The nature and individuality of within-subject variation in energy intake 1-3

Valerie Tarasuk and George H Beaton

ABSTRACT Examinations of observed within-subject variation in the energy intake of 29 adults participating in the Beltsville One-Year Dietary Intake Study suggest that individuals possess characteristic patterns of variability in total food intake (expressed as energy intake). Although the day-to-day variation appears to contain a sizable random component, significant nonrandom components were detected in the observed variation of all but one subject. Up to 37% of the total variance observed for a subject could be explained by the long- and short-term patterns identified in food intake. Both the shape and the amplitude of these patterns were unique to the individual subject, suggesting that observed within-subject variance is a function of the particular combination of environmental and biological pressures on the individual’s total food intake at any one time and of the methodological errors inherent in the estimation of this intake. Am J Clin Nutr 1991;54:464-70.

KEY WORDS Energy intake, intraindividual variation, variation in energy intake, food intake behavior

Introduction

A comprehensive understanding of the food intake behavior of individuals is fundamental to the development of data-collection strategies appropriate to the specific goals of dietary intake studies. The extent to which intake estimates represent subjects’ usual intakes depends on how well data collection has encompassed major sources of variation in actual intake over the time frame of interest. The accurate interpretation of intake data also requires an understanding of the sources of variation in intake that have been included and those that have been excluded from the data collection. However, there has been little research into the nature of the observed variability in individual subjects’ intakes from one day to the next.

The best estimate of day-to-day variation in an individual’s intake is the within-subject variance calculated from two or more observations of actual intake. The estimate comprises both variation in actual intake across the days of data collection and measurement errors. Statistical treatments of within-subject variance, either in the development of data-collection protocols or in analyses of its impact on statistical tests and derived estimates, assume that it represents purely random variation in reported intake (1-13). Some indication of the presence of nonrandom components in observed within-subject variance in energy and nutrient intake comes from examinations of the relationship between the number of days of intake data sampled per subject and the reliability of resultant mean intake estimates. Reliability does not improve with increased numbers of days as rapidly as would be expected if intakes on adjacent days were truly random and independent (1, 14, 15). The observed nonindependence must reflect the presence of patterns in the day-to-day variation of individuals’ intakes, although the precise nature of these patterns is not well understood.

Further indication of patterns in the observed day-to-day variation in individuals’ energy and nutrient intakes comes from analyses of variance in population surveys. Components of the pooled (group) within-subject variance estimate include day of week (1, 3, 16-23), sequence of observation (8; C Ritenbaugh, GH Beaton, CS Goodby, C Feldman, M Aickin, unpublished observations, 1988), and method of data collection (3, 19, 24). However, the limited strings of intake data generally available for individual subjects have precluded detailed examinations of day-to-day variation within individuals. Apart from some evidence of patterns in energy and macronutrient intake corresponding to menstrual-cycle phases in humans (25-36), there has been little study of the nature of variability in individuals’ food intakes.

The objective of this paper was to describe the patterns of variation in daily intake that exist within individuals. Longitudinal intake data for the 29 adults in the Beltsville One-Year Dietary Intake Study (35) were examined to characterize the nature of day-to-day variation in individuals’ energy intakes across 365 consecutive days. A study of components of the pooled within-subject variance in energy intake observed in these same subjects was presented by Basiotis et al (19). An examination of differences in the overall magnitude of observed variance for individual subjects was also conducted (unpublished observations).

