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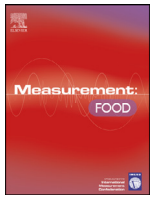

Assessment of bias and associated factors for food portion quantification with photos in Brazil

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ABSTRACT

Background: Food portion size estimation is an important source of error in obtaining dietary data. While food portion photos are known to aid the food portion estimation, the validation of photos are required.
Objective: This study aimed at evaluating the bias and associated factors in quantifying the size of food portions eaten during lunch, and estimated by a 24-Hour Recall (24HR) interview, with and without the use of photos. Design and Participants: A validation study was carried out with 140 adults in the Brazilian cities of Curitiba and Aracaju. Data collection began in the first semester of 2017, lasting approximately one year. On the first day, participants consumed foods during a lunch with 10 possible items; each weighed after selection. The following day, a 24HR interview was applied. Participants were randomly allocated into two groups, according to the use of food portion photos during the interview.
Main outcome measures: Means of the consumed and reported food amounts, and the difference between them were estimated.
Statistical analyses performed: The effect of the use of photos was obtained by evaluating the odds of correctly estimating each food portion, (±10% and ±25%), using logistic regression. Additionally, the effect of using photos, the main predictor, was adjusted by other variables (e.g. age and educational level). Results: Rice, beans and meatballs had the greater differences between the assessed groups. The odds of success in estimating the portion size were greater amongst those that used the photo to estimate their consumption of rice and beans; while the contrary was observed for meatballs. Carrot, lettuce and juice had similar biases between the groups. Furthermore, educational level, cooking habit, and study centre location influenced the correct estimation of some foods.

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Conclusion: The evaluated photos can assist to estimate food consumption, especially two traditionally Brazilian foods, rice, and beans. The use of the meatball photo was unsatisfactory and further assessments are needed for the remaining photos. Thus, the evaluated photos album can be a useful tool in estimating Brazilian food consumption although further developments and assessments are also granted.

Introduction

The study of associations between food consumption and the occurrence of diseases has been hampered due to errors present in the assessment of diet [1,2]. In particular, estimation of food portion sizes has been pointed out as an important source of measurement error in obtaining dietary data, which will influence the amounts of food reported and may lead to biased conclusions [3,4].

In an attempt to mitigate errors in estimates and harmonize investigations of dietary data, visual resources, such as photographs of food portions, household measurements, and food shapes, have been widely developed and validated as tools to help in dietary evaluations [3,5–11]. This has been done mostly in Europe and the United States, with fewer evaluations in low and middle-income countries [3], such as in Malawi in Africa [9] and Ecuador in South America [12].

The use of photos seems to help to obtain more accurate estimates of the amount of food consumed [5,8,11–21]. However, a recent systematic review concluded that there is still a lack of validated portion size estimation tools and a need for more studies with applicability to targeted settings and populations [3].

Further to that, most of the published studies so far have focused their assessment on using a real-time (i.e. perception assessment) or recall approach (conceptualization-memory assessment) for portion size estimations in the overall population [3], without actually comparing participant responses related to the use and non-use of visual resources during a 24 h dietary recall (24HR) for an actual evaluation of the use of photos during the dietary assessment. The use of the photos with 24HR is of great interest since it has been suggested as the most suitable method for monitoring dietary intakes of populations [22,23].

Moreover, studies in different settings around the world have evaluated influences on the estimate of bias, including sex, educational level, age, Body Mass Index (BMI), familiarity with and training in the estimation of food consumption, as well as culture and region in which the study was intended to be used [5,11,15,16,20,21,24–26]. However, the results were not always in agreement. For example, some found that men tend to underestimate their portion sizes as compared to women [11,24,25] while others found no statistical difference [5,15,20]. Likewise, having a higher educational level seemed to help in the quantification of portion sizes [21,26] while this was not noted in some other studies [5,11].

Towards developing a visual aid in Brazil, a photographic album of food quantification [27] was developed along with a Brazilian version of the computerized 24HR GloboDiet software [28]. The authors expected that the album could assist in food portion quantification, with or without the need for the GloboDiet software. As an independent tool, the photo album could aid in the recall of the amount of each food consumed. Combined with any other dietary methodologies, such as dietary records or non-computerized 24HR, the use of the photographic album would also contribute to the harmonization and standardization of dietary data collection in the country.

Latest results of the VALIDA Study, "Validation of instruments to quantify the Brazilian diet", which evaluated the cognitive ability of perception in adults using the above-mentioned photo album, indicated that the photos seemed to help in recall of the quantification of food portions. The average error was −1.1% for printed photos and +6.4% for digital. Nonetheless, the observed error percentage varied from food to food. For printed photos, the range of error percentage varied from −18.5% (Margarine) to 20.8% (Chicken); while for digital photos varied from −20.2% (Margarine) to 39% (Popcorn). Now, complementing what has been assessed, the present analysis of the VALIDA study intended to assess the use of photos to assist memory in adults when quantifying food portions in an interview-based 24HR dietary survey.

Considering the lack of validation studies in Brazil, the need for more validation studies targeted to specific populations, the lack of consensus related to the aspects that influence the validity of portion size photographs, and the recently developed manual of food portion quantification in Brazil, the objective of this study was to evaluate bias and associated factors in estimating food portions during lunch, estimated by a 24HR interview, with and without the use of printed photos. We hypothesize that the photos will aid the report of food intake quantities during the 24-hour interview influenced by different aspects in this population, such as educational level.

