Within- and Between-Person Variation in Nutrient Intakes of Russian and U.S. Children Differs by Sex and Age[1,2]

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ABSTRACT Within- and between-person variation in nutrient intake has been characterized in different adult populations, but little is known of country, age, or sex differences among children. The objectives of this study were as follows: *1*) to describe the mean intake, within- and between-individual CV and variance ratios of nutrient intake among children ages 9–18 y old in Russia and the United States in 1996; *2*) to compare the age and sex-related differences in nutrient intake variance within and between countries; and *3*) to hypothesize about the feasibility of using within-individual variance estimates from one nationally representative sample to adjust the usual intake distributions in another nationally representative sample. Mean intakes of all nutrients except magnesium were significantly higher among U.S. children ($P < 0.001$); within-person variation was higher among the U.S. children, possibly indicating greater access to a wide array of foods. Strong differentials existed in variance components by sex in both countries, although not in the same direction, and differed by age in U.S. girls. Ratios of within- to between-person variance in 8 of 11 nutrients were lower among Russian (range: 0.9–1.6) than U.S. children (range: 1.4–1.7), suggesting that day-to-day bias may not affect Russian dietary recalls as strongly as in the United States. Researchers are encouraged to use these estimates to conduct sensitivity analyses of usual intake distributions in their own data when multiple days of data collection are not feasible. J. Nutr. 134: 3114–3120, 2004.

KEY WORDS: • *diet recall* • *within-individual variation* • *between-individual variation* • *children* • *Russia*

Defining the prevalence of inadequacy is usually the desired goal for epidemiologic studies of nutrient adequacy, for which estimation of long-term, usual nutrient intake is required (1–7). Ideally, observation of diet over many days, weeks, or months would be preferred, but due to cost and respondent burden, less than ideal, shorter-term methods are often employed to estimate nutrient intake (6). Day-to-day fluctuations from the usual intake can be partially removed during analysis when the contribution of within-individual (day-to-day, inter-individual) variation is known. This adjustment is crucial when only a single 24-h recall is collected (8). Several methods for applying statistical adjustment have previously been developed and suggested, but all require at least an estimate of within-individual variation or biomarkers (3,4,8–10). Within- and between-individual variances can be calculated from multiple days of intake collected from at least a subsample of individuals, or an estimate may be borrowed from another sample (9).

Although many studies characterized the within- and between-individual variation of nutrient intake of adults (7,11–22), there is a large gap in the literature concerning within- and between-individual variation of nutrient intake among children (7,13,23–24).

Dietary intake differs by country, sex, and age. Among adults, there are differences in intake patterns as well as variance estimates (14,25–26); therefore, we are concerned that there is a need to be specific for children when applying variance estimates from other cultures, sexes, and ages to estimate or adjust distributions.

The Russia Longitudinal Monitoring Survey (RLMS)[5] and the Continuing Survey of Food Intakes by Individuals (CSFII), dietary surveys with comparable dietary assessment methodology but very different food supply issues (such as numbers of foods available for a child to eat), offer a unique opportunity to analyze differences between an economically developed and a transitional country. Both surveys collected nonconsecutive 24-h recalls, and

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[5] Abbreviations used: CSFII, Continuing Survey of Food Intake by Individuals; CV_b, between-individual CV; CV_w, within-individual CV; DRI, Dietary Reference Intakes; FCT, food composition table; RIN, Russian Institute of Nutrition; RLMS, Russia Longitudinal Monitoring Survey; S_b^2, the estimated between-individual variance; S_w^2, the estimated within-individual variance.

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RLMS training and interviewing methods were based upon CSFII multiple-pass methods.

The objectives of this research paper were as follows: *1*) describe the mean, between- and within-individual variation, and variance ratios of nutrient intake among children ages 9–18 y in Russia and the United States in 1996; *2*) compare the age and sex-related differences in nutrient intake variance within and between countries; and *3*) hypothesize about the feasibility of using within-individual variance estimates from one nationally representative sample to adjust the usual intake distributions in another nationally representative sample.

