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Publication date	2016-10-21
Original citation	Riordan, F., Ryan, K., Perry, I.J., Schulze, M.B., Andersen, L.F., Geelen, A., van't Veer, P., Eussen, S., van Dongen, M., Wijckmans-Duysens, N. and Harrington, J.M. (2016) 'A systematic review of methods to assess intake of sugar-sweetened beverages among healthy European adults and children: a DEDIPAC (DEterminants of DIet and Physical Activity) study', <i>Public Health Nutrition</i> , [In Press], pp. 1–20. doi: 10.1017/S1368980016002639.
Type of publication	Article (peer-reviewed)
Link to publisher's version	https://www.cambridge.org/core/journals/public-health-nutrition http://dx.doi.org/10.1017/S1368980016002639 Access to the full text of the published version may require a subscription.
Rights	© The Authors 2016
Embargo information	Access to this article is restricted until 12 months after publication by the request of the publisher.
Embargo lift date	2017-10-21
Item downloaded from	http://hdl.handle.net/10468/3233

Downloaded on 2018-08-23T18:53:25Z



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A systematic review of methods to assess intake of sugar-sweetened beverages among healthy European adults and children: a DEDIPAC (DEterminants of Diet and Physical Activity) study

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Submitted 24 September 2015; Final revision received 19 August 2016; Accepted 24 August 2016

Abstract

Objective: Research indicates that intake of sugar-sweetened beverages (SSB) may be associated with negative health consequences. However, differences between assessment methods can affect the comparability of intake data across studies. The current review aimed to identify methods used to assess SSB intake among children and adults in pan-European studies and to inform the development of the DEDIPAC (DEterminants of Diet and Physical Activity) toolbox of methods suitable for use in future European studies.

Design: A literature search was conducted using three electronic databases and by hand-searching reference lists. English-language studies of any design which assessed SSB consumption were included in the review.

Setting: Studies involving two or more European countries were included in the review.

Subjects: Healthy, free-living children and adults.

Results: The review identified twenty-three pan-European studies which assessed intake of SSB. The FFQ was the most commonly used (n 24), followed by the 24 h recall (n 6) and diet records (n 1). There were several differences between the identified FFQ, including the definition of SSB used. In total, seven instruments that were tested for validity were selected as potentially suitable to assess SSB intake among adults (n 1), adolescents (n 3) and children (n 3).

Conclusions: The current review highlights the need for instruments to use an agreed definition of SSB. Methods that were tested for validity and used in pan-European populations encompassing a range of countries were identified. These methods should be considered for use by future studies focused on evaluating consumption of SSB.

Keywords

Sugar-sweetened beverages
Dietary assessment
Europe
DEDIPAC

A poor-quality diet is associated with non-communicable diseases^(1–4) and there is a growing body of research indicating that the consumption of sugar-sweetened beverages (SSB) may be associated with negative health consequences, including the development of metabolic syndrome and higher blood pressure⁽⁵⁾, an increased risk of diabetes⁽⁶⁾, increased body weight⁽⁷⁾ and obesity⁽⁸⁾. One of the recommendations made by the WHO Global

Strategy on Diet and Physical Activity is the limiting of sugar and salt intake⁽⁹⁾. SSB include drinks that are sweetened with sugar, other calorific sweeteners and corn syrups, as well as encompassing carbonated and non-carbonated drinks. In recent years there has been a global increase in the consumption of SSB^(10,11), which are characterised by their low nutritional content and failure to provide a feeling of fullness⁽¹²⁾.

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Recent studies suggest that levels of overweight and obesity are increasing in Europe^(13,14). However, while evidence suggests that reducing the intake of SSB would lead to a significant reduction in the incidence of obesity as well as other chronic illness such as diabetes (type 2)^(15,16), the link between obesity and intake of SSB is one that continues to be examined, with mixed results^(8,17–22). Many reasons for this inconsistency have been indicated, including methodological differences between studies and differing characteristics of assessment instruments, such as differences in the units of serving size, frequency categories and the definitions of SSB used⁽¹⁷⁾. Using standardised instruments and assessment methods across European populations has the potential to strengthen the investigation of associations between SSB and health outcomes such as obesity and to facilitate the collection of valid and comparable dietary intake data, along with the tracking of regional trends⁽²³⁾.

There has been increasing focus on the standardisation and harmonisation of food classification systems and food composition databases between European countries (e.g. the International Food Data Systems Project, the Eurofoods initiative, the Food-Linked Agro-Industrial Research programme, COST Action 99, TRANSFAIR study, EURO-FIR, etc.)^(23–29). The IDAMES (Innovative Dietary Assessment Methods in Epidemiological Studies and Public Health) project has evaluated new methods of dietary intake assessment in Europe⁽³⁰⁾, developing the European Food Propensity Questionnaire for use in European countries. Although the European Food Safety Authority indicates that a computerised method (e.g. EPIC-SOFT or similar) should be used for collection of standardised dietary intake data at the European level^(31,32), standards have not yet been developed for the assessment of dietary intake, including intake of SSB, as part of aetiological studies. Thematic Area 1 of the DEDIPAC (Determinants of Diet and Physical Activity) project⁽³³⁾, a pillar of the EU Joint Programme Initiative ‘Healthy Diet for a Healthy Life’, in part aims to address this gap by determining the most effective, harmonised methods of dietary intake assessment and preparing a toolkit of the most useful measurement tools of dietary intake that can be used extensively across Europe^(33,34). The aim of the current systematic literature review was to identify suitable assessment methods that may potentially be used to measure intake of SSB in European children and adults in pan-European studies. These methods will later be assessed for their effectiveness as part of their inclusion in the DEDIPAC toolkit.

Methods

Data sources and study selection

The current review adheres to the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews

and Meta-Analyses) Statement. The protocol for the review can be accessed from PROSPERO (CRD42014012890)⁽³⁶⁾. A systematic literature search was conducted for pan-European studies that assessed the intake of SSB. A definition of SSB that encompasses drinks with pre-added sugar, including soft drinks and energy drinks (carbonated and non-carbonated drinks) and cordials/squashes, was used; that is, the definition excluded drinks where sugar is added by the consumer (e.g. coffee and tea) and diet soft drinks. Two authors, F.R. and K.R., independently conducted a search of PubMed, EMBASE and Web of Science databases, using combinations of search terms for SSB such as ‘carbonated drink/s’, ‘soft drink/s’, ‘fizzy drink/s’, ‘energy drink/s’, ‘sugar-sweetened beverage/s’ and ‘soda/s’, along with keywords for dietary intake including ‘diet’, ‘eating’, ‘consumption’ and ‘intake’, and search terms for European countries (see online supplementary material, Supplemental Table 1). All searches were limited to literature published from 1990 through to 9 June 2014 (Fig. 1).

Titles and abstracts of the sourced articles were independently screened by F.R. and K.R. If in doubt regarding inclusion, the article was retained for full-text review. Any disagreement during the full-text review stage was resolved through consultation with a third author, J.M.H. Articles were included if they assessed the intake of SSB within two or more European countries (EU countries as defined by the Council of Europe)⁽³⁶⁾. The aim of the review was to identify instruments that are suitable to assess SSB intake in the general, healthy adult or child populations. Therefore, study participants were required to be free-living, healthy populations of any age. Hospital-based populations, along with studies which focused on a specific disease subgroup (e.g. diabetic patients) or any fixed societal subgroups (e.g. pregnant women), were excluded. If studies included or compared two cohorts, one of which was a healthy general population, they were included. Intervention studies were eligible provided intake of SSB was measured at baseline. Similarly, case-control studies were included if intake was assessed in population-based controls. Studies were included only if they assessed intake of SSB at the level of the individual; that is, studies which assessed household-level consumption of SSB were excluded (Fig. 1).

Reference lists of all included papers, along with relevant meta-analyses and literature reviews, were reviewed for further publications not identified by the original search. Databases were also searched using the names of individual European projects listed in the DEDIPAC Inventory of Relevant European Studies, a compilation of studies which is an ongoing part of DEDIPAC. Authors were contacted to obtain full versions of the relevant instruments or questionnaires and some articles, and the Endnote library of a concurrently occurring systematic literature review on methods to assess intake of fruits and vegetables (F&V)⁽³⁷⁾ was reviewed for further studies.

Data extraction and quality assessment

Data extraction was carried out using the same approach as outlined in the F&V review⁽³⁸⁾; that is, extracting details on study design, number and names of European countries involved, sample size (total and number for each country), age range of the included population, the method used and its description (including frequency categories for FFQ, total number of items/items that referred to SSB, details of nutrient intake assessment, details of portion estimation), mode of administration, and details on the validity or reproducibility testing. Originally sourced articles describing the methods in the most detail were selected for inclusion, with further information obtained from articles sourced from reference lists. One reviewer (F.R.) extracted the data for each study, which was confirmed by the other reviewer (K.R.).

