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ORIGINAL ARTICLE

Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe

CA Vereecken[1], M Covents[2], W Sichert-Hellert[3], JMF Alvira[4], C Le Donne[5], S De Henauw[1], T De Vriendt[1], MK Phillipp[6], L Béghin[7], Y Manios[8], L Hallström[9], E Poortvliet[9], C Matthys[1], M Plada[10], E Nagy[11] and LA Moreno[4], on behalf of the HELENA Study Group[12]

[1]*Department of Public Health, Ghent University, Ghent, Belgium;* [2]*Private consultant;* [3]*Forschungsinstitut für Kinderernährung, Institut an der Rheinischen Friedrich-Wilhelms Universität Bonn, Dortmund, Germany;* [4]*Escuela Universitaria de Ciencias de la Salud, Universidad de Zaragoza, Zaragoza, Spain;* [5]*INRAN - Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione (National Research Institute for Food and Nutrition) Research Group Food Safety-Exposure Análisis Via Ardeatina, Rome, Italy;* [6]*Medizinische Universität Wien, Vienna, Austria;* [7]*Centre d'Investigation Clinique, Hôpital Cardiologique, CHRU de Lille, Lille, France;* [8]*Department of Nutrition and Dietetics, Harokopio University, Athens, Greece;* [9]*Unit for Preventive Nutrition, Department of Biosciences, Karolinska Institutet, Huddinge, Sweden;* [10]*Department of Social Medicine, School of Medicine, Preventive Medicine and Nutrition Clinic, Heraklion, Crete, Greece and* [11]*Medical Faculty, Department of Paediatrics, Pécs, Hungary*

Objective: To describe the development of a European computerized 24-h dietary recall method for adolescents, and to investigate the feasibility of self-administration (self report) by comparison with administration by a dietician (interview).
Methods: Two hundred and thirty-six adolescents (mean age 14.6 years (s.d. = 1.7)) of eight European cities completed the 24-h recall (Young Adolescents Nutrition Assessment on Computer (YANA-C)) twice (once by self-report and once by interview).
Results: A small but significant underestimate in energy (61 (s.e. = 31) kcal) and fat (4.2 (s.e. = 1.7) g) intake was found in the self-reports in comparison with the interviews; no significant differences were found for the intake of carbohydrates, proteins, fibre, calcium, iron and ascorbic acid. Spearman's correlations were highly significant for all nutrients and energy ranging between 0.86 and 0.91. Agreement in categorizing the respondents as consumers and non-consumers for the 29 food groups was high (kappa statistics $\geqslant$0.73). Percentage omissions were on average 3.7%; percentage intrusions: 2.0%. Spearman's correlations between both modes were high for all food groups, for the total sample ($\geqslant$0.76) as well as for the consumers only ($\geqslant$0.72). Analysing the consumer only, on an average 54% of the consumed amounts were exactly the same; nevertheless, only for one group 'rice and pasta' a significant difference in consumption was found.
Conclusion: Adaptation, translation and standardization of YANA-C make it possible to assess the dietary intake of adolescents in a broad international context. In general, good agreement between the administration modes was found, the latter offering significant potential for large-scale surveys where the amount of resources to gather data is limited.
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Keywords: dietary assessment; computer; self-administration; 24-h recall; validation

Introduction

Many European countries have carried out national or regional dietary surveys in adolescents, which provide valuable information;[1–4] however, differences in methodology, population groups and age categories make it difficult to use these data for a detailed evaluation of dietary intake in Europe.[1,2,5] An agreed and validated methodology for assessing food and nutrient intakes across Europe will be of great value;[6] therefore, one of the main aims of the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) Study was to develop and harmonize an innovative method for assessing food and nutrient intake in adolescents across Europe.

The main dietary assessment tools for collecting dietary data at an individual level are food records, 24-h dietary

Correspondence: Dr CA Vereecken, Ghent University, Department of Public Health, University Hospital, De Pintelaan 185, bloc A, 2nd floor, 9000 Ghent, Belgium.
E-mail: Carine.Vereecken@UGent.be
[12]See Appendix at the end of the supplement on page S82.

recalls and food frequency questionnaires. The EFCOSUM project considered 24-h recalls as the best method to get population mean intakes and distributions for participants aged 10 years and over in different European countries: 24-h recalls are suitable in varying cultural settings (due to the open-ended and therefore not culturally based format), they have a relatively low respondent and interviewer burden and are cost-effective.[7]

Moreover, designing an instrument to evaluate adolescents' eating habits also needs to address the unique concerns of the adolescent population:[8] adolescents are less interested in participating in dietary studies than younger children. In addition, their great food requirements, unstructured eating patterns and increased degree of out-of-home eating may cause forgetfulness, irritation and boredom, resulting in non-compliance when intakes have to be recorded on an almost hour-to-hour basis.[9]

The increased availability of computers in schools and at home, as well as the efficiency and economy (that is, complex branching, standardization, no out-of-range data, substantive savings in administrative and data processing costs) and the acceptability in the spirit of respondent preference of computer-assisted questioning, has made it technically, financially and practically feasible and attractive to use computer-administered questioning in large-scale dietary surveys.

