RESEARCH
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Does Providing Assistance to Children and Adolescents Increase Repeatability and Plausibility of Self-Reporting Using a Web-Based Dietary Recall Instrument?

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ABSTRACT

Background It is important to find ways to minimize errors when children self-report food consumption.

Objective The objective of this study was to investigate whether assistance given to children completing a self-administered 24-hour dietary recall instrument called SACANA (Self-Administered Child, Adolescent and Adult Nutrition Assessment) increased the repeatability and plausibility of energy intake (EI) estimates.

Participants/setting The study was conducted between October 2013 and March 2016 in a convenience sample of 395 children, aged 8 to 17 years, from eight European countries participating in the I.Family study.

Design SACANA was used to recall the previous day's food intake, twice in a day, once with and once without assistance.

Main outcome measures The difference in EI between the first and second recalls was the main repeatability measure; the ratio of EI to basal metabolic rate was the plausibility measure.

Statistical methods Generalized linear mixed models, adjusted for sex, age, and body mass index *z*-score, were used to assess whether assistance during the first vs second recall influenced repeatability and plausibility.

Results The difference in estimated EI (EI from second recall minus EI from first recall) was significantly lower ($P<0.001$) in those assisted at first (median=−76 kcal) than those assisted at second recall (median=282 kcal). Modeling showed that EI at assisted first recall was 19% higher (95% CI 1.13 to 1.24) than in assisted second recall. Overall, 60% of recalls had a plausible EI. Modeling to estimate the simultaneous effects of second vs first recall and assistance vs no assistance on plausibility showed that those assisted at first recall had significantly higher odds of a plausible recall than those unassisted (odds ratio 3.64, 95% CI 2.20 to 6.01), with no significant difference in plausibility of second recall compared to the first (odds ratio 1.48, 95% CI 0.92 to 2.35).

Conclusions When children are assisted at first recall, the plausibility and repeatability of the later unassisted recall improve. This improvement was evident for all ages. A future, adequately powered study is required to investigate the age range for which assistance is advisable.

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DIETARY ASSESSMENT IN LARGE-SCALE EPIDEMIOlogic studies of children is moving toward the use of repeated administration of quantitative 24-hour dietary recall (24hdr) instruments.[1] Because only short-term recall is required and the effort required to complete the instrument is limited,[2,3] 24hdrs yield more valid data in children than other methods.[1] Various 24hdr dietary assessment instruments have been developed and tested in several countries.[4-8] However, no one method of dietary assessment is optimal for children of all ages,[2,9] and consistent recommendations on the earliest age at which children can be relied upon to accurately report a full day's food consumption are not available.[2,4]

One way of overcoming the problem of recall in children is to use proxy reports from parents or caregivers. The European Food Consumption Validation Project to determine how best to perform dietary assessment across Europe[2] suggested that for schoolchildren (aged 7 to 14 years) a parent/caregiver should assist the child so as to complement information obtained from the child.

However, parents may not be confident reporting on meals for which they have no direct knowledge.[10] Furthermore, parental knowledge of foods eaten by their children is associated with family characteristics (eg, number of shared meals) that are not independent of dietary quality,[11,12] so parental involvement may introduce bias. Although automated web-based instruments may be easier to use than those that are not web-based or computerized,[13] variable prior experience in using a computer can bias results. Thus a recently published review of experience with an online 24hdr advised that children aged 10 to 13 years should complete the initial recall assisted by a researcher.[10]

As part of the I.Family study—that from 2012 to 2017 investigated determinants of food choices, lifestyle and health in European children and their parents[14]—a web-based self-administered 24hdr called SACANA (Self-Administered Child, Adolescent and Adult Nutrition Assessment)[15] was developed. The aim of the present study was to investigate whether assistance given to children while self-administering SACANA increased the repeatability and plausibility of estimates of energy intake (EI) derived from the completed recall. Children recalled their previous day's food intake using SACANA twice in 1 day, once with the assistance of a dietitian/interviewer, and once without assistance. It was hypothesized that assistance at first recall would improve performance at the second unassisted recall.

