed quantitative snack and beverage FFQ for adolescents.

The reliability of the FFQ was adequate at a group level for snack and beverage intake because mean differences were small and kappa values and correlation coefficients fell within the common range [13]. Significant mean differences between both administrations of the FFQ were observed for the frequency of unhealthy and healthy

Table 3 Mean difference and confidence intervals (CIs), as well as limit of agreement (LOA), kappa, prevalence-adjusted and bias-adjusted (PABAK) and Spearman's rho values, for the validation study

	Mean agreement (%)*	95% CI (%)*	LOA (%)*	Kappa	PABAK	Spearman's rho
Frequency of unhealthy snacks per day	252.9	214.8, 297.9	58.9, 1088.9	0.13	0.24	0.27
Frequency of healthy snacks per day	142.9	112.2, 182.4	26.4, 776.3	0.16	0.25	0.39
Quantity of unhealthy snacks consumed per day (g)	325.8	261.8, 404.6	47.4, 2238.7	0.18	0.27	0.31
Quantity of healthy snacks consumed per day (g)	214.3	161.1, 285.8	29.7, 1548.8	0.28	0.32	0.42
Healthy snack ratio (%)	111.2	89.5, 138.4	24.8, 500.0	0.25	0.30	0.35
Frequency of unhealthy beverages per day	82.6	67.1, 101.9	14.8, 460.3	0.33	0.39	0.63
Frequency of healthy beverages per day	75.3	66.5, 85.3	21.6, 262.4	0.13	0.27	0.17
Quantity of unhealthy beverages consumed per day (mL)	108.9	84.3, 140.6	15.0, 790.7	0.49	0.55	0.69
Quantity of healthy beverages consumed per day (mL)	104.0	90.0, 120.0	24.4, 441.6	0.31	0.38	0.44
Healthy beverage ratio (%)	100.5	91.4, 110.7	38.7, 261.2	0.43	0.48	0.68

*Antilogs in percentages: mean agreement of 100% for quantity of unhealthy snacks would suggest exact agreement, whereas mean agreement of 325.8% indicates that the FFQ overestimates the quantity of unhealthy snacks by 285%, on average. FFQ, food frequency questionnaire.

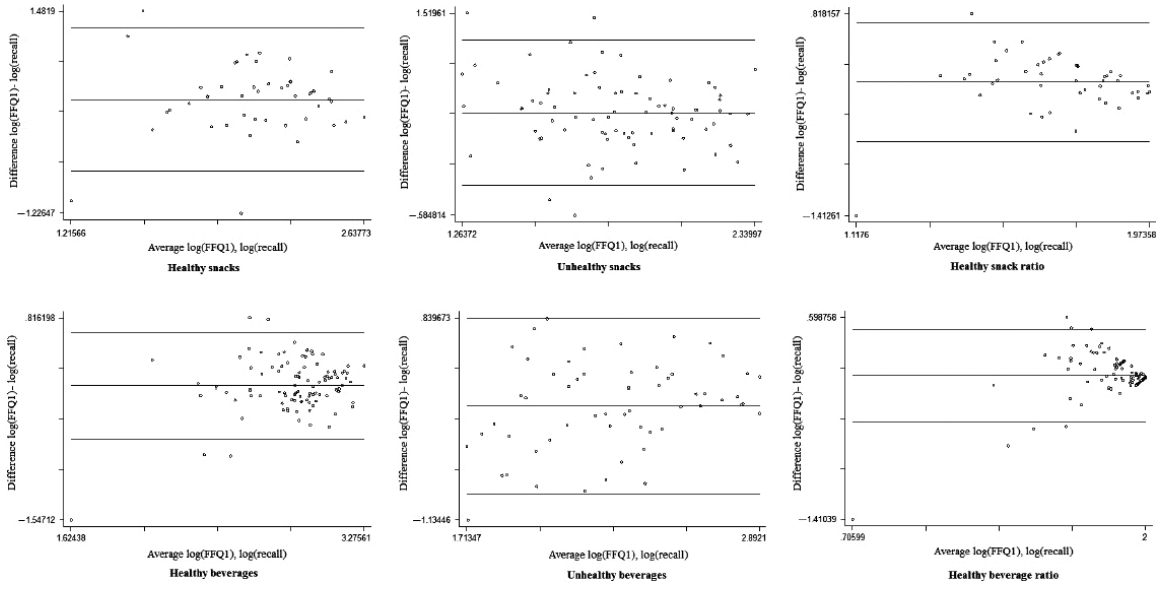

Figure 1 Bland–Altman plots for snack and beverage intake in the validation study. FFQ, food frequency questionnaire.

snacks, the quantity of unhealthy and healthy snacks, and the quantity of unhealthy beverages. These differences, however, were small and not higher than 30%, indicating a discrepancy of only 0.3 snacks or 30 g eaten more per day. LOAs, on the other hand, were large, indicating that reliability is inadequate at an individual level. Because the present study is the first to specifically measure snack and beverage intakes, no comparable reliability studies could be found. Findings were therefore compared with reliability studies that capture total food intake in adolescents. The study by Watson *et al.* [43] also used Bland–Altman plots to test the reliability of a FFQ in adolescents and reported similar results: small mean differences but large LOAs. Other reliability studies of FFQs in adolescents, reported similar ranges of kappa values and correlation coefficients [24,37,39].