As with the review of methods to assess F&V intake⁽³⁷⁾, a comprehensive quality appraisal of each included article was not conducted as part of the current review; however,

relevant validation studies were referenced where possible and data were extracted from these studies by M.v.D., S.E. and N.W.-D. To determine which instruments would be appropriate to use in pan-European studies, two criteria were applied: (i) the instrument was tested for validity and/or reproducibility; and (ii) the instrument was used in more than two countries simultaneously that represent a range of European regions. A range implied that at least one country from at least three of the Southern, Northern, Eastern and Western European regions, as defined by the United Nations, were included⁽³⁸⁾.

Results

Description of the included studies

The initial search identified 1949 papers, of which 1290 remained once duplicates were removed. After title and abstract screening, 1188 papers were excluded (Fig. 1).

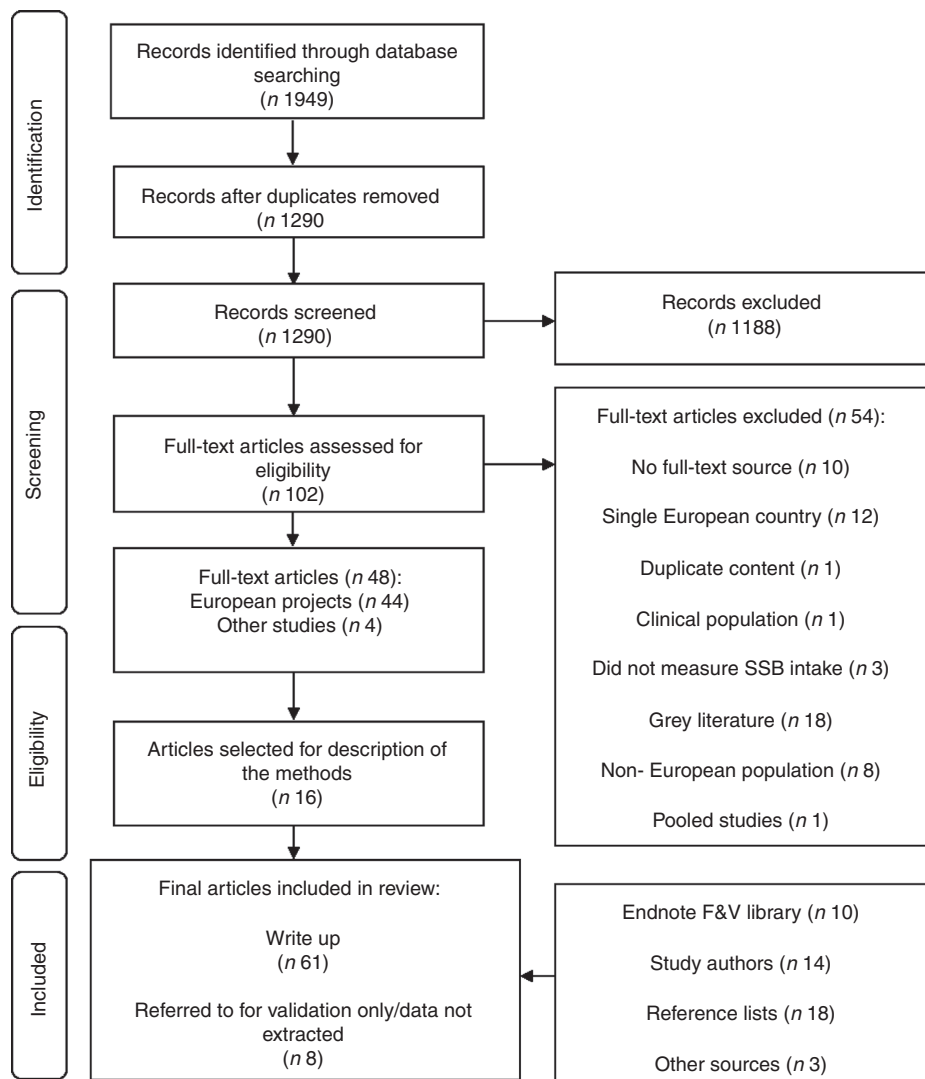


Fig. 1 Flow diagram showing study selection process for the current review (SSB, sugar-sweetened beverages; F&V, fruits and vegetables)

Full-text papers were sourced and reviewed for 102 papers, of which forty-eight were ultimately retained. These articles were grouped according to the major European project to which they belonged ($n = 44$) or as 'Other' if they did not belong to a project ($n = 4$; see Fig. 1 for breakdown of papers). From these forty-eight articles, sixteen articles were selected which best described the background to the project or the method used; one to three articles were typically selected per project, with the exception of the ToyBox study where articles obtained from authors were used in favour of the sourced article. Reviewing the reference lists yielded eighteen further articles in which the methods were described^(29,39–55).

Fourteen further articles were obtained through correspondence with authors; and ten articles were obtained from the F&V Endnote library, which identified seven additional studies assessing the intake of SSB, namely CNSHS (Cross National Student Health Survey)^(56,57), HAPIEE (Health, Alcohol and Psychosocial factors in Eastern Europe)^(58,59), Finbalt Health Monitor⁽⁶⁰⁾, MEDIS (MEDiterranean Islands Study)⁽⁶¹⁾, MGSD (Mediterranean Group for the Study of Diabetes)⁽⁶²⁾, ISAAC (International Study of Asthma and Allergies in Childhood)^(63,64) and the Finnish and Russian Karelia study⁽⁶⁵⁾. Unpublished details on the instruments used as part of the I.Family Project⁽⁶⁶⁾, successor to the IDEFICS (Identification and prevention of Dietary-and lifestyle-induced health Effects In Children and infantS) study, were obtained through contact with the IDEFICS group. Articles on the background and validity testing as part of the Food4Me project, published after the search dates, were also added to the review ($n = 3$). The characteristics of the included studies^(29,39,40,42–58,62–119) are described in Table 1.

As with the F&V review⁽³⁷⁾, the term 'study' refers to a larger project and not individual analyses/publications arising from the same project and using the same methodology. In total, sixty-one articles on twenty-three studies were included in the current review: original search ($n = 16$), from reference lists ($n = 18$), from the concurrent F&V review ($n = 10$), from authors ($n = 14$) and added subsequently ($n = 3$). In total, twelve large pan-European studies were identified which assessed intake of SSB^(29,39,44,50,51,62,64,66,67,80,105,110) along with eleven smaller studies which typically were conducted in two to four countries^(56,58,60,61,65,71–73,76,78,107). Twelve studies assessed the intake of SSB in children, aged 3–6 years^(82,83), 2–9 years^(39,40,79), 8–12 years^(63,64) or 10–12 years^(51,76,77), or adolescents^(39,44,66,67,71–73,76,78). Fourteen studies assessed intake among adults only^(29,42,56,59–62,65,72,103,107,110), two of which assessed student populations^(56,107). Three studies, the ENERGY (European Energy balance Research to prevent excessive weight Gain among Youth), ToyBox and the I.Family projects, assessed both children and their parent or guardian^(51,66,80–90). A further eight articles were sourced in which validity and/or reproducibility testing for the identified methods was described^(91–94,96,99,120).

Dietary assessment methods

Types of methods

Several methods were used to assess dietary intake of SSB in the identified studies, but most used FFQ ($n = 24$)^(47,51,54,56,59–65,67,69,71–73,76,82,101,103,107,110,121). Other methods identified through the review were 24 h recalls (24-HDR; $n = 6$)^(48,51,52,78,113,122) and diet records/diet diaries⁽¹⁰²⁾. Most studies assessed intake of SSB using a single method, although four – ENERGY, IDEFICS and I.Family Project, and HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) – used and described a second assessment methodology that supplemented or tested the study's primary method for validity. FFQ along with 24-HDR were used in the ENERGY, IDEFICS and HELENA projects. EPIC (European Prospective Investigation into Cancer and Nutrition) used a highly standardised 24-HDR, EPIC-SOFT, in a representative sub-sample from each cohort, which served as a common reference measurement across the different study populations, to calibrate and account for differences in the country-specific FFQ used as part of the study^(50,92,112). Since a common FFQ instrument was not used across all countries in EPIC, only the EPIC-SOFT instrument is discussed in the present review. Similarly, as the EYHS (European Youth Heart Study) FFQ was reported as part of the Danish component of the study, so only the 24-HDR, preceded by the 1 d record, is discussed herein.

According to the two selection criteria (Table 1), several study instruments appeared appropriate to assess intake of SSB in future pan-European studies. Instruments that had been used among adult populations and that fulfilled the criteria included EPIC-SOFT, the Food4Me FFQ, the SENECA (Survey in Europe on Nutrition and the Elderly; a Concerted Action) modified dietary history method, the ToyBox Primary Caregiver's Questionnaire and the ENERGY parent questionnaire. Three instruments used to assess intake among adolescents, namely HELENA-DIAT (Dietary Assessment Tool), the HELENA online FFQ and the HBSC (Health Behaviour in School-aged Children) FFQ, fulfilled the criteria, as did the IDEFICS 24-HDR (SACINA) and Children's Eating Habits Questionnaire (CEHQ-FFQ), the ENERGY Children's Questionnaire (FFQ and pre-coded 24-HDR) and the ToyBox Children's Questionnaire (FFQ), all of which were used among children. The I.Family instrument was based on those developed for the IDEFICS study. The 24-HDR preceded by the 1 d qualitative food record used in the EYHS was tested for validity among children from the USA but not in a European population⁽⁹⁹⁾. The 24-HDR was compared with observational data on consumption collected by parents and teachers. The instruments selected according to the two criteria are indicated by ticks in Table 1. However, in order to make the review more comprehensive, details on all the identified methods are provided.