To our knowledge, only three computer-based tools have been developed to collect self-administered 24-h dietary recall data in children and adolescents. The Food Intake Recording Software System (FIRSST)[10] was designed in the US to assist fourth-grade schoolchildren in reporting their diet. Moore *et al.*[11] developed a tool to measure fruit and snack consumption for Welsh 9- to 11-year-olds, and the Young Adolescents' Nutrition Assessment on Computer (YANA-C)[12] was developed to collect dietary data in Belgian Dutch-speaking adolescents.

These tools are, however, designed for specific population groups, whereas in the frame of the HELENA Study, a multilingual software package suitable for culturally diverse adolescent populations is necessary. For this purpose, the Belgian-Flemish YANA-C[12] tool was revised and enhanced.

In this paper, the international YANA-C tool will be described and the feasibility of self-administration will be investigated in adolescents from 8 European cities by comparison of self-administered YANA-C data with interviewer-administered YANA-C data.

Methods

Instrument

Young Adolescents' Nutrition Assessment on Computer[12] consists of a single 24-h recall guiding users through six 'meal occasions' (breakfast – morning snacks – lunch – afternoon snacks – evening meal – evening snacks), embedded within questions that help the respondents to remember what they ate (When did you have a meal? With whom did you eat?).

For each meal occasion, adolescents are invited to select all food items eaten at that occasion from a standardized menu structure that opens as a pop-up screen (Figure 1). For each selected item, one or more extra screens are provided to gather quantitatively detailed information on portions and portion sizes (Figure 2). More than 2600 pictures of more than 300 food items (multiple portion sizes per food item) are included to enhance the estimation of the consumed amounts. Several measurement units (for example, spoon, can, glass, gram and so on) are used and, if suitable, more than one measurement unit is present for the same food item.

When appropriate, a text box appears on the screen probing for food items often eaten in combination with other items (for example, chips, 'Don't forget mayonnaise/ketchup etc!'). The respondent can add items not listed in the program by clicking the last group labelled 'item not found'. Respondents selecting this option are provided with a screen asking for a description of the food item, the unit (for example, gram, piece and so on) and the amount consumed. Moreover, a search engine helps to locate a food in the menu structure in case the participant cannot find an item.

A warning is given when extreme amounts are entered; zero values are not accepted.

After completing each meal occasion, the program checks for beverages, for milk when cornflakes are consumed and for butter or margarine when bread is consumed. At the end of the 24-h recall, the program checks the entries for occurence of fruit, vegetables and sweets. If one of these items has not been entered, the adolescent is asked whether it really was not consumed. The interview ends with an overview of all food entries on the different meal occasions (Figure 3), asking the adolescents to review and confirm their intake. If necessary, they can go back to each food item and meal occasion to make corrections. After entering a password, which is done by a staff member, the energy intake is shown (as a check for the staff member) and the data are stored in a txt file.

The main modification of the original YANA-C version to be useful in an international context was the open translation engine, which currently allows for 10 countries/languages to participate. An easy-to-handle and easily maintainable definition system was developed using standard XLS-files for definition of the different screens, menu structure and food items.

The original (Dutch) text of the main screens and the menu structure, including more than 800 food items hierarchically organized into 25 food groups, were translated into an English version and distributed to all collaborating centres.

A protocol was created to make the XLS-files adaptable and maintainable to the local language and food culture by local

