# Effectiveness of the US Department of Agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women[1–3]

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## ABSTRACT

**Background:** National surveys of food intake rely on the 24-h dietary recall method for assessing the nutrient intakes of Americans.

**Objectives:** This observational validation study was conducted under controlled conditions to test the effectiveness of the US Department of Agriculture (USDA) 5-step multiple-pass method for dietary recall; to test the ability of normal weight, overweight, and obese women to recall food intake; and to test the accuracy of macronutrient recall.

**Design:** Women ($n$ = 49) aged 21–65 y with a body mass index (in kg/m$^2$) of 20–45 selected all meals and snacks for 1 d from a wide variety of foods. A 24-h dietary recall with the use of the USDA 5-step multiple-pass method was administered by telephone the following day. Analysis of variance and covariance tested the overall accuracy of recall and the effect of BMI on dietary recall.

**Results:** As a population, the women overestimated their energy and carbohydrate intakes by 8–10%. No significant differences between mean actual and recalled intakes of energy and the macronutrients were observed in the obese women. Normal-weight and overweight women significantly ($P < 0.01$) overestimated their energy, protein, and carbohydrate intakes. Recalled fat intake was not significantly different from actual intake in women across the BMI range studied.

**Conclusions:** The USDA 5-step multiple-pass method effectively assessed mean energy intake within 10% of mean actual intake on the previous day. Obese women more accurately recalled food intake than did overweight and normal-weight women despite undereating on the day of the study. *Am J Clin Nutr* 2003;77:1171–8.


**KEY WORDS** Food intake, energy intake, obesity, dietary assessment, 24-h dietary recall, 5-step multiple-pass method, US Department of Agriculture, women

## INTRODUCTION

Scientists strive to assess the outcome of eating (ie, nutrient intake) with assessment tools that are easy to administer and are affordable in terms of time and money. One reason for conducting nutrient assessments is the importance of diet as a determinant of risk of disease or malnutrition. Other reasons include the need to assess the nutrient adequacy of the diet in groups and populations, to quantify the exposure of a population to food contaminants, and to provide baseline information for educators and policy makers who develop educational materials, provide guidance, and design nutrition interventions.

Methods typically used to assess dietary intake include diet histories, dietary recalls, food-frequency questionnaires, and diet records with or without duplicate collection of food (1–4). Misreporting of food intake by participants in dietary surveys has been well documented (5, 6). Data from published studies conducted in metabolic ward (7) or outpatient (8) settings suggest a significant underreporting of energy intake from dietary recalls, particularly by overweight and obese women. In contrast, other studies in outpatients (9–11) found overreporting of energy intake on 24-h dietary recalls. About 50% of the women whose eating was observed by Myers et al (11) overreported their energy intake on 24-h dietary recalls.

The US Department of Agriculture (USDA) has surveyed the food intake of the American population since 1935 using various dietary recall methods (12). Recently, the current dietary recall method was enhanced to aid recall and to reduce respondent burden and is referred to here as the USDA Automated Multiple Pass Method, a 5-step multiple-pass 24-h dietary recall method. This dietary assessment method has been used jointly by the US Department of Health and Human Services, National Center for Health Statistics, and the USDA Food Surveys Research Group for dietary data collection entitled "What We Eat in America" in the National Health and Nutrition Examination Survey since 2002. The present study was conducted as an observational validation of this dietary recall method in obese, overweight, and normal-weight women. We asked 3 primary questions. Under controlled conditions, *1*) can the USDA 5-step multiple-pass method be used by women to accurately assess energy, protein, carbohydrate, and fat intakes; *2*) do obese [body mass index (BMI; in kg/m$^2$) ≥ 30.0], overweight (BMI ≥ 25.0 < 30.0), and normal weight (BMI < 25.0) women differ in their recall of food intake; *3*) are macronutrients selectively under- or overreported? Our hypothesis was that

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Received December 27, 2001.

Accepted for publication October 9, 2002.

recalled intake would be an underestimate of actual energy, protein, carbohydrate, and fat intakes, especially in women whose BMI was ≥ 25.0.

## SUBJECTS AND METHODS

### Subjects and recruitment

Data were obtained from 49 women who were recruited by e-mail from among the > 2000 scientific, technical, administrative, and service employees of the USDA Agricultural Research Service (Beltsville, MD). Nutrition or health care professionals were excluded. Other exclusion criteria included pregnancy, lactation, diabetes, and chronic consumption of medications that affect appetite. Subjects taking prescription medications for hypertension, hypercholesterolemia, headache, and osteoarthritis were included.