SUBJECTS AND METHODS

Study population and sampling design. Data used in the study were derived from the RLMS and CSFII. The RLMS is a large, multistage, stratified area sample of the population of the Russian Federation, designed to capture household and individual responses to economic change; data were collected 11 times since 1992. Detailed methodology pertaining to the survey was published previously (27,28). In 6 of the rounds, a single 24-h recall was collected; 2 nonconsecutive recalls were collected in 1996. The Russian sample consists of 1573 children, 9.0–18.9 y old, from the RLMS Round 7, (conducted from October to December 1996). Of these, 1525 completed two 24-h recalls and another 66 were excluded because income data were missing; 46 children were excluded due to implausibly high intakes of several nutrients. The final sample consisted of 1413 (90%) children. Dietary intake of children aged 9.0–9.99 y was collected by asking an adult proxy who spent the most time with the child, usually the mother. Effort was made to include the child in the report. Children $\geq$ 10 y old self-reported their intake, assisted by a caregiver (89%). When necessary, interviewers visited children' s schools to collect additional dietary information from teachers or school cafeteria workers. Diet recalls were collected by trained interviewers for each member in the household, using color photographs of foods to assist in assessing portion sizes. Dietary recall methods were based on the CSFII multiple-pass methodology. The intake data were edited, first by supervisors in the field, and again by nutritionists at the Russian Institute of Nutrition (RIN), Russian Academy of Medical Sciences; this close monitoring allowed interviewers to resolve questions while still in the field. All records were processed at the RIN. The most recent RIN food composition table (FCT) was used to assign nutrient values for foods eaten. The 2003 RIN food composition database was used for the analysis of the RLMS. This FCT consists of 2535 food products and dishes. Of these, 821 are commodity food products (such as meat, cheese, vegetables), and 1714 are dishes based upon recipes using the food products. Chemical analysis for most of the 821 products was conducted by Skurikhin and Volgarev (29). The chemical compositions of ~50–80 products were taken from other FCTs, including the German FCT for imported European foodstuffs. This study was approved by the institutional review board of the University of North Carolina' s School of Public Health.

The CSFII is a series of cross-sectional nationally representative surveys of the kinds and amounts of food eaten in the United States (30). In 1994, 1995, and 1996, 2 interviewer-administered 24-h recalls, using a multiple-pass approach, were collected 3–10 d apart, on 1 weekday and 1 weekend day. Recalls were collected over the entire 12-mo period. Dietary intake of children aged 9.0–11.99 y was collected by parental proxy. Children $\geq$ 12 y old self-reported their intake (63%). In each survey year, the food composition database was updated, both to add new food items and to increase the precision of nutrient breakdown as improved methods became available. In this study, we applied the most recent U.S. FCT to assign nutrient values to foods eaten. The full sample consisted of 751 children; 41 children were excluded due to implausibly high intakes. The final sample consisted of 645 (86%) children, 9.0–18.9 y old, with complete data obtained from interviews in 1996.

The U.S. sample was age and sex standardized to the distribution in the Russian population to facilitate comparison. The samples from both countries were stratified into 4 age and sex groups corresponding to the life stage and sex group parameters for Dietary Reference Intakes (DRI) of the U.S./Canadian DRI. These parameters are based upon estimated nutrient requirements, not intakes (31). We examined country differences between Russian and U.S. children for the aggregated sample of children, 9–18 y of age, and sex and age group differences within each country.

Dependent variables. Dependent variables were intakes (continuous) of energy and 10 nutrients. Not all nutrient values of public health significance (such as folic acid) were available in the Russian FCT; therefore, we reported the selected nutrients that were available. Mean and SEM, within- and between-person variation, S_w (the square root of the estimated within-person variance), and S_b (the square root of the estimated between-person variance) were estimated within the model, and ratios of within- and between-individual variance were expressed as S_w^2/S_b^2. The CV were calculated as: $CV_w = [S_w/\text{mean intake (nutrient)}] \times 100$; $CV_b = [S_b/\text{mean intake (nutrient)}] \times 100$.

Statistical methods and explanatory measures. Data management was done using SAS for UNIX, Version 8.0; data analysis was done using Stata versions 7.0 and 8.2. A mixed effects regression model with a maximum likelihood estimator was used to estimate mean intake and within- and between-person variation, stratified by country, sex, and age-sex groups. Previous reports in the literature found that age, sex, and education were significant factors explaining the variability in dietary intake of Canadian adults (22). In our models, we controlled for the fixed effects of poverty (using self-reported income and country-specific, household-level poverty indices: 1 = below poverty line, 0 = above) and urban residence, controlling crudely for the effects of relative affluence and urban residence in the 2 countries. By no means do we claim that the samples are comparable because Russia and the United States differ dramatically in both economic and urban resources. Researchers generally control for the effects of poverty and residence in predictive models of dietary intake; therefore, we controlled these effects in the present model. The effect of including the covariates was to reduce the observed size of the between-person variation effect.

