

A short training program improves the accuracy of portion-size estimates in future dietitians

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SUMMARY. The objective of this study was to determine whether a short training program, using real foods, would decrease their portion-size estimation errors after training. 90 student volunteers (20.18±0.44 y old) of the University of the Basque Country (Spain) were trained in observational techniques and tested in food-weight estimation during and after a 3-hour training period. The program included 57 commonly consumed foods that represent a variety of forms (125 different shapes). Estimates of food weight were compared with actual weights. Effectiveness of training was determined by examining change in the absolute percentage error for all observers and over all foods over time. Data were analyzed using SPSS vs. 13.0. The portion-size errors decreased after training for most of the foods. Additionally, the accuracy of their estimates clearly varies by food group and forms. Amorphous was the food type estimated least accurately both before and after training. Our findings suggest that future dietitians can be trained to estimate quantities by direct observation across a wide range of foods. However this training may have been too brief for participants to fully assimilate the application. **Key words:** portion size; accuracy; training program; future dietitians.

RESUMEN. Un programa de entrenamiento breve mejora la precisión en la estimación de raciones en futuros dietistas. El objetivo del presente estudio fue determinar si un programa de entrenamiento breve, con alimentos reales, podría reducir el error en la estimación de raciones tras el entrenamiento. 90 estudiantes voluntarios (20,18±0,44 años) de la Universidad del País Vasco (España) recibieron un entrenamiento en técnicas observacionales, y se valoró su capacidad para estimar el peso de alimentos durante y después de un periodo de tres horas de entrenamiento. Dicho programa incluyó 57 alimentos de consumo habitual que representan una amplia variedad de formas (125 formas diferentes). Los pesos estimados se compararon con los pesos reales y la efectividad del programa se determinó examinando los cambios en el porcentaje de error absoluto a lo largo del tiempo. Los datos se analizaron con el programa SPSS vs. 13.0. Los errores en la estimación de raciones disminuyeron tras el entrenamiento para la mayoría de los alimentos. Además, la precisión en la estimación varió ampliamente según el grupo de alimentos y las formas. Los alimentos que se estimaron con menor precisión fueron los amorfos, tanto antes como después del entrenamiento. Nuestros resultados sugieren que el programa de entrenamiento implementado para la estimación de raciones en un amplio rango de alimentos por observación directa resulta eficaz en futuros dietistas. Sin embargo, este entrenamiento pudo ser demasiado breve para que los participantes asimilaran su aplicación. **Palabras clave:** Raciones de alimentos, precisión, programa de entrenamiento, futuros dietistas.

INTRODUCTION

Current methods of assessing dietary intake appear to be ineffective, and have resulted in inaccurate reports of intake. One potential source of error in dietary intake studies is portion-size estimation (1-3). Many investigators have recommended training people in portion-size estimation techniques to improve their ability to make accurate estimations (4-6).

Research related to portion-size estimation spans several broad areas: factors that affect portion-size estimation (7), types of measurement aids used (2,8-10), the validation of portion-size estimation when using aids (11-15), and determination of average or standard portion sizes for use when portion-size information cannot be obtained any other way (1).

Although several studies support the concept that training in portion-size estimation improves the accuracy of dietary reporting in adults (1,16,17), few studies have been conducted to evaluate the efficacy of such training in university students of Human Nutrition and Dietetic. Dietitians frequently find a barrier to control the amount of food consumed by patients, and they play a decisive role in the accurate estimation of the portion size when they use methods to obtain dietary intake data, such as the direct observation of eating, the food record, the food frequency questionnaires, and the dietary recalls. Most of these methods rely on the individual's ability to keep accurate records or recall food consumed and on the interviewer's ability.

Dietitians can work as clinical professional who have duties for planning, education, supervision and evaluation of a clinically devised eating plan to restore the patient to func-

tional nutritional health (18). Moreover dietitians can research about nutrition and health-interactive issues. And in many cases the foods records were reviewed to ensure accuracy and completeness (i.e., portion sizes provided) by a dietitian. It is, therefore, essential that the program in nutrition and dietetic include formation and training on nutritional assessment and inside of this area on portion-size estimation.