After attendance at information meetings, the 100 applicants who expressed interest in participating were ranked by BMI. Subsequently, 54 women were selected on the basis of BMIs ranging from 20 to 45. Before enrollment, we asked the subjects to allow time for full participation in the study. We informed them that snacks would be available for takeout, but that meals would be consumed at the Beltsville Human Nutrition Research Center (BHNRC) Human Study Facility (HSF). Three women dropped out before completing the dietary recall portion of the study, and the data from one outlier were excluded because they indicated gross misreporting of food intake; therefore, data from 49 women are summarized in the present study.

The Institutional Review Board at the Johns Hopkins University School of Public Health approved the study protocol. Each potential subject gave written informed consent and received a medical evaluation by a physician. The evaluation included a medical history and measurement of blood pressure, height, and weight.

### Experimental design

Because of the requirements of informed consent, we told prospective subjects that the purpose of the study was to test the foods prepared in the BHNRC HSF and to study food selection and recall in women. A debriefing interview via the telephone was given among the time requirements of the study, but no detail was provided in advance as to the nature of the debriefing process.

We studied each subject during a 2-wk period. On Thursday morning of the first week, the subjects reported to the BHNRC for measurement of body fat by dual-energy X-ray absorptiometry (DXA). On Monday, Tuesday, or Wednesday of the second week, the subjects ate all meals during the day at the BHNRC HSF. Snacks were available for takeout. Subjects returned to their work or attended to personal business between meals, ie, they were not housed at the BHNRC. Two subjects were scheduled to eat at the HSF each day, and each subject ate alone at a time they selected. The appointments were 45 min apart, which allowed each subject sufficient time to select and consume the food in a relaxed manner. After dinner, the subjects received a USDA Food Model Booklet (13) and some measuring guides, including a ruler and measuring cups and spoons, that they were told would be needed during the debriefing interview. The subjects were reminded of the time for the debriefing phone call, but no instructions on the use of the Food Model Booklet were provided at that time. Each participant received a 30–45-min debriefing phone call the following afternoon between 1400 and 1700 (on a Tuesday, Wednesday, or Thursday); this call included a dietary recall as described below.

### Body composition

Weight was measured with an electronic balance to the nearest 0.01 kg, and height was measured to the nearest 0.1 cm with a stadiometer. BMI was defined as weight (kg)/height$^2$ (m). Percentage body fat was determined at the BHNRC by DXA (model QDR-4500A, software version 9.08D; Hologic Inc, Bedford, MA). The subjects were asked to consume nothing for 3 h before the scan, to dress in metal-free clothes, and to remove all jewelry.

Body weight was measured during the recruitment phase of the study and again on the day of the DXA measurement. The time between recruitment and body-composition measurement varied from 2 to 6 wk, and the difference between these 2 weights was used as an estimate of body weight maintenance.

### Menu and portion design

The same foods were offered to each subject and are listed in **Table 1**. Weight, volume, or package size was determined for each food item. The subjects were asked to select from a wide assortment of food items displayed cafeteria-style and to consume as much as they wanted. They were instructed to consume only food provided by the BHNRC HSF during the study day. In an attempt to allow for differences in individual energy requirements and personal preferences, more than one serving of each item was available. For example, bread, luncheon meats, bacon, and sausage were packaged singly, but 4–6 servings of each item were available. Items such as sugar, yogurt, cereal, cream cheese, jelly, margarine, butter, salad dressing, potato chips, pretzels, candy, cookies, peaches, macaroni and cheese, pizza, soft drinks, and water were offered in commercially prepared portion-controlled packaging, but ≥ 3 packages of each item were available. Food items were available for snacking and for takeout. Subjects were instructed to eat as much or as little as they wanted. Foods with different fat and dietary fiber contents and nutrient densities were offered at each meal.

All foods consumed were recorded, and uneaten foods were returned and measured. Uneaten takeout items were returned on the day after the debriefing phone call along with the measuring guides and the Food Model Booklet (13). Adjustments to the actual food intake record were made if necessary.

### Dietary recall

The USDA 5-step multiple-pass method (14, 15) was used in a telephone dietary recall on the day after each woman ate at the HSF. The same trained interviewer administered the recall to all subjects. First, the subjects were familiarized with the Food Model Booklet and then were led through the interview step by step. The multiple-pass method is outlined in **Figure 1**. This method consists of 5 steps: *1*) the quick list, which is an uninterrupted listing by the subject of foods and beverages consumed; *2*) the forgotten foods list, which queries the subject on categories of foods that have been documented as frequently forgotten; *3*) a time and occasion at which foods were consumed; *4*) the detail cycle, which elicits descriptions of foods and amounts eaten aided by the