In previous studies that describe within- and between-individual variation, nutrients, which are notoriously nonnormal, were examined for distributional assumptions, and often transformed to reduce skewness, then back-transformed to facilitate interpretation. There are 3 serious problems with that method, as discussed extensively in the economics literature (32): *1*) transforming is not necessary if the model residuals are homoscedastic across the covariates, with the corollary that the model based upon transformed values may not fulfill the assumption of homoscedasticity; *2*) estimates based upon transformed nutrient data are difficult, if not impossible, to interpret meaningfully; and *3*) naïve back-transformation, by applying the inverse or exponent, may introduce considerable bias to the estimates (Department of Statistics, Iowa State University, unpublished data). Some nutrition researchers have chosen to transform nutrients before analysis and accept that back-transformation will introduce some unmeasurable bias (12,13). Others have reported that transforming did not change variance ratios appreciably and report untransformed results (18,22).

Methods have previously been described for removing the bias introduced by back-transformation for intake estimates. Back-transformation of estimated usual intakes, into the original scale, should be modified to reduce the bias that is introduced when the naïve back-transformation is applied to means. An approach derived by Carriquiry and Dodd (unpublished) and described by Carriquiry (6) corrects the naïve back-transformation of estimated usual intakes simply by introduction of a term that depends on the within-individual variance, i.e., the larger the within-individual variance, the larger the correction to the naïve back-transformation. However, no method exists to remove the bias from variance estimates, which are the focus of this report. We examined the distribution of each nutrient and found evidence of skewed distributions for all nutrients. We tested the assumption of homoscedasticity across covariates in the models and found significant violations. We then transformed the nutrients using both a logarithm and Box-Cox transformation, and again tested for homoscedasticity. Neither method of transformation removed the heteroscedasticity problem. Therefore, because transfor-

TABLE 1

Demographic characteristics of Russian and U.S. children[1]

	Girls				Boys			
	9–13		14–18		9–13		14–18	
Age group, *y*	Russia[2]	U.S.[3]	Russia	U.S.	Russia	U.S.	Russia	U.S.
n	402	176	320	150	371	196	320	123
Age, *y*	11.0 ± 1.4	10.9 ± 1.4	15.8 ± 1.4	15.7 ± 1.3	10.9 ± 1.4	10.8 ± 1.4	15.8 ± 1.4	15.6 ± 1.4
Below poverty, %	45	24	46	22	44	22	37	25
Urban, %	74	72	70	76	70	77	72	76

1 Values are means ± SD or %.
2 Data derived from the RLMS.
3 Data derived from the CSFII.

mation did not improve the model assumptions and back-transformation would introduce bias to the variance estimates, all results are reported for untransformed data.

A separate model was fitted for energy and 10 nutrients for each age/sex group in both surveys using the xtreg procedure in Stata. Testing of mean intakes was via *t* test. Because both surveys used a complex, multistage cluster design, an estimate of the SE for mean intakes was calculated via a stratified bootstrap approach, in which multiple samples of individuals in each age/sex and country group were formed by sampling with replacement from the set of individuals in the group. We used 1000 bootstrap samples to obtain the SE, treating the strata and cluster as the sample unit in each survey.

RESULTS

Demographic characteristics of the study children. Overall, the samples were drawn from similar populations in Russia and the United States. Even before age and sex standardization, the mean age and sex distribution of the U.S. sample was very similar to that of the Russian sample. In Russia, 36% of children belonged to families with incomes below the poverty line, compared with 23% in the U.S. Additionally, more U.S. children lived in urban areas than Russian children **(Table 1)**.