Materials and methods

This is a validation of the Brazilian GloboDiet food portion quantification album through a validation study, which assessed the bias in food quantification during the 24HR interview. It was developed at the Federal University of Paraná (UFPR) in Curitiba and the Federal University of Sergipe (UFS) in Aracaju, as part of the "VALIDA" study. The project was approved by the Research Ethics Committee of both universities, number 1,363,816, in 2015. In addition, written informed consent was obtained from all participants. Data collection began in the first semester of 2017, lasting approximately one year.

The study locations of Curitiba and Aracaju have economic and cultural differences that can impact their food habits. Curitiba, located in southern Brazil, is a region with a significant cultural impact from the European colonization. It is the capital of Paraná state, with an estimated population of 1963,726 individuals in 2021, a human development index (HDI) of 0.823, and a Gini Index of 0.55. Aracaju, located in the Northeast region, obtains its cultural characteristic greatly from the cultural mix between Brazilian, African, and European indigenous populations. Aracaju is the capital of Sergipe state, with an estimated population of 672.614 inhabitants, an HDI of 0.777, and a Gini Index of 0.62, considered less developed than the city of Curitiba [29].

Photo album of food portions used in the study

We used a photo album of food portions developed with the Brazilian population in mind [21,27]. The album has 96 photos, 32 new photos produced in the first half of 2015, and 64 already existing photos, taken from the International Agency for Research on Cancer (IARC)/World Health Organization (WHO) album, developed in Europe and adapted for use in Brazil [27,30]. The instrument contains the following methods of food quantification: photos of household measurements and food portions, food shapes, and standard units. Photos of food portions refer to graduated options, from smaller to larger options. A fork and a knife (or spoon) are used as reference measurements in the photos to assist in the portion estimation.

In this study, 10 foods were evaluated: rice, beans (black beans in Curitiba and carioca beans in Aracaju), meatballs, lettuce, grated carrots, salt, white vinegar, fruit juice (grape juice in Curitiba and mango juice in Aracaju), water, and fruit (apple in Curitiba and mandarin Aracaju). The selection of foods was based on the following criteria: representation of different food groups and formats (e.g. liquids, solids and amorphous); frequency of consumption by the population based on data