**TABLE 1**
Food items offered at each meal

| Breakfast | Lunch | Dinner |
|---|---|---|
| Original English muffin | White bread | Dinner roll |
| Oat-bran English muffin | Whole-wheat bread | Garlic breadstick |
| Bagel, plain | Rye bread | Vegetable lasagna |
| White bread | Sliced ham | Baked chicken breast |
| Whole-wheat bread | Sliced turkey | Chicken gravy |
| Scrambled egg | Sliced bologna | Beef tips |
| Bacon | Sliced American cheese | Beef gravy |
| Sausage | Macaroni and cheese | Rice |
| Powdered minidonuts | Peanut butter | Noodles |
| Chocolate-covered minidonuts | Fruit jelly | Mashed potatoes |
| Sugar-coated corn flakes | Frozen pizza | Broccoli |
| Bran flakes with raisins | Lettuce for salad or sandwich | Green beans |
| Wheat and rice flakes | Tomato slices | Corn kernels |
| Orange juice | Raw baby carrots | Lettuce for salad |
| Apple juice | Raw celery sticks | Tomato slices |
| Navel orange | Mustard | Raw baby carrots |
| Delicious apple | Mayonnaise | Raw celery sticks |
| Cream cheese, regular or light | Italian dressing, regular or fat-free | Italian dressing, regular or fat-free |
| Butter | Ranch dressing, regular or light | Ranch dressing, regular or light |
| Margarine, regular or light | Tomato juice | Tomato juice |
| Fruit jelly | Butter | Butter |
| Tea and decaffeinated tea | Margarine, regular or light | Margarine, regular or light |
| Coffee and decaffeinated coffee | Apple juice | Apple juice |
| Milk, skim, 2%, or whole | Milk, skim, 2%, or whole | Milk, skim, 2%, or whole |
| Sugar | Soda—cola, regular or diet | Soda—cola, regular or diet |
| Artificial sweetener | Soda—lemon-lime, regular or diet | Soda—lemon-lime, regular or diet |
| Bottled water | Potato chips | Potato chips |
| Salt and pepper | Pretzels | Pretzels |
| | Chocolate candy | Chocolate candy |
| | Shortbread cookies | Shortbread cookies |
| | Fig bar cookies | Fig bar cookies |
| | Chocolate cake, chocolate frosting | Chocolate cake, chocolate frosting |
| | Apple pie | Apple pie |
| | Ice cream, vanilla | Ice cream, vanilla |
| | Chocolate syrup | Chocolate syrup |
| | Canned peaches | Canned peaches |
| | Navel orange | Navel orange |
| | Delicious apple | Delicious apple |
| | Tea and decaffeinated tea | Tea and decaffeinated tea |
| | Coffee and decaffeinated coffee | Coffee and decaffeinated coffee |
| | Sugar | Sugar |
| | Artificial sweetener | Artificial sweetener |
| | Bottled water | Bottled water |
| | Salt and pepper | Salt and pepper |

interactive use of the Food Model Booklet and measuring guides; and *5*) the final probe review.

The Food Model Booklet is a newly designed tool to improve portion-size estimates of consumed foods (13). The booklet is spiral bound and contains 8 sections: *1*) the forgotten foods list, *2*) glasses and mugs, *3*) bowls, *4*) mounds, *5*) circles, *6*) grid and thickness blocks, *7*) wedges, and *8*) shapes and chicken pieces.

### Coding of food intake

The USDA FOOD CODING DATABASE (16) was used to code all food data, including the actual food intake from foods selected minus plate waste and recalled food intake. The nutrient composition of the food consumed and reported was determined by using USDA SURVEY NUTRIENT DATABASE (17). This database provides the nutrient composition, including the energy, protein, fat, carbohydrate, and mineral contents of the foods commonly consumed in the United States.

### Statistics

The statistical analyses were performed with PC-SAS (version 8.2; SAS Institute Inc, Cary, NC). The significance level was set at $\alpha < 0.05$.

A repeated-measures analysis of variance was conducted to compare total population estimates of actual and recalled intakes. The repeated-measures analysis of variance models the covariance between actual and recalled intakes and adjusts for any inequality in variances by calculating least-squares means as the measure of central tendency.

Furthermore, to test the relation between BMI and accuracy of recall, comparisons of recalled and actual intakes were conducted via analysis of covariance (ANCOVA) by using least-squares mean estimates at preplanned BMI values. These values were