Means and variance components for energy and nutrients of Russian and U.S. children. Mean reported energy intake was lower among Russian than U.S. children by 972 kJ (232 kcal), or ~11%. Mean magnesium intake was ~4% higher among Russian children, but intake of all other nutrients was significantly lower among Russian children ($P < 0.001$). The CV_w (% of within-individual CV) for energy, protein, carbohydrate, iron, thiamin, niacin, and vitamin C was lower among Russian children; fat intake (+0.8 higher than U.S. children), calcium (+2.4), and magnesium (+1.0) were slightly higher, and riboflavin was much higher (+20.3) among Russian children. The CV_b (% of between-individual CV), in contrast, was higher for most nutrients among the Russian children, except for iron (−2.2) and vitamin C (−0.9). Eight of the 11 S^2_w/S^2_b nutrients were lower among Russian (range: 0.9–1.6) than U.S. children (range: 1.4–1.7) **(Table 2)**.

Within-/between-individual nutrient ratios by sex within countries. Overall, the within- to between-person variance nutrient ratios were higher among U.S. than Russian children. Russian girls displayed greater within-person variation than boys for all nutrients (data not shown). Russian girls also had lower between-person ratios for all nutrients except thiamin and vitamin C than boys; therefore, the within-/between-person variance ratios were higher among girls for all nutri-

TABLE 2

Intakes of selected nutrients, CV, and variance ratios of Russian and U.S. children[1,2]

	Intake		CV_w		CV_b		Variance ratio	
	Russia	U.S.	Russia	U.S.	Russia	U.S.	Russia	U.S.
					%			
Energy, *kJ*	7511 ± 121.1	8484 ± 151.5*	23.5	29.7	26.4	21.5	0.9	1.4
Protein, *g*	53.6 ± 1.0	71.3 ± 1.4*	30.1	37.5	29.4	22.0	1.0	1.7
Fat, *g*	62.1 ± 1.5	74.2 ± 1.6*	39.6	38.8	34.5	25.0	1.1	1.6
Carbohydrate, *g*	255.0 ± 4.2	275.1 ± 5.1*	25.5	32.1	26.7	23.3	1.0	1.4
Calcium, *mg*	485.4 ± 13.3	869.2 ± 22.1*	44.4	42.0	39.8	31.3	1.1	1.3
Iron, *mg*	13.7 ± 0.3	15.3 ± 0.4*	34.9	44.3	28.6	30.8	1.2	1.4
Magnesium, *mg*	241.8 ± 4.1	233.2 ± 4.6*	36.2	35.2	26.1	24.6	1.4	1.4
Thiamin, *mg*	0.9 ± 0.0	1.6 ± 0.0*	37.5	39.2	29.1	25.3	1.3	1.6
Riboflavin, *mg*	0.9 ± 0.0	2.0 ± 0.1*	59.4	39.1	36.7	27.7	1.6	1.4
Niacin, *mg*	10.8 ± 0.2	20.8 ± 0.5*	39.2	42.6	27.8	23.9	1.4	1.8
Vitamin C, *mg*	53.5 ± 2.1	90.5 ± 3.3*	70.2	71.4	51.1	52.0	1.4	1.4

1 Intake values are means ± SE, n = 1413 Russian children; n = 645 U.S. children. * Different from Russian children, $P < 0.001$.
2 All analyses were adjusted for age, sex, poverty status, and urban residence.

ents, except riboflavin. Among U.S. children, girls had higher within-person variation than boys for all nutrients except carbohydrates. However, U.S. girls also had higher between-person variance than U.S. boys. Variance ratios of U.S. girls were the same as that of U.S. boys for protein and carbohydrate, but lower for all other nutrients **(Fig. 1)**.

Within-/between-individual variation by sex and age group. In both countries, older boys had significantly higher intakes of all nutrients than younger boys ($P < 0.001$), whereas among girls the pattern was not as direct. Among Russian girls, thiamin, and niacin intakes were significantly higher among older girls ($P < 0.05$), but not other nutrients or energy. Among U.S. girls, energy and macronutrient intakes were the same or tended to be higher ($P > 0.05$) for older girls. Mean intakes of calcium, iron, magnesium, thiamin, and riboflavin were all significantly lower among older U.S. girls ($P < 0.001$), whereas niacin and vitamin C intake were higher compared with younger girls ($P < 0.001$) **(Table 3)**.