The results of the validation analyses showed that mean differences for beverage intake (frequencies, absolute intakes and healthy beverage ratio) were small. The FFQ underestimated the frequency of beverages consumed by 0.25-fold for healthy beverages and by 0.17-fold for unhealthy beverages and overestimated the quantity of unhealthy and healthy beverages consumed by respectively 8.9 or 4 mL. For the healthy beverage ratio, almost perfect agreement (mean difference = 100.5%) was observed. Mean differences for absolute snack intakes were large, whereas the mean difference for the healthy snack ratio was small. Differences in absolute snack

consumption corresponded to an overestimation of 225 g of unhealthy snacks and 114 g for healthy snacks. Snack foods are abundant in our environment [44] and adolescents are thus presented with wide range of snack options each day, making it difficult for adolescents to estimate their snack consumption for the past month. Other studies also already reported that it is difficult to capture this highly variable food intake pattern of adolescents [18,45]. In addition, adolescents may have ticked several snacks for a small frequency in the FFQ, leading to a larger overall amount estimated in the FFQ than actually consumed. Twenty-eight different snack options were presented in the FFQ. To limit the ticking of too many snacks and the related overestimation of absolute snack intake, it might be better to offer less choice and to group some of the snack items. For all outcomes, however, Spearman's correlation coefficients and ranking ability were considered acceptable. Here, the findings were also compared with validation studies in adolescents that measured total food intakes with a FFQ by lack of comparable studies. Other FFQ validation studies also found rather large discrepancies between both methods of food intake estimation but found acceptable ranking ability [24,37,39,43]. LOAs, obtained via Bland–Altman plots, were wide for all outcomes of the validation study. This indicates that the FFQ is thus inadequate for estimating snack and beverage intake at an individual level. The latter is also in concordance with these other validation studies of FFQs in adolescents [27,38,40,44].

For means of intervention evaluation, a good test–retest reliability and precise estimates of intakes at a group level are necessary to detect changes [13,14]. Small mean differences were observed between the repeated administration of the FFQ for all outcomes; however, large differences were observed between the FFQ and the 24-h recalls except for the healthy snack and beverage ratio. Thus, only the healthy snack and beverage ratio are appropriate for evaluating dietary change in intervention studies. For means of cross-sectional research, mainly a moderate to good ranking ability [13,14] is needed, which was achieved for all outcomes.

The present study was the first to develop and report on the reliability and validity of quantitative snack and beverage FFQ, incorporating the evaluation of snack food at snack times, for the purpose of epidemiological or intervention studies. Other strengths of the present study are its use of standard portion sizes to help the portion size estimation, a sample that contained a balanced amount of boys and girls and the use of Bland–Altman plots alongside correlation coefficients to assess reliability and validity. Previous research already showed that correlation coefficients can be misleading indicators of agreement [37]. The present study, however, also had some limitations. First, the sample population was obtained via convenience sampling and therefore the results might not be generalisable to other populations. Second, the selection of the items of the snack-and-beverage centered FFQ was based on the frequentness of consumption by the general population of adolescents; thus, it could be possible that not every adolescent feels that he or she is able to fully describe his or hers snack and/or beverage intake. Third, the source of error of a 24-h recalls tends to be more correlated with the error in an FFQ as a result of reliance upon memory and conceptualisation of portion sizes [13]. For example, the use of biomarkers, with errors that are are uncorrelated with FFQs, would have greatly increased both respondent and researchers burden. Fourth, a possible memory effect could have occurred in the reliability study; some adolescents might have remembered their answers to the FFQ1 when completing the second FFQ. Cade *et al.* [13] stated that, when there is a very short interval between the repeated administration of the FFQ, participants could indeed remember their previous responses. Two weeks, however, is a not uncommon interval in reliability studies in adolescents [46]. A larger interval between both FFQs was also not possible because the Easter examination period was approaching. Fifth and finally, when using this FFQ to estimate the effect of interventions, the FFQ should be complemented with a 24-h recall or another instrument that captures the total diet to account for possible spillover effects on other eating behaviours.

Conclusions

The reliability and the validity of the snack and beverage FFQ were found to be acceptable at a group level for the purpose of analysing diet–disease relationships. Caution, however, should be exercised when presenting and researching absolute snack intakes, especially for unhealthy snack intake. The reliability and the validity of the snack and beverage FFQ was also found to be acceptable at a group level for the purpose of analysing intervention effects, although only for the healthy snack and beverage ratios.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported, that no important aspects of the study have been omitted and that any discrepancies from the study as planned (and registered with) have been explained. The reporting of this work is compliant with the STROBE guidelines.

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Conflict of interests, source of funding and authorship

The authors declare that there were no conflicts of interest.
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NDC conducted research, conducted the analyses and wrote the paper. WVL and JV conducted research and helped revise the manuscript. KB, CL and LH designed research and helped revise the manuscript. RV and BD helped revise the manuscript. SE, LM, JVC and PK designed research. All authors critically reviewed the manuscript and approved the final version submitted for publication.

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Supporting information

Additional Supporting Information may be found online in the supporting information tab for this article:
Appendix S1. the snack and beverage FFQ.