Research and Professional Briefs

A Comparison of Two Methods of Measuring Food Group Intake: Grams vs Servings

UTE NÖTHLINGS, DrPH; SUZANNE P. MURPHY, PhD, RD; SANGITA SHARMA, PhD; JEAN H. HANKIN, DrPH, RD; LAURENCE N. KOLONEL, MD, PhD

ABSTRACT

Different measurements can be used to quantify food group intake, such as servings, cups, or grams. Dietary recommendations are given in terms of servings (recently expressed as cup and ounce measurements), but research on disease risks often uses grams as the intake measure. Because serving sizes vary among foods within a food group, the method of expressing food group intake (grams vs servings) may impact disease risk analyses. Daily consumption of eight food groups was calculated as both Food Guide Pyramid servings and grams for 206,721 participants in the Multiethnic Cohort Study who completed a quantitative food frequency questionnaire between 1993 and 1996. Mean grams per serving ranged from 25 g for red meat to 172 g for dairy products. Spearman correlation coefficients between intakes as grams per day and servings per day were 0.85 for grains, 0.97 for vegetables, 0.99 for fruit, 0.95 for dairy products, 0.98 for red meat, 0.93 for processed meat, 1.00 for poultry, and 1.00 for fish. Because there was little effect on the ranking of study participants' intakes due to the method of calculating food group consumption, the two measures are interchangeable in disease risk models.
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To quantify food group intake, measurements such as servings, cups, or grams have been used. Recommendations to the public have traditionally been given in terms of servings (1). Although the recent US Department of Agriculture food plan uses cups and ounce equivalents as the basis of food guidance (2), these measurements are conceptually similar to the servings measurement in that adjustments are made for differing nutrient profiles of foods within a food group (eg, milk and cheese within the dairy group). However, food group intake as an exposure in disease risk analyses is usually quantified as grams per day, which does not make such adjustments.

Because a variety of food items with different usual serving sizes (grams per serving) contribute to a food group, the question of whether grams and servings are interchangeable measures in diet and disease risk analyses arises. Epidemiological models that examine associations of diet and disease rank individuals' intakes to determine whether there is a statistically significant difference in risk between those with higher vs lower intakes. Thus, an important question is whether the two measures rank individuals in the same way.

As a hypothetical example, consider the diets of two individuals. The first individual consumed one serving of 75 g fresh fruit per day and no dried fruit. The second individual consumed three servings of dried fruit (each 25 g) per day and no fresh fruit. If the consumption of fruit was calculated as grams per day, the fruit consumption of both individuals would be the same (75 g). However, if the consumption of fruit was calculated as servings per day, the individual consuming dried fruit would have a higher fruit consumption (three servings vs one serving), and the disease-risk ranking of the two individuals would change. This is an extreme example, and the important question is how much the ranking for a sample of study participants is affected by the method of calculating food group intakes. Thus, to compare gram-based and servings-based measures of intake, we calculated both for a large population participating in the Multiethnic Cohort Study in Hawaii and Los Angeles, CA.

METHODS

Study Population

The Multiethnic Cohort (3) was assembled in Hawaii and Los Angeles between 1993 and 1996 to collect prospective data for interethnic comparisons of diet and cancer relationships. The institutional review boards at the University of Hawaii and the University of Southern California approved the study. Initially, 215,902 study participants within the age range of 45 to 75 years were recruited. For this analysis, individuals with extreme diets were excluded (n=9,181) based on energy and macronutrient intakes. First, a standard deviation for energy intake was calculated after exclusion of the top and bottom 10% tails of the log energy distribution. This robust standard deviation thus was computed assuming a truncated normal distribution. Then, all energy values out of the range

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Address correspondence to: Ute Nöthlings, DrPH, Cancer Research Center of Hawaii, University of Hawaii, 1236 Lauhala St, Suite 407, Honolulu, HI 96813. E-mail: UNothlin@crch.hawaii.edu