Among Russian children, older girls had higher CV_w than younger girls for 8 of the 11 nutrients (excluding riboflavin, niacin, and vitamin C), and higher CV_b for 9 of the 11 nutrients (excluding magnesium and thiamin). There was no observable pattern in the variance ratios of older vs. younger girls. Among U.S. girls, there was no pattern in the difference of CV_w for older vs. younger girls, but the CV_b was higher in 9 of the 11 nutrients, and variance ratios were lower for older girls for all nutrients except energy and riboflavin.

The CV and S_w^2/S_b^2 ratios of Russian boys did not appear to follow any pattern by age, nor did the CV_w for U.S. boys. However, older U.S. boys had lower CV_b values for macronutrients, but higher CV_b values for micronutrients than younger boys. Consequently, the S_w^2/S_b^2 ratios for macronutrients were higher for older U.S. boys; those for micronutrients were lower than for younger U.S. boys.

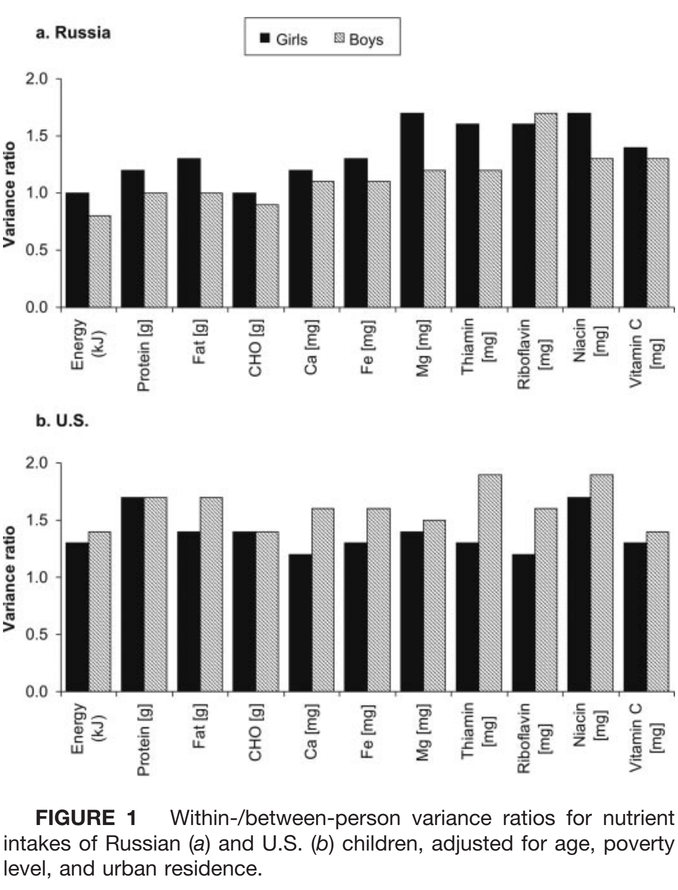

FIGURE 1 Within-/between-person variance ratios for nutrient intakes of Russian (*a*) and U.S. (*b*) children, adjusted for age, poverty level, and urban residence.

DISCUSSION

The major finding of this report is that mean intake, CVs, and variance ratios were all significantly lower in Russian than U.S. children for almost all nutrients. In addition, strong differentials existed in variance components by sex in both countries, although not in the same direction, and differed by age among American girls.

Russia compared with the United States. Russian children had lower within-person CV and more between-individual variation in nutrient intake than U.S. children, suggesting that there is greater day-to-day variation in food intake among U.S. children; this is hardly surprising given the much greater array of food products available in the United States. The S_w^2/S_b^2 ratios for Russian children were ≤1 for energy, protein, and carbohydrate intake, and were lower in general than those of U.S. children; this suggests that the attenuating effects of within-person variation on mean intake estimation are not as strong among Russian children as in other countries. However, as Russia continues to improve economically and diversify its food supply with Western imports and more processed and convenience foods, we may expect the within-person variation to increase over time. It may be more difficult to show changes or find epidemiologic associations with health outcomes among U.S. than among Russian children because associations are difficult to detect when the S_w^2/S_b^2 ratio exceeds unity (1). Our results are not dissimilar to the few papers that have addressed variance components in children (7,13), with the exception of Field et al. (24), who reported higher variance ratios, and Roma-Giannikou (23), who reported lower ratios. Our results may vary due to limited sample sizes, age differences among the populations studied, temporal differences in eating patterns, or differences in the measures of dietary intake. However, it is critical to note this is the first study to examine dietary variance in children by comparing 2 *nationally representative* samples.