MATERIALS AND METHODS

Participants

The study was conducted between October 2013 and March 2016 in a convenience sample of children from seven of the eight centers enrolled in the I.Family study from the following countries: Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden. The Polish center of Rzeszow, which joined I.Family later, was also included. A minimum of 50 children per center, of both sexes, aged 8 to 17 years, was identified by each center as agreeing to recall their diet twice in 1 day. Sample size was calculated based on an expected effect size of a 20% increase in EI due to assistance.

Of 423 children who agreed, 19 were excluded because recalls were missing (one missed both recalls, six missed the first recall, and 12 missed the second recall) and an additional nine children were excluded because estimated EI was at either extreme of the distribution (cutoffs first and last half-percentiles) from the first recall (four children), second recall (four children), or both (one child). Mean time between the two recalls was 106 minutes (median=99 minutes). Because anthropometric measures were missing for 26 children, the models that evaluated EI plausibility involved only 369 children.

Parents or legal guardians of the participating children gave written informed consent for data collection, examinations, collection of biological samples, and analysis and storage of personal data and samples. In addition, each child gave oral consent after being informed orally (from a simplified text) about the study by a nurse immediately before every examination. This procedure was chosen due to the young age of the children. The oral consent process was subject to quality control.

> **RESEARCH SNAPSHOT**
>
> **Research Question:** Does providing assistance for children when they first complete a self-administered 24-hour dietary recall instrument improve the plausibility and repeatability of future completions?
>
> **Key Findings:** When children are assisted at initial compilation, subsequent independent completion is characterized by improved plausibility and repeatability of the energy intake estimates derived from the instrument.

Study participants and their parents/guardians could consent to individual study components while abstaining from others. Ethical approval was obtained from the relevant local or national ethics committees by all study centers.

From SACINA to SACANA

SACANA was developed from a computer-based (offline) instrument called SACINA (Self-Administered Children and Infant Nutrition Assessment)[16] validated in preschool-aged children who had been used (usually by parents) to report their children's food intake in the multicenter study known as Identification and Prevention of Dietary- and Lifestyle-Induced Health Effects in Children and Infants (IDEFICS).[17]

SACANA development was driven by the need to create an instrument that could be self-completed by children (as well as adolescents and adults). Development involved the creation of a more intuitive graphic interface with many new components, including multiple food images with a variety of portion sizes.[15] The list of foods included in SACANA was derived from SACINA food lists and was updated for all countries during the SACANA pilot phase. Many foods were country-specific. In IDEFICS, SACINA was used to estimate energy and nutrient intakes[18,19] and also factors associated with parental misreporting of their children's dietary intake.[20] The main factors influencing misreporting were low socioeconomic status, high child body mass index (BMI), high parental BMI, mother vs father as proxy reporter, and high parental concern about child's weight status.[20]

Dietary Assessment with SACANA

Participants use SACANA to enter the types and amounts of foods and drinks consumed at each food consumption occasion (including snacks) over the 24 hours from waking on the preceding day to waking on the day of recall. Choice of one item usually leads to further choices; for example, choosing milk prompts milks of different fat contents, one of which is chosen. If a food usually consumed at a meal is not chosen, it is prompted and the participant has to choose yes vs no. In the case of yes, portion size is displayed and has to be chosen. Typically breakfast is chosen first and a list of country-specific items commonly consumed at breakfast is presented.

SACANA contains a total of 3,570 food items, some of which are common to some or all countries, others of which are available (presented as choices) only for some countries. All food items present in the food lists have been classified into 145 food groups characterized by common ingredients to render possible analyses of associations of food-group consumption with behavior and health. Food composition tables

(FCTs) are incorporated into SACANA. These were constructed from country-specific FCTs translated into English and harmonized across countries by adopting procedures to prevent and minimize bias.[21] Dietary supplements are not assessed by SACANA. Supplement use was recorded in a health and medical history questionnaire administered to a parent/guardian.[14] Mean times to complete SACANA were 30 minutes for first recall and about 20 minutes for second recall.