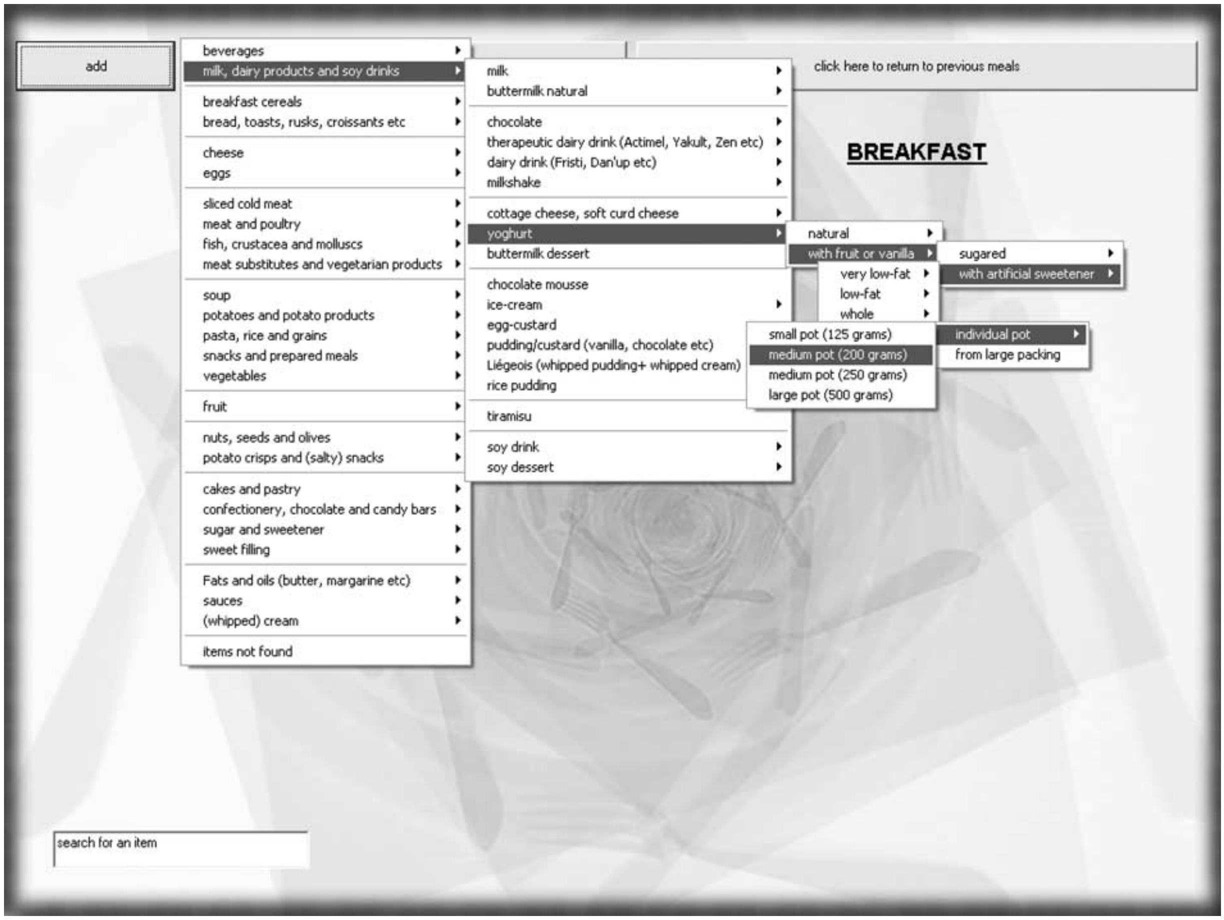

Figure 1 Illustration of the menu structure.

non-technical users. A second protocol was developed to make locally culture-specific food pictures. Each partner contributed to the upgrade of the tool to a European level by making inventories of country-specific food lists and by providing pictures of typical local and traditional dishes and series of portion sizes. A central pool of these pictures was made accessible for all participating centres.

Finally, the final country-specific menu structures were translated back into English.

A pilot test was done in one class in all participating centres.[13]

Microsoft Visual Basic6.0 was used to develop the program, which implies that the current version is a desktop version.

Participants and procedure

Two hundred and thirty-six pupils of eight cities (Athens, Dortmund, Ghent, Lille, Rome, Stockholm, Vienna and Zaragoza) with a mean age of 14.6 years (s.d. = 1.7) participated in the study; of these 49% were boys (Table 1).

The pupils completed YANA-C twice: first self-administered (that is, self-report) according to the standard protocol as described for the HELENA Cross-Sectioned Study, followed by an administration by a dietician (that is, interview).

The self-administration took place in a computer classroom. A staff member gave a short introduction, explained the structure of the program and filled in a fictitious breakfast illustrating the different features of the program. Thereafter, the pupils completed the program autonomously, although two or three staff members (dieticians) were present to give assistance as required. At the end, the researchers checked the overview screen for extreme values; in Ghent also, the energy intake was checked, whereas in the other countries energy values were not yet available in the YANA-C database.