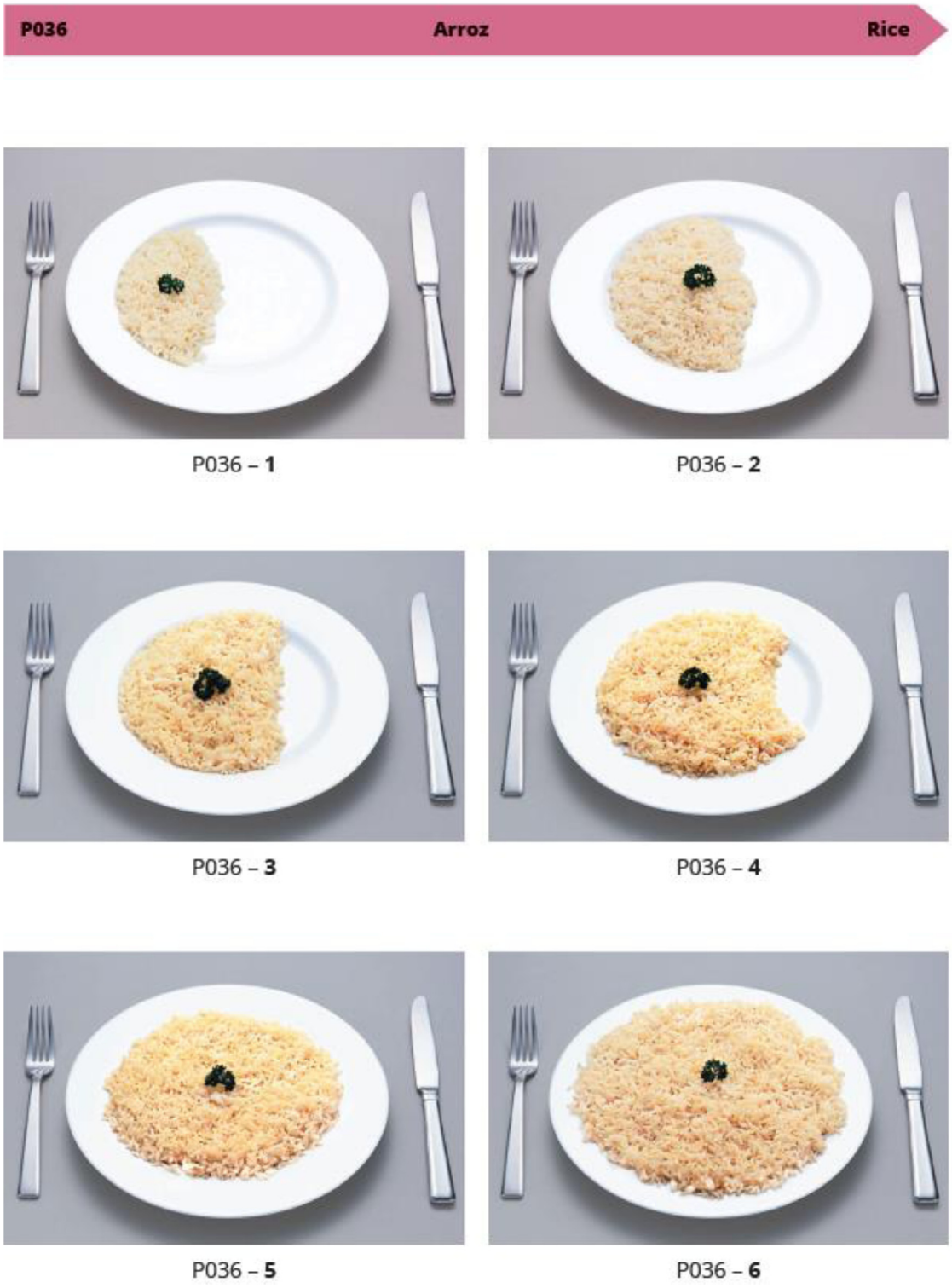

Fig. 1. Food portion photos of rice.

from National Brazilian Food Consumption Survey [31]; consideration of regional culture in Curitiba and Aracaju (bean type), price (juices) and seasonality (fruits). For this selection, it was also considered that the combination of foods provided would be a good representation of lunchtime in the country, including rice and beans with a protein source, two vegetables, two options of beverage, and a fruit. Salt and vinegar were used to season the vegetables. Examples of the pictures are shown in Fig. 1 and the supplementary material. The complete photo album can be found at www.gupea.ufpr.br.

Participants

A total of 140 adult volunteers were recruited (70 in Curitiba and 70 Aracaju) through direct invitation and by posters placed in social media

and the university buildings. These were students, teachers, technicians, general services staff and university visitors. It was a convenience sample, which we considered that we would need at least 50 subjects in each study location with the addition of 20 more for possible dropouts. However, there were no sampling losses during the survey. The inclusion criterion was adults between 18 and 65 years of age. The exclusion criteria were individuals with severe visual or neurological deficits, with food intolerance or allergy, pregnant women, and vegetarians.

Recruitment followed pre-defined quota for sex (half men and half women) and educational level (< or ≥ 9 years of study). These characteristics were expected to influence the validity results and therefore we opted to control them during recruitment [11,21,25,26] to avoid underrepresentation of the assessed groups. In Brazil, 9 years of education are considered elementary education, not including high school.

Furthermore, participants received a unique code based on their characteristics (sex, educational level) at the beginning of the survey, which also indicated whether they would be allocated to one of the groups: photo album use or not. Random.org was used to generate the random allocated codes in a block randomization. As such, recruitment was controlled according to the pre-defined quotas based on sex and educational level and once a group was completed, no further recruitment was conducted for that specific group (e.g. women with more than 9 years of study).

Study design

Pre-test and pilot studies were conducted in both study locations. Researchers were trained regarding all study procedures, especially to prevent discomfort during participants' food consumption and dietary recall. Participants visited the study centre twice between April 2017 and April 2018, as follows:

Day 1 — Study introduction and meal consumption

On the first visit, a questionnaire was applied to identify the participant, and a double-check was done to verify the study criteria inclusion. All participants receive full explanation about the study procedure. Weight and height were then measured to calculate the BMI (kg/m^2), estimated and classified according to the WHO [32]. Participants were also asked about whether they were in the habit of cooking their meals at home (always, sometimes, never or rarely).

Afterward, the individuals were referred to a laboratory, where they could choose to consume or not the offered foods displayed on an open counter, serving themselves freely and repeating if wished. We chose to carry out this assessment during lunchtime given the time and costs involved to offer other meals, which we could not afford it. Household measurements (spoon, ladles) were used to serve all foods, including salt and vinegar (small spoons). The weight of each food was recorded after the individuals placed the chosen amounts, one at a time, on a plate on a scale. Trained researchers discreetly wrote down the weight of the served food while participants were prevented to see the screen numbers on the scale. After consumption, the food leftovers on the plate were weighed and discounted to obtain the actual consumed portion (in grams) for each served food. The digital scales used (Katashi brand - capacity 3200 g and sensitivity 0.01 g) had been calibrated before the study.

Food densities (density = mass/volume) were also measured in triplicate during the study in both centres. To this end, food weight was defined as 30 g and the sample volume was obtained from the displacement of the food in the water.

Meals were carried out in laboratories, similar to kitchens. In an attempt to make the environment more comfortable for individuals, music was played during the meal. The duration of the meals lasted as long as the individuals wished. After the meal, participants answered a questionnaire about the frequency of consumption of the offered foods ("daily", "weekly", "monthly", "annually" and "never") and indicated whether or not they were acquainted with the served food. The number of participants varied from one to three during each session.

Day 2 - 24HR

Individuals were invited to return the day after for another study procedure. They were not informed that a 24HR would be applied and that they needed to remember the food consumed the day before. The 24HR consisted of an interview-based dietary data collection, conducted by five trained nutritionists in a quiet room (3 in Curitiba and 2 in Aracaju).