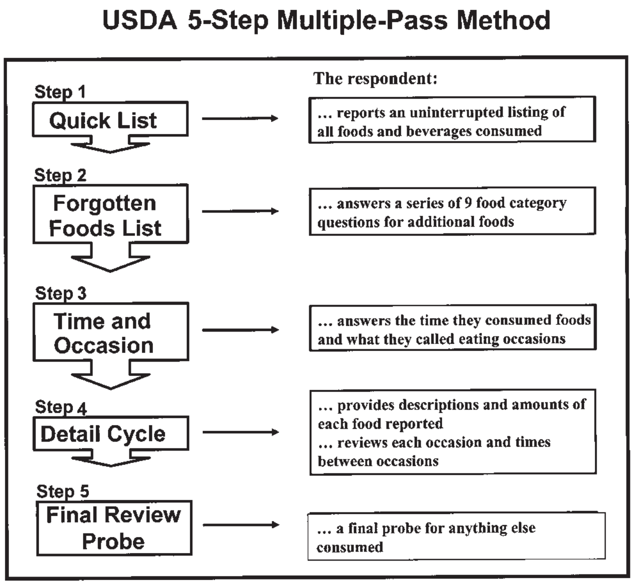


**FIGURE 1.** Outline of the US Department of Agriculture (USDA) 5-step multiple-pass method for dietary recall.

selected as the mean (± SEM) BMI of the subgroups of the study population, ie, normal weight (BMI = 22.2 ± 0.4), overweight (BMI = 27.5 ± 1.4), and obese (BMI = 36.7 ± 1.0). For each subject, the relation between BMI and both actual and recalled intakes was modeled as either a linear (energy, protein, and fat) or quadratic (carbohydrate) function in the ANCOVA. Simultaneously, the ANCOVA modeled the correlation between actual and recalled values measured on the same subject by using the compound symmetry option of the repeated statement in the SAS ANCOVA with mixed-models procedure (PROC MIXED). In addition, the percentage of total energy intake provided by protein, carbohydrate, and fat was calculated for both actual and recalled intakes.

A Bland-Altman plot (18, 19) was prepared to detect possible bias between actual and recalled energy intake and is presented in **Figure 2**.

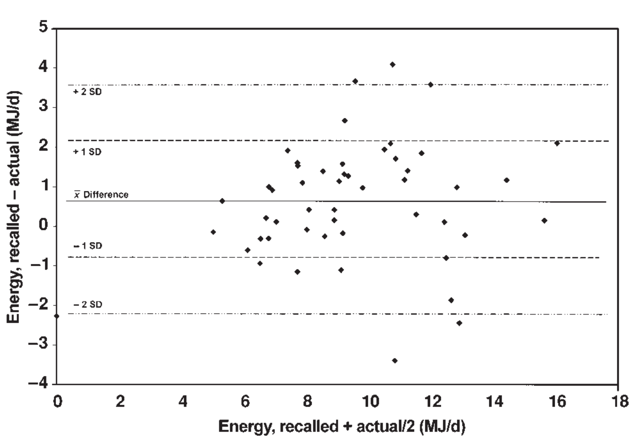


**FIGURE 2.** Bland-Altman plot of the mean difference between recalled and actual energy intakes versus the mean of the recalled and actual energy intakes, indicating ± 1 and 2 SDs from the mean difference. The limits of agreement, which equal 2 SDs of the difference above and below the mean difference, are plotted.

**TABLE 2**
Demographic characteristics of the total population[1]

| | Value |
|---|---|
| Age (y) | 41.2 ± 1.8 (21–63)[2] |
| Height (m) | 1.63 ± 1.1 (1.42–1.75) |
| Weight (kg) | 79.6 ± 2.8 (50.7–119) |
| BMI (kg/m$^2$) | 29.7 ± 1.0 (20.0–44.6) |
| Lean body mass (kg) | 48.4 ± 1.3 (34.6–70.8) |
| Body fat | |
| (kg) | 31.6 ± 1.7 (14.0–58.7) |
| (%) | 38.5 ± 1.0 (23.3–55.9) |
| Mean education (y)[3] | 14 (12–20) |
| Mean income ($)[3] | 31 000–35 000 (<10 000–80 000) |

[1] $n = 49$.
[2] $\bar{x}$ ± SEM; range in parentheses.
[3] Data were collected by range; therefore, SEMs are not possible.

The *x* axis of the plot represents the average of the actual and recalled energy intakes. The *y* axis represents the difference between actual and recalled energy intakes. As described by Bland and Altman (18, 19), the limits of agreement were set as 2 SDs of the difference above and below the mean difference and are plotted in Figure 2.

## RESULTS

### Subject characteristics

The demographic characteristics of the subjects are given in **Table 2**. The population was multiethnic: 14 African American, 2 Asian American, and 33 white American women. None of the women were nutrition or health care professionals. The ranges in education levels and yearly incomes were broad.

### Body composition

BMI was significantly correlated with fat mass ($r = 0.94$, $P < 0.0001$), a finding that validated the selection of BMI as the surrogate for body fatness in this discussion. To determine the stability of body weight within the study population, we calculated the mean difference between the body weight value collected at the medical screening and that collected 2–6 wk later on the day of the DXA measurement. The mean difference was −0.31 ± 1.39 kg. In fact, only 6 women had a variation in body weight of > 1 kg, and all of these women gained weight between the recruitment and the participation portions of the study. None of the subjects reported actively dieting when queried.