Later on the same day, the interview took place in a private room, with the dietician behind the computer and the student only seeing the screen when a picture had to be selected. The structure of the program was followed but the dietician was allowed to ask extra questions or give extra explanations to select the correct food items and amounts (for example, which brand; when no meat was consumed at dinner, whether this was forgotten; explain what is mini, regular, king size). At the overview screen (Figure 3), every food entry was repeated by meal occasion; for empty meal

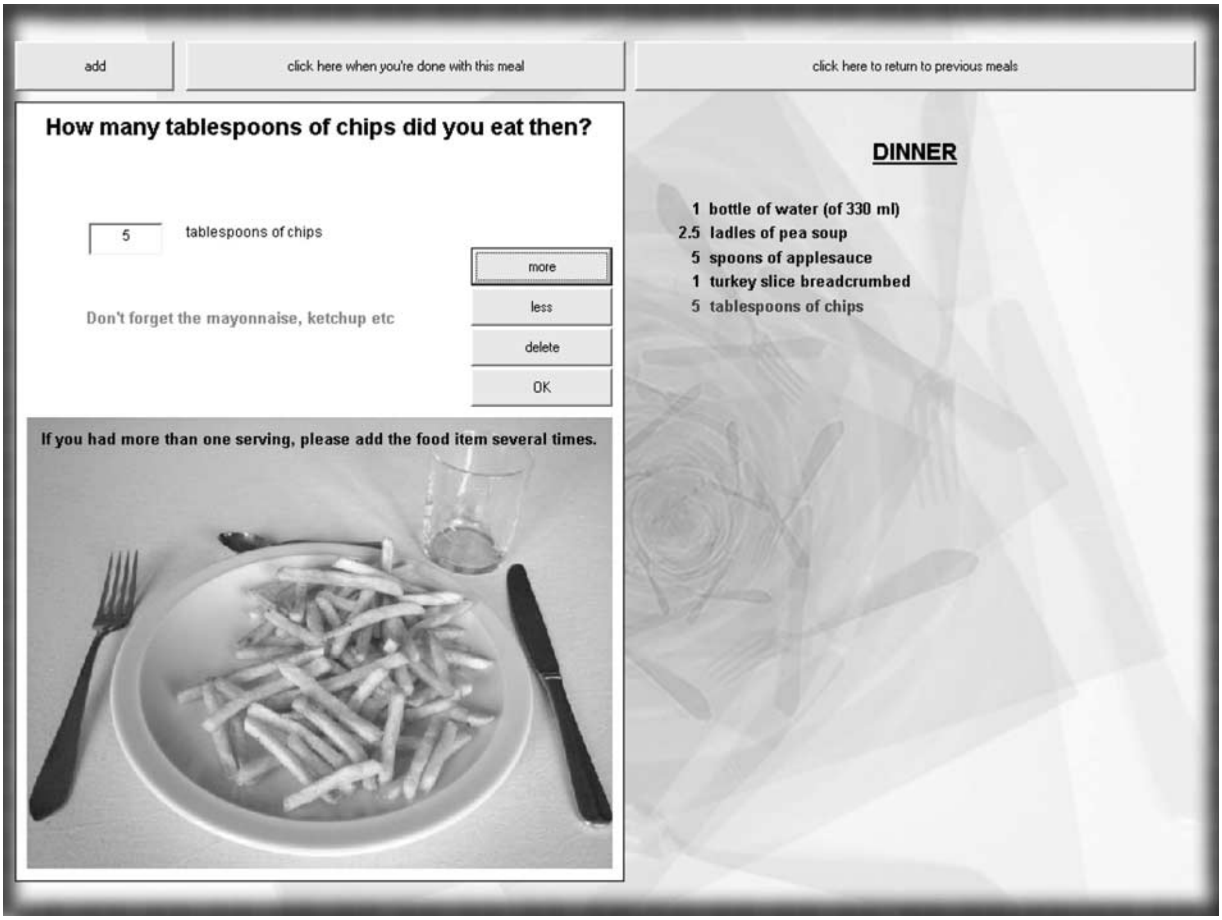

Figure 2 Illustration of the portion size selection.

occasions, the question was asked again whether nothing was forgotten.

Analyses

Total energy and nutrient intakes (carbohydrates, protein, fat, fibre, calcium, iron and ascorbic acid) were calculated using country-specific nutrient composition databases (for Ghent and Lille, the Belgian[14] and the Dutch Food Composition Tables;[15] for Dortmund and Vienna, the German Nutrient Database (BLS, Bundeslebensmittelschlüssel);[16] for Rome, the Italian (INRAN) database;[17] for Stockholm, the Statens Livsmedelsverk (SLV),[18] for Zaragoza, a Spanish database;[19] and for Athens, the Nutritionist V diet analysis software (First Databank, San Bruno, CA, USA) and updated to include traditional Greek foods and recipes, as described in Food Composition Tables and Composition of Greek Cooked Food and Dishes[20,21]).

For all countries, except Germany, composite dishes were disaggregated into their food components. Food items were categorized into 29 food groups based on the European Food Groups classification system.[22]

Wilcoxon signed-rank tests, Spearman's correlations and the Bland and Altman[23] method were used (mean, s.e. and s.d. of the difference between self-report and interview are presented) to compare the total energy and nutrient estimates of both administration modes.