464

### TABLE 1
Autoregressive modeling of observed day-to-day variation in individual subjects' energy intakes across 365 consecutive days*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Energy intake</th>
<th>Balance period</th>
<th>Degree of polynomial</th>
<th>Day of week†</th>
<th>AR</th>
<th>AC</th>
<th>$R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>15.120 ± 3.281‡</td>
<td>INCL</td>
<td>7</td>
<td>1, 6, 7</td>
<td>Absent</td>
<td>0.0270</td>
<td>24.66</td>
</tr>
<tr>
<td>2</td>
<td>12.668 ± 2.399</td>
<td>INCL</td>
<td>2</td>
<td>—</td>
<td>Absent</td>
<td>0.0235</td>
<td>6.39</td>
</tr>
<tr>
<td>3</td>
<td>6.607 ± 2.964</td>
<td>—</td>
<td>7</td>
<td>1, 7</td>
<td>Present</td>
<td>0.2394</td>
<td>12.68</td>
</tr>
<tr>
<td>4</td>
<td>10.458 ± 2.085</td>
<td>—</td>
<td>3</td>
<td>1, 7</td>
<td>Present</td>
<td>0.1259</td>
<td>12.13</td>
</tr>
<tr>
<td>5</td>
<td>13.318 ± 3.967</td>
<td>INCL</td>
<td>7</td>
<td>1</td>
<td>Present</td>
<td>0.1380</td>
<td>12.74</td>
</tr>
<tr>
<td>7</td>
<td>9.572 ± 2.300</td>
<td>INCL</td>
<td>—</td>
<td>1, 6</td>
<td>Absent</td>
<td>0.0317</td>
<td>9.32</td>
</tr>
<tr>
<td>10</td>
<td>15.084 ± 3.099</td>
<td>INCL</td>
<td>4</td>
<td>6, 7</td>
<td>Present</td>
<td>0.1236</td>
<td>12.62</td>
</tr>
<tr>
<td>12</td>
<td>9.997 ± 2.420</td>
<td>INCL</td>
<td>—</td>
<td>—</td>
<td>Present</td>
<td>0.1080</td>
<td>1.82</td>
</tr>
<tr>
<td>13</td>
<td>10.332 ± 2.302</td>
<td>INCL</td>
<td>3</td>
<td>1, 7</td>
<td>Absent</td>
<td>0.0617</td>
<td>13.16</td>
</tr>
<tr>
<td>15</td>
<td>12.718 ± 2.670</td>
<td>—§</td>
<td>3</td>
<td>1, 7</td>
<td>Absent</td>
<td>0.0148</td>
<td>37.00</td>
</tr>
<tr>
<td>16</td>
<td>10.900 ± 2.597</td>
<td>INCL</td>
<td>—</td>
<td>1, 5, 7</td>
<td>Absent</td>
<td>-0.0111</td>
<td>8.80</td>
</tr>
<tr>
<td>18</td>
<td>10.576 ± 2.609</td>
<td>INCL</td>
<td>1</td>
<td>1, 7</td>
<td>Present</td>
<td>0.1268</td>
<td>8.53</td>
</tr>
<tr>
<td>38</td>
<td>12.441 ± 3.114</td>
<td>INCL</td>
<td>6</td>
<td>1, 6</td>
<td>Present</td>
<td>0.1498</td>
<td>14.19</td>
</tr>
<tr>
<td>Female subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>8.858 ± 1.949</td>
<td>INCL</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>0.0891</td>
<td>1.12</td>
</tr>
<tr>
<td>20</td>
<td>7.683 ± 2.152</td>
<td>INCL</td>
<td>4</td>
<td>1, 6, 7</td>
<td>Present</td>
<td>0.1217</td>
<td>23.45</td>
</tr>
<tr>
<td>21</td>
<td>7.754 ± 2.421</td>
<td>—</td>
<td>1</td>
<td>1, 6</td>
<td>Absent</td>
<td>0.0220</td>
<td>5.50</td>
</tr>
<tr>
<td>22</td>
<td>6.042 ± 1.809</td>
<td>INCL</td>
<td>3</td>
<td>1, 7</td>
<td>Absent</td>
<td>0.673</td>
<td>10.70</td>
</tr>
<tr>
<td>24</td>
<td>8.765 ± 3.265</td>
<td>INCL</td>
<td>1</td>
<td>1, 7</td>
<td>Present</td>
<td>0.1141</td>
<td>16.36</td>
</tr>
<tr>
<td>25</td>
<td>8.503 ± 2.217</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>Present</td>
<td>0.2200</td>
<td>7.09</td>
</tr>
<tr>
<td>26</td>
<td>9.521 ± 2.816</td>
<td>INCL</td>
<td>3</td>
<td>1, 7</td>
<td>Present</td>
<td>0.1257</td>
<td>7.71</td>
</tr>
<tr>
<td>27</td>
<td>6.543 ± 2.581</td>
<td>—</td>
<td>4</td>
<td>1, 7</td>
<td>Absent</td>
<td>0.0655</td>
<td>9.18</td>
</tr>
<tr>
<td>28</td>
<td>9.611 ± 2.359</td>
<td>INCL</td>
<td>6</td>
<td>1, 5, 7</td>
<td>Present</td>
<td>0.2110</td>
<td>14.05</td>
</tr>
<tr>
<td>30</td>
<td>8.010 ± 2.308</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>0.0830</td>
<td>0.00</td>
</tr>
<tr>
<td>32</td>
<td>8.342 ± 1.582</td>
<td>—</td>
<td>3</td>
<td>1, 7</td>
<td>Present</td>
<td>0.1104</td>
<td>23.38</td>
</tr>
<tr>
<td>33</td>
<td>8.338 ± 1.715</td>
<td>INCL</td>
<td>6</td>
<td>—</td>
<td>Present</td>
<td>0.1420</td>
<td>9.56</td>
</tr>
<tr>
<td>34</td>
<td>7.853 ± 2.031</td>
<td>—</td>
<td>5</td>
<td>—</td>
<td>Absent</td>
<td>0.0862</td>
<td>4.44</td>
</tr>
<tr>
<td>35</td>
<td>5.952 ± 1.790</td>
<td>—</td>
<td>5</td>
<td>1, 7</td>
<td>Present</td>
<td>0.1877</td>
<td>13.09</td>
</tr>
<tr>
<td>36</td>
<td>7.170 ± 2.674</td>
<td>INCL</td>
<td>2</td>
<td>1, 4-7</td>
<td>Absent</td>
<td>0.0356</td>
<td>33.32</td>
</tr>
<tr>
<td>37</td>
<td>4.792 ± 1.817</td>
<td>INCL</td>
<td>—</td>
<td>2, 7</td>
<td>Present</td>
<td>0.1713</td>
<td>8.99</td>
</tr>
</tbody>
</table>