### Comparisons of actual and recalled intakes in the total population

The actual and recalled intakes of energy, protein, carbohydrate, and fat for the study population as a whole are given in **Table 3**. There was a 4-fold range in the actual intake of energy, and intakes of protein, carbohydrate, and fat varied greatly among the participants. The largest mean difference between actual and recalled intakes was for carbohydrates (9.7%); however, the mean differences between actual and recalled intakes for all of the macronutrients were < 10%. For the population as a whole, recalled energy ($P < 0.01$) and carbohydrate ($P < 0.01$) intakes were significantly greater than actual intakes, whereas the differences between actual and recalled intakes of protein ($P = 0.05$) and fat ($P = 0.06$) were not statistically significant.

**TABLE 3**
Actual and recalled intakes and the difference between actual and recalled intakes of energy, protein, carbohydrate, and fat[1]

| | Actual intake | Recalled intake | Difference (actual − recalled intake)[2] | Percentage difference[3] |
|---|---|---|---|---|
| | | | | % |
| Energy (MJ/d) | 9.27 ± 0.38 (4.97–15.58) | 9.95 ± 0.39 (4.94 –17.10) | 0.69 ± 0.21[4] (−3.39–4.09) | 8.3 ± 2.2 |
| Protein (g/d) | 85.5 ± 3.9 (28–198) | 90.8 ± 4.3 (28–180) | 5.4 ± 2.7 (−28.7–57.5) | 7.3 ± 3.2 |
| Carbohydrate (g/d) | 285.5 ± 12.4 (114–488) | 310.7 ± 14.0 (139–579) | 25.3 ± 6.4[5] (−99.6–124.7) | 9.7 ± 2.0 |
| Fat (g/d) | 86.8 ± 5.6 (32–205) | 91.7 ± 5.9 (34–206) | 4.8 ± 2.5 (−42.2–46.1) | 7.1 ± 3.0 |

[1] Least-squares $\bar{x}$ ± SEM; range in parentheses. $n = 49$.
[2] A negative value indicates an underestimation; a positive value indicates an overestimation.
[3] Actual − recalled intake/actual intake × 100.
[4,5] Significantly different from zero (Tukey-adjusted mean comparisons from a mixed-model ANOVA): [4] $P < 0.05$, [5] $P < 0.01$.

A Bland-Altman plot of the differences between actual and recalled energy intakes against the average energy intake (average of actual and recalled energy intakes) is shown in Figure 2. This plot illustrates the variability of the under- and overestimation of food intake by individual subjects. Three women overestimated their energy intake by >2 SD above the mean difference, whereas 2 women underestimated their energy intake by >2 SD below the mean difference. Therefore, only 5 women (≈10%) were outside the limits of agreement (>±2 SDs of the mean difference) between these 2 methods.

### Macronutrient intakes as a percentage of energy in the total population

In the population as a whole, we found statistically significant differences between actual and recalled intakes of protein, (15.9% ± 0.6 compared with 15.6% ± 0.6; $P < 0.02$) and carbohydrate (52.1% ± 1.4 compared with 53.0% ± 1.5; $P < 0.005$), respectively. However these small differences were unlikely to have any biological significance. There was no significant difference between actual and recalled intakes of fat (34.3% ± 1.2 compared with 33.7% ± 1.3; $P = 0.06$).

### Comparisons of actual and recalled intakes by body mass index

Actual macronutrient intakes of protein, carbohydrate, and energy among the normal-weight, overweight, and obese women were not significantly different; however, actual fat intake was significantly greater ($P < 0.05$) in the obese women than in the normal-weight women. When recalled intakes were compared with actual intakes by ANCOVA at preplanned BMI values (**Table 4**), no significant difference in energy, protein, carbohydrate, and fat intakes was evident in the obese women. Normal-weight and overweight women significantly overestimated their intakes of energy, protein, and carbohydrate ($P < 0.01$). Although recalled fat intakes were greater than actual fat intakes, the difference was not statistically significant; however, fat intake increased as BMI increased.