To further identify sources of error, the matched records of the food groups were categorized as (1) agreements of non-consumers (food group items not reported in either administration method), (2) agreements of consumers (food groups with identical amounts consumed according to both administration methods), (3) agreements on consumption but with differences in amounts consumed, (4) omissions (food group items reported only in the interview) and (5) intrusions (food group items reported only in the self-report). Kappa statistics were calculated for measuring the agreement between methods in consumption versus non-consumption of the different food groups. Kappa values <0 are considered as poor, 0–0.20 = slight, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = substantial and 0.81–1.00 = almost perfect.[24]

Spearman's correlations and Wilcoxon signed-rank tests were conducted to compare the intake of the food groups according to both administration methods.

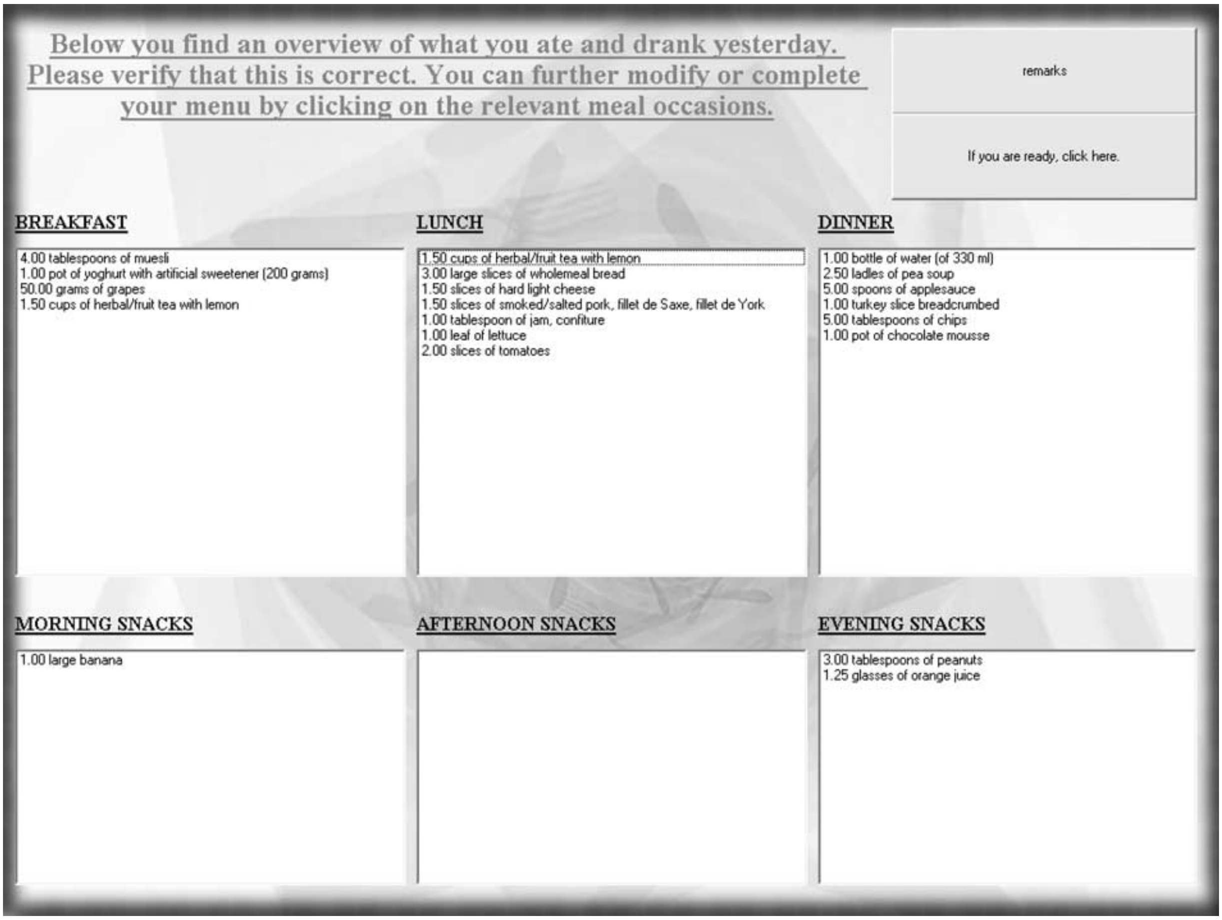

Figure 3 Illustration of the overview screen.