Specifically, the 24HR interviews were conducted using GloboDiet software [28], which is based on the multiple pass method and has been previously validated for monitoring and epidemiological purposes [33–35]. The software includes the following parts: a) individual identification; b) definition of the meal and place of consumption; c) quick listing of foods consumed; d) description and quantification of foods; and e) general review of the 24HR. In the quantification step, the software offers different estimation options depending on food characteristics: photos of food portions and household measurements, household measurements without photos, standard portions, food shapes, and standard units in grams or ml. Based on the initial allocation, participants could be in either one of the groups for the quantification step of the 24HR:

Group with the printed photo album (n = 71): Participants who were subjected to the 24HR interview with the help of photos of food portions (for rice, beans, meatball, carrot, and lettuce), photos of standard units (for fruit - apple and tangerine) and photos of household measurements (glasses for water and juice, spoons for salt and vinegar). Fractions, multipliers and in-between photos selections were allowed.

Group without the printed photo album (n = 69): Participants who were subjected to the 24HR interview without the help of photos, and reported the quantities consumed in a traditional way using standard units and household measurements.

Data analysis

The recorded data about the true intake were entered into the EpiData software version 3.1 [36]. The recalled food data in the computerized 24HR were automatically saved in the software during the interview. Subsequently, all 24HR data were checked for inconsistency (e.g. extreme values) and missing information. Notes of inconsistencies created automatically by the software or entered by the interviewer were treated in a standardized way directly in GloboDiet, using as reference household measurement information from the national survey, when applicable [31]. Then, information on the 24HR recalled portions from the lunch meal and those actually measured on the first day were tabulated in EpiData, and exported to SPSS software version 22.0 [37], where they were grouped by individuals.

After determining the weights of the consumed and recalled food portions from the lunch meal occasion, the difference between the estimated and the true portion size was calculated (i.e., bias) in grams. Then, the relative bias was estimated in grams (=estimated weight-true weight/true weight).

The means of consumed and recalled food portions, as well as the means of bias and relative bias of each food, with and without the photo album use, were calculated. All participants who did not consume a particular food or who usually did, but said they had not eaten it during the 24HR (n = 3), were omitted from the analysis. Here it was assumed that participants who did not report an eaten food did not have the chance to use the photo to quantify the consumption and, therefore, the photo´s use could not be assessed. Furthermore, each recalled portion size was determined to be within a certain range of true. With this intent, we evaluated proportions ±10% and ±25% of true intake, as previously used [19], and carried out logistic regression

Table 1
Characteristics of the study participants according to photo album use.

Characteristics	Total (n 140)				With photo album (n 71)				Without photo album (n 69)				
	n	%	Mean	SD	n	%	Mean	SD	n	%	Mean	SD	p
Sex													
Women	72	51			36	51			36	52			0.86
Men	68	49			35	49			33	48			
Study centre													
Curitiba	70	50			36	51			34	49			0.87
Aracaju	70	50			35	49			35	51			
Age (years)			31	11			32	12			30	11	
18 – 45	115	82			57	80			58	84			0.56
46 - 65	25	18			14	20			11	16			
Educational level (years of study)													
Low (< 9)	47	34			23	32			24	35			0.77
High (≥ 9)	93	66			48	68			45	65			
BMI (kg/m2)			25	5			25	4			25	5	
Underweight (< 18.5)	4	3			3	4			1	2			0.74
Normal weight (18.5 - 24.9)	77	55			38	54			39	57			
Overweight (25 - 29.9)	37	26			20	28			17	25			
Obesity (≥ 30)	22	16			10	14			12	17			
Cooking habit													
Yes/Sometimes	101	72			51	72			50	72			0.93
No/rarely	39	28			20	28			19	28			

p = Chi-square test p-value, except for BMI where Fisher test was performed.
SD = Standard deviation.

to examine differences in the odds of meeting these criteria by album use.

Next, simple and multiple logistic regression analyses were carried out [38]. In the simple logistic regression, only the effect of the intervention (photo album use) was considered. Besides the effect of using photos, the following covariates were also evaluated in multiple logistic regression at first: sex (women and men), educational level (< or ≥ 9 years of study), BMI (kg/m^2), age (years), habit of cooking for self (yes or no), frequency of food consumption (daily, weekly, monthly and annually), interviewer (coded 1 to 5), and centre (Aracaju or Curitiba). The selection of variables to compose the final multiple logistic regression model was carried out separately for each food in two stages: 1) Inclusion of all variables in the model with significant effect at level $\alpha = 20\%$ in unadjusted analyses; 2) Inclusion of variables in the model with significant effect at level $\alpha = 10\%$, when adjusted for the effects of all variables together: sex, BMI, and age. Additionally, the interaction effect between photo album use and study centre (Curitiba and Aracaju) was also investigated to identify a possible regional difference in memory bias. For all analyses, the level of significance considered was 0.05 and the analyses were conducted with the use of the software R (Vienna, Austria), version 3.4.2 [39].

Results

Table 1 shows the characteristics of the study population. Out of 140 individuals, most of them were between 18 and 45 years old (82%), had more than 9 years of study (66%), were normal weight (55%) and were used to cooking for themselves (72%). No significant differences on nutritional status and cooking habit were observed between the groups of individuals who used ($n = 71$) and did not use the album ($n = 69$).

