Number of Days of Food Intake Records Required to Estimate Individual and Group Nutrient Intakes with Defined Confidence[1]

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ABSTRACT The number of days of food intake data needed to estimate the intake of 29 male (n = 13) and female (n = 16) adult subjects, individually and as a group, was determined for food energy and 18 nutrients. The food intake records were collected in a year-long study conducted by the U.S. Department of Agriculture's Beltsville Human Nutrition Research Center. Each individual's average intake of nutrients and standard deviation over the year were assumed to reflect his or her "usual" intake and day-to-day variability. Confidence intervals ($P < 0.05$) for each individual's usual intake were constructed, and from these the number of days of dietary records needed for estimated individual and group intake to be within 10% of usual intake was calculated. The results indicated that the number of days of food intake records needed to predict the usual nutrient intake of an individual varied substantially among individuals for the same nutrient and within individuals for different nutrients; e.g., food energy required the fewest days (averaging 31) and vitamin A the most (averaging 433). This was considerably higher than the number of days needed to estimate mean nutrient intake for this group, which ranged from 3 for food energy to 41 for vitamin A. Fewer days would be needed for larger groups. *J. Nutr.* 117: 1638–1641, 1987

INDEXING KEY WORDS:

• *usual nutrient intake* • *food intake* • *dietary surveys* • *diet status*

Precise estimates of food energy and nutrient intakes are important in assessing the dietary status of an individual and of groups of individuals. However, a number of researchers have demonstrated a day-to-day variability in food energy and nutrient intake. This day-to-day variability adversely affects the statistical precision or accuracy of estimates of intakes, and thus it must be taken into consideration in the design of studies of dietary status and in the interpretation of results (1–7).

The level of day-to-day variability in data that can be tolerated, i.e., the level of accuracy desired, depends on the intended use of the data (8, 9). Nutrient intake estimates may be needed for a day, a year or a lifetime for an individual or for a group. The level of precision needed may also differ by the nutrient studied. For example, higher precision may be desired in the intake estimate of vitamin C, which is not stored in the human body for long periods, than in the intake estimate of vitamin A, which the human body does store for long periods.

METHODS

In the present study, food intake records for 365 consecutive days from a study conducted by the U.S. Department of Agriculture's (USDA) Beltsville Human Nutrition Research Center were used to determine the number of days of food intake records needed to estimate "true" average nutrient intakes for individuals and for groups of individuals with a given degree of statistical confidence or precision (10). For the purpose of this study, a "precise" estimate was defined as an X-day average intake being within 10% of the "true average" intake for the individual or the group 95% of the time. The true average intake was defined as the 365-d average for individuals or groups.

The methodology for calculating the number of days of food intake records required to estimate true average

[1]A preliminary report of this paper was presented at the 1986 Federation of the American Societies for Experimental Biology Meeting in St. Louis, MO [Basiotis, P. P., Welsh, S. O., Kelsay, J. L. & Mertz, W. (1986) Number of days of food intake records required to "accurately" estimate individual and group nutrient intakes. *Fed. Proc.* 45: 705 (abs. 3197)].

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food energy and nutrient intakes with a defined level of precision was based on the statistical theory of confidence intervals (11). Confidence intervals for true mean intake or "usual" intake were set up for individuals and groups, and from these, formulas were derived that allowed us to calculate the number of days required for the X-day average intake to be within 10% of the 1-yr average (assumed true average or usual) intake 95% of the time. We justified treating the X-day average intake as being approximately normally distributed by invoking the Central Limit Theorem (11).

The formula we derived for calculating the number of days of food intake records needed to estimate true average food energy and nutrient intakes for an individual is as follows:

$$X_I = \frac{(Z_a)^2\ (\text{day-to-day variability})^2}{(A)^2\ (\text{true average intake})^2}. \quad (1)$$

X_I represents the number of days required to estimate true average intake for individuals with the defined level of statistical confidence. It depends on an individual's 1-yr average nutrient intake, his or her day-to-day variability in intake, the value of the standard normal cumulative distribution function, Z, appropriately evaluated at the level of statistical significance desired, a, and the level of accuracy desired, A.