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Table 1. Mean daily food consumption for participants in the Multiethnic Cohort Study in Hawaii and Los Angeles, CA

Food group (foods)[a]	Men (n=92,887)			Women (n=113,834)		
	Servings[b]	Grams	g/Serving[c]	Servings	Grams	g/Serving
	←— mean±SD[d] —→			←— mean±SD —→		
Grains (n=345)	8.8±4.5	387±252	44	7.3±4.0	307±201	42
Vegetables (n=263)	4.7±3.2	355±247	76	4.8±3.4	350±248	73
Fruit (n=207)	3.3±3.1	347±324	105	3.8±3.5	391±352	103
Dairy products (n=131)	1.3±1.1	222±210	171	1.3±1.0	223±210	172
Red meat (n=87)	2.0±1.6	51±45	26	1.4±1.2	35±34	25
Processed meat (n=45)	0.5±0.6	25±25	50	0.3±0.4	16±18	53
Poultry (n=48)	1.9±1.8	50±48	26	1.7±1.7	47±47	28
Fish (n=121)	0.8±0.9	26±28	33	0.7±0.7	20±23	29

[a]Number of specific foods contributing to each food group out of 1,286 foods that were used to quantify food frequency questionnaire intake.
[b]Servings for red meat, processed meat, poultry, and fish are counted as ounces of lean meat equivalents.
[c]g/serving calculated as the mean grams per day divided by the mean servings per day.
[d]SD=standard deviation.

(mean±3 robust standard deviation) were excluded. A similar procedure was performed to exclude individuals with extreme fat, protein, or carbohydrate intakes, leaving a total of 206,721 study subjects.

Dietary Assessment

Dietary intake was assessed at baseline using a self-administered quantitative food frequency questionnaire (QFFQ) specially designed and validated for use in this multiethnic population (3,4). The collection of 3-day measured dietary records from approximately 60 men and women of each ethnic group served as the basis for the selection of food items for the QFFQ. The QFFQ asks about the usual frequency and amount of each food consumed. Three portion-size options are given for each food item based on the most common portions from the dietary records. Intake in grams was calculated for each item on the QFFQ based on the reported frequency and portion size. The QFFQ included 180 food items, each of which was quantified as a weighted mean of multiple specific foods. The food mixtures from the QFFQ were disaggregated to the ingredient level using a customized recipe database.

A total of 1,286 specific foods were used to quantify the QFFQ intake. The specific foods or ingredients were then assigned to eight major mutually exclusive food groups (grains, vegetables, fruit, dairy products, red meat, poultry, processed meat, and fish). The foods in each group were specified by the Food Guide Pyramid (5). For each food item, the number of servings was calculated using the Pyramid Servings Database developed by the US Department of Agriculture (1,5-7), providing the number of servings per 100 g of food. For example, 100 g of crackers counted as almost seven servings of grains, whereas 100 g of cooked rice counted as only one serving of grains. Daily food group intake for each of the eight food groups was then calculated as both grams and number of servings for each participant in the Multiethnic Cohort.

Using the underlying algorithm in the Pyramid Servings Database, fat exceeding a predefined limit for each food group was counted as discretionary fat. For example, if meat contained more than 2.7 g of fat per ounce, the excess fat was considered discretionary and separated from the meat intake. For all foods contributing to the meat group, the intake was therefore calculated as ounces of lean meat equivalents.

Statistical Analysis

The ranking of study participants using these two measures of food group intake was compared by calculating Spearman correlation coefficients with SAS software (version 8.0, 1999, SAS Institute Inc, Cary, NC).

RESULTS AND DISCUSSION

The study population was comprised of 92,887 men (45%) and 113,834 women (55%) with a mean age of 60 years for both sexes. The distribution according to ethnicity and sex (male/female) was: African American, 13%/19%; Native Hawaiian, 7%/7%; Japanese American, 28%/25%; Latino, 24%/21%; white, 24%/22%; other ethnicities, 5%/6%. The analysis of the reported intake of foods on the QFFQ resulted in mean energy intake of 2,381 kcal in men and 1,955 kcal in women.