*AR, significance of first-order autoregression among residuals; AC, coefficient of first-order autocorrelation among residuals from regression model; INCL, a dummy variable denoting balance-period days included in the model.
† Indicates days of week with significant, systematic deviation from subject's mean. Day 1 = Sunday.
‡ ± SD.
§ This subject did not have a significant balance-period effect but exhibited a substantial rise in intake after the third balance period. A dummy variable denoting these 5 post-balance days was included in all regression analyses.

### Subjects and methods

**Subjects**

In the Beltsville One-Year Dietary Intake Study, 13 men (22–49 y) and 16 women (20–53 y) recorded their food intakes for 365 consecutive days. The subjects were screened to ensure that they were in good health, were not consuming nutrient supplements, and were not following restrictive dietary practices. For four 1-wk periods during the survey, balance studies were conducted and subjects were required to collect duplicate portions of all foods and beverages consumed. A detailed discussion of the subject selection, training, and data collection was presented by Mertz and Kelsay (35). Energy- and nutrient-intake databases were constructed from the food records by using current United States Department of Agriculture Nutrient Composite Data Bases (35).

A summary of male and female subjects’ energy intakes across the data collection is presented in the first column of Table 1. Data in this table have been adjusted for two outlying values. An outlier, defined as an intake value > 2 SDs above a subject’s mean and not part of a sequence of extreme values, was replaced by the mean of the 2 d adjacent to it.

**Statistical analyses**

All analyses were conducted by using the Statistical Analysis System (SAS) computer package for personal computers, version 6.03 (SAS Institute Inc, Cary, NC).