Each individual's true average nutrient intake is his or her 365-d average. Day-to-day variability is an individual's average daily variability (or intraindividual standard deviation) around his or her true average intake. The Z value from the Normal Statistical Tables at the 0.05 level of significance is 1.96 (11). The level of accuracy desired, A, is 0.1 or 10%.

The formula to calculate the number of days of food records needed to estimate true average nutrient intakes for a group of individuals rather than a single individual is as follows:

$$X_G = \frac{(Z_a)^2\ (\text{total variability})^2}{(A)^2\ (\text{true average intake})^2} \times \frac{1}{\text{Number of individuals in group}}. \quad (2)$$

This formula is similar to the previous one for individuals. However, it uses the mean and standard deviation of the group over 365 d, instead of the mean and standard deviation for an individual. The formula is also divided by the number of individuals in the group. As the number of individuals in the group increases, the number of days required to estimate intake at the desired level of statistical confidence declines (12).

The Beltsville One-Year Dietary Intake Study (10) provided a unique data base for our study. The subjects for the Beltsville study were 29 apparently healthy individuals. There were 13 males, age 21–49 and 16 females, age 20–53, who lived in the Beltsville, MD area. Of the 29 subjects, 6 were scientists from the Beltsville Human Nutrition Research Center; the rest were students with part-time jobs, secretaries, laboratory technicians and other scientists and those in administrative-type positions. Two subjects were from the same household. The subjects were trained to record the kinds of foods they ate (including the ingredients in mixed dishes) and to report the portion sizes. These individuals kept daily food intake records for 365 consecutive days while consuming their customary diets.

Daily intakes of the following nutrients and food components were calculated: food energy, protein, fat, saturated fat, oleic acid, linoleic acid, cholesterol, carbohydrate, crude fiber, calcium, iron, phosphorus, potassium, sodium, vitamin A, thiamin, riboflavin, niacin and vitamin C. The data base used for calculating energy and nutrient content of the diets was constructed with information from the USDA and food companies. These and other details of the data collection procedures were published elsewhere (10).

RESULTS AND DISCUSSION

Using formulas (1) and (2), we calculated the number of days required to estimate confidently the true average intake for food energy and other dietary components for individuals and for the groups of individuals classified by sex. Estimates of the number of days required to estimate true average intake for the 29 nutrients and food components are presented in the tables. Only the results for three dietary components—food energy, iron and vitamin A—are discussed here because of space limitations. These components were chosen for discussion because energy and vitamin A represented the two extremes in the number of days required to estimate true average intake with the required level of confidence. Iron was representative of the mid-range with respect to the number of days needed.

The ranges in the number of days needed to estimate true average intake as defined for an individual are shown in **Table 1**. These are the number of days required for an individual's X-day average intake of food energy, iron and vitamin A to be within 10% of his or her 365-d average intake 95% of the time. Among the 13 males and 16 females participating in this study, those with the least variance in food energy intake would require 14 d of food intake records to estimate their true average intake with the defined confidence. Individuals with greater variance in their day-to-day food energy intake would require a greater number of food intake records to estimate their true average intake. One of the 13 males required 84 d of food intake records for this mean to be a precise estimate of his true average food energy intake, and 1 of the 16 females required 60 d. For iron, the number of days ranged from 18 to 130 d for males and from 28 to 142 d for females.

The data show, as expected (1), a very wide range in the number of days required to estimate true vitamin

TABLE 1

***Ranges and averages of number of days required to estimate true average intake for an individual with given statistical confidence*[1]**

Component	Males (n = 13) Minimum	Males (n = 13) Average	Males (n = 13) Maximum	Females (n = 16) Minimum	Females (n = 16) Average	Females (n = 16) Maximum
Food energy	14	27	84	14	35	60
Iron	18	68	130	28	66	142
Vitamin A	115	390	1724	152	474	1372
Protein	23	36	72	23	48	70
Fat	34	57	131	32	71	114
Saturated fat	30	71	156	42	87	149
Oleic acid	35	68	163	31	85	145
Linoleic acid	77	145	225	82	166	237
Cholesterol	85	139	195	104	200	443
Carbohydrate	10	37	177	16	41	77
Crude fiber	43	82	146	51	86	138
Calcium	30	74	140	35	88	168
Phosphorus	18	32	62	19	41	62
Potassium	17	34	67	25	48	83
Sodium	27	58	140	36	73	116
Thiamin	46	138	405	41	198	728
Riboflavin	13	57	135	31	90	231
Niacin	27	53	89	48	78	126
Vitamin C	90	249	900	83	222	328

[1]Estimated with intake data from 1-yr dietary intake study by the USDA's Beltsville Human Nutrition Research Center.