**TABLE 4**
Actual and recalled intakes of energy, protein, carbohydrate, and fat in normal-weight, overweight, and obese women[1]

| | Intake[2] | | *P* for main effect (ANCOVA)[3] | | |
|---|---|---|---|---|---|
| | Actual | Recalled | Intake | BMI | Interaction of intake and BMI |
| Energy (MJ/d) | | | 0.002 | 0.020 | 0.011 |
| Normal | 8.55 ± 0.55 | 9.29 ± 0.55[4] | | | |
| Overweight | 8.90 ± 0.39 | 9.75 ± 0.39[4] | | | |
| Obese | 10.41 ± 0.52 | 10.56 ± 0.52 | | | |
| Protein (g/d) | | | 0.004 | 0.028 | 0.010 |
| Normal | 72.5 ± 5.8 | 85.2 ± 5.8[5] | | | |
| Overweight | 81.6 ± 4.1 | 89.2 ± 4.1[5] | | | |
| Obese | 97.4 ± 5.6 | 96.0 ± 5.6 | | | |
| Carbohydrate (g/d) | | | 0.0002 | 0.095 | 0.013 |
| Normal | 283.4 ± 21.7 | 324.4 ± 21.7[4] | | | |
| Overweight | 261.0 ± 16.9 | 292.5 ± 16.9[4] | | | |
| Obese | 293.4 ± 19.4 | 303.8 ± 19.4 | | | |
| Fat (g/d) | | | 0.060 | 0.012 | 0.060 |
| Normal | 71.4 ± 8.0 | 76.3 ± 8.0 | | | |
| Overweight | 82.3 ± 5.7 | 87.1 ± 5.7 | | | |
| Obese | 101.0 ± 7.7 | 105.9 ± 7.7 | | | |

[1] Normal-weight ($n = 14$), overweight ($n = 15$), and obese ($n = 20$) groups had mean group BMIs (in $kg/m^2$) of 22.2, 27.5, and 38.7, respectively. ANCOVA, analysis of covariance.
[2] Least-squares $\bar{x}$ ± SEM.
[3] Comparisons were made for recalled and actual intakes at preplanned BMI values and for the interaction of intake and BMI. The models used were linear for energy, protein, and fat and quadratic for carbohydrate.
[4,5] Significantly different from actual intake: [4] $P < 0.001$, [5] $P < 0.01$.

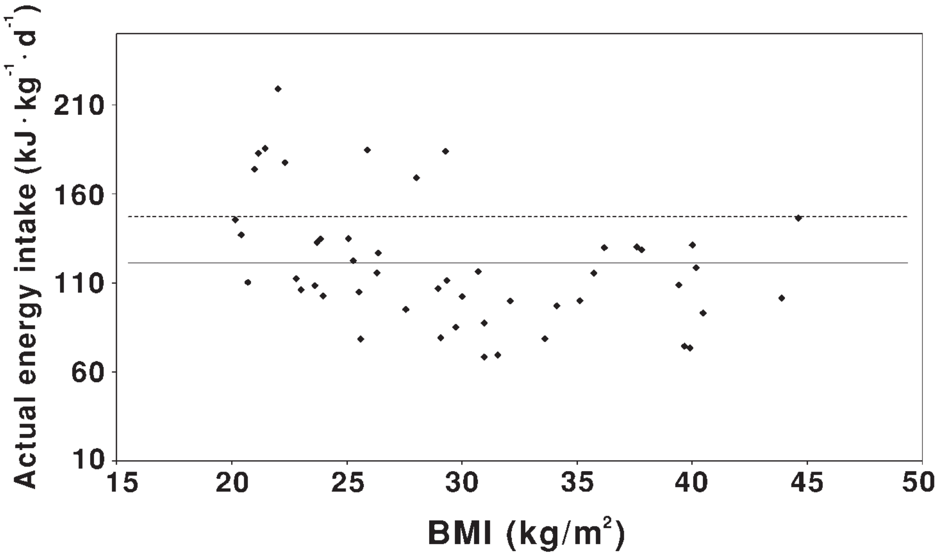


**FIGURE 3.** Actual energy intake versus BMI. The 1989 allowance for energy for women who engage in light activity (147 kJ · kg$^{-1}$ · d$^{-1}$, or 35 kcal · kg$^{-1}$ · d$^{-1}$) is indicated by the broken line; the unbroken line indicates mean energy intake.

### Macronutrient intakes as a percentage of energy by body mass index

When the percentages of actual energy intake from macronutrients were compared at preplanned BMI values, there were significant differences in the percentage of actual energy intake from carbohydrate between the normal-weight (58.4% ± 9.2%) and the overweight (49.2% ± 7.9%; $P < 0.01$) and between the normal-weight and the obese (50.0% ± 10.2%; $P < 0.001$) women. In contrast, the percentage of actual energy intake from fat was higher in the obese (35.6% ± 8.0%) and overweight (37.2% ± 7.3%) women than in the normal-weight women (29.4% ± 8.2%).