Based on the assumption that training in portion-size estimation could reduce estimation error, we developed and tested a practical portion size measurement program in a group of future dietitians. Unlike previous reports on this subject (2,12,19), this study includes a big number of foods and shapes. We sought to determine whether a short training program by direct observation, using real foods, would decrease portion-size estimation error.

METHODS

Sample

Participants consisted of 90 subjects (83 female and 7 male) student volunteers who were recruited through the university. All participants had prior training in nutrition (second academic year) though none of the subjects had experience in the estimation of portion sizes and none of them had received any training on estimation of food portion sizes. The mean (SD) age of the students was 20.18 (0.44) years (range 20-22). All students were classified as normal-weight according to their BMI (20) and their socio-economic status level was medium (21). Participants gave their written informed consent. The University Ethical Committee on Human Research approved the experimental protocol.

Foods

57 foods were selected using several criteria: they are commonly consumed foods (22-24) and they represent a variety of forms: solid (items that have a geometric shape) (n=43), amorphous (n=12), and liquid (n=2). Amorphous foods are those that do not have a specified shape, rather they mound or assume the shape of the container, such as tossed salad, sliced fruit and rice (7). Foods selected were sorted into seven groups: grains (7 foods and 22 different shapes), vegetables (9 foods and 18 different shapes), fruits (4 foods and 8 different shapes), proteins (21 foods and 42 different shapes), fats and oils (4 foods and 10 different shapes), dairy (3 foods and 8 different shapes) and "another" (9 foods and 17 different shapes). "Another" group included: sweets, salt, meat extract and instant coffee. Each student assessed the 57 foods selected previously.

The measurements chosen were common standard portion sizes, such as cup, glass, dish, slice, etc. And the containers chosen were commonly available in convenience stores and local restaurants. We included portion size for the main course and for the accompaniment.

Procedure

Individual practice estimation sessions were conducted during the training period. To reduce any potential for bias, participants were not told specific information about the true purpose of the study before the interview.

Activities to improve observers' food-estimation skills included 4 steps (Figure 1). The step 1-3 carried out for three consecutive hours. During the training program the portion sizes and shapes of each food varied. By varying these factors, it was possible to explore whether this training promote accurate estimates foods in their various forms.

FIGURE 1
Four-step portion-size estimation and measurement training program

Step 1: No visual estimation method (without to see foods)

- Introduce standard units of measurement.
- Practice estimating foods.

Step 2: Direct visual estimation method (with real foods)

- Practice estimating food quantities:
- View the quantity on the plate or in a clear container.
- Touch and handle the foods.

Step 3: Weighed estimation method

- Verify the estimated quantity by using the scales.

Step 4: Short-term memory

- Assess the ability to estimate portion-sizes a week after.
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First, the respondent was asked to report the weight of different foods that is considered a portion size (step 1). The first step involved applying a no visual estimation method (without to see foods) and consisted of a half-hour group session. The aims of this step were to introduce standard units of measurement and to practice estimating foods.

Second, the respondents were permitted to examine and handle the real foods and they were asked to estimate each food weight (step 2). The foods were arranged on a table in the sequence in which participants were to estimate their amounts. Actual food weight was provided after each estimate to allow each observer to evaluate his food specific estimation skills. The second step involved applying a direct visual estimation method and consisted of a one and half hours group session. The aim of the second step was to continue to practice estimating food quantities.

The step 3 consisted of a 1-hours group session in which subjects practiced measuring various foods with the quantity that they considered household measures. Next, participants established the weight using scales (Soehnle Ref. 8025; max 2 kg; 0-1000 g = 1g, 1000-2000 = 2 g). The third step in-

involved applying a weighed estimation method and the aim was to verify the estimated quantity.

Finally, the subjects were asked to estimate portion sizes of the different preweighed food quantities up to 1 week after training (step 4). In the last step no handling of food was permitted. The aim of the fourth step was to assess the ability to estimate portion-sizes a week after (short-term memory).

This study employed three questionnaires that were filled out in the step 1 (no visual), 2 (direct visual) and 4 (1 week after). The sequence of the foods listed on the questionnaires varied according to the sequence in which the foods were to be estimated. Before each step the participants had been trained in the method to fill out the questionnaires.