*Patterns in individuals' variances.* Because the objective was to describe the nature of individuals' day-to-day variation in energy intake over the 365 d of data collection, each subject's data series was analyzed individually. Exploratory, descriptive methods were used and analyses were tailored to each subject

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*WT-INT, 465*
to maximize the potential for accurate depiction of subjects' individual patterns in intake over the year. To search for patterns in subjects' observed day-to-day variations, two time-series diagnostic tools, the autocorrelation and spectral-density functions, were computed for each of the 29 subjects' intake series. Patterns in intake identified from the examination of these functions (36) were modeled by using ordinary least-squares regression procedures (by using PROC REG). The autocorrelation and spectral density functions of the residuals extracted from each regression equation were examined for evidence of additional patterns, which were in turn expressed as regression equations. This systematic decomposition of each subject's intake series continued until no further patterns could be characterized. No attempt was made to differentiate between true variation in intake and variation in the reporting of intake nor was bias in reporting estimated if present. The analyses presented therefore refer to intakes as reported.

As the first step in the decomposition process, polynomial regression models were fitted to each subject's data series to identify gradual, systematic shifts in intake across the year, suggested by the time-series diagnostics. Because most subjects' intakes fell during the balance periods (37), a zero-one dummy variable differentiating these days from other recording days was included in polynomial regression models when balance period had a statistically significant effect ($P \leq 0.05$). First- to seventh-order polynomial regression models were tested on each subject's data. The polynomial regression model selected for a subject was that which explained the highest proportion of variance in the subject's intake as measured by the adjusted $R^2$ (38) while also yielding a statistically significant ($P \leq 0.05$) parameter estimate for the highest-order polynomial term in the equation.

Inspection of the autocorrelation and spectral-density functions of each subject's residual variance (once any long-term pattern in intake had been removed) suggested the presence of recurrent 7-d patterns for some subjects. Each subject's residuals were thus examined for patterns associated with particular days of the week. By using the regression-model selection procedure of PROC REG and including day of week as a dummy variable, days having substantial, recurrent effects on intake for an individual were identified by their ability to explain variance in the residuals. Days that had statistically significant parameter estimates were entered into a regression equation to describe the weekly pattern for the individual, and residuals were again computed from the model.

Autocorrelation and spectral-density functions were computed for each subject's remaining variance and inspected for evidence of further patterned components. Minor cyclic patterns of inconsistent lengths were identified for 18 subjects but none explained $>2-4\%$ of the remaining variance. Because the patterns could not be interpreted, these results are not presented.

To examine the nature of the relationship remaining between intakes on adjacent days once significant balance-period effects, long-term patterns, and weekly patterns in a subject's day-to-day variation had been controlled for, all these effects were entered simultaneously in a single regression model by using PROC AUTOREG. Maximum-likelihood estimates were computed for each parameter on the assumption that the residuals from the model could be described by a first-order autoregressive process. This process can be represented as

$$x_t = a x_{t-1} + e_t$$

where the $x_t$ and $x_{t-1}$ are regression residuals ($t = 1-365$) and $e_t$ are normally and independently distributed errors with a zero mean and a variance of $\sigma^2$ (36). Testing the statistical significance of the autoregressive components (a) provided evidence of the existence of a relationship between intakes on adjacent days. The direction of the relationship was ascertained from the residual autocorrelation coefficient. To test for the presence of significant interrelationships across 3- and 4-d sequences of energy intake, the assumptions of second- and third-order autoregressive processes in subjects' residuals were also examined by using PROC AUTOREG. Five subjects showed significant results for one of these higher-order processes but no subject demonstrated significant first-, second-, and third-order autoregression. The findings suggest that autoregression is primarily a phenomenon among intakes on adjacent pairs of days. Consequently, only results of the analysis of first-order autoregression are presented here.