Energy Assessment Crossover Experiment

The participating children recalled their diet using SACANA twice in one day, once assisted and once unassisted. In the unassisted recall, the child entered foods following the onscreen instructions and illustrations. In the assisted recall, the child followed the onscreen instructions, but the dietitian either made the entries or checked that the child did so correctly. The assisted and unassisted recalls were conducted in random order, not less than 1 hour and not more than 4 hours apart, with no meals in between. In both recalls, the child was allowed to ask a parent or study personnel in the case that there was anything he or she did not understand (eg, in the case that the child did not understand the difference between low-fat and full-fat yogurt it would be explained). The children were randomized either to Group 1 in which the first recall was assisted, or to Group 2 in which the second recall was assisted. EI (in kilocalories) was estimated for the first (EI_1) and the second (EI_2) recalls, by linking recalled foods to the FCT.[21] EIs estimated from assisted recalls are denoted EI_a. Those from unassisted recalls are EI_u.

Anthropometry

Anthropometric measurements were taken serially in the I.Family study using a standard protocol. Only the most recent set of anthropometric measurements was used in the present study. Height was measured to the nearest 0.1 cm with a stadiometer; body weight was measured with a BC418MA instrument (Tanita Europe GmbH, Sindelfingen, Germany) in light underwear to the nearest 0.1 kg. BMI was weight (in kilograms) divided by height squared (in squared meters). Basal metabolic rate (BMR) was calculated from the Schofield equations.[22] BMI was transformed to an age- and sex-specific *z*-score according to Cole and colleagues.[23]

Statistical Methods

Repeatability was assessed by calculating Spearman correlation coefficient (r) between the EI estimates at first and second recalls, and by assessing the difference in EI between the two recalls (EI_2-EI_1). Spearman r was interpreted according to Serra-Majem criteria.[24] The normality of distributions (EI_1, EI_2, and EI_2-EI_1) was assessed using skewness and kurtosis tests.[25] The data were not normally distributed, so the nonparametric Mann-Whitney U test[26,27] was used to test the significance of differences.

Generalized linear mixed models, with EI as continuous response variable, were used to assess whether EI differed between the first and second recall, and to assess whether assistance during the first vs assistance at the second recall influenced EI estimates. A linear mixed model was run first, but because the distributions of residuals were not normal and also right-skewed, a model with a gamma distribution and logarithmic link function was used:

$$\ln[E(EI_{ij})] = u_{0j} + \beta_1 recall2\ vs\ recall1_{ij} + \beta_2 assisted\ vs\ unassisted_{ij} \qquad \text{Equation 1}$$

where EI_{ij} is the energy intake estimated for child j (j=1,…,395) at the i-th recall (i=1 or 2). The parameter u_{0j} is the individual-specific random intercept, assumed to be normally distributed with zero mean and variance Σ. The fixed effect *recall2 vs recall1* is defined as 1 if the i-th recall of child j is the second recall, and 0 if the i-th recall of child j is the first recall. The fixed effect *assisted vs unassisted* is defined as 1 if child j was assisted at the i-th recall and 0 if the child j was not assisted at the i-th recall. The exponential of coefficient β_1 ($\exp[\beta_1]$) estimates the effect of the second vs first recall on EI. The exponential of coefficient β_2 ($\exp[\beta_2]$) estimates the effect of assistance vs non-assistance on EI.