A intake—from 115 to 1724 d for males and from 152 to 1372 d for females. Note that the 365-d average intake of vitamin A cannot reasonably be assumed to be a reflection of the true average vitamin A intake for many of these individuals because the estimates of the number of days were greater than 365 for three males and eight females.

Table 1 also shows the average number of days required to estimate true average food energy, iron and vitamin A intake with defined confidence for the 13 males and 16 females in this study. For food energy, the average number of days required was 27 for the males and 35 for the females. For iron intake, the average number of days required was 68 for the males and 66 for the females. Finally, the average number of days required for vitamin A was 390 for the males and 474 for the females.

In the next part of the study, we treated the 13 males and the 16 females as members of groups, rather than as individuals. Therefore, each day's intake was a group average for the day. **Table 2** shows that the number of days required for the same accuracy for groups of individuals was substantially smaller than for individuals alone. The number of days required to estimate true average energy intake "accurately" for the group of females and for the group of males was 3 d. For iron, the number of days for the group of males was seven and for the group of females it was six. For vitamin A, the average number of days required for the group of males was 39 and for the group of females it was 44.

Recalling formula (2), we observe that to achieve the defined level of statistical precision in intake estimates for groups one can either increase the number of days of food intake records for a set number of individuals or increase the number of individuals with a set number of food intake records (12). This is true if day-to-day correlations of intakes are neglible for statistical purposes. Further analysis of the Beltsville study sample, presented elsewhere, supported this assumption (13). As an example of how these decisions might be made, let us assume that the variance in food energy and nutrient intake exhibited by the individuals in the Beltsville study is representative of all similar sex-age groups in the United States. If a study examined 100 females, then a food intake record for 1 d would be sufficient to estimate true average food energy and iron intakes confidently and 7 d of food intake records would be needed for vitamin A. If the study examined 3 d of food intake records from each female, as in the USDA's Nationwide Food Consumption Surveys (14), then a sample size of 15 individuals would be needed to estimate food energy intake with the defined level of statistical precision, a sample size of 32 would be needed for iron and a sample size of 231 would be needed to estimate vitamin A intake.

In conclusion, for the purpose of this study, an estimate of true average intake was defined as being within 10% of the 365-d average 95% of the time. To achieve this level of statistical precision for a single individual, a relatively large number of days of food intake records was required. To achieve this level of statistical precision for groups, even small groups such as the 13 males and 16 females in this study, a relatively small number of days of food intake records was required.

TABLE 2

***Number of days required to estimate true average intake for groups of individuals with given statistical confidence*[1]**

Component	Estimated number of days required for each group	
	Males (n = 13)	Females (n = 16)
Food energy	3	3
Iron	7	6
Vitamin A	39	44
Protein	4	4
Fat	6	6
Saturated fat	8	7
Oleic acid	6	7
Linoleic acid	13	12
Cholesterol	13	15
Carbohydrate	5	4
Crude fiber	9	9
Calcium	10	7
Phosphorus	4	5
Potassium	4	5
Sodium	6	6
Thiamin	13	16
Riboflavin	7	7
Niacin	5	6
Vitamin C	33	19

[1]Estimated with intake data from 1-yr dietary intake study by the USDA's Beltsville Human Nutrition Research Center.

Equally precise intakes for groups may be obtained by increasing the number of food intake records per individual or the number of individuals in the group. We also found that the number of days of food intake records needed varies substantially from nutrient to nutrient for the same individual. In general, food energy required the fewest daily records and vitamin A the most daily records for both individuals and groups. Finally, the number of days required varies substantially from individual to individual for the same nutrient. On the basis of our data, the range in the number of days required was the smallest for food energy and the highest for vitamin A.

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