The first-order autoregressive model was also used to obtain an unbiased estimate of the proportion of each subject's total variance explained by the collection of patterns identified (ie, the $R^2$) and more efficient estimators of the pattern variables. The ordinary least-squares regression procedures used to identify patterns in day-to-day variation assume that error terms are uncorrelated. In the presence of significant positive autocorrelation, ordinary least-squares regression models overestimate the proportion of variance explained by a particular pattern and exaggerate the statistical significance of the estimated regression parameters that describe it (38). Because the assumption of autocorrelated errors is embedded in the autoregressive model, it provides more efficient estimates. A slight underestimation of $R^2$ occurs when the autoregressive model is fitted to a subject without significant autocorrelation. For three subjects with significant positive autocorrelation, a parameter estimate identified as statistically significant in ordinary least-squares regression analysis was found to be not significant when included in the autoregressive model; these parameters were discarded and the models rerun. Only patterns that achieved statistical significance when an autoregressive error structure was assumed are reported in this paper.

Patterns in within-subject variance across sample. To examine the possibility that some long-term pattern in energy intake might be common to all subjects, series of polynomial and sinusoidal regression models were tested when data for all subjects were entered concurrently in the general linear model (PROC GLM),

$$\text{ENERGY} = \text{SUBJECT} + \text{BALANCE} + \text{BALANCE}\cdot\text{SUBJECT} + (\text{pattern variable})$$

The categorical variables, SUBJECT and BALANCE, were included to control for between-subject differences in full-year mean intake amounts and for balance-period effects. BALANCE\*SUBJECT was included to account for individual differences in the magnitude of the balance-period effect. The pattern variables examined were linear, quadratic, cubic, quartic, and quintic functions of time and sine and cosine functions of time describing one and two cycles per year. The analyses were conducted on the data of the 25 subjects who had begun data collection on the same day.

The possibility of a phasing of a long-term pattern across subjects was also investigated by fitting the same series of polynomial and sinusoidal regression curves to subjects' Z scores [computed
as \((\text{INTAKE} - \text{MEAN}_{365})/\text{SD}_{365}\). For subjects with significant balance-period effects, the residuals drawn from the regression of energy intake on a dummy variable differentiating balance-period days from other recording days were used to compute Z scores; otherwise subjects' raw data were used. The use of standard normal deviates permitted an examination of patterns in variance while controlling for individual differences in the magnitude of that variance.

An analysis-of-variance model was constructed to examine subjects' energy intakes for seasonal patterns while controlling for between-subject differences and balance-period effects. The (PROC GLM) model was

\[
\text{ENERGY} = \text{SUBJECT} + \text{BALANCE} + \text{SUBJECT} \times \text{SEASON}
\]

SEASON distinguished between winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov). Seasonal means were also calculated and compared by using the Student-Newman-Keuls multiple-range test.

**Results and discussion**

**Long-term patterns**

Significant, systematic shifts in mean intake level across the year were noted for 23 of the 29 subjects (Table 1). Figure 1 provides an example of this phenomenon for one subject; the cubic regression curve accounted for 16% of the subject's variance in energy intake over the year. The shapes of the patterns identified in individual subjects ranged from linear slopes to the S-shaped curves characteristic of third- and fourth-degree regressions and the more wavy patterns depicted by sixth- and seventh-degree regressions. The proportion of an individual subject's variance that could be explained by a balance-period effect and/or long-term pattern in intake ranged from 0% to 30%. The magnitude of the systematic shift in a subject's energy intake over the 365 d, as indicated by the SD of the predicted intake values along the fitted curve (ie, the points that together constitute the long-term pattern), ranged from 322 to 1176 kJ (77 to 281 kcal). The average SD in the predicted values was 636 ± 209 kJ (152 ± 50 kcal).

Although the identification of long-term patterns in most subjects' intakes challenges the notion that an individual's mean or usual intake is stationary over time, the small magnitude of change in most subjects' means over time implies that a fairly stable average intake level persists in the midst of day-to-day variation in energy intake.