Table 1 Summary of all studies identified to assess sugar-sweetened beverages (SSB): design, population studied, dietary assessment instruments used and details of testing for validity and/or reproducibility. Studies were selected to be potentially suitable to assess SSB intake based on (i) the instrument was tested for validity and/or reproducibility and (ii) the instrument was used in more than two countries simultaneously which represent a range of European regions; and are indicated by ticks in the last column. Where validation or reliability data was not available for SSB specifically, this is highlighted in bold font

Study	Design	Population	Countries	Instrument(s)	Tested for validity	> 2 countries/ range	Validity	Reproducibility	Instrument selected
Adults CNSHS ^(56,57)	Cross-sectional	Adults/students (n 2651) Age range NR	4 (Germany, Denmark, Poland, Bulgaria)	FFQ		X	No test of validity was performed, but the questionnaire was similar to other FFQ that had been tested for validity	No details†	
ENERGY ^(51,77,108)	Cross-sectional	Adults/parents or guardians (n 6002) Age range NR	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	Questionnaire with FFQ and 24-HDR†	X ⁽⁵¹⁾	X	No details†	The reliability and content validity of the parent questionnaires were tested separately in all participating countries, in five schools per country, using approximately 50 parents per country for the reliability study and 20 parents for the construct validity study	✓
EPIC ^(29,47,49,109)	Longitudinal	Adults (n 519978) 30–70 years	10 (Italy, Spain, Netherlands, Germany, Sweden(Malmö)/Sweden (Umeå), Denmark, France, Greece, Norway, England)	FFQ, 24-HDR (EPIC-SOFT)	X ⁽⁹¹⁾	X	Country-specific FFQ were tested for validity ⁽⁹²⁾ . Data obtained from highly standardised 24-HDR, EPIC-SOFT, carried out in a random sample of each EPIC cohort, were used to account for differences in the FFQ, reducing the measurement error of the FFQ by calibration ⁽¹⁰⁹⁾ EPIC-SOFT was tested for validity against biomarkers as part of the EFCOVAL project ⁽⁹¹⁾ No data on SSB	Unpublished data	✓
ESCAREL ⁽¹¹⁰⁾	Cross-sectional	Adults (n 3187) 18–35 years	7 (France, Spain, Italy, UK, Finland, Latvia, Estonia)	FFQ†			All questionnaires were tested for validity in pilot studies	No details†	
Finbalt Health Monitor ⁽⁶⁰⁾	Cross-sectional	Adults (n 25 044) 20–64 years	4 (Estonia, Finland, Latvia, Lithuania)	FFQ†			No details†	No details†	
Finnish and Russian Karelia study ⁽⁶⁵⁾ (as reported as for the 2002 study)	Cross-sectional	Adults (n 1201) 25–64 years	2 (Russia, Finland)	FFQ†			No details†	No details†	
Food4Me ^(103–105)	Randomised controlled trial	Adults (n 5562) 17–79 years	7 (Ireland, Netherlands; Spain, Greece, UK, Poland, Germany)	FFQ (web-based)	X ^(104, 105)	X	FFQ was tested for validity against 4 d non-consecutive weighed records ⁽¹⁰⁴⁾ using crude correlations and exact level of agreement Good agreement with 4 d weighed food record Tested for validity against the EPIC-Norfolk FFQ ⁽¹⁰⁵⁾ using energy-adjusted correlations, mean/median differences and exact level of agreement Good agreement with EPIC-Norfolk FFQ, which has been tested for validity Note: validation data available only for 'other beverages'§	Reproducibility of the FFQ has been tested ⁽¹⁰⁴⁾	✓
HAPIEE ^{(58)*}	Cross-sectional	Adults (n 28 947) 45–69 years	3 (Russia, Poland, Czech Republic)	FFQ†	X ^(93,94)		The FFQ was based on the Whitehall II questionnaire tested for validity by Brunner <i>et al.</i> ⁽⁹³⁾ and Willett <i>et al.</i> ⁽⁹⁴⁾ No data on SSB	No details†	
I.Family Project ^(66,69,70)	Prospective cohort study (successor of IDEFICS study)	Adults/parents (n > 7000) Age range not determined	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	A diet questionnaire (FFQ) was included as part of the parent questionnaire Online 24-HDR (SACANA)	X	X	Instruments are similar to those used in the IDEFICS project and these were tested for validity	No details†	
Kolarzyk <i>et al.</i> ⁽¹⁰⁷⁾	Cross-sectional	Adults/students (n 1517) Age range NR	4 (Poland, Belarus, Russia, Lithuania)	FFQ†			The FFQ has been tested for validity and recommended by the National Food and Nutrition Institute in Warsaw, Poland	No details†	
MEDIS ⁽⁶¹⁾	Cross-sectional	Adults (n 1190) 65–80+ years	2 (Cyprus, Greece)	FFQ	X ⁽⁸⁹⁾		Tested for validity ⁽⁹⁵⁾ No data on SSB	Tested for reproducibility ⁽⁹⁵⁾ No data on SSB	
MGSD ⁽⁶²⁾	Cross-sectional	Adults (n 4254) Non-diabetics (n 1833) 35–60 years	6 (Greece, Italy, Algeria, Bulgaria, Egypt, Yugoslavia (only diabetics in Yugoslavia))	Dietary history method using questionnaire	X ⁽⁴⁰⁾		100 subjects from various participating centres were evaluated using the 3 d diet diary (two weekdays and a Sunday) in order to test the questionnaire for validity No data on SSB	No details†	

Table 1 Continued

Study	Design	Population	Countries	Instrument(s)	Tested for validity	> 2 countries/ range	Validity	Reproducibility	Instrument selected
SENECA ^(42,43,50,102)	Mixed design (longitudinal and cross-sectional)	Adults/elderly (n ~2600) 70–75 years	12 (Belgium, Denmark, France, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Spain, Switzerland)	Modified dietary history method comprising a 3 d estimated record and meal-based frequency checklist	X ^(54,96)	X	The cross-check dietary history method has been tested for validity ⁽⁹⁶⁾ No data on SSB	No details†	✓
ToyBox ^(80–90)	Intervention multifactorial study	Adults/parents or guardians (n 7056) (providing data at baseline)	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Primary caregiver's FFQ (PCQ)‡	X ⁽⁸³⁾	X	No details†	Interval: 2 weeks Reliability of the PCQ was tested ⁽⁸³⁾ Note: validity data available only for 'water' and 'beverages'	
Adolescents HBSC 2009/10 survey ⁽⁶⁷⁾	Cross-sectional	Adolescents (n 209 320) 11-, 13- and 15-year-olds	37 (England, Norway, Macedonia, Iceland, Netherlands, Portugal, Wales, Italy, Sweden, Latvia, Switzerland, Denmark, Estonia, Scotland, Slovenia, Ukraine, Belgium, Finland, Greece, Croatia, Hungary, Lithuania, Poland, Germany, Greenland, Russia, Armenia, Austria, Belgium, Spain, France, Romania, Turkey, Czech Republic, Ireland, Luxembourg, Slovakia)	FFQ‡	X ⁽⁹⁷⁾	X	Tested for validity against 7 d diet record using crude correlations, mean/median differences and exact level of agreement ⁽⁹⁷⁾ Moderate agreement for 'soft drinks'	Interval: 7–15 d ⁽⁹⁷⁾ Provides reproducible estimates of food group intake	✓
HELENA ^(44,45,52–55,68)	Cross-sectional	Adolescents (n 3000) 13–17 years	9 (Greece, Germany, Belgium, France, Hungary, Italy, Sweden, Austria, Spain) 8 countries used the 24-HDR (as above, except Hungary) Only 5 (Austria, Belgium, Greece, Sweden, Germany) pilot-tested the online FFQ	24-HDR using the HELENA-DIAT (Dietary Assessment Tool)‡ Online FFQ	X ^(52–54) X ⁽⁵⁴⁾	X X	24-HDR tested for validity against 1 d food records and 24-HDR ⁽⁵²⁾ using crude correlations, mean/median differences and exact level of agreement Moderate to good agreement for 'soft drinks' Self-report 24-HDR was compared with interview-administered 24-HDR using crude correlations and mean/median differences, with good agreement ⁽⁵³⁾ Online FFQ tested for validity against four 24-HDR using crude correlations, mean/median differences ⁽⁵⁴⁾ Good agreement for 'soft drinks' The instruments are similar to those used and tested for validity as part of the IDEFICS project	Interval: 1–2 weeks HELENA FFQ has adequate reliability ⁽⁵⁴⁾	✓
I.Family Project ^{(66,69,70)†}	Prospective cohort study (successor of the IDEFICS study)	Adolescents (n > 9000 children of IDEFICS study and their siblings) 12–17 years	8 (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, Sweden)	A diet questionnaire (FFQ) was included as part of the teen questionnaire Online 24-HDR (SACANA)				No details†	
Larsson <i>et al.</i> ⁽⁷¹⁾	Cross-sectional	Adolescents (n 2041) Age range NR	2 (Sweden, Norway)	FFQ‡			No details†	No details†	
Szczepanska <i>et al.</i> ⁽⁷²⁾	Cross-sectional	Adolescents (n 404) Age range NR	2 (Poland, Czech Republic)	FFQ			No details†	No details†	
TEMPEST ^(73–75)	Cross-sectional	Adolescents (n 2764) 12–17 years	4 (Netherlands, Poland, UK, Portugal)	FFQ‡		X	No details†	No details†	
Children Cinar and Murtomaa ⁽⁷⁶⁾	Cross-sectional	Children (n 619) 10–12 years	2 (Turkey, Finland)	Youth FFQ‡			No details†	No details†	
ENERGY ^(51,77)	Cross-sectional	Children (n 7234) 10–12 years	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	Questionnaire with FFQ and 24-HDR‡	X ⁽⁹⁸⁾	X	Construct validity assessed by comparing self-complete questionnaire against questionnaire completed by interview using exact level of agreement ⁽⁹⁸⁾ Moderate to good construct validity for 'soft drinks'	Interval: 1 week Moderate to good reliability	✓