Statistical analyses

The equation for calculating percentage estimation error was $[(\text{estimated portion} - \text{measured portion}) \div \text{measured portion}] \times 100$ (0% error would be a “perfect” score) (25). Effectiveness of training was determined by examining change in the absolute percentage error for all observers and over all foods over time.

Using two methods, the difference method (D) and the absolute value method (AV) performed this calculation. The D method distinguishes between overestimation and underestimation (positive and negative scores, respectively), allowing for evaluation of the mean direction of error for the total test and for each food variable. The AV method ignores positive and negative signs, thus providing the absolute value of the percentage error of estimation. Larger errors are expected with use of the AV method because errors are additive.

Outliers, defined as respondents whose percentage recall error was more than 3 standard deviations outside of the overall mean for a particular food, were not included in analyses for mean percentage estimation error for that food. Eliminating outliers was important because large deviations in a single respondent’s data (for example, a respondent who overestimated the portion size of green beans by more than 1,000%) would have had a major impact on the mean misestimation for that food.

Data were analyzed using SPSS vs. 13.0. (SPSS Inc., Chicago, IL, USA) and reported as median \pm Standard Deviation (S.D.). For each food group (grains, vegetables, fruits, proteins, fats and oils, dairy and “another”) and food type (solid, amorphous and liquid), the difference between percentage estimation errors was analyzed by using Student’s *t* test and the Mann-Whitney U test. Alpha level for all of these analyses was set at $P < 0.05$ (two-tail test).

RESULTS AND DISCUSSION

The mean percentage errors between weighed foods and estimates calculated by the D method according to the food

group were shown in Table 1. A comparison of the scores by the D method revealed that there were no significant differences between the different steps for either food group, except for the grains, fruits and protein groups. Error in estimates of proteins (meat, poultry, fish, beans and eggs) for the D method decreased between step 1 and 2, but estimated weights for this food group showed increase in error over time. In general, dairy, vegetables and fruits were accurately determined before, during and after training, by a small margin.

TABLE 1
Median percentage errors between weighed foods and estimates by food groups (difference method)

Food group (n)	Percentage error (median \pm SD)		
	No visual	Direct visual	1 week after
Overall (57)	21.04 \pm 23.30	25.77 \pm 23.48	23.70 \pm 11.90
Grains (7)	31.87 \pm 48.51*	11.65 \pm 41.40	26.73 \pm 31.04
Vegetables (9)	-14.26 \pm 36.42	-17.10 \pm 37.48	-8.33 \pm 22.91
Fruits (4)	-7.15 \pm 29.45*	-17.36 \pm 26.69‡	1.48 \pm 22.55
Proteins (21)	34.80 \pm 27.87‡	9.20 \pm 22.41	24.20 \pm 38.54
Fats, oils (4)	25.51 \pm 51.74	35.67 \pm 48.61	25.92 \pm 42.09
Dairy (3)	-2.24 \pm 35.74	3.65 \pm 32.71	-1.93 \pm 32.31
Another (9)	54.32 \pm 55.97	42.53 \pm 45.61	35.16 \pm 45.28

Notes. “Overall” refers to all food types. Grains, bread, cereal, rice and pasta; Dairy, milk, yogurt and cheese; Proteins, meat, poultry, fish, beans and eggs; “Another”, sweets, salt, meat extract and instant coffee. *, ‡ and †, step comparison (No visual-Direct visual, Direct visual-1 week after, No visual-1 week after) was significant different, * $P < 0.05$, ‡ $P < 0.01$, † $P < 0.001$

The differences between the portion-size errors were significant for the AV method, for most of the food groups (Table 2). A comparison of these errors revealed that the training program did significantly improve estimation accuracy between step 1 and 4 for all food types, except for the fats and oils, and dairy. Our results concur with others that even short-term exposure to practical portion size measurement program may improve estimation accuracy of food weight (12,26).

Using the AV method of calculating percentage estimation error provides information regarding total error because error are additive. Since percentage estimation error was generally greater by the AV method than by the D method, we found that overall improvement in estimation accuracy was affected by the calculation method.

