Estimates of food quantity and calories: errors in self-report among obese patients[1,2]

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ABSTRACT We report three studies that examine the accuracy and usefulness of food records among dieting obese patients. In study 1 errors in quantity and calorie estimates for 10 common foods averaged 63.9% (quantity) and 53.4% (calories). The results of study 2 indicate that only 53% of entries in daily food records were specified enough to permit objective estimates of the calories consumed. In study 3, blind raters could not predict weight loss based on subjects' self-recorded behavior changes. Collectively, these results question the utility of food records for estimating energy intake or predicting weight loss. *Am J Clin Nutr* 1982;35:727–732.

KEY WORDS Self-report, self-monitoring, food records

Introduction

Assessment of dietary intake has a central role in the treatment of many diseases, including diabetes, coronary heart disease, and obesity (1, 2). Dietary assessment has also been used to support etiological theories, for example, that physical inactivity, rather than excessive food intake, is the primary cause of obesity (3, 4).

Despite widespread use, most information on food intake is based on self-report, and there is considerable uncertainty as to the accuracy of reports of food intake (5). One method of dietary assessment, the 24-h recall, requires that a subject recall all foods eaten during a previous 24-h period. Several studies have shown that the 24-h recall provides a relatively accurate assessment of food intake (6–9). Another method of dietary assessment is self-monitoring, in which a subject is required to make a continuous recording of all foods eaten, their caloric values, and behaviors associated with eating (e.g., the time and place of meals). Self-monitoring is a cornerstone of behavioral treatments for obesity (10); it is used to assess caloric intake and behavior change during weight programs, and has also been used as a treatment procedure, since it produces moderate, although short-lived weight losses (11). Although the accuracy of some self-report dietary assessment methods has been established (5), there have been no reports on the accuracy of self-monitoring as an assessment tool. The three studies reported here were designed to address this issue.

Study 1

An essential requirement of self-monitoring is that subjects be able to estimate the calories and quantity of food consumed. This study evaluated the accuracy with which obese persons, in the absence of training, could estimate the quantity and calorie values of 10 common foods. In many weight reduction programs, patients are asked to eat foods from smaller plates to accentuate the size of each portion and thereby to reduce consumption. A direct test of the assumption that size cues are affected by container size has not yet been made. Therefore, a second goal of this study was to determine whether quantity and calorie estimates would vary as a function of the size of the plate or glass in which the foods were served.

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Methods

Thirty consecutive applicants to a behavioral weight reduction program were selected. All were female; the mean age was 34 yr (range 22 to 67), and the mean percentage overweight was 73% (range 25 to 171%). The subjects reported an average of eight previous diets and 80% of the subjects monitored calories on a previous diet.

Each subject was accompanied by an experimenter to a room in which 10 foods were displayed. The subjects were told that, as part of their initial assessment for the weight program, their ability to estimate the quantity and calories of different foods would be evaluated. The foods were cottage cheese, roast turkey, green beans, boiled ham, cooked spaghetti, cola, potato chips, blueberries, bread, and orange juice. Subjects estimated the quantity of each food in ounces by weight or fluid ounces, then gave an estimate of the number of calories contained in the food. The quantity of each food remained constant across subjects. Each subject viewed five foods in large containers and five in small containers. For each subject foods were randomly matched to container sizes, so that across all subjects each food was displayed equally often in large and small containers. The large plates were 10 in (25.4 cm) in diameter, and small plates were 7 in (17.8 cm) in diameter. The large glasses were 2.5 in in diameter × 3.75 in high (6.4 × 9.5 cm), the small glasses were 2 in in diameter × 3.75 in high (5.1 × 9.5 cm).

Results and discussion

Table 1 illustrates actual values and mean percentage error in quantity and calorie estimates for each food. The quantity was overestimated for all foods (mean 63.9%). The errors ranged from 6% (cola) to 260% (potato chips). The percentage error in calorie estimates was also substantial, ranging from an underestimate of 4.5% (cottage cheese) to an overestimate of 118.5% (green beans). The mean error in calorie estimates, calculated by averaging the absolute value of overestimation and underestimation errors, is 53.4%.

Table 2 illustrates the distribution of calorie and quantity estimates within three error ranges. Averaged across foods, 26% of the quantity estimates were within ± 10% of the foods' actual values; 32% of the estimates were in error by ± 11 to 50%; and almost half the quantity estimates, 42%, were in error by more than 50%. Of the calorie estimates, 14% were in error by 10% or less; 46% were in error by ± 11 to 50%; and 40% were in error by ± 50% or more of the foods' actual values.