Table 1 *Continued*

Study	Design	Population	Countries	Instrument(s)	Tested for validity	> 2 countries/ range	Validity	Reproducibility	Instrument selected
EYHS ^(46,48,78)	Cross-sectional	Children (<i>n</i> 4000) 9 and 15 years	4 (Denmark, Portugal, Estonia, Norway) (sourced studies involve only Denmark)	FFQ, 24-HDR, 1 d qualitative food record	X	X	A 24-HDR preceded by a qualitative 1 d food record has been found to be valid for generating estimates of children's food intake for the purpose of group comparison ⁽⁹⁹⁾ Test for validity was not conducted in European population	No details†	
IDEFICS ^(39,40,79)	Prospective cohort study with an embedded intervention	Children (<i>n</i> 16 224) 2–9 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	CEHQ-FFQ‡ SACINA 24-HDR‡	X ^(40,53,101,112–114)	X	SACINA is based on the YANA-C instrument tested for validity as part of the HELENA study ⁽⁶³⁾ SACINA was tested for validity by Börnhorst <i>et al.</i> ⁽¹¹⁴⁾ using the doubly labelled water technique No data on SSB The validity of the FFQ was assessed by Huybrechts <i>et al.</i> ⁽¹⁰¹⁾ No data on SSB CEHQ-FFQ was tested for validity against 24-HDR using crude correlations, mean/median differences and exact level of agreement ⁽⁴⁰⁾ Low agreement for 'soft drinks'	No fixed interval CEHQ-FFQ provides reproducible estimates of food group intake ⁽¹¹²⁾	✓
I.Family Project ^(66,69,70)	Prospective cohort study (successor of the IDEFICS study)	Children (<i>n</i> > 9000 children of IDEFICS study and their siblings) 2–11 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	A diet questionnaire (FFQ) was included as part of the Children's Questionnaire Online 24-HDR (SACANA)	X	X	FFQ as part of a general questionnaire	Instruments are similar to those used and tested for validity as part of the IDEFICS project	No details†
ISAAC ^(63,64)	Cross-sectional	Children (<i>n</i> ~63 000) 8–12 years	15 (Albania, France, Estonia, Germany, Georgia, Greece, Iceland, Italy, Latvia, Netherlands, Norway, Spain, Sweden, Turkey, UK)	FFQ as part of a general questionnaire		X	No details†	No details†	
ToyBox ^(80–90)	Intervention multifactorial study	Children (<i>n</i> 7056) (providing data at baseline) 3.5–5.5 years	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Children's FFQ‡	X ⁽¹⁰⁰⁾	X	The children's questionnaire is based on a FFQ previously tested for validity and developed by Huybrechts <i>et al.</i> ⁽¹⁰⁰⁾ Tested for validity by comparison with 3 d diet record using crude and de-attenuated correlations, mean/median differences and exact level of agreement Moderate to good agreement for 'sugared drinks'	Interval: at least 5 weeks FFQ provides reproducible estimates of food group intake	✓

CNSHS, Cross National Student Health Survey; ENERGY, European Energy balance Research to prevent excessive weight Gain among Youth; EPIC, European Prospective Investigation into Cancer and Nutrition; ESCAREL, European Study in Non-Carious Cervical Lesions; HAPIEE, Health, Alcohol and Psychosocial factors in Eastern Europe; MEDIS, MEDiterranean Islands Study; MGSD, Mediterranean Group for the Study of Diabetes; SENECA, Survey in Europe on Nutrition and the Elderly; a Concerted Action; HBSC, Health Behaviour in School-aged Children; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; TEMPEST, 'Temptations to Eat Moderated by Personal and Environmental Self-regulatory Tools'; EYHS, European Youth Heart Study; IDEFICS, Identification and prevention of Dietary-and lifestyle-induced health Effects In Children and infantS; ISAAC, International Study of Asthma and Allergies in Childhood; NR, not reported; 24-HDR, 24 h recall; PCQ, Primary Caregiver's Questionnaire; CEHQ, Children's Eating Habits Questionnaire; EFCOVAL, European Food Consumption Validation; YANA-C, Young Adolescents' Nutrition Assessment on Computer.

*Funded by the Wellcome Trust programme grant entitled 'Determinants of Cardiovascular Diseases in Eastern Europe: A multi-centre cohort study' (reference number 064947/Z/01/Z) and developed by Martin Bobak, Anne Peasey, Hynek Pikhart (UCL), Ruzena Kubinova, Lubomíra Milla Novosibirsk, Sofia Malyutina, Oksana Bragina (Prague), Andrzej Pajak, Aleksandra Gilis-Januszewska (Krakow).

†Validity or reproducibility of the instrument was not reported in the article and no reference to validation or reproducibility studies was provided.

‡Original instrument was obtained for review.

§'Other beverages' includes everything except milk, alcoholic beverages, tea and coffee.

Validation

From the studies that were tested for validity or reproducibility and fulfilled the first criterion (Table 1), validity and reliability of FFQ was assessed using FFQ⁽¹⁰⁵⁾, food records^(54,97,100,104), 24-HDR^(40,54) or interviews^(53,98) as reference methods. In eleven studies, validity was assessed by crude correlations (n 7)^(40,52-54,97,100,104), energy-adjusted correlations (n 1)⁽¹⁰⁵⁾, de-attenuated correlation coefficients (n 2)^(40,100), mean or median differences in SSB consumption (n 7)^(40,52-54,97,100,105), exact level of agreement of SSB consumption (n 8)^(40,53,54,97,100,104,105), Bland–Altman plots (n 4)^(40,53,54,105), intraclass correlation coefficients⁽⁹⁸⁾ or weighted kappa (n 2)^(54,100) between the FFQ and reference instrument. In seven studies, reliability of SSB consumption was assessed by correlations (n 5)^(54,83,97,100,112), mean/median differences (n 3)^(54,100,112), weighted kappa (n 2)^(97,112) or intraclass correlation coefficients⁽⁹⁸⁾ between subsequent administrations of the FFQ. Details on the validation and/or reproducibility are provided in Table 1 and, where available, extracted results for the statistical assessments are provided in the online supplementary material, Supplemental Table 2.

Validation data specifically on SSB were available for only six instruments, three among adolescents, the HBSC FFQ, HELENA-DIAT and HELENA FFQ, and three among children, the ENERGY Children's Questionnaire, IDEFICS FFQ and ToyBox Children's Questionnaire. The Food4Me FFQ, for use among adult populations, provided validation data only for 'Other beverages' grouped together, described as including all beverages except milk, alcoholic beverages, tea and coffee⁽¹⁰⁴⁾ and including fruit juices, carbonated beverages and squash⁽¹⁰⁵⁾. These instruments are summarised in Table 2.

Although data were not specific to SSB, the Food4Me FFQ had moderate agreement (0.4–0.6) for 'other beverages' with a 4 d diet record using Spearman's crude correlation ($r=0.66$)⁽¹⁰⁴⁾ and good agreement (>0.6) with the EPIC-Norfolk FFQ using energy-adjusted coefficients ($r=0.79$)⁽¹⁰⁵⁾. In terms of instruments for adolescents, the HBSC FFQ tested for validity against a 7 d diet record had moderate agreement for 'soft drinks' using Spearman's crude correlation ($r=0.46$). HELENA-DIAT had moderate to good agreement with a 1 d food record ($r=0.42$) and 24-HDR ($r=0.65$)⁽⁵²⁾, and the HELENA FFQ had good agreement ($r=0.79$) when tested for validity against four 24-HDR⁽⁵⁴⁾. In terms of instruments to be used among children, the construct validity of the ENERGY questionnaire was tested, with moderate (55%) exact level of agreement for 'soft drinks' between the self-completed questionnaire compared with the questionnaire completed by interview⁽⁹⁸⁾. The ToyBox instrument had moderate to good agreement with a 3 d diet record for 'sugared drinks' ($r=0.57$)⁽¹⁰⁰⁾, while the IDEFICS CEHQ-FFQ tested for validity against a 24-HDR had low agreement (<0.4) for 'soft drinks' using Pearson's crude correlations among children aged <6 years ($r=0.14$) and 6–9 years

($r=0.21$)⁽¹¹³⁾ (see online supplementary material, Supplemental Table 2).