Table 1 Demographic characteristics of the sample

	Gender		*Age (years)*	
	Boys (n)	*Girls (n)*	*Mean*	*s.d.*
Athens (Greece)	19	20	13.4	1.6
Dortmund (Germany)	13	12	14.1	1.5
Ghent (Belgium)	21	11	15.2	1.8
Lille (France)	14	16	14.5	1.4
Rome (Italy)	18	11	14.7	1.4
Stockholm (Sweden)	1	20	15.3	1.3
Vienna (Austria)	11	18	15.5	1.4
Zaragoza (Spain)	19	12	14.8	1.6
Total	116	120	14.6	1.7

Results

Mean energy and nutrient intake for the total sample are presented in Table 2. The Bland and Altman and the Wilcoxon signed-rank tests revealed significant underestimates in energy (61 (s.e. = 31) kcal) and fat (4.2 (s.e. = 1.7) g) intake, in the self-report, in comparison with the interview; no significant differences were found for the intake of carbohydrates, proteins, fibre, calcium, iron and ascorbic acid.

Spearman's correlation coefficients were highly significant for all nutrients ranging between 0.86 and 0.91.

Analyses of energy intake by centre showed a significant underestimation for the self-reports in Ghent only (Table 3).

Comparison of the food group intake showed a good agreement of consumption versus non-consumption with kappa statistics of 0.73 or higher (Table 4). Percentage omissions were on average 3.7%: items most often omitted were 'sauces', 'sugar, jam and syrup', 'chocolate' and 'fat'. Intrusions (items in self-report but not interview) were less common: on average 2.0%, over the different food groups; the highest percentage of intrusions was found for confectionery.

For those who consumed items of a food group according to both methods (consumers), on average 54% had the same intake in both methods. Analyses (Wilcoxon signed-rank tests) restricted to these consumers only showed a significant overestimation of 22 (s.e. = 6) g for 'pasta and rice'; no significant difference was found for the remaining food groups (Table 5).

Table 2 Mean energy (s.e.) and nutrient intake by administration mode, difference (self-report—interview), significance of the difference and Spearman's correlation between both methods for the total sample

	Self-report		*Interview*		*Difference*				
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*s.d.*	P-*value*	*Spearman's*
Energy (kcal)	2160	78	2221	78	−61	31	482	0.004	0.91
Protein (g)	84.1	3.2	86.2	3.0	−2.1	1.6	24.4	0.114	0.90
Carbohydrates (g)	267.5	10.5	271.0	10.2	−3.6	4.5	69.1	0.232	0.91
Fat (g)	84.1	3.6	88.3	3.7	−4.2	1.7	26.0	0.001	0.86
Fibre (g)	17.5	0.7	17.6	0.7	−0.1	0.4	5.6	0.931	0.88
Calcium (mg)	824.8	32.3	852.7	32.8	−27.9	16.2	248.8	0.186	0.87
Iron (mg)	12.3	0.5	12.1	0.5	0.2	0.4	5.8	0.811	0.89
Ascorbic acid (mg)	103.4	5.8	106.8	5.8	−3.4	3.3	50.0	0.384	0.87

P-value = significance of the Wilcoxon signed-rank test.

Table 3 Mean energy (s.e.) intake (kcal) by administration mode and centre, difference (s.e.), significance of the difference and Spearman's correlation (*r*) between both methods

	Self-report		*Interview*		*Difference*			
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	P-*value*	r
Athens	1554	109	1597	115	−43	28	0.110	0.97
Dortmund	2333	269	2437	256	−104	83	0.181	0.87
Ghent	2581	263	2798	266	−217	56	0.001	0.95
Lille	1899	158	1956	172	−57	122	0.371	0.82
Roma	2874	230	2872	176	2	140	0.482	0.80
Stockholm	1928	237	1939	230	−11	122	0.876	0.69
Vienna	1833	232	1846	254	−13	61	0.957	0.90
Zaragoza	2395	186	2422	182	−27	86	0.468	0.88

P-value = significance of the Wilcoxon signed-rank test.

Correlation coefficients between both methods were high for all items, for the total sample ($\geqslant$0.76) as well as for the consumers-only ($\geqslant$0.68).

Discussion

Young Adolescents' Nutrition Assessment on Computer was developed as a self-administered computer tool that could be completed by the adolescents themselves with only minimal professional assistance. Self-administered computer tools have many advantages: standardization of the questions and questioning sequence, fast and easy data processing, immediate results, increased flexibility, as well as increased privacy and confidentiality.[25,26] A major limitation of self-assessment dietary instruments is, however, a potential lack of sufficient food knowledge of the respondents to quantify and categorize the food items in the most accurate way. Hence, in this paper, we compare self-administered YANA-C data, where the adolescents did the classification and quantification of the food items by themselves, with interviewer-administered YANA-C data, in which the classifications and quantifications were done by the dieticians.