In an attempt to determine whether the actual energy intakes of our women met energy requirements, we compared energy intakes per kilogram of body weight per day with the 1989 (20) allowance for energy for women whose physical activity is light (**Figure 3**), ie, 147 kJ · kg$^{-1}$ · d$^{-1}$ (35 kcal · kg$^{-1}$ · d$^{-1}$). Expressed per kilogram of body weight, the mean actual energy intake of the study population as a whole was 120 ± 35 kJ · kg$^{-1}$ · d$^{-1}$ (28.7 ± 8.4 kcal · kg$^{-1}$ · d$^{-1}$), which is less than the energy allowance for women whose physical activity is light. There was no significant difference in energy intake between the normal-weight (144 ± 10 kJ · kg$^{-1}$ · d$^{-1}$, or 34.5 ± 2.3 kcal · kg$^{-1}$ · d$^{-1}$) and overweight (120 ± 8 kJ · kg$^{-1}$ · d$^{-1}$, or 28.6 ± 2.0 kcal · kg$^{-1}$ · d$^{-1}$; $P = 0.06$) women. However, the obese women consumed significantly less energy (102 ± 8 kJ · kg$^{-1}$ · d$^{-1}$, or 24.6 ± 1.9 kcal · kg$^{-1}$ · d$^{-1}$; $P = 0.0014$) than did the normal-weight women.

## DISCUSSION

One of the major goals of national surveys conducted by the USDA and the US Department of Health and Human Services is to assess the dietary intake of a population to facilitate subsequent analysis of the intakes for adequacy or deficiencies or to provide nutrient intake data to other government agencies or to the private sector for subsequent research on nutrient-disease interactions (21–26). In the current study we used the criterion method of direct observation to evaluate the validity of the USDA 5-step multiple-pass method for dietary recall.

### Accuracy of the 5-step multiple-pass method in the total population

To test the accuracy of recalled intakes with the 5-step multiple-pass method, we used ANCOVA and the statistical method devised by Bland and Altman (18, 19). A major finding of this study was that this method can be used in a population of women as an effective means of assessing dietary energy and macronutrient intakes. In our population, the recalled intakes were within 10% of actual intakes. Basiotis et al (27) defined a precise estimate of energy intake as one that is within 10% of the actual intake of a group 95% of the time. The results of the current study suggest that, under controlled conditions, the USDA 5-step multiple-pass method for dietary recall is capable of this precision. It remains to be proven whether this will hold true when the method is tested in larger populations under typical field survey conditions.

The difference between actual and recalled intakes (Figure 2) was outside the limits of agreement set by Bland and Altman (18, 19) in only 5 subjects, with the bulk of the data within ± 1 SD from the mean. There did not appear to be any bias (Figure 2), because there was under- and overestimation of energy intakes throughout the entire range of intakes. Although there was a modest overestimation of total energy and carbohydrate intakes in the population as a whole, there was < 10% disagreement between actual and recalled intakes (Table 3). These data support the effectiveness of the 5-step multiple-pass method for dietary recall in a population of women and agree with the previously published findings of Beer-Borst and Amado (28), who reported the utility of the 24-h dietary recall questionnaire to obtain the median and mean intakes of a population of people. Johnson et al (29) used the USDA 5-step multiple-pass method to assess energy intake in children and found no significant difference, on a population basis, between energy expenditure determined with the doubly labeled water method and that with the multiple-pass method.

One strength of our study was the maintenance of consistency. One person conducted all of the dietary recalls. Similarly, one nutritionist—who had been trained following the guidelines used for conducting the USDA national survey—coded the actual and recalled food intake records. The USDA FOOD CODING DATABASE and SURVEY NUTRIENT DATABASE were used to code and quantitate both actual and recalled intakes. The FOOD CODING DATABASE offers multiple ways of coding food based on different portions and cooking methods typically used in the United States and thereby minimizes errors that can be introduced during the coding of the food consumed.

Although our sample of women was relatively small, our statistical power calculations indicated that we had > 80% power to detect a difference between actual and recalled intakes. The women's food intake was under study for only 1 d; however, the metabolic setting in which the study was conducted afforded significant accuracy in determining the actual food consumed while allowing the women to participate in their daily routines. We also recognize that the artificiality of the observational conditions may have affected the food intake and the ability of the women to recall their food intake accurately. In a smaller population of students, Obarzanek and Levitsky (30) found a high interclass correlation between food consumed in the laboratory and on a habitual basis. Although we can only surmise the effect that eating under our controlled conditions had on the participants, it is possible that their cognitive involvement while selecting foods and eating them in our dining room made it easier for the subjects to recall their food intake. Whether or not these results would apply to the recall of foods selected and eaten away from home in large-scale surveys remains to be proven.

In a review, Fox et al (31) indicated that appropriately designed and administered telephone surveys are as good as and perhaps better than some other methods of dietary assessment. More recently, others found no significant difference between energy intakes assessed by 24-h dietary recalls via the telephone and those in person (32–34). Therefore, we believe that it was unlikely that the administration of the recall by telephone affected the validity of the results.