FFQ

Table 3 summarises the characteristics of the identified FFQ. These instruments are already described in detail as part of the concurrent review on F&V intake⁽³⁷⁾, with the exception of the FFQ used by Cinar and Murtooma⁽⁷⁶⁾ and Kolarzyk *et al.*⁽¹⁰⁷⁾. Therefore, the results focus on aspects which are specific to the assessment of SSB; that is, definitions and portion measurement, of which there were notable differences between the instruments identified. FFQ were used to assess dietary intake, identify determinants of dietary intake or test diet–disease associations and identify disease risk factors.

Range of items and definitions

SSB were referred to as 'soft drinks' (HELENA, Finbalt Health Monitor, ENERGY Parent Questionnaire, CNSHS and MEDIS), 'soft drinks with sugar' (Finnish FFQ of the Finnish and Russian Karelia project, EYHS), 'juice or soft drinks' (Russian FFQ of the Finnish and Russian Karelia project), 'fizzy drinks' (ISAAC, HAPIEE, ENERGY Children's Questionnaire), 'fizzy soft drinks' (Food4Me), 'carbonated drinks (Fanta, Sprite, Coke, Pepsi)' (Szczepanska *et al.*⁽⁷²⁾), 'sweet drinks' (Kolarzyk *et al.*⁽¹⁰⁷⁾) and 'Cola-Cola, Pepsi or other sugary drinks' (MGSD). Where two items referred to SSB on an FFQ, typically one referred to soft drinks, and another referred to squashes or cordials (MGSD, Food4Me) or pre-packed juice (ToyBox).

Few FFQ distinguished between pure fruit juice, and cordials or squashes, with the exception of the ENERGY and Food4Me studies. Some FFQ contained an item that captured intake of a sugarless or low-calorie equivalent (EHYS, HAPIEE, IDEFICS, I.Family, Food4Me, Finnish and Russian Karelia study, and Larsson *et al.*⁽⁷¹⁾).

Portion size

Several FFQ assessed the frequency of consumption only and did not record portion size^(60,63,64,67,71-73,76,107,110). Of the semi-quantitative FFQ that did assess portion size, many did so in-line using a standard measure and asking participants to specify the number of glasses of SSB consumed^(51,54,58,62,73,82), in some cases specifying volume. The MGSD FFQ gave a standard portion as 300 ml or 1 can, whereas in the HAPIEE FFQ this was 2 dl. The EHYS FFQ informed participants that one glass approximated to 1 small glass bottle or 2 glasses approximated to a ½ litre bottle.

The ENERGY and ToyBox children's questionnaires provided the greatest detail on portion sizes. The former questionnaire asked participants to report the number of glasses or small bottles, cans and/or bottles, and specified volumes for each. The ToyBox questionnaire asked participants to select the average portion size ranging from



'100 ml or less' to '1000 ml or more', and provided the volumes of typical containers. As part of the ToyBox FFQ, a photographic food guide was also provided to assist with portion size estimation. The Food4Me FFQ asked participants to select from a range of photographs which were linked electronically to portion sizes (in grams).

Dietary recalls

The characteristics of the identified 24-HDR are summarised in Table 4. The majority of the 24-HDR were used to determine estimates of dietary intake, comparing estimates across regions or over time. These instruments are already described in detail as part of the concurrent review on F&V intake⁽³⁷⁾; therefore only details on portion measurement are reported here.

On the ENERGY 24-HDR, participants could select 200 ml, 350 ml or 500 ml by way of selecting a glass or small bottle, a can or a large bottle, respectively⁽⁵¹⁾. Portion size was also assessed using the HELENA-DIAT, SACINA and EPIC-SOFT instruments. EPIC-SOFT used six quantification methods including photographs and standard measures, both of which were used by the HELENA-DIAT tool. The IDEFICS SACINA tool measured SSB portion by glass using photographs of six different glass sizes. The EYHS 24-HDR interview was accompanied by different-sized drinking glasses and photographs to aid portion estimation.

Diet records/diet diaries

Only one diet record was identified, the self-completed 3 d estimated record which was used in the SENECA study. This instrument is already described in detail in the concurrent review of instruments to assess F&V intake⁽³⁷⁾. The purpose of the study was to examine cross-cultural differences in nutrition and lifestyle factors⁽⁴³⁾ and cross-cultural variations and changes in intake over time⁽¹²³⁾. The population sampled was adults aged 70–75 years. The 3 d record was used in conjunction with a frequency checklist of foods that was adapted to local food customs and the order in which they typically appear, and used during the follow-up interview to verify the record. For example, SSB were listed on the Dutch checklist as 'lemonades with sugar'^(42,102).

Discussion

The aim of the current review was to identify the methods used to assess intake of SSB in pan-European studies. The main dietary assessment methods were the FFQ, 24-HDR and diet record/diet diary. The review identified twelve instruments to assess intake of SSB in children or adolescents in the age range of 2–12 years, seven among children and six among adolescents. Fourteen instruments were identified that assessed intake of SSB among adults,

three of which assessed parents or caregivers. Of the identified FFQ, thirteen could be used among adult populations, six among adolescents and six among children. A few key differences were identified between the methods, some of which have been reported previously^(124,125). For example, in terms of the FFQ, differences included: the definition of SSB used; the number and range of frequency categories; the time period covered by the FFQ; and the approach to determining portion size. Such differences, in particular, how SSB are defined, should be resolved if future instruments are to be standardised across Europe.

The present review is the first to systematically identify and describe instruments used to assess intake of SSB in pan-European studies. Although a growing body of research points to a possible association between the consumption of SSB and obesity, there is currently a lack of standardised instruments available for use in pan-European studies when measuring and monitoring the intake of SSB. A large number of instruments were identified through the review. Similar to the approach used for the concurrent review of methods to assess F&V intake⁽³⁷⁾, to reduce the number of instruments, identify potential instruments for use in future pan-European studies measuring SSB intake and determine those to be included in the DEDIPAC toolbox, two selection criteria were applied: (i) the instrument was tested for validity and/or reproducibility; and (ii) the instrument was used in more than two countries simultaneously which represented a range of European regions.

According to these selection criteria, five instruments were considered appropriate to assess SSB among adults in pan-European studies, namely those used by the EPIC, Food4Me, SENECA, ToyBox and ENERGY studies. However, only the Food4Me FFQ was tested for validity for intake of SSB (but grouped together with other drinks as 'other beverages') using 4 d diet records⁽¹⁰⁴⁾. The HELENA-DIAT⁽⁵³⁾, HELENA online FFQ⁽⁵⁴⁾ and HBSC FFQ⁽⁹⁷⁾ appeared appropriate to assess intake among adolescents and demonstrated moderate to good agreement with 1 d records and 24-HDR, four 24-HDR and 7 d diet records, respectively. Only three of the four instruments selected to be used among children were tested for validity for SSB (IDEFICS FFQ, ENERGY and ToyBox)^(98,100,113) and the ENERGY questionnaire was tested only for construct validity. The IDEFICS and ToyBox instruments demonstrated low agreement with 24-HDR and moderate to good agreement with a 3 d diet record, respectively. It is important to note that these instruments were all tested for validity against other self-report (and potentially error-prone) methods, namely FFQ, food records, 24-HDR or interviews.

The two selection criteria, along with the summary of validation data, indicate the methods which may be appropriate to use in pan-European studies. However, as already outlined in the review of methods to assess F&V

Table 2 Summary of the selected instruments which were tested for validity (*n* 7) for assessment of sugar-sweetened beverages (SSB): design, age group, countries, mode of administration, definition of SSB used and portion estimation