In general, both administration modes agreed very well: Spearman's correlations were high for all nutrients; only for fat and energy intake a significant underestimate was found in the self-reports, most likely reflecting the considerable amount of omissions for sauces, fat, chocolate and cheese (>5%). Nevertheless, the limits of agreement (mean difference +/−2 s.d.) of the Bland and Altman analyses indicate that, on an individual level, considerable difference between both administration modes is possible.

Analyses on energy intake by centre resulted in significant differences only for the Ghent sample. The country sample sizes are, however, too small for final conclusions on the existence of differences between the cohorts. In addition, in a previous study in which the original Flemish YANA-C version was compared with a traditional dietary interview, no significant differences in nutrient and energy intake were found.[12]

Nevertheless, what is valid for one population is not necessarily valid for another population: large differences exist between countries in computer use among adolescents; moreover, food cultures differ and local adaptations to the menu structure were necessary.

Finally, it must be said that the average energy intake was quite low for some centres. This, however, was found for both administration modes.

Kappa statistics between consumers and non-consumers of the different food groups showed a substantial to almost perfect agreement.

A comparison of intrusion and omission rates shows a higher percentage for the latter, which has also been reported by others.[10,27–31]

Intrusions (items reported in self-report but not in interview) might occur from game exploration behaviour or when food, to which a negative health connotation is attached, would be reported less frequently in the interview context. However, the intrusion rate was very low, and so we have no reason to believe either that game exploration increased the reports in the self-reports or that social stigmas influenced the administration modes differently.

Items that were most often omitted were the type of food items that can be characterized as being easy to forget: mainly accompaniments of other foods and sweets ('sauces',

Table 4 Agreement on food group level between both methods for the total sample

	Matches (%)			*Omissions (%)*	*Intrusions (%)*		
	Food group not reported on either method	*Food group reported on both methods*		*Food group reported for 1 method, namely*		*Kappa consumption versus non-consumption*	r
		Self-report = interview	*Self-report ≠ interview*	*Interview*	*Self-report*		
Breakfast cereals	77.5	8.9	9.7	3.0	0.8	0.88	0.90
Bread rolls and flour	9.3	34.3	50.8	4.2	1.3	0.74	0.87
Pasta and rice	51.7	21.6	24.2	1.7	0.8	0.95	0.95
Sweet bakery products	47.0	23.7	23.3	3.4	2.5	0.88	0.90
Savoury snacks	83.1	7.2	5.1	2.1	2.5	0.81	0.84
Sugar, jam, syrup	64.4	15.7	10.2	7.6	2.1	0.77	0.77
Confectionery	70.8	11.9	8.5	5.1	3.8	0.76	0.77
Chocolate	53.0	15.7	20.8	8.1	2.5	0.78	0.83
Fat	30.1	20.8	40.7	6.8	1.7	0.81	0.86
Sauces	40.3	23.3	22.9	10.6	3.0	0.73	0.76
Nuts, seeds, olives	88.1	5.1	3.0	1.7	2.1	0.79	0.78
Pulses, vegetables	26.3	25.8	41.1	4.7	2.1	0.84	0.90
Starch roots, potatoes	45.8	30.5	18.2	3.0	2.5	0.89	0.91
Fruits	33.5	29.7	28.4	5.9	2.5	0.82	0.84
Soups	87.3	7.2	4.2	1.3		0.94	0.94
Water	9.7	22.0	64.4	2.5	1.3	0.82	0.85
Coffee, tea	74.2	13.1	9.7	1.7	1.3	0.92	0.93
Juices	52.1	21.6	19.5	4.2	2.5	0.86	0.87
Carbonated soft drinks	51.7	22.9	19.5	3.0	3.0	0.88	0.92
Alcoholic beverages	96.6	2.1	0.4	0.4	0.4	0.85	0.86
Meat, meat products	17.8	33.5	44.9	2.1	1.7	0.88	0.91
Fish, fish products	79.7	10.2	6.8	3.0	0.4	0.89	0.89
Eggs	74.2	13.6	5.9	3.8	2.5	0.82	0.81
White milk, buttermilk	41.9	30.5	23.3	2.1	2.1	0.91	0.93
Yogurt, quark	76.7	10.2	5.9	5.9	1.3	0.77	0.80
Milk and yogurt beverages	83.1	8.9	3.8	3.0	1.3	0.83	0.84
Cheese	46.6	20.3	23.7	5.9	3.4	0.81	0.86
Creams, milk-based desserts	80.9	8.1	5.5	3.0	2.5	0.80	0.80
Miscellaneous	72.9	12.3	10.6	1.7	2.5	0.89	0.91

Matches: food group reported in both methods or food group reported in neither method. Self-report = interview: the same amount reported in interview and self-report. Self-report ≠ interview: different amount in interview and self-report. Omissions: food group reported in interview, but not in self-report. Intrusions: food group reported in self-report, but not in interview.