EI estimates were classified as low, plausible, or high by calculating EI:BMR ratios and comparing them with expected sex- and age-specific EI:BMR ratios for children, using Goldberg cutoffs[28] modified from those used for adults as suggested by Lioret and colleagues[29] and Sichert-Heller and colleagues.[30] Details of this procedure are available elsewhere.[20]

Recalls with plausible and implausibly high EIs were combined because only four of 738 recalls had implausibly high EI. Factors associated with being a plausible or implausible reporter were investigated using a generalized linear mixed model (Equation 2). These factors were related to the dichotomized EI:BMR response variable Y via a logit link function. The distribution of the response variable was assumed to be binomial:

$$\mathrm{logit}[E(Y_{ij})] = u_{0j} + \gamma_1 recall2\ vs\ recall1_{ij} + \gamma_2 assisted\ vs\ unassisted_{ij} \qquad \text{Equation 2}$$

where the exponential of coefficient γ_1, $\exp(\gamma_1)$ is interpretable as an odds ratio. The odds of being a plausible reporter of EI at the second recall compared with the first. The exponential of coefficient γ_2, $\exp(\gamma_2)$ is also interpretable as an odds ratio: the odds of being a plausible reporter of EI when assisted compared with being unassisted (at a given recall). Both models (Equation 1 and Equation 2) were adjusted for sex, age, and BMI *z*-score. The latter model (Equation 2) was also run without adjustment.

Significance levels were adjusted using the Bonferroni-Holm correction for multiple testing.[31] The significance level was set at $\alpha<.05$. The analyses were performed using Stata version 14.0.[32]

RESULTS

Dietary intake (1 day) stratified by age and sex is shown in Table 1. Mean EI was 1,653 kcal/day in boys and 1,443 kcal/day in girls. EI repeatability, as assessed by Spearman r, was r=0.69 (P<0.001) for Group 1 (children assisted at first recall) and r=0.59 (P<0.001) for Group 2 (children assisted at second recall). Spearman r was better for girls both in Group 1 (girls r=0.71 [P<0.001] vs boys r=0.64 [P<0.001]) and Group 2 (girls r=0.65 [P<0.001] vs boys r=0.54 [P<0.001]).

Table 1. Daily dietary intake[a] of participants[b] as estimated by a self-administered child, adolescent, and adult nutrition assessment (SACANA), by sex and age group

	Boys								Girls							
Age group (y)	n	Body mass index *z*-score[c]	Food energy (kcal/d)	Food quantity (g/d)	Protein (g/d)	Fat (g/d)	Carbohydrate (g/d)	Sugars (g/d)	n	Body mass index *z*-score[c]	Food energy (kcal/d)	Food quantity (g/d)	Protein (g/d)	Fat (g/d)	Carbohydrate (g/d)	Sugars (g/d)
8-9	2	1.85	1,528	1,366	53	60	202	63	7	−0.02	1,646	1,710	66	70	185	52
10	22	0.99	1,364	1,430	54	46	183	55	26	0.74	1,316	1,524	48	48	172	58
11	29	0.91	1,551	1,744	63	54	199	78	33	0.41	1,443	1,534	50	58	178	74
12	33	1.00	1,651	1,692	69	65	193	72	42	0.71	1,349	1,426	49	47	179	64
13	57	0.73	1,638	1,898	67	56	213	91	61	0.46	1,525	1,577	59	60	185	71
14-17	42	0.62	1,901	1,800	72	77	229	80	41	0.76	1,465	1,550	58	59	176	62
All	185	0.82	1,653	1,753	66	61	207	78	210	0.58	1,443	1,533	54	56	179	66

[a]Daily intake estimated as mean of first and second SACANA recalls.
[b]Participants are a convenience sample of 395 children, aged 8 to 17 years, from eight European countries participating in the I.Family study.
[c]Age- and sex-specific *z*-scores of body mass index were calculated according to Cole and Lobstein[23] for 369 children with height and weight measurement available.