The frequency of consumption was different for each food evaluated in the study. Rice was the only food consumed and reported by all participants. The food with the least consumption was water ($n = 16$), followed by salt ($n = 48$), fruit (n=56), and vinegar ($n = 55$).

The mean values of consumed and reported food portions, as well as the mean bias, and relative bias of groups who used the photos, are presented in Table 2. In particular, the relative bias was different for some of the foods evaluated, according to the groups of photo use. The greatest differences were observed for rice (−15% with photo album and +30% without album), beans (−13% with photo album and +116% without album), and meatballs (−24% with photo album and +25% without album). On the other hand, biases between fruit and juice were similar. The largest relative bias, whether the photo album was used or not, was observed in salt estimation (+ 478% with photo album and + 815% without album) and vinegar (+ 639% with photo album and + 501% without album).

The proportions of foods for which the recalled portion sizes were accurate within ±10% and ±25% of true portion sizes (in grams) are shown in Table 3, confirming the results that the foods with the most errors were salt and vinegar, regardless of photo use. For rice, beans, lettuce, water, juice, and salt, the proportions within ±10% and ±25% were higher when using the photo album. For vinegar, the error was similar in the range of ±10% and lower in the range of ±25% (88% vs 93%) while for carrots accuracy of recall was similar in the range of ±10% (88% vs 89%) and ±25% (77% vs 76%). On the other hand, the participants who used the photos made more errors in the estimation of their consumption of meatballs, both in the accuracy range of ±10% (90% vs 76%) and ±25% (71% and 49%). For fruits, the error was similar amongst groups in the ±10% range and greater for the group with photos, in the ±25% range (65% vs 52%).

Due to the low number of participants with a proportion of accuracy within ±10% and ±25% for salt, vinegar and water ($n < 8$), we did not include these foods in the following analyses. The same is true for fruit since the number of participants was low ($n = 56$).

In Table 4, we evaluated the odds of correcting quantifying the food amounts with and without the use of the photo album. Increased odds of success were observed with the use of photos for rice and beans. The odds were 5.9 and 2.9 times higher in the group that used the photo album to assess rice when compared to the group that did not use it, within the ranges of ±10% of ±25%, respectively. For beans, the odds were 3.6 times higher for those who used the photo album as compared to the group that did not use it, within the ±25% range ($p = 0.002$). However, for meatballs the odds were lower for the group using the photo album (OR 0.35 $p = 0.03$ at ±10% range and OR 0.38 $p = 0.008$ at ±25% range). (Table 4). For lettuce, carrots, and juice, the OR was close to 1 within the range of ±10% and ±25%, indicating similar performance between the two groups.

After adjustment (Table 5), a significant association was observed between the album use and educational level in the evaluation of rice. Within the ±10% performance range, increased odds were observed in

Table 2
Number of participants who reported consuming the food item, mean and standard deviation of consumed and estimated portion size in 24hr recall, bias (g) and relative bias, with and without album use.

Food	Album	N	True Portion Size (g)		Estimated Portion Size (g)		Bias (g)		Relative Bias (g)	
			Means	SD	Means	SD	Means	SD	Means	SD
Rice	With	71	114.47	64.16	92.37	63.38	−22.09	51.62	−0.15	0.31
	Without	69	113.58	61.26	153.82	149.42	40.24	120.64	0.30	0.93
Beans	With	71	124.48	57.67	102.56	63.24	−21.91	49.52	−0.13	0.43
	Without	66	117.70	57.40	236.03	156.96	118.33	134.25	1.16	1.33
Meatballs	With	70	119.25	49.30	83.67	47.00	−35.58	48.87	−0.24	0.42
	Without	67	102.34	45.94	120.46	55.85	18.11	45.19	0.25	0.47
Carrot	With	60	25.05	16.94	22.40	10.66	−2.64	17.67	0.15	0.84
	Without	59	26.54	15.73	38.93	41.80	12.39	36.88	0.50	1.14
Lettuce	With	65	16.52	8.92	21.27	15.70	4.75	15.80	0.54	1.40
	Without	60	16.52	11.33	25.30	23.90	8.77	22.30	0.78	1.17
Water	With	9	147.63	64.37	193.88	76.01	46.25	69.89	0.44	0.67
	Without	7	182.06	68.98	253.35	137.06	71.29	179.03	0.82	1.97
Fruit	With	29	137.43	33.13	105.85	40.10	−31.58	48.18	−0.18	0.38
	Without	27	133.55	23.63	110.41	34.67	−23.14	35.97	−0.15	0.28
Juice	With	58	192.43	72.75	226.12	76.72	33.69	68.83	0.24	0.38
	Without	56	194.25	71.57	254.17	103.02	50.92	61.92	0.29	0.38
Salt	With	25	0.59	0.45	1.56	0.94	0.95	1.01	4.78	7.33
	Without	23	0.34	0.36	1.30	1.70	0.95	1.59	8.15	14.71
Vinager	With	27	2.20	1.58	5.72	4.43	3.51	4.74	6.39	17.4
	Without	28	1.76	1.52	7.71	9.44	5.95	9.18	5.01	6.04

Bias = estimated portion size - true portion size.
Relative bias = (estimated portion size- true portion size)/true portion size.
SD = Standard deviation.

Table 3
Proportion of reported intake within ±10% and ±25% of the true intake, with and without photo album use.