'fat', 'sugar, jam and syrup' and 'chocolate'). In addition, in other studies, 'added foods' and sweets have been often omitted or least accurately recalled.[27,31–33] The cross-checks and prompts at the end of the meal/day and the prompts given in relation to accompaniments in the program (for example, when meat is added: 'don't forget the sauce…') seem to be slightly less accurate than when prompting is done by a dietician. Nevertheless, in comparison with the results reported by Baranowski *et al.*[10] and Moore *et al.*,[11] intrusion and omission rates were low, although the results are difficult to compare as other methodologies were used; in addition, their study populations were younger.

Comparison of consumed amounts of the consumers only resulted in a significant difference: an overestimation for the 'rice and pasta' group in the self-reports. However, by comparing 29 food groups, we could have expected that by chance alone at least one item would have differed significantly.

A limitation of the study is that analyses were done on a food group level (for example, fruit) and not on a food item level (for example, apple), and so if the same amount of another food item from the same food group were to be reported in the interview, this would not result in a mismatch in the current analyses. Nevertheless, food consumption is usually reported on a food group level or nutrient level, and differences in food items would most likely be reflected in differences in nutrient intake.

Another limitation of the study is the comparison of the self-report recall with another self-report recall mode: both most likely share systematic variances relating to the participant's cognitive recall abilities, social desirability biases and motivations to comply. In addition, both administration modes used the same instrument, and as the interview was carried out shortly after self-administration (30 min–4 h), some pupils even remembered exactly what they had answered. Moreover, although an interview is often used as a 'gold standard', there might be inaccuracies on the part of the interview as well. Therefore, further research against a stronger validation standard in the different countries is needed.

Table 5 Agreement on food group level between both methods for consumers only

	Self-report		*Interview*		*Difference*			P-*value*	r	N
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*s.d.*			
Breakfast cereals	43	4	45	7	−1	6	38	0.161	0.84	44
Bread, rolls and flour	124	8	129	7	−5	4	51	0.105	0.83	201
Pasta and rice	195	12	173	11	22	6	60	<0.001	0.85	108
Sweet bakery products	121	11	122	10	0	6	63	0.560	0.82	111
Savoury snacks	46	7	50	8	−4	4	21	0.581	0.78	29
Sugar, jam, syrup	32	4	31	4	1	2	17	0.431	0.91	61
Confectionery	25	4	25	4	0	2	15	0.866	0.87	48
Chocolate	63	9	66	10	−3	4	40	0.521	0.79	86
Fat	29	2	29	2	0	1	17	0.991	0.83	145
Sauces	64	6	65	5	−2	4	45	0.555	0.74	109
Nuts, seeds, olives	41	10	34	8	7	5	20	0.236	0.79	19
Pulses, vegetables	138	9	144	10	−6	6	81	0.816	0.86	158
Starch roots, potatoes	154	10	153	9	1	4	42	0.443	0.88	115
Fruits	204	12	198	11	6	7	78	0.433	0.80	137
Soups	320	37	327	39	−7	14	74	0.718	0.95	27
Water	926	47	945	44	−19	26	367	0.140	0.82	204
Coffee, tea	252	26	246	30	5	21	151	0.879	0.68	54
Juices	360	23	331	18	29	19	185	0.424	0.72	97
Carbonated soft drinks	604	54	599	53	4	21	212	0.277	0.92	100
Alcoholic beverages	190	100	199	100	−9	9	23	0.317	1.00	6
Meat, meat products	180	11	176	10	4	7	90	0.975	0.87	185
Fish, fish products	128	16	128	12	1	11	71	0.438	0.73	40
Eggs	46	6	48	6	−2	2	11	0.140	0.97	46
White milk, buttermilk	306	21	302	19	3	14	155	0.854	0.86	127
Yogurt, quark	214	22	194	17	20	11	67	0.068	0.80	38
Milk and yogurt beverages	234	18	222	15	12	11	62	0.811	0.85	30
Cheese	46	4	47	4	−1	2	20	0.861	0.84	104
Creams, milk-based desserts	109	21	117	25	−8	8	44	0.311	0.74	32
Miscellaneous	348	50	335	47	13	10	73	0.119	0.99	54

Mean values are reported in gram. *P*-value = significance of the Wilcoxon signed-rank test; *r* = Spearman's correlation.

Conclusion

Adaptation, translation and standardization of YANA-C make it possible to assess the dietary intake of adolescents in a broad international context. In addition, our results indicate in general a good agreement between the self-reports and the interviews. The latter offers significant potential for large-scale surveys where the amount of time and resources to gather data is limited. Nevertheless, a more thorough validation in each participating country against a stronger standard is advocated.

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Conflict of interest

The authors state no conflict of interest.

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