Sex differences within countries. Within each country, the sexes differed in the magnitude of within-person variation, but the direction of the sex differences was not consistent. More within-/between-individual nutrient ratios were higher in Russian girls and in U.S. boys. The Russian girls tended to have more nutrients with greater within- and lower between-individual variation than boys. This is surprising because the Russian girls consumed smaller amounts of all nutrients relative to boys, except vitamin C (mean intake 54.9 vs. 52.0 mg, respectively; data not shown) and, generally speaking, within-person variation increases as total intake increases. This may indicate that girls consumed more fruits and vegetables than boys, although consumption by Russian children is well below the WHO recommendation of 400 g/d (33). There was no discernible pattern of nutrients with greater within-person variation among U.S. children by sex, but the between-person variation, which is the true difference between individuals, was strikingly different by sex.

Age differences within countries. In both Russia and the United States, older boys consumed significantly greater amounts of energy and all nutrients than younger boys ($P < 0.001$). However, this pattern was not found among the older girls in either country. In the United States especially, older girls' mean micronutrient intake was lower than that of younger girls for several key nutrients. This is consistent with the report by Suitor et al. (34) that 14- to 18-y-old U.S. girls have a higher prevalence of inadequate micronutrient intake

TABLE 3

Intake of selected nutrients, CV, and variance ratios of Russian and U.S. children, by sex and age groups[1,2]