Study/instrument	Design	Age group	Countries	Mode	Definition	Portion estimation
Adults Food4Me ^(103–105) Web-based FFQ	Randomised controlled trial	17–79 years	7 (Ireland, Netherlands, Spain, Greece, UK, Poland, Germany)	Self-admin.	'Fizzy soft drinks, e.g. coca cola/lemonade' 'Low-calorie/diet fizzy soft drinks' 'Fruit squash/cordial/nectar'	X
Adolescents HBSC ⁽⁶⁷⁾ FFQ	Cross-sectional	11-, 13- and 15-year-olds	37 (England, Norway, Macedonia, Iceland, Netherlands, Portugal, Wales, Italy, Sweden, Latvia, Switzerland, Denmark, Estonia, Scotland, Slovenia, Ukraine, Belgium, Finland, Greece, Croatia, Hungary, Lithuania, Poland, Germany, Greenland, Russia, Armenia, Austria, Belgium, Spain, France, Romania, Turkey, Czech Republic, Ireland, Luxembourg, Slovakia)	Self-admin.	'Sweetened soft drinks (cola or other soft drinks that contain sugar)'	
HELENA ^(44,45,52–55,68) 24-HDR	Cross-sectional	13–17 years	8 (Greece, Germany, Belgium, France, Italy, Sweden, Austria, Spain)	Self-admin. Computerised	'Regular soft drinks' 'Diet soft drinks'	X
HELENA-DJAT HELENA ^(44,45,52–55,68) Online FFQ		13–17 years	5 (Austria, Belgium, Greece, Sweden, Germany)	Self-admin.	–	X
Children IDEFICS ^(39,40,79) CEHQ-FFQ*	Prospective cohort study with an embedded intervention	2–9 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	Self-admin. (parents)	'Sweetened drinks including sports drinks, bottled or canned tea, syrup-based drinks and similar' 'Diet coke or diet soft drinks'	
ENERGY ^(51,77) Children's FFQ	Cross-sectional	10–12 years	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	Self-admin.	'Fizzy drinks or fruit squash'. Specified that this was: 'NOT diet drinks and fruit juice'	X
ToyBox ^(80–90) Children's FFQ*	Intervention multifactorial study	3.5–5.5 years	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Self-admin.	'Sugared beverages (Coca-Cola, Pepsi, Fanta, Sprite, Nestea)' 'Fruit juice, pre-packed/ bottled'	X

HBSC, Health Behaviour in School-aged Children; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; 24-HDR, 24 h recall; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health effects In Children and infants; CEHQ, Children's Eating Habits Questionnaire; ENERGY, European Energy balance Research to prevent excessive weight Gain among Youth; self-admin., self-administered.
*Original instrument obtained for review.



Table 3 Summary of the FFQ (*n* 24) identified for the assessment of sugar-sweetened beverages (SSB): number of items, instrument purpose, population, definition of SSB, reference period, mode, frequency categories and portion estimation

Study	Type/number of items	Purpose	Population	Definition	Reference period	Mode	Frequency categories	Portion estimated? (yes/no)
Adults CNSHS ^(56,57)	Non-quantitative General questionnaire One item on SSB	Test association between food patterns and living arrangements ⁽⁵⁶⁾ Test association between diet and stress/depressive symptoms ⁽⁵⁷⁾	Adults/students Age range NR	'Soft drinks'	NR	Self-admin.	5 categories, ranging from 'several times a day' to '1–4 times a month', and 'never'	No
ENERGY ^{(51)*} Adults' FFQ	Semi-quantitative General questionnaire One item on SSB	Determine prevalence of EBRB Identify personal, family and school environmental correlates of EBRB	Adults/caregivers Age range NR	'Soft drinks' defined as: 'Fizzy drinks and fruit squash but NOT diet drinks and fruit juice' Provided examples	Previous week Usual consumption on a day on which SSB consumed	Self-admin.	7 categories per week, ranging from 'never', '1 portion or less per week' to '5 or more portions per day' 6 categories per day, ranging from 'none', '1 glass/small bottle' to '5 or more glasses/bottles'	Yes Assessed in-line Subject can select the number of glasses/ small cartons (250 ml) and regular cartons (330 ml) drank on a day of consumption
ESCAREL ⁽¹¹⁰⁾	Non-quantitative Five-item FFQ Two items on SSB	Assess the prevalence of tooth wear on buccal/facial and lingual/palatal tooth surfaces Identify related risk factors (i.e. fresh fruit and juice intake)	Adults 18–35 years	'Soft drinks, i.e. cola beverages, Sprite, lemonade, Fanta, iced tea, etc.' 'Isotonic drinks/energy drinks, e.g. Isostar, Powerade, Perform, Red-bull, Red Horse, etc.'	Not stated	Self-admin.	4 categories: 'often', 'rarely', 'never', 'don't know' For items ranked as 'often', a choice of 5 categories ranging from 'more than 3 times per week to 'less than once per week' could be selected	No
Finbalt Health Monitor ^{(60)*}	Non-quantitative Sixteen-item FFQ One item on SSB	Assess gender differences in F&V consumption	Adults 20–64 years	'Soft drinks'	Previous week	Self-admin.	4 categories: 'never', '1–2 days', '3–5 days' and '6–7 days'	No
Finnish and Russian Karelia study ^{(65)*} (2002 survey)	Non-quantitative Forty-three-item Finnish FFQ (FINRISK), two items on SSB Twenty-item Russian FFQ, one item on SSB	Determine socio-economic differences in the consumption of vegetables, fruit and berries in two regions	Adults 25–64 years	Finnish FFQ: 'Soft drinks with sugar (e.g. cola etc)' 'Diet soft drinks (e.g. Funlight, Pepsi Max, Light-Cola)' Russian FFQ: 'Juices or soft drinks'	12 months	Self-admin.	6 categories, ranging from 'less than once a month' to 'daily or more often'	No
Food4Me ^(103–105)	Semi-quantitative, web-based, 157-item FFQ	Determine impact of personalised dietary advice on eating patterns and health outcomes	Adults 18–79 years	Under 'Drinks': 'Fizzy soft drinks, e.g. coca cola/lemonade' 'Low-calorie/diet fizzy soft drinks' 'Fruit squash/cordial/nectar'	Previous month	Self-admin.	9 categories, ranging from 'never or less than once a month' to '5–6 times per day' and '> 6 times per day'	Yes Three photographs representing small, medium and large portions Participants could select one of the following options: 'very small', 'small', 'small/medium', 'medium', 'medium/large', 'large' or 'very large', which were linked electronically to portion sizes (in grams)
HAPIEE ^{(58)*}	Semi-quantitative Items: Czech = 136, Russian = 147, Polish = 148 Three items on SSB	Test association between socio-economic indicators and diet ⁽¹¹⁵⁾	Adults 45–69 years	As per generic FFQ 'Fizzy drink' 'Squash' 'Diet/low-calorie fizzy drinks'	Previous 3 months	Interview (Russia & Poland) Self-admin. (Czech Republic)	9 categories, ranging from 'never' to '6 or more times per day' Open-ended section where subject could add any further foods not listed	Yes Assessed in-line A country-specific portion size for each food was specified Participants were asked how often, on average, they had consumed a 'medium serving' of the items – defined as 2 dl or 1 tablespoon (squash)
I.Family Project ^(66,69)	Non-quantitative Sixty-item FFQ Four items on SSB	Assess determinants of eating behaviour	Adults/parents Age range not determined	'Carbonated sugar sweetened drinks (e.g. Coca-Cola, Fanta, non-alcoholic beer, etc.)' 'Diet carbonated drinks (e.g. diet cola, etc.)' 'Sugar-sweetened drinks, not carbonated (e.g. bottled ice tea, syrup-based drinks and similar, fruit juices with less than 100 % fruit, sports drinks, non-alcoholic wine, etc.)' 'Artificially sweetened drinks, not carbonated (e.g. diet ice tea, diet fruit syrup, diet sports drinks, etc.)' Local examples provided	Typical week over the previous month	Self-admin.	7 categories, ranging from 'never/less than once a week' to '4 or more times per day'	No
Kolarzyk <i>et al.</i> ^{(107)*}	Non-quantitative Thirty-nine-item FFQ One item on SSB	Examine the food choices and determine the prevalence of underweight, overweight and obesity	Adults/students Age range NR	'Sweet drinks'	Previous month	Self-admin.	7 categories, ranging from 'not eaten at all' to 'eaten every day'	No