Food	Photo Album		Within ±10% of true		Within ±25% of true	
		N	n	%	n	%
Rice	With	71	19	26.8	36	50.7
	Without	69	4	5.8	18	26.1
Beans	With	71	10	14.1	28	39.4
	Without	66	4	6.1	10	15.2
Meatballs	With	70	7	10.0	20	28.6
	Without	67	16	23.9	34	50.7
Carrot	With	60	7	11.7	14	23.3
	Without	59	6	10.2	14	23.7
Lettuce	With	65	8	12.3	22	33.8
	Without	60	7	11.7	15	25.0
Water	With	9	1	11.1	5	55.6
	Without	7	2	28.6	3	42.9
Fruit	With	29	6	20.7	10	34.5
	Without	27	5	18.5	13	48.1
Juice	With	58	12	20.7	28	48.3
	Without	56	9	16.1	25	44.6
Salt	With	25	2	8.0	5	20.0
	Without	23	1	4.3	3	13.0
Vinegar	With	27	1	3.7	3	11.1
	Without	28	1	3.6	2	7.1

the group that used the photo album (OR 6.1 $p = 0.002$), as compared to those that did not use it. Moreover, individuals with higher education were 4.2 times more likely to correctly estimate the amounts than those with low education ($p = 0.03$). Within the ±25% range, the odds were 3.1 times higher amongst those that used the photo album ($p = 0.002$). The odds of an individual with high education level being able to estimate correctly the amounts of rice were 3 times higher than those with low education ($p = 0.007$). Similarly, individuals with high education level had 2.6 times more chance to estimate correctly the amounts of consumed lettuce as compared to the lower educated ones ($p = 0.04$), within the ±10% range, but not at the ±25% range.

The variables age, BMI, sex, familiarity with the food, and interviewer were not associated with the bias difference between the two groups of album use, thus showing no effect on the presented results.

The quantification of carrots presented similar results amongst the groups. However, increased odds were observed, within the range of ±25%, when adjusting for those who were used to cooking (cooking habit). Individuals who were used to cooking for themselves presented 2.8 times more chance ($p = 0.02$) of correctly estimating the consumed amount than those who did not cook (Table 5).

Furthermore, the effect of the location of the study centre was observed in the evaluation of beans and meatballs, within the ±25% performance range (Table 5). Individuals who used the photo album in Curitiba were 9.9 times more likely to estimate correctly the consumption of beans than those who did not use it ($p<0.001$). On the other hand, the odds of correctly estimating the consumption of meatballs in Curitiba were 0.08 less for the group who used the photo album than those who did not. The same was not observed in the city of Aracaju (OR=1.485; $p = 0.48$ for beans and OR=1.242, $p = 0.74$ for meatballs).

Table 4
Unadjusted Odds Ratio (OR) and 95% confidence interval (CI) by photo album use, within ±10% and ±25% of true intake.

			Within ±10% true intake			Within ±25% true intake		
Foods	**Photo Album**	**n**	**OR**	**CI 95%**	**p***	**OR**	**CI 95%**	**p***
Rice	Without	69	1	–	–	1	–	–
	With	71	5.937	(1.902; 18.531)	0.002	2.914	(1.431; 5.932)	0.003
Beans	Without	66	1	–	–	1	–	–
	With	71	2.540	(0.756; 8.539)	0.131	3.646	(1.599; 8.314)	0.002
Meatballs	Without	67	1	–	–	1	–	–
	With	70	0.354	(0.134; 0.926)	0.034	0.388	(0.191; 0.786)	0.008
Lettuce	Without	60	1	–	–	1	–	–
	With	65	1.062	(0.360; 3.341)	0.912	1.534	(0.704; 3.341)	0.28
Carrots	Without	59	1	–	–	1	–	–
	With	60	1.166	(0.367; 3.702)	0.793	0.978	(0.419; 2.282)	0.96
Juice	Without	56	1	–	–	1	–	–
	With	58	1.362	(0.524; 3.521)	0.525	1.157	(0.553; 2.417)	0.70

*p estimated using simple Logistic Regression.

Table 5
Adjusted Odds Ratio (OR) and 95% confidence interval (CI), by selected variables, within ±10% and ±25% of true intake.

			Within ±10% true intake			Within ±25% true intake		
Food	**Variable**	**Study centre**	**OR**	**CI 95%**	**p***	**OR**	**CI 95%**	**p***
Rice	Without photo album		1	–	–	1	–	–
	With photo album		6.143	(1.937; 19.481)	0.002	3.104	(1.477; 6.522)	0.002
	Low educational level		1	–	–	1	–	–
	High educational level		4.232	(1.151; 15.552)	0.03	3.073	(1.344; 7.025)	0.007
	Cook Yes/Sometimes				1	–		
	Cook no/rarely				0.465	0.08		
Beans	Without photo album	–			1	–		
	With photo album	Curitiba			9.999	<0.001		
		Aracaju			1.485	0.48		
Meatballs	Without photo album	–			1	–		
	With photo album	Curitiba			0.087	<0.001		
		Aracaju			1.242	0.74		
Lettuce	Without photo album				1	–		
	With photo album				1.566	0.27		
	Low educational level				1	–		
	High educational level				2.602	0.04		
Carrot	Low educational level				1	–		
	High educational level				0.924	0.86		
	Cook Yes/Sometimes				1	–		
	Cook no/rarely				2.850	0.02		

*p estimated by multiple logistic regression / adjusted for album use, education, BMI, cooking habit, and frequency of consumption after covariates selection. Data are presented only for those foods that had a covariate influencing the results.