	Sex	Age group, *y*	Intake		CV_w		CV_b		Variance ratio	
			Russia	U.S.	Russia	U.S.	Russia	U.S.	Russia	U.S.
							%			
Energy, *kJ*	Girls	9–13	6900 ± 127.1	7429 ± 189.5	22.8	28.7	23.4	21.3	1.0	1.3
		14–18	6861 ± 163.2	7613 ± 222.1	26.4	33.3	27.1	24.6	1.0	1.4
	Boys	9–13	7404 ± 162.8	8975 ± 208.8	21.8	26.9	26.2	21.2	0.8	1.3
		14–18	9055 ± 221.5*	10270 ± 246.3*	23.1	30.3	27.4	18.3	0.8	1.7
Protein, *g*	Girls	9–13	47.8 ± 1.0	60.3 ± 1.5	28.7	38.9	25.9	19.1	1.1	2.0
		14–18	48.2 ± 1.3	63.5 ± 2.0	33.1	40.3	27.1	26.3	1.2	1.5
	Boys	9–13	52.7 ± 1.2	76.2 ± 2.1	27.0	35.5	30.5	21.8	0.9	1.6
		14–18	67.3 ± 2.0*	88.4 ± 2.8*	30.6	35.5	30.6	19.2	1.0	1.8
Fat, *g*	Girls	9–13	56.4 ± 1.5	63.8 ± 2.0	39.7	37.2	29.7	26.7	1.3	1.4
		14–18	56.4 ± 1.7	66.8 ± 2.1	44.8	43.2	33.2	30.8	1.3	1.4
	Boys	9–13	60.0 ± 2.0	798.2 ± 2.2	34.1	35.5	38.3	23.7	0.9	1.5
		14–18	77.3 ± 2.4*	91.6 ± 2.6*	39.1	39.1	34.4	17.5	1.1	2.2
Carbohydrate, *g*	Girls	9–13	237.5 ± 4.9	246.6 ± 6.8	24.4	31.3	24.3	22.1	1.0	1.4
		14–18	234.3 ± 5.9	246.8 ± 7.1	28.4	34.6	27.4	26.2	1.0	1.3
	Boys	9–13	254.7 ± 5.7	291.4 ± 7.2	24.8	30.3	23.6	22.9	1.0	1.3
		14–18	298.3 ± 8.0*	325.3 ± 9.3*	24.5	32.6	29.9	21.2	0.8	1.5
Calcium, *mg*	Girls	9–13	451.9 ± 12.5	823.2 ± 32.6	43.5	43.9	33.6	29.9	1.3	1.5
		14–18	457.4 ± 21.0	695.8 ± 35.1‡	45.0	42.7	39.0	46.2	1.2	1.0
	Boys	9–13	485.3 ± 21.1	968.4 ± 29.9	41.9	40.4	43.8	26.3	1.0	1.5
		14–18	555.8 ± 20.8*	988.6 ± 38.0*	46.2	40.5	25.3	1.1	1.6	1.4
Iron, *mg*	Girls	9–13	12.6 ± 0.4	13.7 ± 0.5	36.4	48.4	25.7	29.6	1.4	1.6
		14–18	12.7 ± 0.4	13.2 ± 0.6‡	37.0	40.1	29.5	39.5	1.3	1.0
	Boys	9–13	13.7 ± 0.4	16.7 ± 0.6	35.9	44.3	28.7	27.2	1.3	1.6
		14–18	15.9 ± 0.4*	18.1 ± 0.8*	30.6	42.2	29.3	27.7	1.0	1.5
Magnesium, *mg*	Girls	9–13	217.2 ± 4.4	209.2 ± 5.8	36.9	35.2	23.7	23.1	1.6	1.5
		14–18	228.9 ± 5.2	204.1 ± 7.2‡	41.1	38.1	22.5	1.8	1.3	0.9
	Boys	9–13	240.5 ± 6.1	256.5 ± 6.4	36.1	32.5	27.6	23.9	1.3	1.4
		14–18	286.9 ± 7.6*	265.9 ± 9.4*	31.4	35.7	27.5	21.7	1.1	1.6
Thiamin, *mg*	Girls	9–13	0.8 ± 0.01	1.5 ± 0.01	34.7	39.6	25.2	28.4	1.4	1.4
		14–18	0.9 ± 0.02†	1.4 ± 0.01‡	43.0	38.2	24.6	32.4	1.7	1.2
	Boys	9–13	0.9 ± 0.02	1.8 ± 0.04	34.5	40.9	24.4	16.4	1.4	2.5
		14–18	1.2 ± 0.04*	1.9 ± 0.01*	37.0	35.8	34.9	25.6	1.1	1.4
Riboflavin, *mg*	Girls	9–13	0.8 ± 0.02	1.9 ± 0.1	62.2	38.8	34.5	31.3	1.8	1.2
		14–18	0.8 ± 0.04	1.6 ± 0.1‡	61.0	43.6	44.5	34.4	1.4	1.3
	Boys	9–13	0.9 ± 0.03	2.2 ± 0.1	63.0	38.0	30.6	20.4	2.1	1.9
		14–18	1.1 ± 0.04*	2.3 ± 0.1*	51.7	36.8	36.6	26.8	1.4	1.4
Niacin, *mg*	Girls	9–13	9.5 ± 0.2	18.1 ± 0.6	43.9	46.0	23.8	26.8	1.8	1.7
		14–18	9.9 ± 0.3†	18.5 ± 0.7‡	38.5	43.5	26.2	26.4	1.5	1.6
	Boys	9–13	10.5 ± 0.2	22.4 ± 0.6	39.8	41.3	29.1	17.4	1.4	2.4
		14–18	13.5 ± 0.3*	24.9 ± 1.0*	34.8	39.5	29.1	25.2	1.2	1.6
Vitamin C, *mg*	Girls	9–13	54.8 ± 2.5	85.4 ± 4.5	78.0	67.3	43.6	48.5	1.8	1.4
		14–18	55.0 ± 3.4	87.7 ± 6.1‡	69.8	75.7	62.0	59.4	1.1	1.3
	Boys	9–13	49.4 ± 2.7	92.8 ± 5.2	63.4	69.5	56.2	44.2	1.1	1.6
		14–18	55.1 ± 2.4*	97.6 ± 6.8*	66.0	73.6	40.2	56.0	1.6	1.3

[1] Intake values are means ± SE, $n = 1413$ Russian children; $n = 645$ U.S. children. * Different from 9- to 13-y-old boys from the same country, $P < 0.001$. † Different from 9- to 13-y-old girls from the same country, $P < 0.001$. ‡ Different from 9- to 13-y-old girls from the same country, $P < 0.05$.
[2] All analyses were adjusted for poverty status and urban residence.

than younger girls (9–13 y) and Cavadini et al. (35), who found evidence of inadequate intake of dairy, fruit, and vegetable intake in this age group.