Inaccurate calorie estimates could have resulted from incorrect quantity estimates, even if judgments regarding calories per unit serving were correct. To test this, the error in number of calories per unit was calculated (Table 1). The subjects ranged from an underestimate of 49.4% (potato chips) to an overestimate of 206.4% (orange juice); mean error, calculated by averaging the absolute value of under- and over-estimates, was 53.8%. The subjects tended to make larger errors on foods with higher caloric density; across the 10 foods absolute value of error in calories per unit was significantly correlated with actual number of calories per unit, $r(8) = 0.78$, $p < 0.01$.

One-way analyses of variance were used to test calorie and quantity estimates of subjects who viewed foods in large and small containers. Except for one food (cottage cheese), there were no significant differences between

TABLE 1
Actual value and mean percentage error in estimates of quantity, calories, and cal/oz for 10 different foods

Food	Quantity		Cal		Cal/oz	
	Actual	Percentage error	Actual	Percentage error	Actual	Percentage error
	oz		*kcal*			
Cottage cheese	3	+23.3	112	−4.5	37.3	−4.6
Roast turkey	2	+95.0	100	+40.7	50.0	−13.8
Green beans	4	+25.0	34	+118.5	8.5	−37.1
Boiled ham	2	+85.0	133	+38.0	66.5	−16.1
Cooked spaghetti (no sauce)	3	+70.0	156	+4.5	52.0	−25.2
Cola drink	5	+6.0	72	+101.5	14.4	+102.1
Potato chips	1	+260.0	162	+34.8	162.0	−49.4
Blueberries	3	+10.0	56	+60.5	18.7	+70.1
Slice of bread	1	+120.0	63	+33.7	63.0	−13.0
Orange juice	4	+7.5	56	+97.7	14.0	+206.4

TABLE 2
Percentage of estimates in error by 10% or less, 11 to 50%, and more than 50% of the foods' actual values

Food	Percentage of estimates: Quantity estimates			Cal estimates		
	± 10% error	± 11–50% error	± > 50% error	± 10% error	± 11–50% error	± > 50% error
Cottage cheese	13	60	27	3	60	37
Roast turkey	23	23	54	17	53	30
Green beans	33	47	20	3	40	57
Boiled ham	43	20	37	7	47	46
Cooked spaghetti (no sauce)	17	23	60	13	60	27
Cola drink	7	40	53	10	37	53
Potato chips	10	7	83	17	47	36
Blueberries	23	47	30	33	20	47
Slice of bread	47	7	46	10	73	17
Orange juice	40	50	10	23	33	44

estimates made from large and small containers. For cottage cheese, subjects estimated the smaller plate contained fewer calories than the large plate, $F(1, 28) = 4.28$, $p < 0.05$.

A subject who underestimates calories may unknowingly eat more than prescribed, and therefore, be unsuccessful at weight reduction. Fourteen of the 30 subjects in study 1 were accepted to a 27-wk behavioral weight reduction program; nine completed the entire 27 wk. The tendency to underestimate calories was related to program completion. The number of underestimated foods was correlated with dropping out or remaining in the program (the point biserial correlation, $r_{pbi} = 0.76$, $p < 0.01$). Dropouts underestimated 58% of the foods and nondropouts underestimated only 23.3% of the foods. Although total number of underestimated calories was correlated with number of foods underestimated, $r(12) = 0.80$, $p < 0.01$, total underestimated calories was not related to program completion.

After the 27-wk treatment program, weights for three of the five dropouts were obtained. These were combined with the nine program participants and the correlation between number of underestimates and percentage of total weight loss was calculated. The correlation was not significant, $r(10) = -0.46$, $p < 0.10$, although the trend was toward smaller weight losses for subjects with most underestimates.

The results of this study do not support the hypothesis that container size influences calorie or quantity estimates. Requiring subjects to serve food on smaller plates in order to accentuate size cues, and thereby to reduce the quantity of food eaten, must therefore be questioned as a component of behavioral treatments for obesity.