When subjects' intake series were examined simultaneously, no single long-term polynomial or sinusoidal regression curve could be fitted to them, even when between-subject differences in the magnitude of variance were controlled with the use of Z scores. The absence of a common long-term pattern in energy intake implies that systematic shifts in subjects' intakes were not in phase with one another. When the group data were examined by using conventional analysis-of-variance techniques, group mean energy intake was found to vary significantly by season \((P = 0.0005)\), with winter and summer intakes being significantly different from those in fall and spring \((P < 0.0057)\). Working with the same data set, analyzing variation in energy intake by month, Basiotis et al [19] found group mean energy intake to be significantly higher in July, August, December, and January than in other months of the year. Both analyses indicate the presence of deviations in group mean intake corresponding to discrete blocks of time. However, the lack of a common long-term pattern in the intakes of individuals when time was treated as a continuous variable indicates that the seasonal variations observed in group analyses do not explain individual subjects' systematic shifts in mean intake levels across the year. Furthermore, the observed seasonal differences in intake do not appear to underlie any of the smooth functions fitted to individuals. Indeed, it is probable that the seasonal effects identified through analysis of variance merely represent an overlapping of individual subjects' long-term patterns in energy intake rather than a true seasonal pattern.

**Day-of-week patterns**

Twenty-two of the 29 subjects exhibited significant, recurrent weekly patterns in energy intake (Table 1). These patterns accounted for 2–26% of the subject's residual variances. Individual subjects exhibited systematic increases and decreases in intake by day of week, with the magnitude of such shifts ranging from 130 to 2410 kJ (31 to 576 kcal) for any one deviant day. Although all 22 subjects had systematic deviations in intake on weekend days (Saturday and/or Sunday), the weekly patterns of 10 of these subjects also included systematic deviations on \(\geq 1\) weekday. The diverse nature of individual patterns is highlighted in Figure 2, which provides an illustration of the weekly patterns identified for six subjects.

Although there are considerable individual differences in both the nature and the magnitude of weekly patterns observed, the patterns must reflect the influence of our 7-d cultural cycle on individuals' daily food intakes. Some comparisons of group mean energy intakes by day of week among other North American and European samples have also revealed patterns in energy intake (1, 15, 17, 18) although results have been inconsistent (21, 22, 39). Working with the same data set analyzed here and examining variability in energy intake across the entire sample, Basiotis et al [19] found group mean energy intakes on Friday and Saturday to be significantly higher and those on Monday and Tuesday to be significantly lower than those on other days of the week. No subject demonstrated this exact pattern when
data were analyzed individually. The discrepancy between the results of the group and individual analyses highlights the difficulty in generalizing from group phenomena to individual behavior. Although most of our subjects' intakes reflected weekly patterns, their diversity challenges the common perception that there is one typical day of week or weekend effect experienced by all individuals.

Residual autoregression

For 15 of the 29 subjects, statistically significant ($P < 0.05$), first-order autoregression was detected in the residuals remaining after removal of balance-period effects, long-term patterns, and weekly patterns (Table 1). For these subjects, adjacent days of intake were interrelated in a manner separate from and in addition to the long- and short-term patterns already described.
The subjects' autocorrelation coefficients, which ranged from 0.1080 to 0.2394, indicate that their energy intakes on adjacent days were more similar to one another than to intakes on non-adjacent days. The finding challenges the belief that some short-term homeostatic mechanism exists that causes high energy intakes to be followed by low ones (40). The autocorrelation coefficients reported here are much lower than those reported by other authors who have examined correlation between adjacent days' intakes (14, 15, 21; FA Larkin, HL Metzner, and K Guire, unpublished observations, 1988). The present findings also differ in that significant autocorrelation coefficients were uniformly positive; other authors reported 40-45% of subjects with negative autocorrelation (14; FA Larkin et al, unpublished observations, 1988). These discrepancies may be attributed to differences in the number of pairs of adjacent days available for analysis. Previously reported autocorrelation coefficients were based on samples of ≤ 12 d/subject. As well, the autocorrelation reported here was computed after long-term and weekly patterns were controlled for; autocorrelation coefficients computed on subjects' data before these adjustments were slightly higher (ranging from 0.1258 to 0.3373) than those reported in Table 1 but remained uniformly positive and of considerably smaller magnitude than those reported elsewhere.