Older Russian girls had higher day-to-day and between-person CV than younger girls for most nutrients; thus, there was no consistent pattern of higher or lower ratios. This pattern suggests increasing choices among the older girls and greater heterogeneity in the age group. However, there was no such pattern among boys. Among the U.S. girls, there was no pattern in the difference of day-to-day variation in older girls compared with younger girls, but the between-person variation, which reflects differences between individuals' usual intakes, was strikingly higher, and therefore the variance ratios decreased, for almost all nutrients. In contrast, older U.S. boys had lower between-person variation for energy and macronutrients, and higher variation for micronutrients, than the younger boys. These differences, however, are not statistically significant. The within-person variation is not consistently higher in 14- to 18-y-old children than in 9- to 13-y olds; this is somewhat surprising because one would expect older children to have greater freedom to choose a variety of foods than younger children. This suggests that older children could be choosing a more monotonous diet of preferred foods. It is clear that the sex and age differences that affect mean intakes also affect distributional components of dietary intake.

Russian children reported significantly lower intakes of energy and most nutrients than U.S. children. Our results are consistent with the extensive economic changes that have profoundly affected the food supply in Russia since 1992 (27,36). But do U.S. children have high intakes or do Russian children have low intakes? Martinchik et al. (37) reported comparable intake levels among 10-y-old Moscow children from 1992 to 1994 that tended to be lower than those of European children (23,38,39). There is documented inadequate micronutrient intake among Russian and Eastern European children that is consistent with our findings of low mean vitamin C intake (37,40,41). We might expect lower intake if Russian children were significantly shorter than American children; however, in our sample we found height differences among the age and sex groups of <2 cm. Decreased energy needs cannot account for the lower mean intakes among Russian children, which are trivial compared with energy recommendations that vary by <3 kcal/cm (12.55 kJ/cm) (42). Our reported mean nutrient intakes of U.S. children are similar to those reported in other studies (43).

Techniques to adjust usual nutrient intake distributions are available and recommended, but rarely applied. Recent studies reported the prevalence of nutrient inadequacy from a single 24-h recall without attempting to adjust the distribution (44,45). The US/Canadian DRI for group intake requires a usual intake distribution, which cannot be calculated when a single 24-h recall or food record is collected. If an unadjusted distribution is used, bias can be considerable in the estimate of the prevalence of inadequate intake. For example, among 14- to 18-y-old girls from the CSFII, the estimated prevalence of inadequate intakes using 1 d of data was 35 and 54% for thiamin and vitamin C, respectively. When the adjusted intake distribution was used in the calculation, those estimates decreased to 14 and 32%, indicating that the bias that resulted from using only one 24-h recall was 150% in the case of thiamin and 69% in the case of vitamin C (46). We suspect that using variance estimates that are too high or too low may similarly contribute to biased prevalence estimates.

One reason for not adjusting usual intake distributions may be a lack of within-person variation estimates; this paper makes a contribution by providing detailed estimates of within- and between-person variation of energy and nutrient intakes for children.

Although we hypothesize that borrowing a within-individual variance estimate may be one way to avoid day-to-day bias when calculating the prevalence of nutrient inadequacy, or other measures requiring unbiased distributions of usual nutrient intakes, our findings suggest that one must exercise caution when attempting to do so. The applicability of using the variance estimates of one population to adjust the usual intake distribution of another population, and the effect upon prevalence of nutrient inadequacy, will be tested on the full sample of Russian and U.S. children in future research, thereby clarifying the usefulness of borrowing estimates. However, in this paper, we provided variance estimates for nutrients by country, sex, and age stratifications, and urge researchers to use these estimates to conduct sensitivity analyses of usual intake distributions in their own data when multiple days of data collection are not feasible.

Potential limitations include the possibility that the lower variation among Russian children may be an artifact of the study design because 12 mo are represented in the CSFII but only 3 mo (October, November, and December) in the RLMS. However, this bias is likely minimal because seasonality was shown not to affect the diet of U.S. children, possibly due to the widespread availability of most foods year round (47). Additionally, the low intakes of Russian children compared with U.S. children are consistent with Martinchik's study (37), which was conducted in the spring due to concerns that the food supply would most likely be insufficient at winter's end.

In conclusion, mean intake and variance components of energy and nutrient consumption of children vary by country, and differentially by sex and age within countries. Researchers are encouraged to use these estimates to conduct sensitivity analyses of usual intake distributions in their own data when multiple days of data collection are not feasible.

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