Table 3 Continued

Study	Type/number of items	Purpose	Population	Definition	Reference period	Mode	Frequency categories	Portion estimated? (yes/no)
MEDIS study ^(61,95)	Semi-quantitative Total number of items unknown	Test association between energy-generating nutrients and obesity	Adults/elderly 65–80+ years	'Soft drinks'	NR	NR	Frequency assessed on a daily, weekly or monthly basis	No
MGSD ^{(62)*}	Dietary history method using a seventy-eight-item FFQ One item on SSB	Compare the nutritional habits among six Mediterranean countries and with official recommendations	Adults 35–60 years	'Coca-Cola, Pepsi or other sugary drinks'	NR	Interview administered face-to-face	Enter number per day or per week for pre-coded items Open-ended section structured by 7 meals, where participant enters the time, description, quantity and whether food was eaten at home or in a restaurant	Assessed in-line 300 ml, 1 can Assessed separately Household measures
ToyBox ^{(62,63)*} Caregiver's Questionnaire	Semi-quantitative Forty-four-item FFQ Two items on SSB	Measure the effectiveness of an intervention to prevent obesity	Adults/parents or guardians Age range NR	'Sugared beverages (soda drinks like cola, lemonade, ice tea)' (defined as: 'all sugared or sweet-flavoured beverages, carbonated or not, plain or light e.g. Cola and Cola light/zero, Ice Tea, 7-up, Pepsi, Fanta, Fanta non-carbonated, Sprite, Orangina, etc.)' 'Fruit juice, pre-packed/bottled (100 %, nectar etc.)' (defined as 'all fruit juice-based products including 100 % fresh juice bottled or in paper-pack, 30 % fruit juice with added sugar (nectar), sports drinks, smoothies, canned juices, e.g. Life, Tropicana, lemonade, Lucozade')	NR	Self-admin.	7 categories, ranging from '1–3 days per month' to 'every day'	Yes Assessed in-line Portion sizes provided: 1 cup = 250 ml; 1 can = 330 ml, 1 small plastic bottle = 500 ml; 1 glass lemonade = 250 ml
Adolescents HBSC 2009/10 survey ^{(41,67)*} FFQ	Non-quantitative Seven-item FFQ, four mandatory items One item on SSB	Determine health and health behaviours and the factors that influence them ⁽⁴¹⁾ Investigate influence of chronological period of data collection on dietary intake ⁽⁶⁷⁾	Adolescents 11-, 13- and 15-year-olds	'Sweetened soft drinks (cola or other soft drinks that contain sugar)'	Habitual intake over week	Self-admin.	7 categories, ranging from 'never' 'less than once a week' to 'every day, more than once'	No
HELENA ^(54,55)	Semi-quantitative 137-item FFQ Two items on SSB	Assess effectiveness of an intervention to enhance the physical activity and diet of adolescents	Adolescents 13–17 years	'Regular soft drinks' and 'Diet soft drinks' listed under the 'beverages' heading	NR	Self-admin.	Select from typically 10 frequency categories, then select frequency of: units per day', 'units per week' or 'units during the last 30 days'	Yes Assessed in-line Frequency and portion selected together for fruit juices; i.e. 1 glass/2 glass, ..., 10 glasses Assessed separately Photos, four portion sizes (amorphous foods)
I.Family Project ^{(66,69)*}	Non-quantitative Sixty-item FFQ Four items on SSB	Assess determinants of eating behaviour	Adolescents 12–17 years	'Carbonated sugar-sweetened drinks (e.g. Coca-Cola, Fanta, non-alcoholic beer, etc.)' 'Diet carbonated drinks (e.g. diet cola, etc.)' 'Sugar-sweetened drinks, not carbonated (e.g. bottled ice tea, syrup-based drinks and similar, fruit juices with less than 100 % fruit, sports drinks, non-alcoholic wine, etc.)' 'Artificially sweetened drinks, not carbonated (e.g. diet ice tea, diet fruit syrup, diet sports drinks, etc.)' Local examples provided	Typical week over the previous month	Self-admin.	7 categories, ranging from 'never/less than once a week' to '4 or more times per day'	No
Larsson <i>et al.</i> ^{(71)*}	Non-quantitative Thirty-three-item FFQ Two items on SSB	Determine prevalence of vegetarianism Compare food habits among vegetarians and omnivores	Adolescents Age range NR	'Regular soda' 'Light soda'	Not stated	Self-admin.	6 categories, ranging from 'never/rarely' to 'several times a day'. Subjects also report for a typical weekday, times they usually eat and what type of meal they usually eat at the time	No
Szczepanska <i>et al.</i> ^{(72)*}	Non-quantitative Twelve-item FFQ One item on SSB	Assess and compare dietary habits	Middle school age Age range NR	'Carbonated drinks (Fanta, Sprite, Coke, Pepsi)'	Not stated	Self-admin.	5 categories, ranging from 'daily', '3–4 times a week' to 'several times a month', 'less/occasionally', 'never'	No



Table 3 *Continued*

Study	Type/number of items	Purpose	Population	Definition	Reference period	Mode	Frequency categories	Portion estimated? (yes/no)
TEMPEST ^{(73-75)*}	Semi-quantitative Five-item FFQ One item on SSB	Test association of 'subjective peer norms' with eating intentions and diet	Adolescents 12-17 years	'Soft drinks, lemonade or energy drinks' Explained that light soft drinks and mineral water should not be taken into account for the soft drink measure	Per average day	Self-admin.	5 categories, ranging from 'less than 1' to 'more than 4'	Yes Assessed in-line Specified 'glass' as the portion
Children Cinar and Murtomaa ^{(76)*} Pre-adolescent FFQ	Non-quantitative Fourteen-item FFQ One item on SSB	Determine clustering between obesity and lifestyle factors in two countries	Children 10-12 years	'Soft drinks or juice'	Previous week	Self-admin.	4 categories: '6-7 days', '3-5 days', '1-2 days' and 'not at all'	No
ENERGY ^{(51,77)*} Children's FFQ	Semi-quantitative General questionnaire One item on SSB	Determine prevalence of EBRB Identify personal, family and school environmental correlates of EBRB	Children 10-12 years	'Fizzy drinks or fruit squash' Specified that this was: 'NOT diet drinks and fruit juice' Provided examples	Previous week Usual consumption on a day on which SSB consumed	Self-admin.	7 categories per week, ranging from 'never', '1 portion or less per week' to '5 or more portions per day' 6 categories per day, ranging from 'none', '1 glass/small bottle' to '5 or more glasses/bottles'	Yes Assessed in-line Subject can select number of glasses/small cartons (250 ml) and regular cartons (330 ml) drank on a day of consumption
IDEFICS ^{(39,40,79)*}	Non-quantitative Forty-eight-item FFQ Two items on SSB	Determine the aetiology of overweight, obesity and related disorders Test association between diet and cardiovascular risk factors ⁽¹¹⁷⁾ Test association between diet and BMI	Children 2-9 years (parents or guardians as proxies)	'Sweetened drinks including sports drinks, bottled or canned tea, syrup-based drinks and similar' Local examples given. 'Diet coke or diet soft drinks' Local examples given	Typical week over the previous month	Self-admin.	8 categories, ranging from 'never/less than once a week' to '4 or more times per day' 'I have no idea' was also an option	No
I.Family Project ^{(66,69)*}	Non-quantitative Fifty-nine-item FFQ Four items on SSB	Assess determinants of eating behaviour	Children 2-11 years (parents or guardians as proxies)	'Carbonated sugar sweetened drinks (e.g. Coca-Cola, Fanta, non-alcoholic beer, etc.)' 'Diet carbonated drinks (e.g. diet cola, etc.)' 'Sugar-sweetened drinks, not carbonated (e.g. bottled ice tea, syrup-based drinks and similar, fruit juices with less than 100 % fruit, sports drinks, non-alcoholic wine, etc.)' 'Artificially sweetened drinks, not carbonated (e.g. diet ice tea, diet fruit syrup, diet sports drinks, etc.)' Local examples provided	Typical week over the previous month	Self-admin.	7 categories, ranging from 'never/less than once a week' to '4 or more times per day'	No
ISAAC study ^{(63,64)*}	Non-quantitative General questionnaire Eight-item FFQ One item on SSB	Test association between dietary factors, asthma and allergy	Children 8-12 years (parents or guardians as proxies)	'Fizzy drinks'	Not stated	Self-admin.	5 categories, ranging from 'never' to 'once per day or more often'	No
ToyBox ^{(82,83)*} Children's FFQ	Semi-quantitative Forty-four-item FFQ Two items on SSB	Measure the effectiveness of an intervention to prevent obesity	Children 3.5-5.5 years (parents or guardians as proxies)	'Sugared beverages (Coca-Cola, Pepsi, Fanta, Sprite, Nestea)' 'Fruit juice, pre-packed/bottled'	12 months	Self-admin.	6 categories, ranging from '1-3 days per month' to 'every day'	Yes Assessed separately Subjects asked to select from a range of portion for each food, e.g. from '100 ml or less' to '1000 ml or more'. Examples of corresponding portions in grams or millilitres provided for each food item Photo book included in appendix

CNSHS, Cross National Student Health Survey; ENERGY, European Energy balance Research to prevent excessive weight Gain among Youth; ESCAREL, European Study in Non-Carious Cervical Lesions; HAPIEE, Health, Alcohol and Psychosocial factors in Eastern Europe; MEDIS, Mediterranean Islands Study; MGSD, Mediterranean Group for the Study of Diabetes; HBSC, Health Behaviour in School-aged Children; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; TEMPEST, 'Temptations to Eat Moderated by Personal and Environmental Self-regulatory Tools'; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health Effects In Children and infantS; ISAAC, International Study of Asthma and Allergies in Childhood; EBRB, energy balance-related behaviours; F&V, fruits and vegetables; NR, not reported; self-admin., self-administered.

*Original instrument was obtained for review.

†Information on the Food4Me instrument was obtained through contact with study authors.