Additionally, the accuracy of their estimates varied by food group. Gittelsohn et al. (27) have reported a similar trend. In our case, due issue of concern is that observer estimates are relatively less accurate for “another”, fats and oils and proteins. These data should be considered when designing future programs to improve the accuracy of portion size estimates.

TABLE 2
Median percentage errors between weighed foods
and estimates by food groups (absolute value method)

Food group (n)	Percentage error (median±SD)		
	No visual	Direct visual	1 week after
Overall (57)	66.40±12.81	64.28±10.80‡	53.37±10.15*
Grains (7)	58.99±43.22	46.57±29.94	48.60±21.55*
Vegetables (9)	59.49±21.44	49.18±29.15	45.76±21.17‡
Fruits (4)	28.53±15.77	27.19±16.02	23.74±11.46*
Proteins (21)	70.50±19.12‡	46.68±9.63‡	53.49±28.92‡
Fats, oils (4)	67.24±37.86	63.51±31.03	51.26±29.55
Dairy (3)	48.10±25.26	47.13±25.89	31.82±23.39
Another (9)	89.98±36.27	74.18±32.63	62.38±37.28‡

Notes. "Overall" refers to all food types. Grains, bread, cereal, rice and pasta; Dairy, milk, yogurt and cheese; Proteins, meat, poultry, fish, beans and eggs; "Another", sweets, salt, meat extract and instant coffee. *, ‡ and †, step comparison (No visual-Direct visual, Direct visual-1 week after, No visual-1 week after) was significant different, *P<0.05, ‡P<0.01, †P<0.001

We also found that accuracy of estimation varied by food form after training (Table 3): liquids were estimated the most accurately (median error = 14.18%); followed by solids (median error = 14.51%); and finally, amorphous foods (median error = 33.96%) (D method). Amorphous was the food type estimated least accurately both before and after training, which is consistent with reports of portion-size estimation ability in other studies (28-31).

We recognize some critical limitations of this study such as the sample size, the lack of a control condition, and the length of the training program. To improve the accuracy of estimates, additional time should be spent on estimating several foods (amorphous foods, fats and oils, proteins and "another"). Periodic retesting, both during the training and study periods, is recommended to maintain high levels of accuracy for all observers. This training may have been too brief for participants to fully assimilate the application. The translation of cognitive capacity for estimation and measurement skills into accurate food estimation ability is likely to require more than one training session, particularly to produce longer-term result (32).

TABLE 3
Median percentage errors between weighed foods and estimates by food types

Food type (n)	No visual		Direct visual		1 week after	
	D	AV	D	AV	D	AV
Solid (43)	27.75±23.32‡	63.99±13.48	8.09±18.36	51.31±9.53	14.51±22.11	50.04±17.40‡
Amorphous (12)	30.41±50.11	70.46±40.80	35.45±41.22	63.92±24.61	33.96±27.49	60.53±21.48‡
Liquid (2)	10.25±32.44	45.53± 20.60	12.76±49.38	41.23±35.59	14.18±23.20	31.99±15.34‡

Notes "Liquid" refers to milk and oil; D, difference method; AV, absolute value method. *, ‡ and †, step comparison (No visual-Direct visual, Direct visual-1 week after, No visual-1 week after) was significant different.

Since most of the studies related to the portion size estimation training did not use in university students of Human Nutrition and Dietetic, it is not easy to compare with our results. However, we would like to point out that our training program comprise a wide list of foods and different sizes and shapes, what allow to explore whether this training promote accurate estimates foods in their various forms.

This study also shows that precision in portion size estimation is not yet a realistic expectation. The critical questions that remain are: What level of accuracy is realistic and acceptable? What type of training in portion size estimation is necessary to reach this acceptable level?.

Part of the difficulty in establishing an acceptable level of accuracy is the lack of consensus on the expression of error rates. Moreover, acceptable levels of accuracy may differ depending on the use of promotion estimates, i.e., for

nutritional monitoring of populations, or for individual nutrition intervention in health promotion, disease prevention and disease management (33).

In summary, our findings suggest that future dietitians can be trained to estimate quantities by direct observation across a wide range of foods. Additionally our results will assist in the development of more effective training programs for the portion-size estimation, which is likely to reduce respondent errors and promote the collection of accurate data.

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