Table 2. Difference between daily energy intake (EI) estimated from second recall (EI_2) and first recall (EI_1) (measure of repeatability) according to whether the first (Group 1) or second (Group 2) recall was assisted

	All Children				Group 1 First Recall Assisted, Second Unassisted (n=202; 51%)				Group 2 First Recall Unassisted, Second Assisted (n=193; 49%)			
Variable	Mean (kcal)	Standard deviation (kcal)	Median (kcal)	IQR[a] (kcal)	Mean (kcal)	Standard deviation (kcal)	Median (kcal)	IQR[a] (kcal)	Mean (kcal)	Standard deviation (kcal)	Median (kcal)	IQR[a] (kcal)
EI_1	1,476	711	1,398	974 to 1,883	1,651	695	1,586	1,200 to 1,985	1,292	682	1,195	797 to 1,688
EI_2	1,607	696	1,502	1,089 to 1,946	1,544	689	1,450	1,056 to 1,856	1,673	700	1,550	1,165 to 1,991
EI_2-EI_1	132	629	12	−164 to 365	−106	504	−76***	−342 to 76	380	652	282***	0 to 693

[a]IQR=Interquartile range (25th and 75th percentiles of distribution).
***P<0.001 for between-group difference (nonparametric Mann-Whitney U test).

Table 3. Differences between daily energy intake (EI) estimated from second recall (EI_2) and first recall (EI_1) (measure of repeatability) according sex, age class, and whether first (Group 1) or second (Group 2) recall was assisted

	Group 1 First Recall Assisted, Second Unassisted (n=202; 51%)			Group 2 First Recall Unassisted, Second Assisted (n=193; 49%)			
		EI_2-EI_1			EI_2-EI_1		
Variable	n	Median (kcal)	IQR[a] (kcal)	n	Median (kcal)	IQR[a] (kcal)	*P* value[b]
Sex							
Male	89	−87	−422 to 10	96	318	−7 to 812	<0.001
Female	113	−61	−248 to 119	97	236	0 to 616	<0.001
Age class (y)							
8-9	5	−83	−211 to 0	4	267	−485 to 704	0.294
10	17	−83	−587 to 0	31	213	0 to 481	<0.001
11	34	−123	−489 to 0	28	247	−28 to 768	0.002
12	38	−112	−386 to 19	37	253	51 to 886	<0.001
13	65	−32	−232 to 203	53	388	132 to 769	<0.001
14-17	43	−65	−317 to 11	40	192	−13 to 385	0.001
All	202	−76	−342 to 76	193	282	0 to 693	<0.001

[a]IQR=Interquartile range (25th and 75th percentiles of distribution).
[b]*P* values for between-group differences in median EI_2-EI_1 (nonparametric Mann-Whitney *U* test).

Stratification by age class did not reveal systematic differences in EI correlation by age (data not shown).

Results for EI_2-EI_1 (repeatability measure) are shown in Table 2. Children who did the first recall assisted (Group 1) had a significantly ($P<0.001$) lower median difference (−76 kcal) than those who did the first recall unassisted (Group 2) (282 kcal). When children were stratified by age class and sex (Table 3), for both sexes and all age groups, differences between the first and second EI estimates were significantly smaller in Group 1 than in Group 2. Girls had better repeatability than boys, but no clear trend in repeatability (EI_2-EI_1) in relation to age was evident.

The results of the model to simultaneously assess whether EI differed between the first and second recall (EI_1 vs EI_2), and whether assistance ($EI_\mathbf{a}$ vs $EI_\mathbf{u}$) had an effect, are shown in Table 4. The second recall was associated with 1.12 (95% CI 1.07 to 1.17) times higher EI than the first recall. Assistance was associated with 1.19 (95% CI 1.13 to 1.24) times higher EI than no assistance.

Regarding EI plausibility—assessed by categorizing the EI:BMR as either underreported or plausibly reported—155 children (42%) were underreporters at first recall, and 214 (58%) were plausible reporters at first recall. The corresponding figures for the second recall were 140 (38%) and 229 (62%) (data not shown). The simultaneous effects of second recall vs first recall and assistance vs no assistance on the plausibility of EI estimates are shown in Table 5. Assistance during recall significantly increased the odds of a plausible EI (odds ratio 3.64, 95% CI 2.20 to 6.01) compared with no assistance. The odds of a plausible EI in the second recall did not significantly differ from that in the first (odds ratio 1.48, 95% CI 0.92 to 2.35).