Variance explained

The proportion of total variance explained by the balance-period effects and the long-term and weekly patterns identified ranged from 0% to 37% (Table 1). On average the patterns explained 12.5% of an individual subject's total observed variance across the 365 d. No patterns were discernible for one subject's data. There was no apparent relationship between the proportion of variance explained and the total observed variance.

The proportion of each subject's variance that remains unexplained may contain other undefined patterns. Minor cyclic components were identified in the residual variance of 17 subjects although the cycle lengths could not be interpreted. The unexplained variance may also be a function of nonrandom but perhaps irregular influences on energy intake or the reporting of it. For example, significant menstrual-cycle effects on energy intake were identified through an aggregate analysis of data available for 14 of the 16 women in this sample (25). (The absence of continuous data on subjects' menstrual-cycle activity across the year precluded the modeling of these effects within individuals.) Other authors also noted systematic shifts in energy intake across the menstrual cycle (26-32). The irregularity of the menstrual cycle in humans is well-documented however (41-43). Patterns in energy intake associated with such irregularly timed influences would be unlikely to be detected by the time-series diagnostic techniques used in the present analyses but would contribute to subjects' total observed variance. Festive occasions also present irregular but nonrandom influences on intake, as evidenced by a significant increase in group mean energy intake on Christmas and Thanksgiving in this sample. As well, the unexplained proportion of subjects' total variance must reflect myriad indeterminate environmental influences on subjects' food intake and random and/or systematic errors in the data collection process. Within this data set it is impossible to distinguish between these sources of variance.

Conclusions

Examination of the day-to-day variation in energy intake exhibited by 29 adults over 365 d of recording indicates the range of potential influences on individuals' food-intake behaviors. Two of the patterns identified in subjects' energy intakes can be attributed to external influences on intake. The balance-period effects illustrate individuals' responses to methodological changes in data collection or study procedures. The weekly patterns reflect behavioral responses to a cultural pattern. The only clear evidence of a physiological influence on day-to-day variation in energy intake of subjects in this sample comes from the identification of intake patterns associated with the menstrual cycle (25). Although the observed long-term patterns and positive autocorrelation may reflect physiological and/or environmental pressures on total food or energy intake and/or the reporting of it, further interpretation is hampered by the absence of descriptive data on subjects' lifestyles and activity levels during data collection.

These analyses also indicate that day-to-day variation in energy intake is a highly individual phenomenon. Both the shape and the amplitude of observed patterns in energy intake were characteristic of the individual subjects. Subjects did not exhibit similar weekly or long-term intake patterns. Although cultural and perhaps environmental factors influenced subjects' observed intake behaviors, the nature of the influences and/or the responses to them varied tremendously between subjects. The heterogeneity of intake patterns in these subjects provides an important caveat to the extrapolation from patterns identified in the pooled within-subject variance of a sample to individuals' food-intake behaviors.

These analyses were performed with only 29 subjects. Although they demonstrate the individuality of patterns of variation in daily intake within individuals, generalization of specific results to larger populations is tenuous. Nevertheless, to the extent that the subjects are typical of US adults, some inferences for the interpretation of intake data can be drawn. Results of the present study challenge the statistical assumption that within-subject variance is purely random. As much as 37% of a subject's observed variance across 365 d of data collection could be explained by as few as three patterns. The identification of patterns in all but one subject's intake series helps to explain the empirical observation that the reliability of mean intake estimates for individuals is not a simple function of the number of days of data collected (14) and that intake estimates derived from consecutive-day samples are more likely to misclassify subjects than are those drawn from samples of nonconsecutive days (15). Nonrandom components of within-subject variance must exist even in the limited strings of data collected in large-scale dietary surveys. The implications of these findings for the design and interpretation of dietary data collections is the subject of another paper.

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References