Table 1 provides an overview of the daily intake of each food group. The numbers of specific foods contributing ranged from 345 for grains to 45 for processed meats. Both gram and serving measurements identified men as eating larger amounts in most food groups than women did. Mean grams per serving of foods in the food groups ranged from 25 to 26 g for a serving of red meat to 171 to 172 g for dairy product servings.

Spearman correlation coefficients between the two measures are shown in Table 2. For both men and women, the mean correlation coefficient was 0.96. The highest correlation was observed for poultry and fish in both sexes (r=1.0) and the lowest for grains (r=0.85 for men and r=0.84 for women). A stratification of this analysis by ethnic group showed no substantial changes to these results. The range of correlation coefficients was still 0.83 (grains in white women) to 1.00 (fish and poultry in each ethnic group).

Table 2. Spearman correlation coefficients between food consumption measured as number of servings per day or grams per day in the Multiethnic Cohort Study in Hawaii and Los Angeles, CA

Food group	Men (n=92,887)	Women (n=113,834)
	←——— r ———	———→
Grains	0.85	0.84
Vegetables	0.96	0.97
Fruit	0.99	0.99
Dairy products	0.94	0.95
Red meat	0.98	0.98
Processed meat	0.92	0.93
Poultry	1.00	1.00
Fish	1.00	1.00

The comparison of food group intake as grams per day to the number of servings per day for vegetables, fruits, dairy products, red meat, processed meat, poultry, and fish showed only minimal effects on ranking of study participants within these groups. The very high correlation coefficients for fish and poultry occurred because there is little variation in the serving sizes (almost always 1 oz). Furthermore, both are naturally lean food groups, and therefore not much discretionary fat had to be separated when converting grams to ounces of lean meat equivalents. The effect on ranking was greater for grains, because the range of gram weights for foods within this group is large.

Both ways of measuring intake are suitable for ranking food group intakes in diet and disease analyses. Epidemiological investigations of diet and disease often use gram weights for foods because calculating servings is not required, and assumptions about grams per serving are not needed. Although the Pyramid food group servings scheme (5) serves as a standardized scheme in the United States, this may not be appropriate in other countries. Thus, grams of intake is a more standardized measure, especially when comparing findings from international studies. However, for purposes such as dietary guidance, servings or cups will usually still be the measurement of choice.

One limitation of this analysis is that we investigated only one food servings scheme, although it would be the one of choice for most studies within the United States because it permits comparison to national food guidance. The recent change of measurements in the most recent *Dietary Guidelines for Americans* (released in 2005) does affect our findings, but only marginally, because the conversion of servings to cups is predominantly proportional (2). However, other schemes for quantifying servings, such as those used in other countries, might perform differently. In particular, the grams per serving might vary across specific groups.

Although our sample is from Hawaii and California, the cohort was population-based to maximize application of findings to the US population. Furthermore, the consistency of findings across the ethnic strata illustrates the robustness of our results, which renders them more likely to apply to the US population. We chose to investigate only eight major food groups, in contrast to more detailed subgroups, to maximize the heterogeneity in serving sizes. Thus, these analyses should be the most sensitive to possible differences in ranking of food group intakes.

To our knowledge, this is the only study that has compared different measurements of food group consumption with respect to ranking of study participants' intakes. The strength of this analysis is the large cohort of more than 200,000 study participants and the variety of consumption habits due to their different ethnic backgrounds. Furthermore, the dietary assessment instrument used in this analysis was extensive and detailed, yielding many different foods within each food group.

CONCLUSIONS

There was little impact of the method of calculation of food group intake—servings vs grams per day—on the study participants' intakes. The two methods of analyzing the exposure to food group intake in diet and disease models are interchangeable for most analyses.

This work was supported by grant R37 CA054281 from the National Cancer Institute, US Department of Health and Human Services.

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