### Accuracy of recall in normal-weight, overweight, and obese women

Published reports offer conflicting results on the accuracy of dietary assessment by obese women with a variety of assessment methods. A group of obese women, who were unsuccessful dieters (35), significantly underreported their food intake despite the belief that the researchers could verify their reporting accuracy. Using food records, Black et al (24) found that the reported intakes of obese and previously obese women were 73% and 64% of measured energy expenditure, respectively, suggesting that these women underreported their intake. Poppitt et al (7) noted selective underreporting of food intake in face-to-face interviews of both obese and nonobese women who were observed while restricted to a metabolic live-in facility. In contrast, using a self-administered questionnaire, Lindroos et al (36) reported that dietary intakes of the obese subjects were at least as valid and reproducible as were those of the nonobese subjects. Likewise, Klesges et al (37) reported no bias by obese parents in reporting the food intake of their children with the use of 24-h dietary recalls.

Our second major finding was that obese women accurately recalled their food intake, whereas normal-weight and overweight women significantly overestimated their intakes of energy, protein, and carbohydrate (Table 4). In the obese women, we found a small (4%) and statistically nonsignificant difference between mean actual and recalled intakes of energy, protein, carbohydrate, and fat (Table 4). These findings are in contrast with those of an earlier observational validation study (11) in a group of 40 college students who were observed eating lunch in a college cafeteria. Using a 24-h dietary recall method, they asked the participants to recall all the food they had consumed on the day before and found no significant difference in the accuracy of reporting lunch intake between the normal-weight and obese women.

The overestimation of energy we found for the group as a whole can be explained by the overreporting of carbohydrate and protein intakes by the normal-weight and overweight women. Our finding of overreporting food intake is not as common as is underreporting; however, it is not the first time that overreporting has been noticed. Myers et al (11) found mean recalled intakes to be larger than actual intakes because of overreporting in 50% of the female population.

### Undereating but not underreporting in normal-weight, overweight, and obese women

Because we did not estimate energy requirements from doubly labeled water experiments, we used indirect comparisons to determine whether the actual energy intakes could possibly meet energy requirements. When we compared the energy intakes per kilogram of body weight per day in our population with those used by the Food and Nutrition Board (20) (Figure 3), 16% of our population had an energy intake $> 125\ kJ \cdot kg^{-1} \cdot d^{-1}$, 22% had an energy intake of $126\ kJ \cdot kg^{-1} \cdot d^{-1}$ (indicating moderate or very light activity), and almost 61% had energy intakes below the allowance for energy for women who engage in very light activity. If indeed they consumed sufficient energy to meet their requirements on the day they were studied, it would indicate that these women were typically very sedentary. Another possibility is that the energy intake of these women on the day that we studied them was less than their energy requirement, ie, less than their habitual energy intake. A very low mean energy intake ($103 \pm 7.9\ kJ \cdot kg^{-1} \cdot d^{-1}$) supports the conclusion that the obese women underate on the day of observation.

It is possible that the obese women we studied were affected by the desire to meet social expectations or that the foods offered were not those that they usually consumed and therefore they ate less while under observation. Similarly, the mealtimes may not have been typical or the number or nature of the snacks may have differed. Figure 3 indicates that it was not just the obese women whose energy intakes were $< 126\ kJ \cdot kg^{-1} \cdot d^{-1}$; therefore, it is likely that many of our women underate while under observation. The purported undereating in our obese subjects and the accurate recall of dietary intake may explain some of the underreporting observed among obese women in earlier studies in which actual intakes were not observed (8, 35).

### Conclusions

The USDA 5-step multiple-pass method for dietary recall is considered valid for assessing dietary intake in a population of women because the study population recalled their intake within 10% of their actual intake. Under the conditions of our study, the obese women more accurately reported their food intake than did the overweight and normal-weight women. The normal-weight and overweight women overreported their carbohydrate intake. The overreporting might be explained by errors in portion-size estimation of specific foods. This possibility requires further examination of the data on a food-by-food basis.

We are grateful for the contributions to this research made by Lori Borrud and Betty Perloff during the experimental design, by Matthew Kramer during the statistical analysis, by Rhonda Stout during the menu planning and coding of food intake, by Teri Greenfield for conducting the dietary recalls, and by the staff of the Beltsville Human Nutrition Research Center Human Study Facility for food preparation and dietetic supervision.

JMC, LAI, and AJM contributed to the study design and data collection. JMC and BTV were responsible for the data analysis. JMC, LAI, BTV, and AJM wrote the manuscript. None of the authors had any conflict of interest to disclose. All authors were employees of USDA Agricultural Research Service at the time the study was conducted.

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