Moreover, the average relative bias related to the estimate of beans estimated with the photo album use in Curitiba (−0.02 g or 2%) was considerably lower than that observed in Aracaju (−0.25 g or −25%), suggesting that the impact on the photo album use in Curitiba was greater. Regarding the meatballs, the average relative bias without the use of the album was lower in Curitiba (−0.08 g or −8%) than in Aracaju (0.58 g or +58%) – Table 6.

Discussion

The effect of using photos to estimate food portion sizes during the 24HR interview and its associated factors were evaluated in this study. Overall, the results showed that the bias was smaller with the use of the photo album when estimating rice and beans. On the other hand, the meatball photo contributed to greater chances of error in the food quantification. Furthermore, the estimation of carrot, lettuce and juice did not show significant differences between the two assessed groups, suggesting that the photos had no effect on the quantification of these foods.

It is noteworthy to observe the smaller error in the estimation of the rice and beans. These two foods are culturally traditional in the country and are among the three most consumed foods by the Brazilian population [31,40]. Therefore, they are important sources of nutrients, and the error in their estimation may have an important impact on the prediction of population consumption.

The intakes of salt and vinegar presented the largest relative biases in all assessments. Even though it was not possible to infer more about their assessment due to the small sample size, our results suggest that household measurements photos could not help the estimation of these two ingredients. In fact, the assessment of ingredients like salt is often hampered in dietary assessment [41]. Individuals do not measure the amount of added salt when cooking. Adding and tasting are a common practice done when seasoning food and this poses a limitation in estimating salt intake from home cooking.

Two factors were associated with bias when estimating food portions with the use of the photo album: educational level and cooking habit. A high educational level seems to contribute to the chances of correctly estimating amounts of rice and lettuce. These findings are in line with that

Table 6
Number of times consumed, means and standard deviation of true and 24-h recalled portion sizes, bias (g) and relative bias (g) of beans and meatball per study centre, with and without photo album use.

Food	Study centre	Photo album	n	True Portion Size (g)		Estimated Portion Size (g)		Bias (g)		Relative Bias (g)	
				Means	SD	Means	SD	Means	SD	Means	SD
Beans	Curitiba	With	36	121.30	66.70	113.76	76.15	−7.86	51.38	−0.02	0.48
		Without	33	118.03	56.02	265.27	167.57	147.24	143.57	1.42	1.47
	Aracaju	With	35	127.74	47.40	91.37	44.83	−36.37	43.67	−0.25	0.34
		Without	33	117.38	59.63	206.80	142.13	89.41	119.47	0.90	1.14
Meatball	Curitiba	With	36	127.66	57.48	84.79	38.08	−42.87	43.82	−0.27	0.32
		Without	33	118.55	47.54	106.69	48.41	−11.86	32.40	−0.08	0.19
	Aracaju	With	34	110.34	37.67	82.48	55.48	−27.85	53.26	−0.21	0.51
		Without	34	86.60	38.87	133.82	59.95	47.21	35.98	0.58	0.43

Bias = estimated portion size - true portion size.
Relative bias = (estimated portion size- true portion size)/true portion size.
SD = Standard deviation.

observed by Huybregts et al., where women who attended schools had a greater chance of correctly estimating their food consumption. Similar results were also found in the VALIDA study, in which individuals with low education had greater difficulty in quantifying food portions using virtual photos on tablets compared to individuals with higher education [21,26]. The study suggested that Brazilian individuals with low education may have difficulties in using photos, due to their interpretation and the way they usually consume the food. For example, the fact that they consume their food packed in aluminium containers (so-called "marmitas") seems to make it difficult to interpret the photographs; the foods are often mixed in the containers and the quantities are not easily estimated [42]. Therefore, it is recommended that interviewers try to help these individuals more and make sure that visual resources are correctly understood during the dietary evaluation. We suggest, for instance, that interviewers spend more time and attention during the quantification of foods from an interviewee with low education, making sure that what is being reported is the most accurate information the participant can give.

The effect of cooking habit was a contradictory result observed in this study. The chances of success in estimating carrot correctly were 2.8 times higher amongst those who did not cook as compared to those who did ($p = 0.02$). This information did not match with the findings from the qualitative assessment of the VALIDA study, in which it was reported that individuals who were used to cooking had less difficulty in the use of the photos [42]. No other study seems to have evaluated the habit of cooking when validating photos to estimate food consumption. We, therefore, suggest that these results should be further evaluated and clarified.

No association was found between the bias in the estimates of food consumption and the variables age, BMI, sex, and familiarity with the food. This finding differs from that observed in some studies [25,43] but is in line with others [8,16,44,45]. This perhaps can be explained by the inherent characteristics of the different samples. Since this is the first study showing results from Latin America, the observed lack of association between results owing bias and sample characteristics could therefore be informative.