Table 4 Summary of the 24 h recalls (24-HDR; *n* 6) identified for the assessment of sugar-sweetened beverages (SSB): population, instrument purpose, mode, structure, prompts and portion estimation

Study	Population	Purpose	Mode	Structure	Prompts	Portion estimation
EPIC ^(49,118)	Adults 30–70 years	Provide comparable food consumption data between several European countries	EPIC-SOFT One 24-HDR Computerised Face-to-face interview	1. 'Quick list': chronological entry of all foods and recipes consumed during day 2. Foods are entered per meal 3. Each 'quick list' item is described and quantified	Yes. Program mediated Checklist of easily forgotten foods	Estimated Six quantification methods including photos, shapes, household measurements, standard units, standard portions, volume method and 'unknown' method 4–6 portion sizes
HELENA ^(52,53,68)	Adolescents 13–17 years	Assess food and nutrient intakes	HELENA-DIAT Two non-consecutive 24-HDR (within 2 weeks) Computerised Self-admin.	Six meal occasions	Yes. Program mediated Checked entries for the occurrence of F&V and sweets to ask adolescents if this was 'really not consumed?'	Estimated Photographs Standard units, e.g. spoon, can, glass, grams
EYHS ^{(46,48,78)*}	Children 9 and 15 years	Examine personal, environmental and lifestyle influences on cardiovascular risk factors Examine changes in diet intake over time ⁽¹¹⁹⁾	One 24-HDR Paper-based Face-to-face recall interview preceded by 1 d qualitative food record	Pre-coded food checklist on the 24-HDR Recorded: type/description/ location	Yes. During face-to-face interview	Estimated Different-sized drinking glasses, plates, spoons and food pictures of most common foods and food groups in different portion sizes were used to estimate food quantities
ENERGY ^{(51,108)*}	Children 10–12 years	Determine prevalence of EBRB Identify personal, family and school environmental correlates of EBRB	One 24-HDR Paper-based Self-admin.	Single question asked number of 'Fizzy drinks or fruit squash' consumed yesterday Six options ranging from 'none' to '5 or more'	No	Estimated (in-line) Subject can select number of glasses/small bottles (250 ml), cans (330 ml) and bottles (500 ml)
IDEFICS ^(39,40) (SACINA)	Children 2–9 years (parents or guardians as proxies)	Determine the aetiology of overweight, obesity and related disorders	SACINA One 24-HDR Computerised Face-to-face-interview Hungary: self-admin. 24-HDR completed at home	6 meal occasions	Yes. Program mediated Showed intake and asked participants 'What food items are missing?'	Estimated Photographs, 6 glass sizes
I.Family Project ^{(70)*}	Children and adolescents 8 years or older Parents No age range determined	Identify determinants of food choice and lifestyle	SACANA One 24-HDR Online self-admin.	Meal occasions 1 breakfast, 1 lunch, 1 dinner; snacks and drinks as needed	Yes. Program mediated	Accurate portion size in grams or millilitres and graphical images and photos

EPIC, European Prospective Investigation into Cancer and Nutrition; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; EYHS, European Youth Heart Study; ENERGY, European Energy balance Research to prevent excessive weight Gain among Youth; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infants; EBRB, energy-balance-related behaviours; self-admin., self-administered; F&V, fruits and vegetables.
*Original instrument obtained for review.



intake⁽³⁷⁾, ideally, an instrument should be tested for validity in the population in which it will be used and the purpose for which the instrument is intended should be taken into account. For example, most FFQ identified by the review were used to examine determinants of dietary intake or examine the diet–disease associations, in contrast to the 24-HDR and diet records which were used mainly to assess intake for cross-cultural comparisons, or over time. FFQ are typically designed to be population-specific, to capture dietary customs and foods⁽¹²⁵⁾, and so the FFQ may not be the ideal instrument to use across several countries.

However, the current review has indicated how questions relating to SSB may best be structured, even across country-specific FFQ. For example, self-administered instruments should define SSB and provide examples to aid respondent comprehension. Furthermore, more than one item may be necessary to assess SSB; that is, the use of a single term such as ‘soft drinks’ to capture SSB may not be sufficient to fully assess intake of SSB as that term does not differentiate soft drinks, diet soft drinks and squashes. An agreement on a standardised way to assess SSB intake across instruments, including a requirement on assessing portion size in a systematic manner (i.e. clarifying units for participants, e.g. beaker = 250 ml), would be a key step in harmonising the data collection in different regions. The feasibility of using the instrument is also an important consideration. Of the seven instruments that were tested for validity, three were self-administered, paper-based FFQ (IDEFICS, ToyBox, HBSC) which may require less resources (i.e. Internet/computer, personnel and time resources) than online or computer-based self-administered FFQ (HELENA, Food4Me) or 24-HDR (HELENA-DIAT). As discussed in the paper on methods to assess F&V intake⁽³⁷⁾, suitability of the instrument, based on the purpose of the study, must be weighed against feasibility.

When reflecting on the best approach to assess SSB intake, balancing purpose against feasibility is particularly relevant. A 24-HDR or diet record can offer a more detailed and potentially more accurate⁽¹²⁶⁾ account of an individual’s SSB intake (particularly if records are maintained throughout the day by respondents, and/or prompted appropriately e.g. as part of HELENA-DIAT). Furthermore, as recalls or records capture SSB intake in the context of overall consumption for the day, they also offer the potential to explore intake in the light of other dietary components and dietary/meal patterns throughout the day; such as the association of consumption of sugar-rich foods with skipped/missed meals or as a marker of poor diet quality⁽¹²⁷⁾. However, given food intake has the potential to vary from day to day, it is generally accepted that where assessing an individual’s usual intake is of interest, a single 24-HDR is not appropriate. As SSB ideally should be consumed on an occasional basis, it is possible that an assessment over a limited time period may not reliably reflect usual intake. Much of the current research around SSB has a strong policy focus, tracking global or

country-level consumption frequency and relating this to wider health concerns such as obesity or type 2 diabetes^(11,16,128). FFQ, particularly if made more comparable across regions (e.g. through standardising frequency categories and definitions of SSB), are valid for this purpose, and do not incur the same respondent burden and expense as the multiple 24-HDR or records which would be required to approximate an individual’s usual intake. However, given the different opportunities offered by the different methodologies, it can be argued that to obtain a broader understanding of patterns of SSB consumption overall, both FFQ and diet records should be utilised. For example, the questionnaire used by the ENERGY study included elements of the FFQ and 24-HDR for the purposes of assessing SSB intake among children⁽⁵¹⁾.

The current review is strengthened by the use of a comprehensive, broad search strategy, supplemented by hand-searching reference lists. Instruments were sourced through contact with study authors and reviewing the results of the review on methods to assess F&V intake. However, there remains the possibility that we did not identify all relevant articles. It is important to note that where a copy of the original instrument or article could not be accessed, the instrument description may be limited. The review is limited to articles published up to June 2014 and we cannot exclude the possibility that new instruments to assess SSB may have become available since the review was completed. Although we would expect more recent instruments to be similar to those identified by our review (i.e. predominantly FFQ and 24-HDR), it is possible that further online tools may have been developed. The advent of tools such as the Food4Me and HELENA FFQ^(55,106), both which are administered online, suggests the move towards this approach, which also offers the opportunity for delivering personalised feedback messages on the basis of food intake data entered by participants.

While the review limited its focus to pan-European studies, as mentioned in the concurrent review on F&V intake⁽³⁷⁾, this is not to assert that other instruments tested for validity as part of non-European studies would be unsuitable for assessing intakes across Europe. Beyond examining the outcomes of validation studies, as was the case when reviewing instruments to assess F&V intake⁽³⁷⁾, the quality of the identified instruments was not assessed in the current review owing to the lack of an appraisal tool to rate dietary assessment instruments on the basis of their characteristics. As with the F&V review⁽³⁷⁾, comparing the characteristics of the instruments identified in the current review could inform how quality standards around dietary assessment instruments might be developed. Although the quality of each instrument could not be fully assessed, the review has provided a shortlist of potential instruments for use in future pan-European studies through selecting instruments that had been used across more than two European countries and those tested for validity for SSB intake. These results will contribute to the development of

the DEDIPAC toolbox of dietary intake assessment methods, which should provide a basis for appraising and selecting suitable instruments to use in future pan-European studies.

Conclusion

The present review has identified a range of instruments to assess intake of SSB. Results indicate key differences between the identified instruments. In order to standardise and harmonise assessment methods between European countries and increase the accuracy with which intake of SSB is measured, it is essential that a clear and agreed definition of SSB be used: one which clearly explains what is captured by the term 'soft drinks', and which distinguishes between sugar-free or light drinks and sugared drinks, and between pure fruit juices and squashes. The review has indicated seven methods that were tested for validity and used in pan-European studies. These methods may be most suitable to assess the intake of SSB among adult, child or adolescent populations in future pan-European studies.

Acknowledgements

Financial support: The preparation of this paper was supported by the DEDIPAC Knowledge Hub. This work was supported by the Joint Programming Initiative 'Healthy Diet for a Healthy Life'. The funding agency supporting this work was The Health Research Board (HRB), Ireland (DEDIPAC/2013/1). *Conflicts of interest:* None. *Authorship:* F.R. planned and conducted the review, and drafted and revised the paper. K.R. planned and conducted the review, and drafted the paper. I.J.P. drafted and revised the paper. M.B.S. contributed to the planning, and drafted and revised the paper. L.F.A. contributed to the planning, and drafted and revised the paper. A.G. drafted and revised the paper. P.v.V. drafted and revised the paper. S.E. conducted the review of validation data, and drafted and revised the paper. M.v.D. conducted the review of validation data, and drafted and revised the paper. N.W.-D. conducted the review of validation data, and drafted and revised the paper. J.M.H. contributed to the planning, and drafted and revised the paper. *Ethics of human subject participation:* Not applicable.

Supplementary material

To view supplementary material for this article, please visit <http://dx.doi.org/10.1017/S1368980016002639>

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