DISCUSSION

The web-based 24hdr SACANA completed by children aged 8 to 17 years has been shown in this study to have good repeatability for EI estimates, and that repeatability (EI_2-EI_1) improved by assisting children at first use. The findings also indicate that, irrespective of age class or sex, when children are assisted at first recall they can complete the second recall without assistance with good repeatability and plausibility, and this is consistent with the recommendation of Kirkpatrick and colleagues[10] that a researcher should be present to provide guidance when children first attempt to complete the instrument. No clear trends in repeatability and plausibility in relation to age emerged, although several studies have

Table 4. Results of generalized linear mixed model[a] investigating effect of the first recall vs the second and of assisted vs nonassisted energy intake reporting

Recall	Exp(β)[b]	Standard deviation[b]	95% CI[b]	*P* value[b]
Second vs first	1.12	0.02	(1.07-1.17)	<0.001
Assisted vs unassisted	1.19	0.02	(1.13-1.24)	<0.001

[a]Model adjusted for age, sex, and body mass index *z* score.
[b]Derived from the generalized linear mixed model. The exponent of regression coefficient expressed the relative increase in energy intake in the second recall compared with the first, or the increase in reported energy intake in the assisted recall compared with the unassisted recall.

Table 5. Odds ratios (ORs)[a] and 95% CIs of participants[b] reporting plausible[c] energy intake at first self-administered child, adolescent, and adult nutrition assessment (SACANA) recall vs second, and at assisted SACANA recall vs unassisted

	Unadjusted Model			Adjusted Model[d]		
Recall	OR	95% CI	P^e value	OR	95% CI	P^e value
Second recall vs first recall (reference)	1.56	1.02-2.34	0.039	1.48	0.92-2.35	0.10
Assisted recall vs unassisted (reference)	3.75	2.35-6.00	<0.001	3.64	2.20-6.01	<0.001

[a]ORs of reporting plausible energy intake obtained from generalized linear mixed models.
[b]Participants are 369 children, aged 8 to 17 years, from eight European countries participating in the I.Family cohort study.
[c]Plausibility of reported energy intake obtained by comparing ratio of energy intake to basal metabolic rate, with expected age- and sex-specific energy intake-to-basal metabolic rate ratio, using Goldberg cutoffs for children, modified from those used for adults as described in text.
[d]Adjusted for age, sex, and *z*-score of body mass index.
[e]*P* values derived from generalized linear mixed model.

found that children's ability to complete self-administered dietary increases with age.[4,9,10]

Regarding the plausibility of EI estimates, it was found that almost 40% of EI estimates were implausibly low. This high proportion was expected because underreporting is a known characteristic of 24hdr instruments.[1,33] Because the recalls took place on 1 day only, a single day of intake has a wider distribution than does usual intake, with more respondents in the distribution tails.[3] The validity of self-reported SACANA in measuring to sugar intake was investigated in recent article.[34] The present study did not validate SACANA, but assessed the repeatability and plausibility of recall. Other variables (eg, water content of diet) were not investigated. However, most important nutrients (eg, macronutrients, most minerals, and B vitamins) have been shown to correlate with EI, and EI is widely accepted as a surrogate measure of recall completeness.[33]

A study limitation is that repeatability was only assessed for recalls 1 to 4 hours later. Because a gold standard measure of dietary intake is not available, the possibility of overestimation of repeatability due to a memory effect cannot be excluded. Another limitation lies in the fact a convenience sample of children (and parents) who agreed to participate was studied, and not enough children in different age classes were recruited to have the power investigate the effect of age on recall repeatability and plausibility.

CONCLUSIONS

We found that when children are assisted with the initial compilation of a web-based 24hdr, subsequent independent completion is more likely to be plausible and repeatability improves. A future, adequately powered study is required to investigate the age range for which assistance is advisable.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

All authors contributed to the acquisition of the data, revised the article, and approved the final version of the manuscript. V. Pala and V. Krogh conceived the study and participated in its design and coordination, V. Pala and R. Murtas drafted the manuscript, and R. Murtas provided the statistical analysis.