These results also indicate that, generally, obese persons make large errors in estimating food quantity and calories. The mean error in calories of 63.9% would mean that a day's intake of 2000 cal would be estimated at 3280 cal. Such a subject would err 1 lb worth of calories every 3 days! The distribution of errors shows that these results are not due to a few highly deviant estimates—42% of the quantity estimates and 40% of the calorie estimates were in error by more than 50% of the foods' actual values. These results should be qualified because they are not based on actual self-monitoring of food intake. Nevertheless, they suggest that accurate self-reports on food intake during a weight program may require specific training of subjects to that end. The finding that foods with the highest caloric density had the highest level of error suggests that training, if undertaken, would be most profitably addressed to foods with high calorie densities.

Study 2

Study 1 shows that obese persons, in the laboratory, make large errors in estimating the calorie value of foods. This suggests that training in food estimation techniques may be necessary to ensure accurate self-report during a weight program. Study 2 addresses the accuracy of self-report in a different way—food records completed in the course of a weight reduction program received detailed analysis for their accuracy and completeness.

Methods

Subjects were 25 female participants in a 27-wk behavioral weight reduction program who were randomly selected from a larger pool of 40 patients receiving concurrent treatment. Their mean age was 42 yr (range 22 to 55) and their mean percentage overweight was 73% (range 24.8 to 147.5%). All subjects were required to keep daily food records in a diet diary. They recorded the time and place of each food eaten, its quantity, and the number of calories.

Subjects received the standard training in this task administered to all patients entering the diet clinic. This consisted of a detailed explanation of the diet diary, its role in the weight program, and discussion of the importance of accurate and complete food records. Furthermore, a calorie guide was provided to maximize the accuracy of recording. The records completed during the 3rd wk of the program were selected for analysis; thus, the subjects received therapist feedback on the accuracy and completeness of their food records for 2 wk before the study week.

For purposes of this analysis all food diary entries were assigned to one of three categories: *1*) entries that included specific quantity and calorie estimates; *2*) entries with quantity estimates omitted; *3*) entries for which calories and quantity were omitted. For entries that were recorded with both quantity and calorie estimates, the accuracy of subjects' conversion from quantity to calories was determined. This was done by examining the accuracy of a subject's calorie conversions based on her estimate of quantity, irrespective of possible errors in that measure. For example, the calorie guide indicates that 1 tb of margarine contains 100 cal. If a subject recorded 4 tb of margarine, the correct total would be 400 cal.

Results and discussion

Of diary entries 53% included both quantity and calorie estimates, 23% were without quantity estimates, and 24% had both quantity and calories omitted. The average subject erred in 46% of the entries which listed both quantity and calories; 26% of the entries were overestimates and 20% were underestimates. Thus, even assuming the subjects accurately estimated portion size, there were large errors in the simple act of using the calorie guide to estimate calories. The overall error, combining over- and underestimates, was 371 cal/person. The accuracy of subjects' estimates when quantity alone or when quantity and calories were both omitted, cannot be determined. It is notable, however, that 47% of the entries fell into these unverifiable categories.

For those subjects who participated in both studies 1 and 2 ($n = 13$) there was a tendency to underestimate the same proportion of foods in the food record as in the laboratory, $r(11) = 0.50$, $p < 0.10$. In study 2 the tendency to underestimate diary entries was negatively correlated with attrition from the treatment program, $r_{pbi}(23) = -0.42$, $p < 0.05$. Thus, in contrast to the results of study 1, the more diary underestimates a subject made, the less likely she was to drop out of the program. The number of diary underestimates was not related to weight loss in the 3rd wk of the program (the week from which diaries were drawn), $r(23) = 0.23$, nor to weight loss at program termination, $r(23) = 0.24$. Finally, the total error (percentage of entries that were over- and underestimates) in diary entries was not related to 3rd wk weight loss, $r(23) = 0.32$, nor to weight loss at the end of the program, $r(23) = 0.23$.

These results show that food records are relatively incomplete and inaccurate among patients who participate in a weight control program. Although the data do not bear on the accuracy of subjects' quantity estimates, they show a high proportion of quantity estimates omitted and large errors when subjects converted food quantity to actual calorie values. More extensive training and/or regular feedback may be necessary to produce accurate and complete food records.

Study 3

The results of study 2 show that records of food intake made in the course of a weight program do not reflect actual calorie values. Therefore, judgments about calorie intake based on these estimates may not be accurate. However, it may be possible to predict weight loss based on a more global consideration of the diet diary.

Methods

The diaries of 10 female participants in a behavioral weight reduction program were selected for study. Their mean age was 44.6 yr (range 24 to 53) and the mean percentage overweight was 63.3% (range 24.8 to 147.5%). The women were randomly selected from a larger pool of 40 patients receiving concurrent treatment. The single constraint in selection was that the subjects manifest a broad range of weight losses occurring between the 1st and 12th wk of the weight program. In fact, weight changes ranged from a gain of 0.4% of body weight to a loss of 8.7% of body weight. The average change in body weight was −5.4%.