When evaluating the effect of the location of the study centre, the chances of correctly estimating portion size was higher amongst those who used the photo album in Curitiba than in Aracaju. Aligned with the results of Curitiba, an acceptable error was observed in the evaluation of beans using the printed photos in the perception analysis of the VALIDA study (1.2%). A possible explanation for different centre results could be the fact that the beans served and consumed by the participants were different in the two locations. While "carioca beans" were served in Aracaju and "black beans" were served in Curitiba, a unique set of photos of black beans was used in the validation at both locations. It is therefore suggested that the usefulness of the photograph is higher when the observed picture is identical to the food consumed. Nevertheless, the literature has studies that show that amorphous foods, such as "beans with broth", can be also estimated with less precision depending on the individual perception [3,20,21].

The less precision of amorphous foods may be related to their irregular shape and the depth of the utensils depicted in the photos, which can distort the concept of volume, and may therefore influence the validity results. This has been noted with two foods in the perception assessment of the VALIDA study, in which Popcorn and Feijoada were not well estimated [21].

Meatballs represent another food where an interaction between the location of the study centre and the bias was observed. Only in Curitiba, the chance of a correct report (± 25%) was lower for the group that used the photo album compared to those who did not use it. It should be noted that the meatballs portrayed had a specific characteristic in relation to the other photos used. Each portion image presents two options of meatball sizes in the same photo (see supplementary material). Consequently, individuals interpreted this photo inappropriately and meatball intakes were underestimated. It is therefore suggested that this photo be reviewed since its use reduced the chances of obtaining more accurate estimates in the consumption of meatballs. In addition, images with dubious interpretation, such as the picture of the meatball, can cause errors in dietary evaluation and should be used with caution.

In an attempt to clarify the regional differences found in the study, the usual frequency of the consumed foods per study centre was also evaluated. However, no associations were found between the frequency of food intake and the observed bias in estimates of portion size. Food densities of the served foods in each study centre were also investigated since this can influence the final served amounts. For instance, the density of the beans served in Aracaju could be different from the one prepared in Curitiba due to its mode of preparation or intrinsic content. However, there were no differences in the reporting between them (results not presented).

Limitations and strengths of the study

The present study may present some limitations. First, the controlled food intake ambience may have interfered in the results of the validation study. Participants may have been more attentive to their food intake, which may have helped them remembering what was eaten during the 24-HR therefore probably leading to smaller biases in the assessment. If this was the case, however, it happened to both groups. Second, the interviewers who administered the 24HR also participated in the weighing and serving of the foods; this may have influenced the food recall. However, we stress that interviewers were trained to limit potential inferences in the recall of food consumption. Third, the food consumption was different amongst the participants, impacting on the number of in-

vestigated foods. Consequently, the results of water, salt, vinegar and fruit were fairly inconclusive. Fourth, only 10 foods were evaluated in the two Brazilian cities studied. Nevertheless, these represented different types of foods and can already give us an idea of the performance of the manual. Fifth, a convenience sample was used and may not be representative of the general population, thus requiring further investigations. Sixth, the assessment included only one meal recalled in only one day of 24HR, which is justified by the study complexity of controlling a full day of food consumption. Finally, it could be questioned whether participants who consumed a specific food but did not report eating it should be included in the analysis, to account for extra source of underreporting. We opted for excluding those reports because we considered that the description of a food is a different component of the 24HR and that the actual use of the photo for quantifying a consumed portion could not be assessed if the food was not even recalled. Nonetheless, sensitivity analyses showed us that the results would not change with their inclusion.

We believe that this study was essential to verify how the use of photos can assist individuals in quantifying foods during the actual assessment of 24HR. In fact, memory is an important source of error associated with 24HR and evaluating the benefits and limitations of the album use towards reducing this bias contributes to the obtaining of less biased dietary data and consequently more precise dietary assessments. Therefore, it is expected that the study will contribute to the harmonization of dietary data collection in Brazil and Latin America [28].

Furthermore, our results highlighted the challenges in obtaining accurate food estimates, as some foods and individuals presented numerous errors in the evaluations, out of the range considered acceptable. This corroborates with the scientific literature on the need for continuous studies in the area of self-reported dietary assessment. We acknowledge that accurately evaluating portions consumed by individuals is a complex task, requiring well-designed and controlled methodologies.

Conclusion

In conclusion, the use of the photo album was beneficial and contributed to better estimates of two traditional Brazilian foods, rice, and beans. However, the meatball photo seems to have contributed negatively to the quantitative estimate in one of the centres. Furthermore, educational level, cooking habit, and study centre location may have influenced the correct estimate of the consumption of some foods. Thus, it is concluded that the evaluated photos album can be a useful tool in estimating the Brazilian food consumption. It is suggested, however, that the meatball photograph should be revised and adapted as well as it is desirable that the remaining photos should be further assessed.

The most important take home messages from our study to other global contexts refers to 1) the confirmation results that educational level plays a role in the quantification of foods, 2) the identification of cooking habits as an aspect influencing the ability to recall some of the food quantities, 3) the confirmation that the same food portion photo may have different validity results across populations/regions.

Author contributions

GRF, DGDS, CCBA, SAC, DMM, RMF, SPC conceptualized the study. GAFP, HSL, NASK, LSM, TZCM, BNFS, GRF collected the data. CAT, GFR e SPC conducted the analyses and wrote the first draft with contributions from other authors. All authors provided final approval of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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