The diaries of each subject from wk 1 to 4 were combined into a single booklet and the diaries from wk 9 to 12 were combined into another booklet. The 10 pairs of booklets were evaluated by three independent raters who were blind to the subjects' identities. The raters knew from which weeks the booklets were drawn, and that all subjects had participated in a behavioral weight reduction program. Rater 1 was a registered dietician with 18 yr experience in conducting weight loss classes; her classes were behavioral in nature and included use of food diaries. Rater 2 was a registered dietician with 10 yr experience in weight reduction programs, including the use of self-monitoring. Rater 3 was a nurse who was familiar with behavioral weight reduction procedures but who had never conducted a weight loss class. They were asked to assign a score on a scale of 1 to 10 to each subject, based on the apparent degree of behavior change that occurred between the first 4 wk and the 9th through 12th wk of the weight program. The raters were asked to consider the following variables in making their judgments: quality of food, quantity of food, number of calories consumed, and the frequency of meals and snacks. The raters were then asked, based on their ratings, to rank the subjects according to the degree of behavior change they demonstrated. Each rater took several hours to complete this task.

Results

Percentage loss in body weight was calculated by substracting a subject's mean weight in wk 9 through 12, from her mean weight in wk 1 through 4, then dividing by the mean weight of wk 1 through 4. The subjects were then ranked according to actual percentage loss in body weight. Spearman's rank order correlation coefficient, p, was calculated to determine the relationship between subjects' weight change ranks and the behavior change ranks assigned by the raters. The correlation for rater 1 was $p = 0.30$; for rater 2, $p = -0.22$ and for rater 3, $p = 0.07$. None of these is significant. A rank order correlation between percentage weight loss and the average of the rater's ranks also yields an insignificant correlation, $p = -0.08$. Finally, a measure of agreement between the three raters was obtained by calculating the coefficient of concordance (w) for the three sets of behavior rankings. This analysis yields an insignificant coefficient, $w = 0.49$, indicating a level of concordance about halfway between total agreement and total disagreement.

These results do not support the hypothesis that accurate predictions of weight loss are possible from subjects' self-report of food intake. This may be so for several reasons. First, inaccuracies in the food records may render them nonrepresentative of subject's eating behavior. Second, noneating factors such as amount of exercise were omitted from the raters' analyses and consideration of these factors may be essential to predict weight loss. Finally, the low level of agreement between raters, while showing the complexity of the task also suggest that raters did not use similar criteria to predict weight loss—a single scale, used consistently, may have produced better results.

General discussion

Within the limits noted in each of the studies above, these results suggest that there are substantial errors in self-reports of food consumption. The errors may be derived from several sources, including subjects' difficulties estimating quantity and calories; the incomplete nature of food diaries, despite training and short-term feedback; and errors in converting food quantities to actual calories. These findings have implications for both research and practice. The practice of rewarding subjects contingent on reports in food diaries must be questioned because self-monitored intake may not reflect actual intake. Furthermore, etiological research exploring differences in self-monitored intake between obese and nonobese people may have questionable validity.

There are several reasons why these results on self-monitoring may differ from those reported by Stunkard and Waxman (5) on the 24-h recall. The 24-h recall relies primarily on a subject's memory of the foods he or she has consumed, and minimally on a subject's skill or motivation. Self-monitoring, in contrast, requires sufficient degrees of skill and incentive to accurately translate observed foods on a continuing basis to their actual quantity and calorie values. There is, accordingly, more potential for error in the self-monitoring procedure.

Study 3 showed that neither experienced nor inexperienced raters could predict weight loss from behavior change recorded in diaries. This raises questions concerning the use of food diaries to evaluate subjects' performance in weight programs. These results are in disagreement with reports by Mahoney (12) and Ost and Gotestam (13) who reported significant correlations between weight loss and ratings of behavior change based on food records. Results of the present study may be more reliable, however, because the raters were blind as to subjects' success in the program. With regard to the relationship between adherence to prescribed behaviors and weight loss (14, 15), these findings support the use of direct observation of eating behaviors, as opposed to self-report.

Finally, the correlation reported in study 1 between number of food underestimates and program attrition suggests that this procedure should be examined further as a predictor of weight reduction success.

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